

DETERMINANTS OF EXPORTS IN TURKISH PROVINCES: A SPATIAL
DYNAMIC PANEL DATA ANALYSIS

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DYNAMIC PANEL DATA ANALYSIS**

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ABSTRACT

DETERMINANTS OF EXPORTS IN TURKISH PROVINCES: A SPATIAL DYNAMIC PANEL DATA ANALYSIS

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This thesis investigates why export performance differs across Turkish provinces and how spatial linkages shape these differences. This study groups the determinants of provincial exports into three blocks which are economic-financial structures, knowledge-innovation and accessibility-connectivity by using balanced annual panel data from all 81 NUTS-3 Turkish provinces over 2008-2023. The empirical strategy combines dynamic cross-sectionally augmented error-correction models with dynamic spatial panel estimators. This strategy allows to analyze long-run relationships as well as short-run dynamics and spatial spillovers. The results show that imports and manufacturing activity support higher export growth and negative significant error-correction terms imply rapid adjustment back to long-run equilibria. Human capital and innovation matter more as a bundle than through any single proxy, while improvements in connectivity tend to raise local exports but may create competitive pressure on neighboring provinces.

Keywords: Provincial Exports, Spatial Dependence, Spatial Econometrics, Spatial Dynamic Panel Models, Spillover Effects

ÖZ

TÜRKİYE İLLERİNİN İHRACAT BELİRLEYİCİLERİ: MEKÂNSAL DİNAMİK PANEL VERİ ANALİZİ

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Bu tez, Türkiye’de iller arasındaki ihracat performansı farklılıklarının neden ortaya çıktığını ve bu farklılıkların mekânsal bağlantılar tarafından nasıl şekillendirildiğini incelemektedir. Çalışma, 2008–2023 dönemi için tüm 81 NUTS-3 Türk iline ait dengeli yıllık panel veriyi kullanarak il ihracatının belirleyicilerini üç blok altında toplamaktadır. Bunlar, ekonomik-finansal yapı, bilgi-innovasyon ve erişilebilirlik-bağlantısallıktır. Ampirik strateji, dinamik kesit-genişletilmiş hata düzeltme modellerini dinamik mekânsal panel tahmincileriyle birleştirmektedir. Böylece, hem uzun dönem ilişkilerin hem de kısa dönem dinamiklerinin ve mekânsal yayılma etkilerinin birlikte analiz edilmesine imkân tanınmaktadır. Bulgular, ithalat ve imalat faaliyetlerinin ihracat büyümesini desteklediğini, negatif ve anlamlı hata düzeltme terimlerinin ise uzun dönem dengesine hızlı bir dönüşe işaret ettiğini göstermektedir. Beşerî sermaye ve inovasyon tek bir gösterge üzerinden değil, bütün olarak ele alındığında daha anlamlı bir rol oynamakta ve bağlantısallıktaki iyileşmeler ise yerel ihracatı artırırken komşu iller üzerinde rekabet baskısı yaratabilmektedir.

Anahtar Kelimeler: İl İhracatı, Mekânsal Bağımlılık, Mekânsal Ekonometri, Mekânsal Dinamik Panel Modelleri, Yayılma Etkileri

To my family

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TABLE OF CONTENTS

PLAGIARISM	iii
ABSTRACT	iv
ÖZ.....	v
DEDICATION	vi
ACKNOWLEDGMENTS.....	vii
TABLE OF CONTENTS	viii
LIST OF TABLES	xii
LIST OF FIGURES.....	xiv
LIST OF ABBREVIATIONS	xv
CHAPTERS	
1. INTRODUCTION.....	1
1.1. Background and Motivation.....	3
1.2. Research Questions and Objectives	4
1.3. Methodological Overview	5
1.4. Contributions and Structure of the Thesis.....	8
2. LITERATURE REVIEW.....	11
2.1. Theoretical Background	11
2.1.1. Classical Economic Theory.....	12
2.1.2. New Trade Theory	13
2.1.3. New Economic Geography Theory.....	14
2.1.4. The Gravity Model and Spatial Interdependence.....	15

2.2.	Empirical Determinants of Provincial Exports	16
2.2.1.	Economic Size and Industrial Structure.....	19
2.2.2.	Infrastructure, Accessibility, and Connectivity.....	20
2.2.3.	Human Capital, Knowledge, and Innovation.....	21
2.2.4.	Institutional and Policy Environment.....	22
2.2.5.	External, Market and Trade Linkages	22
2.3.	Spatial Dimensions in Provincial Export Studies	23
2.4.	Research Gap and Positioning	26
3.	METHODOLOGY.....	27
3.1.	Non-Spatial Econometric Framework.....	27
3.1.1.	Conventional Panel Data Models.....	28
3.1.2.	Panel Unit Roots and Cointegration.....	30
3.1.3.	Error Correction Model (ECM)	31
3.2.	Spatial Econometric Approach	32
3.2.1.	Spatial Dependence and Spatial Heterogeneity	33
3.2.2.	Tests for Spatial Dependencies	34
3.2.3.	Spatial Weight Matrix	36
3.2.4.	Spatial Regression Models.....	38
3.2.5.	Spatial Panel Data Models	42
3.2.6.	Model Estimation.....	46
3.2.7.	Direct and Indirect Effects (Spillover Effect)	47
3.2.8.	Model Selection and Spatial Diagnostics.....	49
3.3.	Estimation Strategy, Endogeneity and Robustness.....	50
4.	EXPORT LANDSCAPE OF TÜRKİYE - A BRIEF OVERVIEW	51
5.	DATA AND DESCRIPTIVE ANALYSIS.....	59

5.1.	Data Sources, Time Coverage, and Sample Design.....	59
5.2.	Baseline Variables and Transformations.....	61
5.3.	Spatial Data and Distance Structures	62
5.4.	Descriptive Statistics and Stylized Facts.....	63
6.	EMPIRICAL RESULTS	68
6.1.	Preliminary Tests: Dependence, Stationarity and Cointegration	68
6.1.1.	Cross-Sectional Dependence (CD) Tests	68
6.1.2.	Panel Unit Root Tests.....	70
6.1.3.	Treatment of Non-stationary Variables.....	71
6.1.4.	Panel Cointegration Tests.....	72
6.2.	Static Panel Estimation Results (Non-Spatial Benchmarks).....	74
6.2.1.	Model Specification	75
6.2.2.	Macro and Finance Model Results.....	75
6.2.3.	Education and Innovation Model Results	77
6.2.4.	Infrastructure and Connectivity Model Results	78
6.2.5.	Testing for Spatial Dependency: Moran's I.....	80
6.3.	Spatial Panel Estimation Results and Spillovers.....	81
6.3.1.	Model Specification	82
6.3.2.	Model I: The Impact of Macro-Financial Factors.....	82
6.3.3.	Model II: The Impact of Education and Innovation.....	85
6.3.4.	Model III: The Impact of Connectivity	88
6.4.	Main Findings	90
7.	CONCLUSION	93
	REFERENCES.....	96
	APPENDICES	

A. ROBUSTNESS TESTS	105
B. ADDITIONAL FIGURES AND TABLES.....	115
C. DIRECT/INDIRECT/TOTAL EFFECTS	117
D. TURKISH SUMMARY / TÜR KÇE ÖZET	121
E. THESIS PERMISSION FORM / TEZ İZİN FORMU	130

LIST OF TABLES

Table 2.1	Literature Review on Non - spatial Determinants of Provincial Export ...	17
Table 2.2	Literature Review on Spatial Dimensions in Provincial Export Studies...	23
Table 3.1	Direct and Spillover Effects of Spatial Models.....	48
Table 5.1	Variable Definitions and Data Sources	61
Table 5.2	Summary Statistics	64
Table 6.1	Cross-sectional Dependence Test Results for Main Variables.....	69
Table 6.2	Pesaran (2007) Unit Root Test Results for Main Variables	70
Table 6.3	Pesaran (2007) Unit Root Test Results for First Differenced Variables ...	70
Table 6.4	Cointegration Results	73
Table 6.5	Macro/Finance, Dyn-CCE ECM for Provincial Export Growth.....	76
Table 6.6	Education-Innovation, Dyn-CCE ECM for Provincial Export Growth	77
Table 6.7	Connectivity, Dyn-CCE ECM for Provincial Export Growth.....	79
Table 6.8	Global Moran's I Test Before Spatial Models	80
Table 6.9	Spatial Error-Correction Model for Provincial Export Growth (1)	83
Table 6.10	Spatial Error-Correction Model for Provincial Export Growth (2)	86
Table 6.11	Spatial Error-Correction Model for Provincial Export Growth (3)	89
Table Appendix A. 1	Estimation Results of the Model I - Fixed Effects.....	105
Table Appendix A. 2	Estimation Results of the Model I - Random Effects	106
Table Appendix A. 3	Hausman Test Results of Model I.....	107
Table Appendix A. 4	Estimation Results of the Model II - Fixed Effects	108
Table Appendix A. 5	Estimation Results of the Model II - Random Effects.....	109
Table Appendix A. 6	Hausman Test Results of Model II	110
Table Appendix A. 7	Estimation Results of the Model III - Fixed Effects	111
Table Appendix A. 8	Estimation Results of the Model III - Random Effects.....	112
Table Appendix A. 9	Hausman Test Results of the Model III - Fixed Effects	113

Table Appendix B. 1 Pairwise Correlation Matrix.....	116
Table Appendix C. 1 Robustness Test for Model III – FE- Distance Matrix	114
Table Appendix C. 2 The Impact of Macro-Financial Factors (K6 Matrix).....	117
Table Appendix C. 3 The Impact of Education and Innovation (K6 Matrix).....	118
Table Appendix C. 4 The Impact of Connectivity (K6 Matrix).....	119
Table Appendix C. 5 The Impact of Connectivity (300 km Matrix)	120

LIST OF FIGURES

Figure 3.1. Visualizing Panel Data Estimators: Within/Fixed and Random Effect ..	29
Figure 3.2. Spatial Dependency Visualization of Neighbors	33
Figure 3.3. Moran’s I Diagram of Exports of Provinces in Türkiye (Year 2024).....	36
Figure 3.4. Types of Contiguity Matrices	37
Figure 3.5. Distance and K/Near Matrices	37
Figure 3.6. Row Standardization Procedure Illustration	38
Figure 3.7. Spatial Models Derived from General Nested Model.....	40
Figure 4.1. GDP of the World's Leading Economies in 2024	51
Figure 4.2. World Population, 2008-2024 (in billions).....	52
Figure 4.3. Population of World’s Top Economies in 2024 (in billions).....	52
Figure 4.4. Global Export and Import Volumes (US\$ at current prices in trillion) ..	53
Figure 4.5. World Merchandise Exports, Top Economies (2024)	54
Figure 4.6. Boundaries of the Turkish Provinces	54
Figure 4.7. Export Value and Global Share of Türkiye (%) (2008-2024)	55
Figure 4.8. Provincial Real Exports (ln USD), 2008.....	56
Figure 4.9. Provincial Real Exports (ln USD), 2023.....	56
Figure 4.10. σ -Convergence in ln Real Exports (Levels), 2008–2023.....	57
Figure 4.11. σ -Convergence in ln Real Exports per Capita, 2008–2024	58
Figure 5.1. Choropleth Maps of Export and Import in Türkiye (2008-2023).....	65
Figure 5.2. Choropleth Maps of MGDP, CRDT and POPD	65
Figure 5.3. Choropleth Maps of Road Density in Türkiye (2008-2023).....	66
Figure 5.4. Choropleth Maps of WEDU, PAT and PSGR	66
Figure 5.5. Pairwise Scatter Plots of Key Variable	67
Figure Appendix B. 1 Time-series Boxplots	115

LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CD	Cross-sectional Dependency
CET	Classical Economic Theory
CS	Cross Section
FE	Fixed Effect
ECM	Error Correction Model
GM	Gravity Model
GMM	Generalized Method of Moments
GVC	Global Value Chain
RE	Random Effect
SAR	Spatial Autoregressive Model
SDM	Spatial Durbin Model
SEM	Spatial Error Model
NEG	New Economic Geography
NTT	New Trade Theory
TFP	Total Factor Productivity

CHAPTER 1

INTRODUCTION

Local capacity and network linkages are the main contributors to regional export performance in Türkiye. The scale, industrial depth, logistics, and knowledge are the elements of local capacity, and transport corridors, supplier-buyer relations, and network infrastructures are the representations of the network linkages. In the last decade, total global exports have risen. Of course, the contribution to the global export is unevenly distributed as logistic networks, GDP's and population etc. are not the same all over the world. Empirical studies on provincial exports are made to understand the positive drivers of export performance and point market size, productivity, manufacturing intensity, connectivity, and innovation as a positive driver of export. (Agur, 2016; Brodzicki et al., 2018; Cabral & Alvarado, 2021).

Türkiye-focused spatial studies on provincial exports agree with these elements by adding spatial view and claiming provinces with seaports or border-gates export more (Abar & Tekmanlı, 2018)¹; import composition supports provincial export growth (Gençosmanoğlu & Yamanoglu, 2023)²; and agglomeration economies raise exports (Doğan, 2022)³. In parallel, non-spatial panel studies show that logistics quality and value-chain participation (imports) matter, while innovation and design activity correlate with export capacity of Türkiye (Solmaz, 2024; Türkcan, 2018).

The number of researches on export performance of Türkiye is growing but provincial export studies are still limited. Existing studies put efforts mostly on export-growth

¹ Cross-sectional SAR/SEM/SAC spatial analysis for 2023.

² Dynamic Spatial Autoregressive (DSAR) compared with SAR/SEM/SAC/SDM, years 2004-2021, annual study

³ SAR/SDM analysis between 2007-2019, annual

relationships or convergence dynamics as well as spatial clustering patterns. In the spatial studies, agglomeration, import penetration, infrastructure and innovation elements of provinces are examined by using static spatial panel models such as SDM/SAR/SEM or β -convergence frameworks without using long-run export equations. Most of these studies on spatial analysis use agglomeration, infrastructure, innovation or import elements to explain export. However, none of them test for cointegration between exports and their determinants or use error-correction term to explain the run adjustment mechanism of export. On the other hand, the studies where panel ARDL and error-correction models are employed at the provincial level, are mostly focused on the link between exports and GDP.

As a result, there is still more to investigate about spatial and long-run dynamics of export such as long-run spatial relationship between provincial exports and its drivers as well as the adjustment mechanism of exports from its deviations from long run equilibrium.

This study addresses that gap by estimating a provincial export function within a spatial and dynamic panel error-correction framework, allowing for both long-run cointegration and short-run dynamics.

Dynamic spatial ECM (SARAR/SDM-type) models are estimated for 81 Turkish provinces by using STATA software. Moreover, matrix alternatives such as k-nearest and inverse-distance matrixes are used for robustness check and direct and indirect of neighbors are reported to determine whether there are spatial dependencies between provinces or not.

According to literature survey, to be able to understand the effects of variables such as economic size and industrial structure, infrastructure, accessibility and connectivity, human capital, knowledge and innovation, institutional and policy environment, external market and trade linkages, they are integrated into different models. The aim of the study is not only to confirm the effects of all the variables but also to present how much they help locally and how much spillover comes from neighbors.

The thesis contributes to the literature by two means. Firstly, the study creates bridges between non-spatial Turkish export studies and spatial ones but with richer model

structures dynamic spatial ECM (SARAR/SDM-type) and comparative neighborhood structures (distance, K/near matrixes –robustness check). Secondly, this study examines whether spillover effects exist among neighbors or not. It means that the study is not only showing the effect of explanatory variables on export but also direct and indirect effects (spillover effects) of neighbors.

In this thesis, firstly the studies about provincial export are analyzed and presented as a literature survey. Then, non-spatial and spatial methods are explained as spatial models are used in the study. Afterwards, the provincial spatial interactions on export presented in Figure 4.8 and Figure 4.9. The maps obviously show that provinces are not islands and there are some clustering spatial effects of some economic variables. The main claim of the thesis is that geography should be considered to have robust and unbiased results while setting up econometric models that may be connected with some geographical elements.

1.1 Background and Motivation

In the literature, New Trade Theory (NTT), New Economic Geography (NEG), and Gravity/Spatial Interdependence Models can explain the export determinants of Türkiye. The effect of capacity and specialization is certain. Large, rich and productive regions tend to export more and manufacturing specialization is a big plus (Brodzicki et al., 2018; Cabral & Alvarado, 2021). Firm-side capabilities such as labor productivity, ease of access to capital, and R&D/FDI developments may lead to faster export growth (Agur, 2016). When we come to the access side, connectivity seems an important determinant of export. Road density and transportation infrastructure support export performance in spatial models in researches about Mexico (Abar & Tekmanlı, 2018; Brodzicki et al., 2018; Escobar Gamboa, 2010). Another group of variables that may affect Türkiye's provincial export is knowledge and information. Türkcan (2018) shows that Turkish provinces with a higher number of registered innovations (patents, utility models, and designs) have stable long-run relations to exports. Spatial literature about Türkiye puts more on it. Provinces show higher exports in seaport/border gates and positive spatial interaction, said Abar & Tekmanlı

(2018). Dynamic spatial models document rapid conditional convergence of provincial exports per capita and a positive role for import composition (Gençosmanoğlu & Yamaoğlu, 2023). Spatial panels focused on agglomeration indicate that urbanization and localization boost export numbers (Doğan, 2022).

In summary, literature surveys clearly show that own fundamentals are important, of course. On the other hand, neighbor spillover/indirect effects may affect export performance. With all these findings, policymakers and scholars should consider neighbor effects and indicate which variables lead to spillovers. The effects can be mapped and show where those spillovers are strongest. When the causes can be determined, policymakers can use these patterns and apply in different region to boost exports. This thesis is designed to examine whether spillover effects exist in Türkiye or not. If it exists, where and how much? To achieve that, spatial-dynamic models were estimated for all provinces by using different weight matrices that range from administrative borders to real trade frictions. Direct/indirect/total effects are reported so that the empirical results can be translated into actionable policies.

1.2 Research Questions and Objectives

Research Questions

RQ1- Do provincial exports in Türkiye have spatial dependence when we consider export dynamics and province/time fixed effects?

RQ2- Which provincial characteristics (e.g., manufacturing share, human capital and innovation, connectivity) may lead to higher exports after controlling for dynamics and fixed effects?

RQ3-How much of the export gain is from the province itself (direct effect), and how much of it comes from neighbors (indirect/spillover effect)?

RQ4- Do spillovers change when the weight matrices (W) differ (contiguity, k-NN/inverse-distance)?

Objectives

To be able to answer research questions, the thesis follows four main objectives. The first one is to document the time-series and cross-sectional determinants of provincial exports. For this purpose, to apply cross-sectional dependence, unit roots and cointegration tests and also, if there is cointegration, to derive an error correction term to capture long-run adjustment. The second one is to build a non-spatial panel model including dynamic specifications as a benchmark to determine if there is a need for an extension to spatial models. The third objective is to estimate spatial panel models with various weight matrices that include a lagged dependent variable and an error-correction term to address whether direct and indirect effects of neighbors exist or not. The final objective is to ensure the robustness and policy relevance of the spillover patterns in order to recommend province-level strategies to raise Türkiye's overall export performance.

1.3 Methodological Overview

This thesis combines dynamic panel methods and spatial econometrics to explain how provincial determinants and networks between units shape Türkiye's exports. The empirical strategy is designed in stages. First, time-series properties and long-run relationships are examined in a non-spatial base panel framework. After that, static spatial models are established from a macro perspective and then restricted spatial models are also applied for robustness control. Finally, dynamic spatial panel models are used to study the endogenous growth effect of exports on provinces. The results, especially spillover effects of neighbors are reported according to the different weight matrices.

Data and variables

In this thesis, export performance and spatial relations of Türkiye's provinces are examined over the period of 2008-2023. Türkiye has 81 provinces and all provinces are included in the study.

The dependent variable is provincial exports by origin, deflated to real USD by using the U.S. CPI Index and used in logarithmic form. Although explanatory variables are divided into five channels⁴ according to the literature survey, and most of them are found to be significant and cross-sectional dependencies even after the dynamic spatial models. Chapter 5 documents all construction steps, transformations (including log and per capita forms), and data sources in detail.

Time-series properties and long-run relationships.

Before beginning to model estimation, the time-series properties of dependent and independent variables are analyzed. Panel unit root tests show that most of the main determinants of export, as itself, have unit roots integrated of order one I(1). Moreover, variables are stationary in first differences. With these findings, panel cointegration tests are applied to analyze whether provincial export and its determinants have a long-run relationship. The I(1) cointegration allows us to set Error Correction Model and the ECM shows long-run relationships. This finding shows that export growth responds to both current changes and past deviations from the long-run equilibrium. This step does two things. First, it proves modelling export in dynamic form. Secondly, the estimated error-correction term, which shows how far each province is from its long-run export equilibrium, is added into the spatial models. In this way, dynamic spatial models combine long-run equilibrium adjustment with short-run and spatial dynamics for a purpose rather than adding dynamics in an ad hoc way.

Spatial Networks/Matrices (W)

To capture relationships between Türkiye's provinces, K6 weight matrix (W) is used. The base K6 matrix, includes nearest six provinces from their center points. However, trade may not differentiate according to distance. To search this hypothesis 300 km inverse distance matrix is used for robust results. In addition,

⁴ (i) economic size and industrial structure (e.g. provincial income, manufacturing share), (ii) infrastructure, accessibility and connectivity (road density, selected logistics indicators, air connectivity), (iii) human capital, knowledge and innovation (education shares, patents, trademarks), (iv) institutional and policy environment (credit relative to provincial GDP), (v) external market and trade linkages (import composition, especially intermediate and capital goods).

Model structure and estimation

The modelling strategy has three main steps in literature. The first one is to estimate base, non-spatial panel models with province and time fixed effects and error correction term from cointegration step. This base model shows provincial fundamentals without adding spatial view, and also error correction term provides information about how rapid provinces tend to adjust the changes in long-run export equilibrium.

Secondly, in the literature, it is suggested that spatial dependency tests need to be applied to static panel models. In addition, as it is established CS ECM model, error correction term is obtained to use in spatial model.

The third step is to build the workhorse dynamic Spatial Durbin model with spatially correlated errors (SAC/SDM-SEM type) in error-correction form. Evidence from cointegration and ECM process and the convergence finding of exports presented in Figure 4.10 and Figure 4.11 shows that there is dynamic structure of provincial export. FE/RE selection can be done by Hausman test results. The dynamic Spatial Durbin model with spatially correlated errors (SAC/SDM-SEM type) in error-correction form structure allow exports to depend on their own lag, the spatial lag of export and spatial lags of main explanatory variables. The addition of error correction term obtained from the ECM provide adjustment to long run equilibrium. Provinces not only react to their neighbor's export and characteristics but also react and adjust towards its own long run equilibrium.

Impact decomposition and interpretation.

In the spatial models, coefficients do not directly show the magnitude of the impact in provincial units. To show the direct and indirect effects, the thesis follows LeSage & Pace (2009) effects presentations and reports direct and indirect (spillover) as well as total impacts for the variables by using different types of weight matrices rather than focusing only on coefficients. The details of the impact calculations are provided in section 3.2.7 and section 6.3.

Diagnostics and robustness

After applying different estimation models, standard diagnostics and robustness checks are applied. For non-spatial models, residual properties and convergence speeds are examined. After building spatial models, Moran's I and related tests are used to determine remaining spatial dependence and compare fixed versus random effects. Robustness is assessed by using different weight matrices and the lag structure of the spatial models. Further details and results are reported in Chapter 6.

1.4 Contributions and Structure of the Thesis

This thesis makes three main contributions to the literature about province level export determinants and relations of Türkiye.

First of all, it develops spatial dynamic panel framework for all 81 provinces by using set of variables which are used in different province level researches. Apart from standard variables used often in literature, the thesis applied more specific variables such as credit depth, higher educated population, granted patent numbers and so on. The result show that only a subset of variables that are categorized into five in Chapter 2 and gives significant and meaningful results when dynamic and spatial dependence are taken into account. Rather than presenting result as "significant" or "positive", the thesis reports direct, indirect and total effects.

One of the main contributions to literature is that, the study combines panel cointegration and error-correction ideas into spatial panel modelling. By establishing long-run relationship between exports and its explanatory variables, error correction term is obtained. Then, error correction term is used in the workhorse model, dynamic Spatial Durbin model with spatially correlated errors (SAC/SDM-SEM type) in error-correction form. In this way, the spatial specification is not just a lagged-dependent-variable extension, but a model that jointly captures short-run dynamics, long-run adjustment and spatial spillovers.

Lastly, the thesis compares alternative spatial weight (spatial networks) and report the impact results separately (direct, indirect effect). These easy-to-read result reports may

help policy makers while their decision-making processes. These important to mention effect or relations (for example, human capital or credit variables) are summarized (if necessary). They are not precise policy recommendations but rather spatially explicit summaries that can inform provincial export policies.

Structure of the thesis

Chapter 1 – Introduction

Inform about the background and motivation, research questions, methodological overview and main contributions.

Chapter 2 – Literature Review

Reviews the theoretical foundations (Classical Trade Theory, New Trade Theory, New Economic Geography, Gravity and Spatial Interdependence) and gather empirical findings for spatial and non-spatial determinants

Chapter 3 – Methodology

Present econometric framework that used in the study including non-spatial panels, panel unit-root and cointegration tests, the error-correction model, spatial weight matrices, static and dynamic spatial panel specifications, model selection procedures and the impact decompositions

Chapter 4 – Export Landscape of Türkiye – A Brief Overview

Describes where export of Türkiye states, how the spatial footprint of exports changed over time

Chapter 5 – Data and Descriptive Analysis

Defines the variables, data sources and transformations, introduce descriptive statistics, presents maps and basic convergence diagnostics and provide information about first evidence on spatial dependence and heterogeneity across provinces

Chapter 6 – Empirical Results

Reports the main non-spatial and spatial estimates, presents direct, indirect and total effects by W , compares alternative network structures, and discusses robustness with

respect to lag structures, outcome definitions and spatial matrices. Province-level spillover profiles are also presented.

Chapter 7 – Conclusion

Summarises the key findings, discusses their implications for provincial export policy, acknowledges data and modelling limitations and suggests directions for future research.

In this way, the thesis connects facts about Türkiye's export geography to a spatial-dynamic econometric framework.

CHAPTER 2

LITERATURE REVIEW

In this chapter relevant literature on the determinants of regional export performance is reviewed. Firstly, theoretical foundations of trade and regional export models are presented and the main researches on how spatial linkages, spillover effects, and interregional dependencies can influence trade outcomes (especially export) are addressed. The following sections summarize empirical studies on the key factors that try to explain export performance. These studies are grouped under some categories such as economic size and industrial structure, infrastructure and logistics, human capital and innovation, institutions, policies and incentives, and external and macroeconomic factors etc. to have some inspirations on this thesis study. This structure sheds light on this thesis and allows for a systematic understanding of how different regional characteristics contribute to export capacity while also supporting the spatial dynamic panel framework adopted in this study.

2.1 Theoretical Background

The determinants of trade and export performance have long been studied by international and regional economists and academicians over the years. Various theoretical frameworks have been developed to explain how regions or countries do trade and what factors affect their export capacity as well as if geographical conditions shaping the economic interactions or not. The Classical Economic Theory (CET) mainly focuses on the differences in productivity and factor endowments. The CET is explaining those components as the main sources of comparative advantage, while the New Trade Theory (NTT) emphasizes and points out drivers of specialization of trade as increasing returns to scale and the market size. In addition, the New Economic

Geography (NEG) use spatial elements—such as location, transportation, and agglomeration economies—to explain the uneven geographic distribution of production and exports.

More recent approaches, such as the Gravity Model (GM) and spatial econometric frameworks, extend these theories explained above by explicitly modeling spatial interdependence and spillovers among geographic locations such as regions or provinces as well. These geographically extended perspectives suggest that a region's export performance is not only determined by its internal characteristics but also by the some of the characteristics or conditions of its neighbors. It is essential to understand why regional disparities in economic size, industrial structure, infrastructure, and human capital can lead to spatially heterogeneous export outcomes. This section provides an overview of these theoretical foundations which helps to build the empirical structure of this thesis study.

2.1.1 Classical Economic Theory

The pioneer trade explanations and trade analysis studies are made by classical economists who underlined differences in productivity and factor endowments as the main drivers of international specialization. According to Ricardo (1817), countries should focus on producing goods for which they possess a comparative advantage, defined by lower opportunity costs compared with other nations. It is originally formulated by classical economists such as Adam Smith and David Ricardo in an international context but this principle can be applied to regions within a country that differ in their resource composition and production efficiency.

The Heckscher–Ohlin (H–O) model further developed this view by introducing factor endowments as the core determinants of trade patterns (Ohlin, 1933). The model assumes that regions tend to export goods that intensively use their abundant factors of production, such as capital, labor, or land. This framework also provides a basis for key theorems like the factor price equalization, Stolper–Samuelson, and Rybczynski theorem which explain the impacts of trade on income distribution and production structures (Jones, 2008). These theories have limitations because of some assumptions

like identical production methods, uniform consumer preferences, and the exclusion of factor-intensity reversals (Feenstra, 2015).

The empirical models in this thesis, H–O framework is considered by including the variables such as manufacturing share, educational attainment, and investment proxies. The aim is to explain how the disparities in productive capacity across provinces, and how variations in factor composition and industrial structure affect provincial export performance in Türkiye. However, classical models do not fully explain the reasons behind the geographic concentration or clustering of trade. Such phenomena, which lie outside the scope of neoclassical theory, are analyzed in detail in the following sections of this research.

2.1.2 New Trade Theory

The New Trade Theory (NTT), which was firstly structured by Krugman in 1979 and then developed together with Helpman and Krugman in 1985. The theory uses increasing returns to scale and imperfect competition to explain. NTT explains also the dynamics of trade between structurally similar regions. The theory emphasizes the significance of economies of scale and product differentiation in monopolistic competition unlike traditional models. It claims that businesses can lower their average prices and may offer more and more products in larger marketplaces. It encourages businesses to trade with each other in the same industries (Krugman, 1980).

This theory asserts that provinces/regions with larger economies and diverse industries tend to succeed in foreign markets. Regional GDP serves as a proxy for market size, representing the aggregate productive capacity within an economy. Moreover, diverse industrial structure makes learning new things and share technical knowledge easier through shared infrastructure and people within an economy (Helpman & Krugman, 1985).

As a result, the NTT provides a strong theoretical framework for using economic size (like real GDP) and industrial structure (like manufacturing share) as the main explanatory variables in the empirical model which tries to explain trade or foreign trade which might be export. However, the theory is not good enough for explaining

the factors that lead to the emergence of economies of scale and industrial specialization in certain geographic regions and why similar trends occur in some geographic regions. The “home market effect”⁵ and subsequent transport cost and market access mechanisms try to explain this mysterious spatial concentration. This puzzle is explained by the New Economic Geography point of view and it is discussed in next section.

2.1.3 New Economic Geography Theory

Early founder of The New Economic Geography (NEG) is considered as Krugman because of his article that he wrote in 1991. In his article, he explained the interaction between increasing returns to scale, transport costs, and labor mobility and how these interactions lead to the spatial concentration. The framework of his work is called core-periphery model where circular causation occurs⁶ (Krugman, 1991). Later on, Venables (1996) introduced vertical production linkages in his paper “*Equilibrium Locations of Vertically Linked Industries.*”. He claims that both customer and suppliers may cause spatial clustering because they both creates cost and demand linkages. This means producers want to locate closer to his customer and also his supplier. It creates industrial clustering even without labor mobility.

The next noteworthy academical contribution is studied by Fujita et al. (1999). The comprehensive study includes core-periphery equilibrium, market potential etc. In this study, there are few more concepts added to understand the geographical clustering. The study claims that transportation cost and market access also may cause geographical concentration of economies. Puga (1999), also contributed the literature by confirming the effect of transportation cost on clustering, and he also examined the concept of trade liberalization.

⁵ The demander of a specific good in a country or region becomes the exporter of that product due to the increasing returns to scale and trade costs (Krugman, 1980).

⁶ Circular causation, a self-reinforcing process in which firms and workers concentrate in regions offering better market access (Krugman, 1991).

In summary, the NEG framework add geography into economic activities to explain why spatial concentrations occurs.

2.1.4 The Gravity Model and Spatial Interdependence

The Gravity Model for economies which is similar to Newton's Law of Gravitation⁷ is firstly founded by Tinbergen (1962). He explains the trade between two countries as Newton did for the gravity. He claims that trade between economies increases when economic mass (GDP, population etc.) increases. On the other hand, gravity/trade decreases when the distance between economies increases. However, his work was completely empirical.

The earliest theoretical contributions to the literature are made by Anderson (1979), he signed the first derivations of Gravity Model by proving that trade flows naturally follow a gravity form according to consumers behaviors or product differentiation by origin. Anderson & van Wincoop (2003), derived new variables apart from distance and bring out complete multilateral resistance idea. The work claims that trade between countries not only depends on distance – gravity in Newton's formula – but also depends on how many trade barriers they have with all of their other partners. The multilateral resistance term contains borders and national divisions and they have more effect on bilateral trade than just only distance.

Behrens et al. (2012) worked also with Gravity Model and they demonstrated that multilateral resistance can be seen as a spatially dependent scheme. They turned the gravity model into a Spatial Autoregressive (SAR) process. In this way, with the SAR model, it can be seen that a country's trade flows depend on how its neighbor's trade. This Dual Gravity model clearly shows that how two-dimensional variables affect each other across space and time.

⁷ Newton's law of gravity, the force that pulls every other particle of matter in the universe toward it, is inversely proportional to the square of their distances from one another and directly proportional to the product of their masses.

Although, the term “spatial econometrics” was first⁸ presented as a book by Paelinck & Klaassen (1979) and definitive founding work of modern spatial econometrics book is written by Anselin (1988), when it comes to the spatial correlation and lag models, it can be said that LeSage & Pace (2009) discussed geographical dependence and spatial heterogeneity, presenting spatial lag and spatial error models clearly in their publications. This publication inspired most of the academicians as it unifies the theory and application. They demonstrate the dependent nature of outcomes across regions and how missing this correlation biases estimations. Trade flows are a classic example of spatial interaction in the context of gravity. P. J. Elhorst (2014) extended modern spatial econometrics to panel data and enabled dynamic and fixed-effect modeling of spatial dependence.

In conclusion, evolution of trade analysis of regions, provinces and countries shows that economic interactions include geographical bias. The theoretical framework proves that international and interregional economic activities cannot be explained without spatial linkages. In the light of the literature reviewed above, spatial panel models provide a framework to explain the export determinants of Turkish provinces and how neighbor provinces are affecting the export of each other provinces.

2.2 Empirical Determinants of Provincial Exports

The literature of theoretical frameworks on trade and regional export models tries to explain the main structure of the trade, while empirical researchers apply those concepts to real-world data to understand the determinants of trade. The main question of what the major determinants of export success are is still being worked on by researchers.

Export as a subject has been extensively studied in the literature. However, the export performance of the provinces or regions still has some room to improve. Especially

⁸ Measures of spatial autocorrelation were first introduced by (Moran, 1948, 1950) and Geary (1954), and later systematized by (Cliff & Ord, 1973, 1981), whose works laid the statistical foundation for modern spatial econometrics.

panel econometric studies on the export of province are not as numerous as export studies of the countries. The literature review studied the non-spatial determinant of provincial export, which can be seen in Table 2.1.

Table 2.1 Literature Review on Non - spatial Determinants of Provincial Export

Author(s) & Year	Analyzed Region & Period	Estimation Method / Methodology	Key Variables*
Şaşmaz (2025)	14 Turkish land-border provinces, 2004–2021	Static panel (FE/RE)	Dep.: Exports (lnexp / lnexp). Indep.: GDP per capita, Population, Government spending, Trademarks, Patents, Time dummies (EU crisis, Syria inflow, heterodox policy).
Nazarczuk et al. (2024)	380 Polish counties (LAU-1), 2004–2019 (annual)	Two-step System GMM (dynamic panel, with county & year FE)	Dep.: Exports; Exports per capita; Exports per sq. km. Indep.: Foreign-owned enterprises (FOEs), Human capital (share with higher education), Social capital (election turnout), Road density / distance to road network, Distance to nearest SEZ, Industrial employment share.
Solmaz (2024)	81 provinces of Türkiye, 2009–2021	Dynamic panel (System-GMM; Arellano-Bover/Blundell-Bond)	Dep.: Provincial exports (log). Indep.: Logistics performance, Lagged exports, Partner-country per-capita income, Imports/GRP, Real exchange rate
Pan et al. (2023)	28 Chinese provinces (industry-level), 2008–2017 (annual)	Static panel regressions and dynamic panel (GMM)	Dep.: Exports. Indep.: Industrial agglomeration, Labour productivity, Industrial output, Number of enterprises, Flagship enterprises, Financial expenditure, Scientific expenditure
Türkcan (2018)	81 Turkish provinces, 2003–2017 (annual)	Panel cointegration (Johansen–Fisher)	Dep.: Exports. Indep.: Patent registries, Utility model registries, Design registries.

Table 2.1 (continued)

Cabral & Alvarado (2021)	32 Mexican states, 2007–2015	Static and dynamic panel data (FE/RE, System GMM)	Dep: Manufacturing exports (log) / Indep: State GDP, ratio of manufacturing to total GDP, FDI stock, real exchange rate, U.S. manufacturing production index
Brodzicki et al. (2018)	35 NUTS-2 regions in Spain and Poland, 2005–2015	Panel data (OLS, PCSE-PSAR1)	Dep: Regional exports (log) / Indep: GDP per capita, manufacturing share, agricultural share, FDI, population, area, border access, sea access, TFP, innovation (R&D), infrastructure (rail, road, maritime)
Wang & Badman (2016)	Trade Partners (GMP): 108 partners, 2006–2015; Copper (CTP): 21 partners; Regional block (RTP): MERCOSUR, 1994–2015)	Augmented gravity panel: FE-GLS, RE-GLS, and IV-GMM (for endogeneity)	Dep.: Export value. Indep.: Exporter GDP, Importer GDP, GDP per capita difference, Real exchange rate, Distance, Common language, Common border, APEC/CAN/MERCOSUR dummies
Agur (2016)	10 Canadian provinces × 8 product categories, 1997–2014 (annual)	Random-effects panel; factor-augmented panel regression	Dep.: Exports / export growth. Indep.: Relative export price, Labor productivity, Real wages, Capital stock, R&D (industry, province), FDI, Vocational training. Controls: Energy share, Population density, Foreign-import ratio, Inter-provincial import ratio, Female participation, Unionization.
Ciżkowicz et al. (2013)	16 Polish regions, 1999–2008	Panel data (OLS, GLS)	Dep: Export intensity / Indep: Human capital, road density, labor productivity, industrial share, FDI, wages, agriculture share, border access
Vieira & Haddad (2011)	27 Brazilian states, 1996–2009 (annual; state GDP up to 2008)	Fixed Effects; Two-step System GMM	Dep.: Exports. Indep.: Trade-weighted real exchange rate (RER), Trade-weighted foreign GDP, Commodity prices, State GDP.

Table 2.1 (continued)

Matthee & Naudé (2008)	354 magisterial districts in South Africa, 1996–2004	Panel data (Tobit, Random-Effects Tobit, GLS)	Dep: Manufactured exports (log) / Indep: local GDP (home-market effect), distance to nearest port (transport cost), surface area (transport cost proxy)
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Source: Created by the author

*The table's key variables don't fully represent all the variables used in the related studies.

Note: Dep.=Dependent Variable, Indep.=Independent Variables

Although, there are not many studies on provincial export, classification of the independent variables that studied to explain the export is also complex. This classification of the literature is made to have consistent empirical results while selecting the variables in the spatial econometric model by using

Although, the groups have different variables than each other, the countries or provinces with strong industrial structures are tend to have better infrastructure, more skilled population and investment incentives. It may cause biased estimation because of serial correlation but this section reviews the most important empirical findings and puts them into five groups which are: (i) economic size and industrial structure, (ii) infrastructure, accessibility, and connectivity, (iii) human capital, knowledge, and innovation, (iv) institutional and policy environment, and (v) external, market, and trade linkages.

2.2.1 Economic Size and Industrial Structure

The economic size and industrial structure boost export. As the academic works proves, economic scale, income, productivity, and industrial depth, they are all supporting the areas to do more and more exports. Brodzicki et al. (2018) use Polish and Spanish NUTS-2 data to show that regions with more people and a higher GDP per capita realize more exports. An increase in population by 1 percent leads to increase of 0.5% of exports, while income causes 0.4-0.7% increase. It means that more people, more income cause more export. There is also a large, positive relationship for TFP. It increases the export by 1 percent. Another important contribution by the authors is that regional manufacturing share provides an extra

boost, and regions with access to the sea or a border have higher effects of the variables mentioned. These findings are exactly in line with home-market/scale effect of NTT and NEG as there is agglomeration and market access that boost exports.

In many studies, labor productivity and a larger capital stock led to faster export growth as Agur (2016) presented the same results for Canada. In this study, the results shows that R&D and FDI also help to the export performance. The study has an important lesson that is the sustainable export performance may be because of being better equipped and more productive. In this way, the companies can be successful in foreign markets. This is in line with NTT (variety and quality frames) and the Classical focus on factor-based efficiency.

Ciżkiewicz et al. (2013) discover that in Polish regions, foreign-owned employment correlates with improved export intensity. They explain that finding as international companies tend to be suppliers of international markets and in most cases, they led export. Cabral & Alvarado (2021) demonstrate that in Mexico, both FDI stock and the manufacturing-to-GDP ratio increase manufacturing exports. Moreover, the long-term impact of FDI to exports is found significant.

All of these empirical studies support the theoretical frameworks of NNT (scale and product scope) and NEG (industrial clusters and input sharing), as well as connection to Classical Trade Theory about productivity. The studies shows that regions/provinces that are larger, wealthier, more productive, and more specialized in industry tend to have higher export levels.

2.2.2 Infrastructure, Accessibility, and Connectivity

In the literature review, it is obvious that connectivity has positive effect on export performance. However, the effective access of connectivity nodes quality by means support exports rather than quantity. Brodzicki et al. (2018) report positive relationship between exports and rail capacity for Spanish and Polish regions as railway is popular in EU. When we come to the motorways, it has contribution to export but not as much as railway.

For Türkiye, Solmaz (2024) finds that a Logistics Performance Index ⁹ has a clear and positive relationship with exports in dynamic panel estimates. At the cross-border provinces, cross-sectional spatial evidence shows higher exports where seaports and border gates are present (Abar & Tekmanlı, 2018).

Finally, in Mexico, when the spatial dependence is taken into account, road density is positively related to exports (Escobar Gamboa, 2010). The common mechanism is familiar from NEG and the Gravity Model. The findings support the theory that if infrastructure lowers trade costs, it expands export volumes.

2.2.3 Human Capital, Knowledge, and Innovation

It is a common belief that specialized or educated population may be related to the export performance of the country because the people can either produce goods or ideas. For Turkish provinces, Türkcan (2018) discovered a positive long-run relationships between registered innovation outputs and exports in her study. She claims that innovation not only increase the export numbers, it may cause the diversification of the products and help to build sustainable export performance as it is mentioned and explained in NTT and NEG theories of localized knowledge spillovers. Şaşmaz (2025) also contributed to the literature with his work by showing that trademarks and patents are positively linked to both exports and income within Türkiye's border cities. In a different context, Agur (2016) shows that labor productivity, capital accumulation, and R&D are all associated with better export performance.

The findings from all the authors clearly show that provinces with higher educated/skilled population and innovative ideas/expenditures not only boost the exports, they also help provinces to have healthy and sustainable export capacity.

⁹ Logistics Performance Index (LPI) is a composite metric that bundles various indicators to measure both the access to and quality of transport infrastructure and logistics

2.2.4 Institutional and Policy Environment

Political decisions and institutional capacity can influence the exports of provinces for sure. For Türkiye's cross-border provinces, Şaşmaz (2025) found that higher public spending is associated with higher exports. Moreover, total exports and provincial development tend to move together. The findings are consistent with theories structured by NEG, Classical and New Trade perspectives. Looking beyond Türkiye, spatial-dynamic studies made by D'Ingiullo et al. (2023) for Italy, underscore the positive contribution of rule of law and banking depth to export propensity. It may be because stable rule of law environment can get more FDI and as they tend to do more export, export can get higher. Banking depth also may contribute to the companies to scaling up and exporting more.

2.2.5 External, Market and Trade Linkages

External demand, macro integration, and value-chain participation may increase the regional exports. In Brazil, Vieira & Haddad (2011) show that higher partner-country income is associated with higher exports. It is also explained in the theoretical background sections and they are in line with Gravity (market size) and the demand-pull side of NTT. An additional gravity perspective from Peru by Wang & Badman (2016) finds positive impact of importer's GDP and Peru's GDP, and also having regional trade agreements (e.g., APEC, MERCOSUR). They are mentioned how institutionalized integration expands exports capacities. Similar findings made by Solmaz (2024), and he documented for Turkish provinces that stronger import intensity (a proxy for GVC), higher partner-weighted income increase exports. In summary, provinces more integrated in buyer markets and global supply chains trade abroad.

Before turning to Section 2.3, it is important to mention that findings in the literature presented in Sections 2.2.1 - 2.2.5 are incomplete. In reality, trade between provinces and countries are not bounded/fenced as sometimes countries do. Normally, firms buy inputs, share infrastructure, and compete (or collaborate) across borders. It means that

what happens in one province can spill into another. This is precisely the intuition behind Section 2.1.4 (Gravity and Spatial Interdependence) that trade outcomes reflect the wider network of neighbors that shape market access and diffusion.

The next section is about spatial dimensions of provinces/countries and how is the relations spill over.

2.3 Spatial Dimensions in Provincial Export Studies

In Section 2.1 and 2.2 summarized the theoretical and empirical determinants of trade and also export performances, this section reviews the spatial panel studies that empirically test the spatial relationships. The recent literature is selected according to the dependent variable of this thesis (export) or the econometric model structure which explains the spatial dynamics of export performance.

Table 2.2 Literature Review on Spatial Dimensions in Provincial Export Studies

Author(s) & Year	Analyzed Region & Period	Estimation Method / Methodology	Key Variables
D’Ingiullo et al. (2023)	103 Italian provinces, 2004–2016	Dynamic panel (SYS-GMM, dySAR, dySDM) - <i>k-nearest neighbours (k=8), row-standardized</i>	Dep.: Export performance (exports/GDP). Indep.: Rule of law, Imports/GDP, Manufacturing employment share, Specialization, Graduates (tertiary), Banking development, Coast dummy, Airport dummy.
Gençosmanoğlu & Yamanoğlu (2023)	81 provinces of Türkiye, 2004–2021	Dynamic Spatial Autoregressive Model (DSAR) – Contiguity-based Matrix, row-standardized	Dep.: Real exports per capita (growth and convergence) / Indep.: Imports (total, intermediate, capital, consumer goods), spatial lags of exports and imports

Table 2.2 (continued)

Doğan (2022)	81 provinces of Türkiye, 2004–2018	Static Spatial Panel (SAR/SEM/SDM) + Spatial Finite Mixture	Dep.: Provincial exports (log). Indep.: Urbanization (URB), Localization (LOCAL), Motorway & Railway length, Distance to port, Education (schooling shares), Public investment
Abar & Tekmanlı (2018)	81 Turkish provinces, 2013 (cross- section)	Spatial econometrics: SAR, SEM, and SAC (general), contiguity and 10-nearest inverse- distance	Dep.: Exports. Indep.: Border-gate dummy, Seaport dummy, Imports, Provincial development index.
Márquez- Ramos (2016)	19 Spanish NUTS-2 regions, To 45 countries, 2000–2008	Spatial autoregressive gravity model (SAR) with port variables; IV and dynamic panel robustness (Arellano– Bond)	Dep.: Bilateral exports. Indep.: Origin & destination income, GDP per capita, distance, language, borders (France/Portugal), FTA, remoteness, port facilities in origin, port quality in destination
Escobar Gamboa (2010)	32 Mexican states, 1994–2002 (annual)	Spatial panel SAC/SARAR (spatial lag of exports + spatial error) via FG2SLS, contiguity and inverse- distance W, row- standardized	Dep.: Exports (also Exports/GDP in robustness). Indep.: Lagged GDP (size), Population, Wages, Electricity price, Road network density, Industrial agglomeration, FMP (US demand), time dummies

Source: Created by the author

*The table's key variables don't fully represent all the variables used in the related studies.

Note: Dep.=Dependent Variable, Indep.=Independent Variables

Spatial models are questioning whether neighbors affect the exports or not. In Türkiye, a dynamic spatial panel study (SAR) conducted to understand the relationship between provincial import and export with a row-standardized contiguity matrix shows that there is quick conditional convergence between provincial imports and exports. When neighbors' export growth raises that contributes a positive effect on own export growth (Gençosmanoğlu & Yamanoğlu, 2023). A complementary spatial panel analysis about provincial export of Türkiye highlights positive spatial findings about the role of urbanization and localization economies while public investment also contributes positively (Doğan, 2022). Another spatial study (cross-sectional spatial model) for Turkish provinces confirms that provinces with seaports and border-gates tend to export more and have positive spatial interaction with others (Abar & Tekmanlı, 2018).

All three province-level Türkiye's studies prove the NEG theory. The theory claims that market access and agglomeration raise exports, and those gains can spill to the neighbor provinces when contiguity defines the network.

Beyond Türkiye, for Spain, the studies show that infrastructure of network channels is spatially significant. Márquez-Ramos (2016) constructs a port-corrected spatial weight that geographic contiguity with port importance and destination-port quality. The results show that both owned and neighbors' ports boost exports. Spatially lagged exports also have effects often larger than the direct port effect. This finding is exactly what Gravity Model Theory presented in section 2.1.4 would predict when trade costs are shaped by transport nodes.

Another study is conducted for Mexico, with an inverse-distance, row-standardized matrix, a spatial SAC/SARAR model found positive clustering, and reports that road density and state size improve export performance. However, here is the neighbor effect is not statistically significant (Escobar Gamboa, 2010). In Italy, dynamic spatial panels with a k-NN matrix ¹⁰ mentioned strong direct positive relations with rule of

¹⁰ The K-Nearest Neighbors (k-NN) matrix is a type of spatial weight matrix used in spatial models. It is denoted as W^{k-NN} and used to define the connectivity of interaction between geographical units.

law, imports/GDP, manufacturing share, and banking depth. (D’Ingiullo, Di Bernardino, Odoardi & Quaglione, 2023).

Although the studies conducted on provincial export are limited, outlined spatial literature shows that logistics networks and clustering create spillovers. Most of the effect still comes from a province’s own effort, but neighbors add an extra contribution. These empirical findings are supporting the main hypothesis expressed by NEG (market access and clustering) and Gravity/Spatial Interdependence (network-mediated spillovers).

However, in the literature there is still some missing researches about the spatial export performance analysis of provinces. The section 2.4 explains how this thesis will fill that space in the literature.

2.4 Research Gap and Positioning

Most of the existing work on provincial exports in Türkiye focuses either on long-run relationships or on short-run dynamics. In addition, most of the studies on exports use non-stationary either spatial or non-spatial dynamic models. Also, studies using panel cointegration or ECM techniques estimate non-spatial long-run relations between exports and other explanatory variables.

Dynamic panel models and GMM applications capture short-run persistence without modelling spatial spillovers. Spatial contributions, mostly rely on static SAR/SEM/SDM specifications or dynamic models without an explicit error-correction structure. Therefore, they identify spillovers but do not link them with long-run equilibrium. As a result, it is known little about how provincial exports in Türkiye adjust back to their long-run paths after shocks.

This thesis fills that gap on dynamic Spatial Durbin model with spatially correlated errors (SAC/SDM-SEM type) in error-correction form. The model is allowing long-run equilibria, short-run responses and spatial spillovers jointly and within a unified block structure of determinants.

CHAPTER 3

METHODOLOGY

In this section, firstly, panel data analysis is discussed. The main static panel data analysis methods, namely Fixed Effects and Random Effects panel models are introduced as well as Error Correction Model. After that, within the framework of spatial econometrics, the SAR (Spatial Autoregressive), SEM (Spatial Error), and SDM (Spatial Durbin) models are explained. Subsequently, the concept of the Spatial Weight Matrix is introduced, and information and some details are provided about the spatial panel data analysis, which is the most striking method used in this thesis.

Afterwards, the dynamic Spatial Durbin model with spatially correlated errors (SAC/SDM-SEM type) in error-correction form econometric model presented to examine the factors determining provincial exports in Türkiye are defined, and the structure of the data models is presented. Finally, employed estimation methods in this thesis are explained. The potential endogeneity issues are discussed, and robustness checks are conducted to assess the consistency and reliability of the empirical results.

3.1 Non-Spatial Econometric Framework

The empirical analysis in this thesis is based on a provincial panel data set covering 81 NUTS-3 provinces of Türkiye over the period 2008–2023. This structure as it combines both cross-sectional and time-series variation is called panel data. Arellano (2003) defined panel data as any dataset that contains repeated observations over time for “individuals” such as workers, households, firms, industries, regions, or countries. Baltagi (2005) also made similar definition and defines panel data as dataset that combines observations for multiple entities—such as households, countries, or firms. Wooldridge (2010) similarly agrees with other scholars and states that panel data also

known as longitudinal data as datasets that contain repeated observations over time for the same cross-sectional units, such as individuals, households, firms, or cities.

In panel data literature, the idea is to relate provincial exports to a set of time-varying variables such as economic size, manufacturing specialization, infrastructure, human capital and financial access. At the same time, unobserved, time-invariant provincial factors and common time shocks should be eliminated.

As provinces differ in many dimensions which are difficult to measure such as historical trade links, institutional quality, geography, industrial culture it may cause biased estimations. Hsiao (2003), Baltagi (2005) and Wooldridge (2010) emphasized these advantages of panels. These advantages of panel data are the ability to control for individual heterogeneity, increasing the amount of information in the data, and reducing multicollinearity among regressors.

On the other hand, panel data do not explain all relationships among variables and cross sections. Most of the time, as presented in Chapter 2, regional panels often have short time dimensions. Also, panel data often shows cross-sectional dependence which may be cause of national shocks or spatial spillovers. As discussed by Baltagi (2005), ignoring such cross-sectional dependencies (CD) can cause biased estimations and invalidate panel unit root and cointegration tests.

In line with this literature, some empirical strategy followed in stages. Firstly, conventional static panel models (e.g. fixed effects, random effects) are used as a baseline to characterize the relationship between exports and their determinants. Finally, with the help of conventional and modern panel model estimations, spatial panel frameworks are established to capture if there is provincial relationship and spillover effects.

3.1.1 Conventional Panel Data Models

In this thesis, the static panel specification is the starting point.

$$y_{it} = \alpha + \beta' X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

y_{it} denotes the log of export or log of export per capita of the province i at time t . Economic structure, infrastructure, human capital, financial development and local public expenditures are captured by a vector X_{it} . μ_i denotes the unobserved time-invariant provincial effects while λ_t captures common year-specific shocks, and ε_{it} is an error term.

The model (1) is discussed by Hsiao (2003) and Baltagi (2005). Unobserved heterogeneity is either modeled as a fixed parameter or as a random draw while time and/or unit (province) effects are considered.

In Türkiye case, μ_i can be provinces' differences in geography, historical trade orientation, institutional quality or industrial culture which cannot be directly observed but are likely affect export performance of the units.

Fixed and Random Effects

There are two famous approaches for handling the unit effects, μ_i (province in this study). The fixed-effect (FE) estimator allows correlation between μ_i and the explanatory variables. For example, province's unique "entrepreneurial culture" may affect its GDP.

The model uses "within" transformation that subtracting each province's own long-term average from its yearly data (Figure 3.1). By focusing only on how much each province changes from its own average over time, the estimation cancels out all of the time-invariant, unobserved effects.

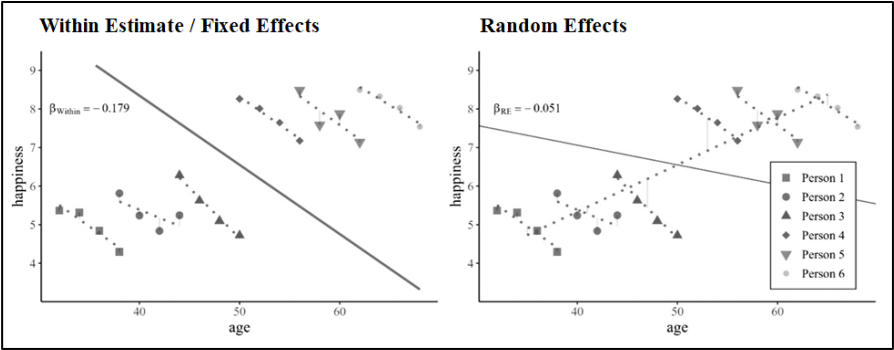


Figure 3.1. Visualizing Panel Data Estimators: Within/Fixed and Random Effect

Source: (Rüttenauer & Kapelle, 2025)

The random-effect (RE) estimator assumes that there is no correlation between μ_i and the explanatory variables and it can be estimated via feasible GLS. Baltagi (2005) shows that the choice between FE and RE should rely on both theoretical considerations and specification tests such as the Hausman test.

As the variables used in this thesis (e.g. GDP/GDP per capita, infrastructure, education level) may be correlated with province-specific unobservable variables as expected. The fixed-effects specification forms the main static benchmark and it is complemented by random-effects estimates. After the model set ups, LM and Hausman diagnostics¹¹ are applied for robustness.

3.1.2 Panel Unit Roots and Cointegration

Most of the variables used in this thesis are non-stationary which are represented by I(1) and they are stationary only when their first differences are taken, which are called non stationary or stationary under integrated of order one I(1).

Conventional panel regressions may create spurious relationships if such non-stationarity is ignored. This problem is solved and documented in the literature by Banerjee (1999), Baltagi (2005) and Breitung & Pesaran (2008).

Panel unit root tests extend univariate unit root procedures to both cross-section and time variated data. The first-generation unit root tests assume that cross-sectional units are independent Breitung & Pesaran (2008). However, in this thesis cross-sectional tests show that there are dependencies between sections which is expected for provinces because of common national shocks or using the same resources.

To solve this problem, Pesaran (2007) proposes augmented unit root test which remains consistent even in the presence of sectional dependence. In this thesis, Pesaran's CADF/CIPS panel unit root test implemented by using STATA software.

¹¹ Hausman, J. A. (1978). Specification Tests in Econometrics. *Econometrica*, 46(6), 1251. <https://doi.org/10.2307/1913827>

This choice is consistent with the literature and the argument that “second-generation” unit root tests are more appropriate.

Cointegration

If the variables used in the empirical model are all $I(1)$, long-run relationships need to be controlled. Panel cointegration tests can be used to check this statement. The idea behind this cointegration test is that if the linear combinations of $I(1)$ variables are stationary, they are cointegrated. Westerlund (2007) develop some error-correction-based panel cointegration test and focus on error-correction form.

It catches both long-run and short-run dynamics as well as dependence within and between cross sectional units. In this thesis, Westerlund (2007) cointegration test is applied by using STATA software.

In this thesis, the time-series properties of provincial exports and their determinants are examined in two steps. First, panel unit root tests are applied using the pescadf implementation of Pesaran’s (2007) cross-sectionally augmented test. The aim is to find whether the series are $I(1)$ in the presence of cross-section dependence. Secondly, learning the integration of variables, panel cointegration is tested using Westerlund (2007) error-correction-based statistics. Establishing panel cointegration on variables motivates the error-correction specification discussed in Section 6.1.4.

Formal definitions of the test statistics can be found in Pesaran (2007) and Westerlund (2007).

3.1.3 Error Correction Model (ECM)

The Error Correction Model (ECM) provides an overview on how short-run dynamics adjust when the system gets out of equilibrium. To be able to run this model, it is needed to do be done panel unit root test and cointegration tests. If the variables have unit root $I(1)$ and cointegration tests shows long-run relationship then ECM can be set. The idea comes from Engle & Granger (1987)’s insight that if $I(1)$ variables are cointegrated dependent variable response to past deviations from the long run equilibrium as well as current changes.

For non-spatial panel setting, a simple ECM equation can be written as

$$\Delta y_{it} = \alpha_i + \phi_i(y_{i,t-1} - \beta_i'x_{i,t-1}) + \gamma_i'\Delta x_{i,t} + \mu_i + \tau_t + \varepsilon_{it} \quad (2)$$

where y_{it} denotes the dependent variable in province i at time t , x_{it} is a vector of independent variables, Δ is the difference operator, μ_i and τ_t are province and time effects, while ε_{it} is error term.

The term,

$$EC_{i,t-1} = y_{i,t-1} - \beta_i'x_{i,t-1} \quad (3)$$

is lagged deviation from long run equilibrium, while ϕ_i is called as error-correction coefficient.

If dependent and independent variables are cointegrated $EC_{i,t-1}$ need to be stationary and ϕ_i is expected to be negative as some changes upward in the long run equilibrium occurs, there need to be some adjustment to downward. The magnitude of ϕ_i gives information about adjustment speed, values close to zero means slow convergence speed and vice a versa (Banerjee, 1999; Breitung & Pesaran, 2008).

The second term $\gamma_i'\Delta x_{i,t}$ gives information about short run effects of changes in the regressors on dependent variable. With the help of $\gamma_i'\Delta x_{i,t}$, ECM separates short run effects from long run effects.

In this thesis ECM mainly serves in two ways. First, finding cointegration between provincial export and explanatory variables and correct the long run equilibrium with $EC_{i,t-1}$. Secondly, it offers a link to dynamic spatial models and help to adjust changes on long run equilibrium.

3.2 Spatial Econometric Approach

Spatial econometrics allows users to model situations where economic outcomes are dependent through location or and space. In other words, “what happens in province does not stay in the province”. In more formal terms, spatial econometry deals with spatial interaction effects and spatial heterogeneity.

Variables examined in a location can be affected by the same characteristics or variables of its neighbor locations and it can be systematically differ according to location. These systematical spatial dependencies, autocorrelations and spatial regressions are formalized and pioneered by the works Moran (1950), Cliff & Ord (1973, 1981), Anselin (1988), LeSage (1998), LeSage & Pace (2009), P. J. Elhorst & Vega (2013), P. J. Elhorst (2014), Tatoğlu (2022) and many other studies.

In this thesis, spatial econometric methods are used to understand how provincial exports in Türkiye react not only to local determinants but also some determinants of neighbor provinces. The models are created at the province level $i = 1, \dots, 81$ and period $t = 2008, \dots, 2023$.

3.2.1 Spatial Dependence and Spatial Heterogeneity

Spatial dependence can be explained as existing relationship between different locations especially near ones. Anselin (1988) explained spatial dependence in two ways. The first one is that the data cannot spill equally especially while collecting data in regional or provincial levels. They might spill over boundaries. In this case, data in different neighbors become correlated. This may cause spillover effect and dependencies as it can be seen at Figure 3.1. The second one is that location is important as economic activities are not dependent. If an event occurs in region 1 affects region 2.

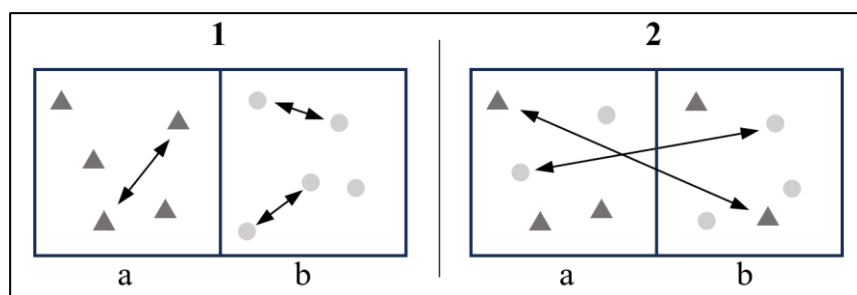


Figure 3.2. Spatial Dependency Visualization of Neighbors

Source: The Author

Spatial Dependence

There are three main types of spatial interaction are usually defined in the literature. The first one is endogenous interaction effects. It means that there is a dependency in the dependent variables of observations. The second one is exogenous interaction effects. In other word, explanatory variables have the dependencies. The neighbor's explanatory variable affects city itself. The final one is interaction in the error term. It means, there is spatial correlations, dependencies in the error terms (P. J. Elhorst, 2014).

Spatial Heterogeneity

Another important subject to mention is spatial heterogeneity which is defined as the instability according to locations (Anselin, 1988). It is systematic differences in endogenous variables (e.g. provincial real export) and/or exogenous variables (e.g. share of manufacturing in provincial GDP) and/or dependency in error terms. In this thesis, provincial fixed effects and time effects may be already captured by panel models through μ_i and λ_t in model (1) and spatial dependencies are captured by spatial econometric models presented in Section 3.2.4 and Section 3.2.4.4.

3.2.2 Tests for Spatial Dependencies

Before using spatial models, the common way to discover if there is a spatial dependency or not is to use some kind of spatial dependency tests. Pioneer researchers about dependencies are (Moran, 1948, 1950) and Geary (1954) created tests for spatial autocorrelation based on either contiguity matrix or distance matrixes. There is also LM test which use residuals of non-spatial fixed effect panel models. LM test also has another purpose apart from detecting the spatial dependence, which is selecting the efficient type of empiric model whether the model is SAR or SEM. Therefore, to show how to deal with spatial dependency, in this section Geary I Index and Moran's I test is presented. LM test is presented in section 3.2.8.

Geary I Index

$$c_W = \frac{n-1}{2 \sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij} (y_i - y_j)^2}{\sum_i (y_i - \bar{y})^2} \quad i \neq j \quad (4)$$

H_0 : The differences between neighbors have no correlation.

$c_W < 1$: Positive spatial correlation

In this thesis Moran's I Test is used for spatial autocorrelation tests.

Moran's I Index

$$I_W = \frac{n}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij} (y_i - \bar{y})(y_j - \bar{y})}{\sum_i (y_i - \bar{y})^2} \quad i \neq j \quad (5)$$

H_0 : There is no spatial correlation between neighbors.

$I_W > 0$: Positive spatial correlation

The statistic was introduced by Moran (1950) and it becomes the standard benchmark for calculating global spatial dependence.

Morans Diagram

Moran's Diagram is a scatter plot divided into four quadrants and shows the autocorrelation between locations. On the x-axis there is observations of the dependent variable y and on the y-axis there is a lagged dependent variable Wy of neighbors. Lag term represents the effect of neighbor's dependent variable on observed locations rather than representing time lags (**Figure 3.3**).

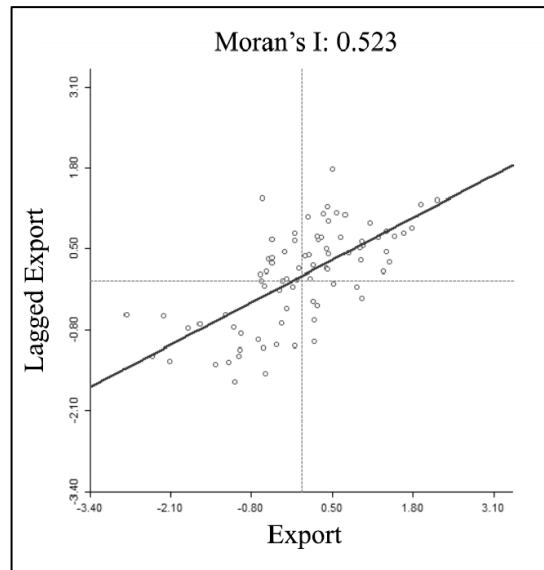


Figure 3.3. Moran's I Diagram of Exports of Provinces in Türkiye (Year 2024)

Source: Authors Calculations

In the diagram, upper right (high-high) and bottom left area (low-low) shows the positive spatial correlation. On the contrary, bottom right (high-low) and upper left (low-high) has negative correlations (Bouyad Agha et al., 2018).

In this study before the spatial model settings, the Moran's I tests are applied to show the spatial autocorrelation. Moreover, the same Moran's I test are applied also after the spatial econometric model specifications.

In line with Elhorst (2014), LM diagnostics for spatial lag and spatial error dependence are computed using the residuals from a non-spatial fixed-effects panel model. These tests serve a dual purpose: they provide evidence on the presence of spatial dependence and offer preliminary guidance as to whether a SAR-type or SEM-type specification is more appropriate.

3.2.3 Spatial Weight Matrix

Spatial interactions are represented with $N \times N$ matrixes and denoted as W representing the weights of the locations. The size of weights is showing how much this location affects. In the literature, W is introduced in different ways to use in spatial models

(Anselin, 1988; P. J. Elhorst, 2014; Tatoğlu, 2022). However, three different types of matrixes are introduced in this study.

The first one is contiguity matrix. This is the binary expressions of the neighbors. It can be seen at Figure 3.4. LeSage (1998), use Rook, Queen and Bishop expressions to illustrate the matrixes. Define $W_{ij} = 1$ if the place shares common side with neighbors. Queen matrix also add vertex neighboring in its concept while Bishop matrix only includes vertex neighbors in the model.

Rook			Queen			Bishop		
0	1	0	1	1	1	1	0	1
1		1	1		1	0		0
0	1	0	1	1	1	1	0	1

Figure 3.4. Types of Contiguity Matrices

Source: The Author

The second type of a matrix is distance matrixes. Distance between neighbors is used to create these matrixes. As distance increases, the relation expected to decrease. To be able to achieve this aim distances should be used in inverse form as illustrated at Figure 3.5 (LeSage, 1998).

Distance			Inverse Distance			K/near (3)		
5 km	10 km	15 km	1/5	1/10	1/15		1	0
5 km		5 km	1/5		1/5	1	1	0
10 km	20 km	20 km	1/10	1/20	1/20	0	0	0

Figure 3.5. Distance and K/Near Matrices

Source: The Author

The final one is k near matrixes and it can be seen at Figure 3.5. This matrix uses either binary or distance values in the vector. The nearest k locations are selected and added into matrixes (P. J. Elhorst, 2014).

Although the row transformations in inverse distance matrixes are destroying the distance effects, they still capture the relative importance of neighboring units. As it is applied in most of the studies in the literature (e.g. (LeSage, 1998)), all of the matrixes are used in row standardized forms (Figure 3.6) in the study.

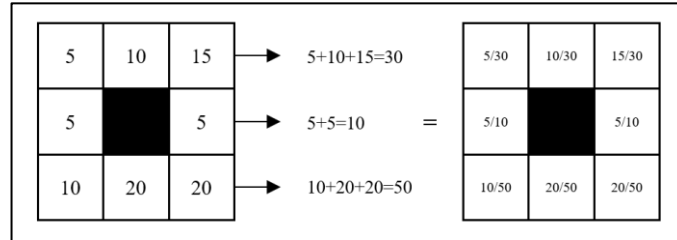


Figure 3.6. Row Standardization Procedure Illustration

Source: The Author

All of the weighted neighborhood information collected in matrixes are representing in equation form below:

$$y = \rho W y + X \beta + \varepsilon \quad (6)$$

where y is $N \times 1$ vector of dependent variables of provinces ($N = 81$), X is an $N \times K$ matrix of explanatory variables, and W is $N \times N$ spatial weight matrix which is either constructed as contiguity, inverse distance or inverse distance k-near matrix.

In this thesis, for 81 Turkish provinces, K-6 near matrix and 300 km inverse distance matrix are used to check robustness.

3.2.4 Spatial Regression Models

In the literature, as it is explained in Section 3.2.1, there are basically three different types of spatial interactions explained by P. J. Elhorst (2014). Endogenous interactions between endogenous dependent variables Y , interactions between exogenous explanatory variables X and the interactions of error terms ε of provinces. The studies combine some or all of them and creates different spatial models.

The early studies started and focused on spatial lag model (Spatial Autoregressive Model - SAR) and spatial error model (Spatial Error Model – SEM). P. J. Elhorst

(2014) gives some historical progress of spatial models. In 2007, at the first World Conference of the Spatial Econometrics Associations, mixture of interaction both on endogenous variable and error terms model is promoted. This is the birth of SAC model. After that, LeSage & Pace (2009) extended the literature by adding exogenous interaction and endogenous interaction effect to create Spatial Durbin Model (SDM).

Later on, more studies and researches are held and some more interaction models are created such as SLX, SAC, SARAR and SDEM. However, all of the models can be created from General Nesting Spatial Model which is called GNS (Figure 3.7). In this thesis only GNS, SDM, SAR and SEM models will be presented.

3.2.4.1 General Nesting Spatial Model (GNS)

The GNS Model has all the possible three interactions between endogenous variables, exogenous variables and the error terms. It is represented in equation (4) (Manski, 1993).

$$Y = \rho WY + \alpha \iota_N + X\beta + WX\theta + u, \quad (7)$$

$$u = \lambda Wu + \varepsilon$$

Where the spatial weight matrix W is $N \times N$ and shows the interaction between cross sections. WY represent the endogenous effects of dependent variable and ρ (spatial autoregressive coefficient) represent the size of the effect while $X\theta$ shows the interaction between explanatory variables. In terms of the error interaction, Wu capture the interactions between disturbance terms and λ (spatial autocorrelation coefficient) shows the strength of them. β and θ are $K \times 1$ response parameter vectors (P. J. Elhorst & Vega, 2013) (P. J. Elhorst, 2014).

The spatial models presented in the literature all can be derived from GNS equations (Figure 3.7) by restricting some of the different parameters in equation (4).

The main models being used by academicians and researchers are Spatial Autoregressive Models (SAR), Spatial Error Model (SEM), Spatial Autoregressive Combined Model (SAC) and Spatial Durbin Model (SDM) models. SDM model

captures both endogenous and exogenous interactions while SAC captures endogenous and error interactions.

It can be seen at Figure 3.7 that SAR and SEM can be derived from GNS model by restricting some variables. SAR has only endogenous interaction effect while SEM captures only error interaction effects.

In this thesis, final version of spatial model used is SDM so only GNS, SDM, SAR and SEM models will be explained in details.

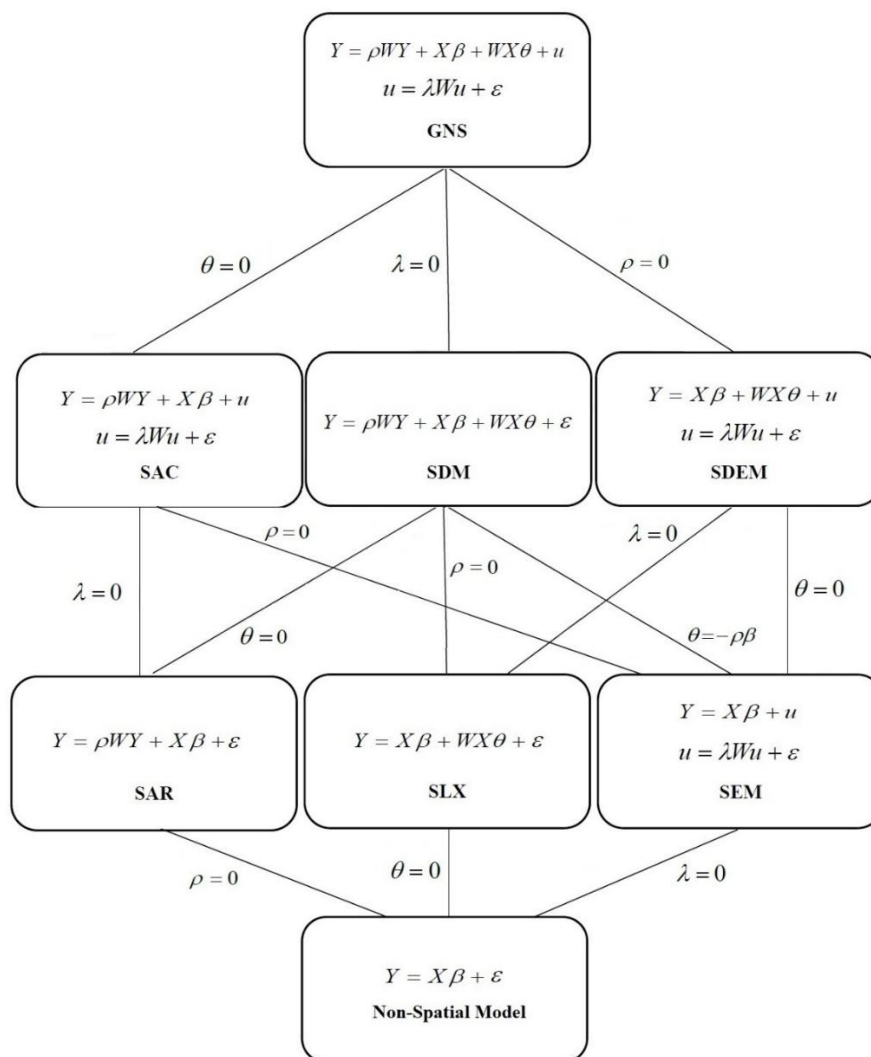


Figure 3.7. Spatial Models Derived from General Nested Model

Source: Yamanoğlu (2022)

3.2.4.2 Spatial Durbin Model (SDM)

General Nesting Model is already mentioned at equation (4);

$$Y = \rho WY + \alpha \iota_N + X\beta + WX\theta + u, \quad (7)$$
$$u = \lambda Wu + \varepsilon$$

SDM is the version of GNS by restricting the λ . SDM only captures endogenous and exogenous interaction effects between neighbors.

$$Y = \rho WY + \alpha \iota_N + X\beta + WX\theta + u, \quad (8)$$
$$u = \varepsilon$$

In this setting, the SDM is used to capture spatial autocorrelation by including not only the usual regressors X but also their spatial lags¹² WX . This allows to trace not only explanatory variable in the location also neighbors. LeSage & Pace (2009) introduce SDM as a model which combines internal and external spatial effects via both the spatially lagged dependent variables and covariates.

The model is estimated using (Quasi) Maximum Likelihood (Q/ML). Following LeSage & Pace (2009) and P. J. Elhorst (2014), this method deals with both the spatial lag of the dependent variable and the spatial lags of the regressors to provide consistent estimates.

3.2.4.3 Spatial Autoregressive Model (SAR)

SAR can be derived from GNS by restricting the λ and θ . SAR captures endogenous interaction effects between neighbors.

¹² Spatial lag is different than temporal lag, which captures over time, the spatial lag represents a multidirectional interaction among cross-sectional units (Anselin, 1988).

$$Y = \rho WY + \alpha \iota_N + X\beta + u, \quad (9)$$

$$u = \varepsilon$$

SAR model captures spatial autocorrelation in the dependent variables in panel data models. It assumes that outcome of the model, dependent variable, is not only influenced by its own characteristics, but also it is affected by the outcomes of its neighborhoods.

Spatial Autoregressive (SAR) models are mostly estimated by Maximum Likelihood (ML) and Generalized Method of Moments (GMM) estimators also employed as robust alternatives when endogeneity or non-normality of errors is a concern.

3.2.4.4 Spatial Error Model (SEM)

SEM captures only error interaction effects between neighbors. When restricting $\rho = \theta = 0$ in GNS model, we obtain model below.

$$Y = \alpha \iota_N + X\beta + u, \quad (10)$$

$$u = \lambda W u + \varepsilon$$

SEM is used when spatial dependence occurs not in the dependent variable itself but only in the disturbance term. The logic behind this model is to collect error interaction effect of any shocks occurs in one region which transmitting to neighbors.

If spatial correlation in the errors is ignored, OLS becomes inefficient. Therefore, SEM is often estimated by ML, but many applied studies use the GM estimator proposed by Kelejian & Prucha (1999).

3.2.5 Spatial Panel Data Models

In section 3.2.4, the basic cross-sectional SAR, SEM and SDM specifications is introduced. In Section 3.2.5 extends these models to a panel setting with province and time effects. Elhorst (2014) provides an overview of spatial panel data models especially fixed and random effect models as well as fixed coefficients, random

coefficient and multilevel models. He recommends that researchers first decide whether the spatial dependencies should be modelled or not and in what form. Secondly, applied researchers need to decide whether spatial and/or time-specific effects should be added into the model or not and whether these should be treated as fixed or random.

3.2.5.1 Fixed-Effects Spatial Panel Models

All of the spatial models derived from GNS can be used in fixed effects models according to the nature of data and autocorrelations. In this thesis dynamic Spatial Durbin model with spatially correlated errors (SAC/SDM-SEM type) in error-correction form is used.

First of all, fixed effects notation of SDM is introduced below.

$$y_{it} = \rho \sum_{i \neq j} w_{ij} y_{jt} + \sum_{i \neq j} w_{ij} x_{jt} \theta + x_{it} \beta + \alpha_i + \varepsilon_{it} \quad (11)$$

$$\text{where } u_{it} \stackrel{i.i.d.}{\sim} \mathcal{N}(0, \sigma^2)$$

In this thesis, notations i represents the Turkish province (1th to 81th) and t is the time units from 2008 to 2023. w_{ij} is the spatial weight matrix showing the interaction between cross-section units. Types of matrices are explained in section 3.2.3. In addition, $\rho \sum_{i \neq j} w_{ij} y_{jt}$ is the neighbor's spatial interaction (spatial lag) on dependent variable (export or export per capita in this case) and ρ is the coefficient of this estimation procedure. Effects such as random shocks are not only affect to the provinces, also affect the neighbors. This is called global spatial spillover. Moreover, $\sum_{i \neq j} w_{ij} x_{jt} \theta$ represent the interaction of exogenous independent variable and θ is the coefficient. As there is no error interaction, $u_{it} = \varepsilon_{it}$.

Secondly, SAR in fixed effect models is presented.

$$y_{it} = \rho \sum_{i \neq j} w_{ij} y_{jt} + x_{it} \beta + \alpha_i + u_{it} \quad (12)$$

$$\text{where } u_{it} \stackrel{i.i.d.}{\sim} \mathcal{N}(0, \sigma^2)$$

The same with SDM, $\rho \sum_{i \neq j} w_{ij} y_{jt}$ captures the spatial interaction of neighbors on dependent variable and ρ is the coefficient of this estimation procedure.

The third one is SEM model in fixed effects.

$$y_{it} = x_{it}\beta + \alpha_i + u_{it} \quad (13)$$

$$u_{it} = \lambda \sum_{i \neq j} w_{ij} u_{jt} + \varepsilon_{it}$$

$$\text{where } u_{it} \stackrel{i.i.d.}{\sim} \mathcal{N}(0, \sigma^2)$$

The spatial interaction in SEM model is captured through $\lambda \sum_{i \neq j} w_{ij} u_{jt}$ term. The one and only interaction is captured by error term (Bouyad Agha et al., 2018).

The spatial regression models introduced in Section 3.2.4 are usually presented for a cross-section data. However, in this thesis, dependent variable export or export per capita are observed for 81 provinces between 2008 and 2023. The data is in panel format with time and units. Spatial panel data models extend the standard SDM, SAR and SEM models over time while capturing dependence across neighbor provinces with the help of different weight matrices (P. J. Elhorst, 2014).

3.2.5.2 Random-Effects Spatial Panel Models

In this spatial random effect models, unobserved individual effects considered as no correlation with independent variables in the RE model. They can either be captured in error terms or constant terms according to the literature. The SAR model has the same structure as fixed effect SAR model except that the unit effect considered as random (Bouyad Agha et al., 2018):

$$y_{it} = \rho \sum_{i \neq j} w_{ij} y_{jt} + x_{it}\beta + \alpha + u_{it} \quad (14)$$

$$u_{it} = \alpha + \varepsilon_{it}$$

$$\text{where } \varepsilon_{it} \stackrel{i.i.d.}{\sim} \mathcal{N}(0, \sigma^2)$$

There are two recommendations for SEM random effect model. The first one is the spatial effect is included only for time error term.

$$y_{it} = x_{it}\beta + u_{it} \quad (15)$$

$$u_{it} = \alpha_i + \lambda \sum_{i \neq j} w_{ij} u_{jt} + v_{it}$$

$$\text{where } v_{it} \stackrel{i.i.d.}{\sim} \mathcal{N}(0, \sigma^2)$$

Second one claims that spatial interaction structure affect both the individual effects and error term.

$$y_{it} = x_{it}\beta + \alpha + u_{it} \quad (16)$$

$$u_{it} = \alpha_i + \lambda \sum_{i \neq j} w_{ij} u_{jt} + v_{it}$$

$$v_{it} = \alpha_i + \varepsilon_{it}$$

$$\text{where } \varepsilon_{it} \stackrel{i.i.d.}{\sim} \mathcal{N}(0, \sigma^2)$$

3.2.5.3 Dynamic Spatial Durbin Panel Model

A spatial dynamic model needs to take into consideration to four critical econometric challenges which are temporal autocorrelation within spatial units, spatial dependence between spatial units at each time unit, unobserved spatial and temporal heterogeneity and the last one is potential endogeneity because of explanatory variables (P. J. Elhorst, 2014).

In his book P. J. Elhorst (2014), presents the generalized dynamic model in space and time and he explains that generalized model has some empirical problems. However, it is easy to see from macro perspective so that it is presented below. In this thesis, the dynamic nesting model is called General Nesting Dynamic Spatial Model (GNDSM).

$$Y_t = \alpha Y_{t-1} + \gamma WY_t + \delta WY_{t-1} + X_t\beta_1 + WX_t\beta_2 + X_{t-1}\beta_3 + WX_{t-1}\beta_4 + Z_t\eta + v_t \quad (17)$$

$$v_t = \theta v_{t-1} + \lambda Wv_t + \mu + \phi_{tN} + \varepsilon_t$$

$$\mu = \rho W\mu + \psi$$

Y_t is $N \times 1$ vector representing the dependent variable of spatial units ($i = 1, 2, 3 \dots N$), within a time unit of $t = 1, 2, \dots, t$. X_t ($N \times K$ matrix) denotes the explanatory variables and Z_t is $N \times L$ matrix existing with endogenous explanatory variables. While W

denotes weight matrix and the $t - 1$ represent the serial lagged value. α, γ and δ are response parameters of temporal lagged dependent variable Y_{t-1} , spatially lagged dependent variable WY_t and temporal and spatial lagged dependent variable of WY_{t-1} . On the other hand, the same story follows with exogenous explanatory variable X_t . The coefficients of $\beta_1, \beta_2, \beta_3$ and β_4 are the coefficient of exogenous explanatory variable, spatially lagged exogenous explanatory variable, temporal lagged exogenous variable and both temporal and spatial lagged exogenous explanatory variable while η is the coefficient of endogenous explanatory variable of Z_t . μ contains all spatial and time-invariant happening to avoid from biased estimation. In this thesis, dynamic spatial effects are reported by using dyn-SDM model which can be created by using GNDSM.

3.2.6 Model Estimation

There are couple of estimation strategies have been created by academicians and researchers to have robust and consistent results for spatial panel data models. There are three well known and accepted estimation model in the literature: (quasi) maximum likelihood (QML or ML), instrumental-variables and generalized method of moments (IV/GMM), and the final one is Bayesian Markov chain Monte Carlo (MCMC) methods. In empirical studies with spatial panel data analysis, the first two estimation methods dominate (P. J. Elhorst, 2014). One of the main popular characteristics of QML and GMM estimators is that they do not have normality assumptions on disturbance terms. Therefore, the first two method are presented below and QLM is used for estimation method in this thesis.

IV/GMM Estimators

IV/GMM estimators can be except as the extension of the instrumental-variables and GMM tradition of Arellano–Bond type estimators to spatial panels. (Kelejian & Prucha, 1998, 1999) proposed generalized moments procedures for SAR and SEM-type models, and GMM estimators for spatial dynamic panels are developed later on.

When IV/GMM estimators are compared with conventional ML, their main advantage is that they are based on weaker distributional assumptions about the disturbance term.

Moreover, they can accommodate heteroskedasticity. In addition, they allow researchers to deal with endogenous regressors by using instruments. However, IV/GMM estimators also have some disadvantages such as weak-instrument problems, non-automatically constrained spatial parameters, and their finite-sample performance.

ML and QML estimators

Early spatial econometric models were estimated by ML which is built by Ord (1975). After, LeSage & Pace (2009) used ML and make it more suitable for spatial estimations. ML estimators are popular in spatial panel literature because it is efficient and provide strong consistent results. However, there are problems with ML estimation of spatial panel models when T is moderate. It estimates all the time and unit dummies together with spatial parameters and with moderate T it may result biased estimations. Lee & Yu (2010) solve this problem and add transformation-based QML estimators. It eliminates individual or time effects while keeping spatial structure of the model. It works even in dynamic specifications with lagged dependent variable under the regularity conditions. P. J. Elhorst (2014), use QML estimator and develop studies with it and recommend to use QML with dynamic spatial models as well as static ones.

In this thesis, SAR, SEM and SDM frameworks are discussed as alternative spatial specifications. However, empirically, the analysis focuses on SARAR/SDM type of dynamic spatial error-correction model. The models are estimated with province and time effects by QML.

3.2.7 Direct and Indirect Effects (Spillover Effect)

OLS model does not allow for spillover effects since it assume that outcomes for different units are independent of each other. Although SEM model considers spatial correlation do not provide any spillover effects. However, SDM and SAR can introduce spillover effects (P. J. Elhorst & Vega, 2013). SAR model,

$$Y = \rho WY + \alpha \iota_N + X\beta + u \quad (9)$$

can be reduced to

$$Y = (1 - \rho W)^{-1} \alpha \iota_N + (1 - \rho W)^{-1} X \beta + (1 - \rho W)^{-1} \varepsilon \quad (18)$$

When partial derivatives of $E(Y)$ with respect to x_{kN} taken,

$$\left[\frac{\partial E(Y)}{\partial x_{1k}} \dots \frac{\partial E(Y)}{\partial x_{Nk}} \right] = (1 - \rho W)^{-1} \beta_k \quad (19)$$

The direct effects can be obtained by diagonal elements of the matrix while spillover effects can be seen from the off-diagonal element. The effects are presented on Table 3.1.

Table 3.1 Direct and Spillover Effects of Spatial Models

	Direct Effect	Spillover Effect
OLS/SEMS	β_k	0
SAR/SAC	Diagonal elements of $(1 - \rho W)^{-1} \beta_k$	Off-diagonal elements of $(1 - \rho W)^{-1} \beta_k$
SLX/SDEM	β_k	θ_k
SDM/GNS	Diagonal elements of $(1 - \rho W)^{-1} [\beta_k + W \theta_k]$	Off-diagonal elements of $(1 - \rho W)^{-1} [\beta_k + W \theta_k]$

Source: (P. J. Elhorst & Vega, 2013)

The SDM model has both endogenous and exogenous variable and spatial effects except spatial error term. SDM and its reduced form is presented below.

$$Y = \rho W Y + \alpha \iota_N + X \beta + W X \theta + u, \quad (7)$$

$$Y = (1 - \rho W)^{-1} \alpha \iota_N + (1 - \rho W)^{-1} (X \beta + W X \theta) + (1 - \rho W)^{-1} \varepsilon \quad (20)$$

When partial derivatives of $E(Y)$ with respect to x_{kN} taken,

$$\left[\frac{\partial E(Y)}{\partial x_{1k}} \dots \frac{\partial E(Y)}{\partial x_{Nk}} \right] = (1 - \rho W)^{-1} [I \beta_k + W \theta_k] \quad (21)$$

The direct effects can be obtained by diagonal elements of the matrix while spillover effects can be seen from the off-diagonal element. The effects are presented on Table 3.1. (P. J. Elhorst & Vega, 2013))

3.2.8 Model Selection and Spatial Diagnostics

Findings about unit roots, cointegration and cross-sectional dependence are reported in Chapter 6. At this moment, while considering the pre findings, main model should be chosen. To be able to do this the procedures planned in three steps. The first one is deciding whether non-spatial panel model is sufficient or need extension to the spatial panel models. The second one that under the choice of using spatial panel model which specifications (e.g. SDM, SAR and SEM) should be used. The third one is fixed or random effect sufficient for the provincial panel.

The first step starts from non-spatial fixed-effect panel regression of provincial exports on its determinants. Residuals of conventional FE panel model are tested for spatial dependencies by using Moran's I and LM tests. Significant test statistics shows that spatial panel structure is needed.

Second step starts with a question. Which spatial model should be used? In the literature (LeSage & Pace, 2009) and (J. P. Elhorst, 2003; P. J. Elhorst, 2014; P. J. Elhorst & Vega, 2013) are suggesting to estimate SDM model as a first step. SDM has spatially lagged dependent as well as spatially lagged independent variable.

After setting SDM model (8), there are some tests applying on SDM by restricting some coefficients to test whether SDM or SAR/SEM model should be used by imposing

$$y = \rho WY + \alpha I_N + X\beta + WX\theta + u, \quad (8)$$

$$u = \varepsilon$$

$\theta = 0$ clear the spatial lags of regressors from the model and obtain SAR model, while $\theta = -\rho\beta$ collapses the SDM to a SEM model.

In this thesis, SDM is the starting point. After that, Wald-type test is applied and decide whether SDM or SEM/SAR.

The third step of model selection concerns the unobserved heterogeneity, FE or RE. The provincial data, it is understandable to allow unit and time specific effects which captures unobservable characteristics like geography or national shocks. Both FE and

RE can be applied in STATA software. Hausman test is used to compare and choose between FE and RE models.

Hausman test basically test the zero correlation between random effects and explanatory variables. As, SDM has spatially lagged dependent variable the coefficient of lagged variable is also included the test calculations (P. J. Elhorst, 2014).

Exports are persistent over time and Section 3.2.5 motivates the use of dynamic spatial SDM as well as cointegration findings. The diagnostic reports and comparison results is presented in Chapter 6.

3.3 Estimation Strategy, Endogeneity and Robustness

This section briefly presents the estimation strategy of the thesis. The solutions to potential endogeneity, dynamics and cross-sectional dependence are explained. The baseline specification of this study is a dynamic spatial model with province and time fixed effects. The model is estimated by QML.

Dynamic spatial error correction model of SDM/SARAR includes a lagged export variable and it captures feedback from past exports to current regressors. Key variables such as provincial credit and income enter in smoothed form. As robustness checks, factor-augmented non-spatial panel models are estimated using the DCCE estimator to capture unobserved common shocks. Detailed test results and robustness estimates are reported in Chapter 6.

CHAPTER 4

EXPORT LANDSCAPE OF TÜRKİYE - A BRIEF OVERVIEW

This chapter provides a global and regional macro frame about foreign trade especially export. In the first part, the size of the economies, export and import volumes are introduced to understand what is the size of the market. Then, GDP and export structure is mentioned from Türkiye's perspective. To understand the differences between the provinces, province level examination is presented.

Global GDP and Trade

Most part of world production and trade are still made by big economies. In 2024, global GDP realization is estimated at USD 110.4 trillion, while good exports realized as USD 24.9 trillion (UNCTAD, 2025a, 2025b). Figure 4.1 shows how much GDP is produced by top global countries.

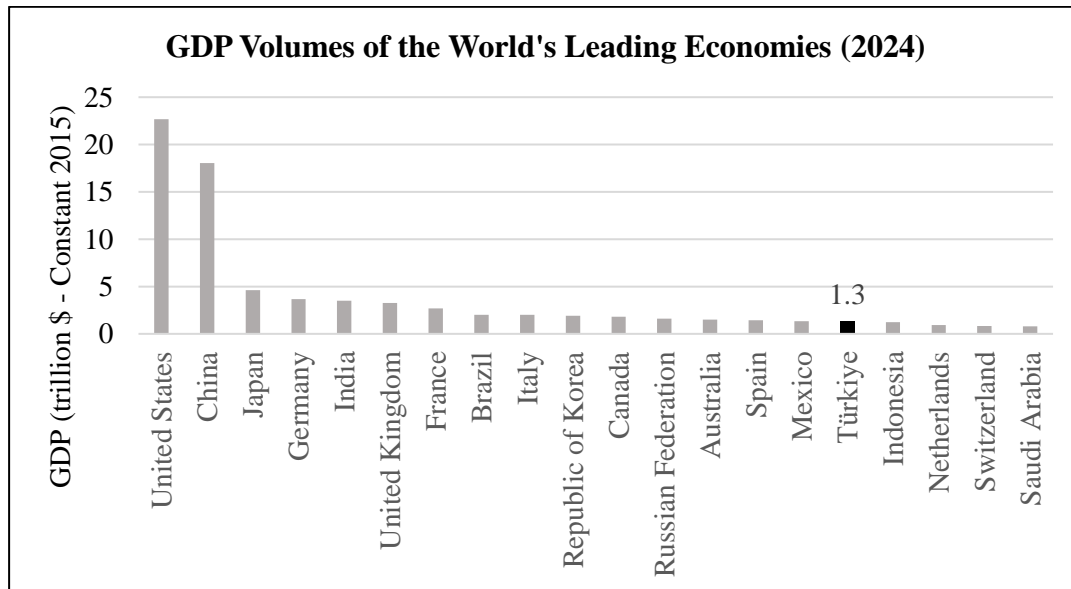


Figure 4.1. GDP of the World's Leading Economies in 2024

Source: Created by Author, (UNCTAD, 2025a)

It is obviously seen that the economies of United States, China, and Japan much bigger than other economies. It might be the result of population of course. The correlation can be seen at Figure 4.4. and Figure 4.3.

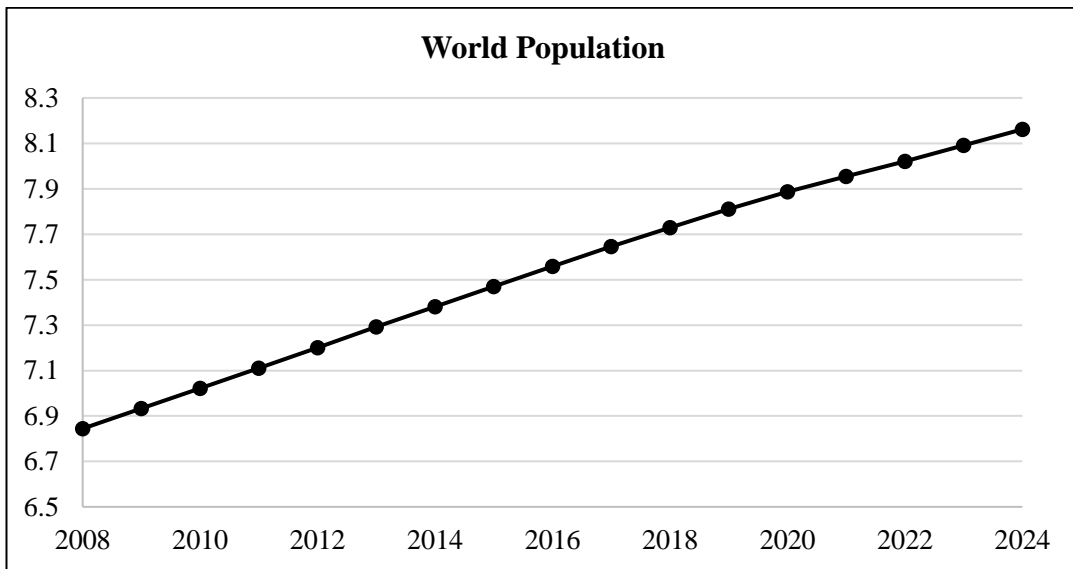


Figure 4.2. World Population, 2008-2024 (in billions)

Source: Created by Author, (UNCTAD, 2024)

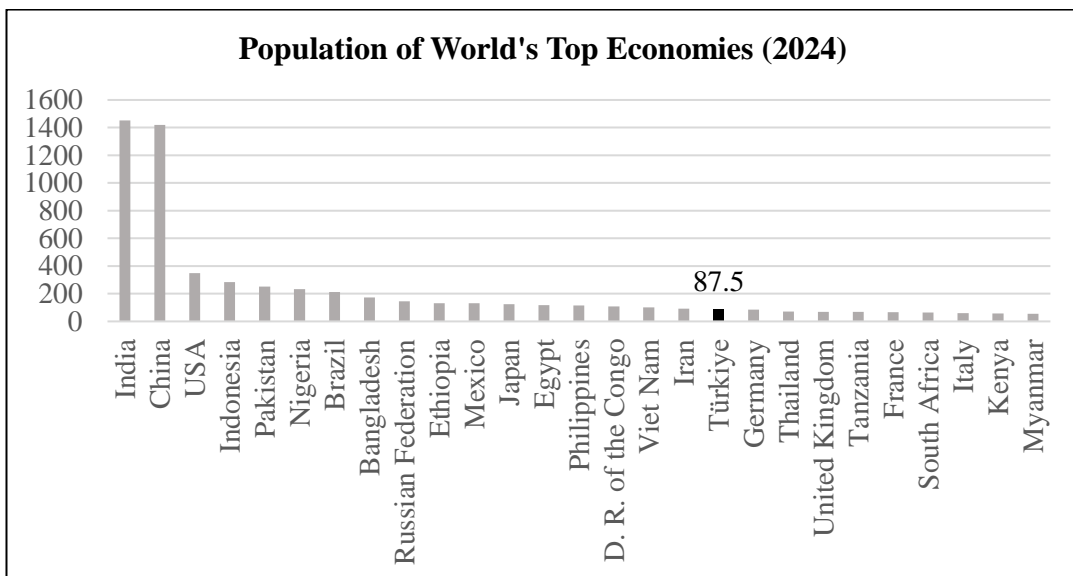


Figure 4.3. Population of World's Top Economies in 2024 (in billions)

Source: Created by Author, (UNCTAD, 2024)

Global Export and Import

Figure 4.5 shows that world trade has grown rapidly between 2008–2024. There were three main drops in global trade that can be seen from the Figure 3.5. They are the well-known global shocks. In 2009, world trade falls from about 16.5 to 12.8 trillion USD. This drop was the after effect of collapse in demand and trade finance during the global financial crisis. Around 2015–2016, volumes dropped again to roughly 16 trillion USD again. This was the outcome of the oil and commodity price depressions, China’s slowdown. In 2020, because of the pandemic, trade volumes decreased again to about 17.9 trillion USD. In 2021, trade volumes sharply increased. The global economy has strong capacity for recovery and it can be seen the recovery starting from 2011 at the Figure 4.4.

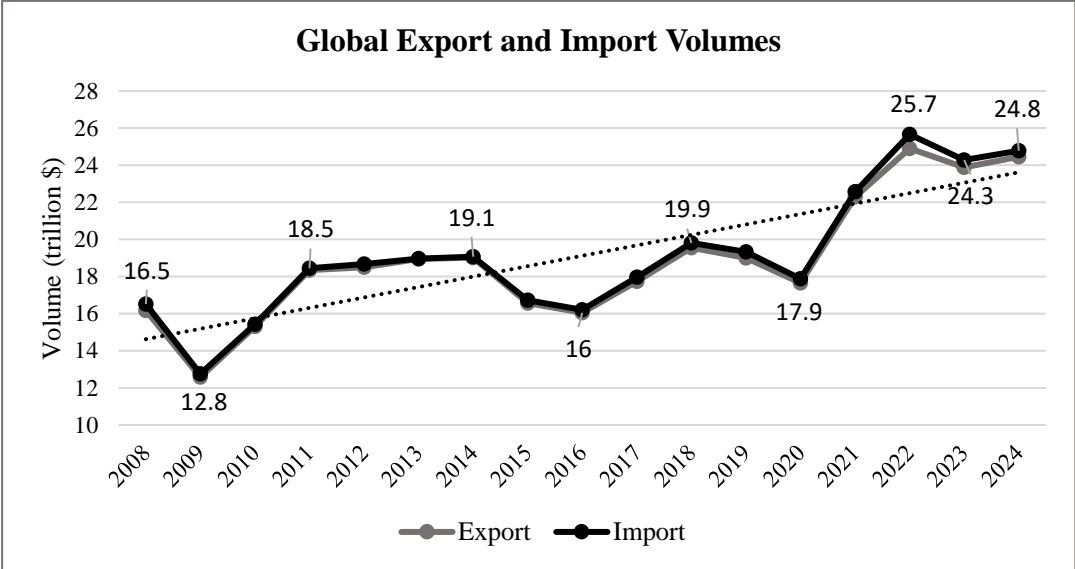


Figure 4.4. Global Export and Import Volumes (US\$ at current prices in trillion)

Source: Created by Author, UNCTAD (2025b)

When we look at world merchandise export volumes at Figure 4.5, China is the leader of 2024 with \$3.58 trillion (14.6% of world exports), followed by the United States at \$2.07 trillion (8.4%), Germany at \$1.68 trillion (6.9%), and the Netherlands at \$0.92 trillion (3.8%). Türkiye places 30th, with exports of about \$262 billion and a 1.07% global share (UNCTAD, 2025b).

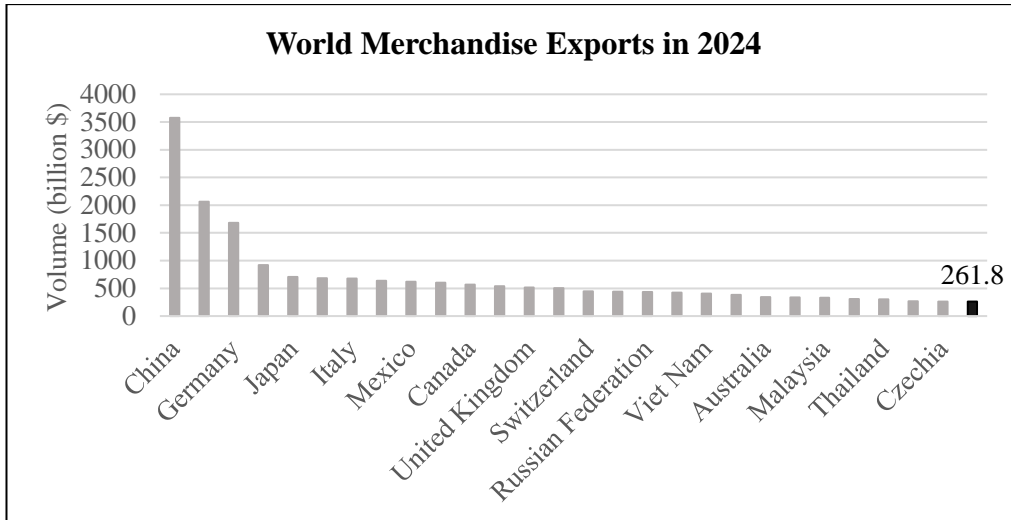


Figure 4.5. World Merchandise Exports, Top Economies (2024)

Source: Created by Author, UNCTAD (2025b)

Türkiye in the global picture - Macro snapshot.

Türkiye is a mid-sized, manufacturing-oriented economy with 85,7 million population (TURKSTAT, 2025a). Türkiye has 1,3 trillion US Dollar GDP (at constant prices at 2015) in 2024 (UNCTAD, 2025a). The location of Türkiye has a strategic advantage as being a corridor between Europe’s single market and Asia. To be able to understand the result of the spatial analysis the district (il) map (81 provinces) administrative geography underlying our provincial analysis can be seen in Figure 4.6.



Figure 4.6. Boundaries of the Turkish Provinces

Source: Created by Author, Ministry of National Defense (2025)

The merchandise export volume in current prices in USD and the global share of Türkiye can be seen at Figure 4.7. From 2008 to 2024, Türkiye’s exports rose from 132 billion to 261 billion US \$, while the world total moved from 16,2 trillion to 24,5 trillion US \$ (UNCTAD, 2025b). The global share of Türkiye increased slightly from 0,8% to 1,1%. It means that Türkiye higher its share in global context while increasing the export volume. It might be explained in couple of ways such as deepening manufacturing corridors.



Figure 4.7. Export Value and Global Share of Türkiye (%) (2008-2024)

Source: Created by Author, UNCTAD (2025b)

Spatial export change in Türkiye’s provinces

Export of Türkiye increased from 2008 and 2024. However, which city has higher contribution to the total export and is there any spatial dependencies or effects between cities has still no answer. It can be seen from the Figure 4.8 that large urban–industrial hubs has unequal share comparing other cities in 2008. And as it can be seen at Figure 4.9, the large economies has some spillovers to their neighbors. Moreover, some low expor ranked cities in 2008 increased their share faster than the large cities. There are

2 question come to minds. The first one is that is there real spillover effect between cities. The other one is that is the difference between cities converging or not?

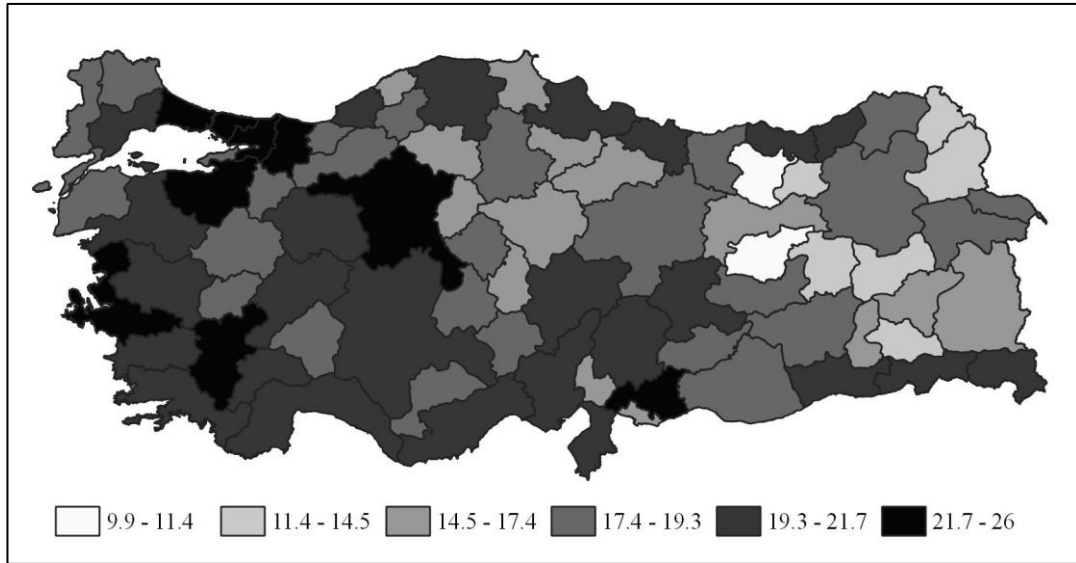


Figure 4.8. Provincial Real Exports (In USD), 2008

Source: Created by Author, The Author using the data obtained from TURKSTAT (2025b)

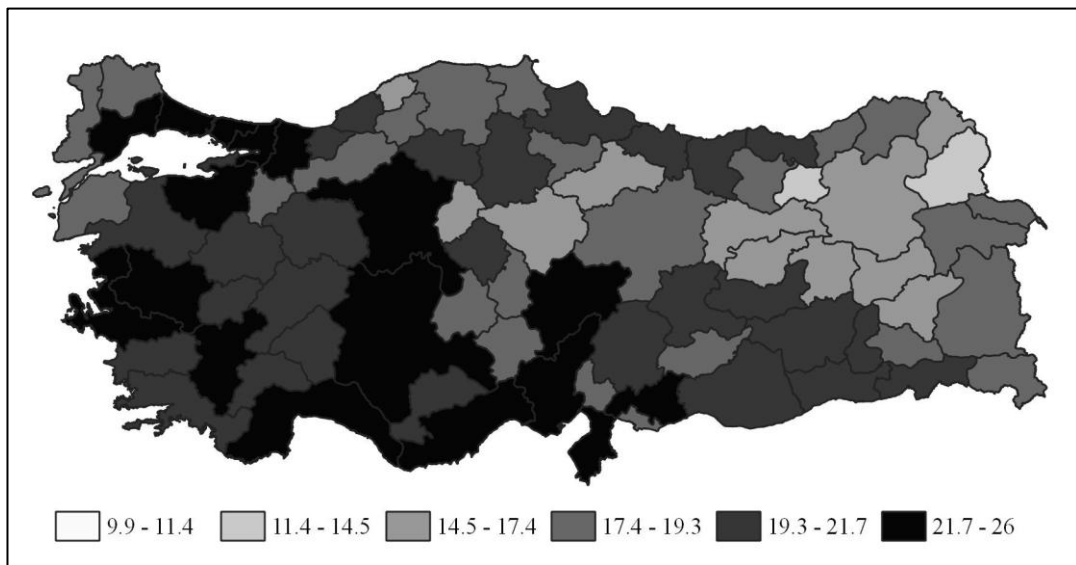


Figure 4.9. Provincial Real Exports (In USD), 2023

Source: Created by Author, TURKSTAT (2025b)

σ -convergence (levels and per capita)

Sigma convergence¹³ of ln real export Figure 4.10 and ln real export per capita Figure 4.11 falls between 2008 and 2023, but with small cycles. For ln real exports (levels), coefficient of variation declines from 0.137 (2008) to 0.114 (2024). It means of 0.023 log-points decrease (-16.8%).

When we come to for ln real exports per capita, coefficient of variation declines from 0.351 (2008) to 0.258 (2024). This means of decrease of 0.093 log-points (-26.5%)

In short, both ln export and ln export capita have σ -convergence but it is stronger in per-capita terms.

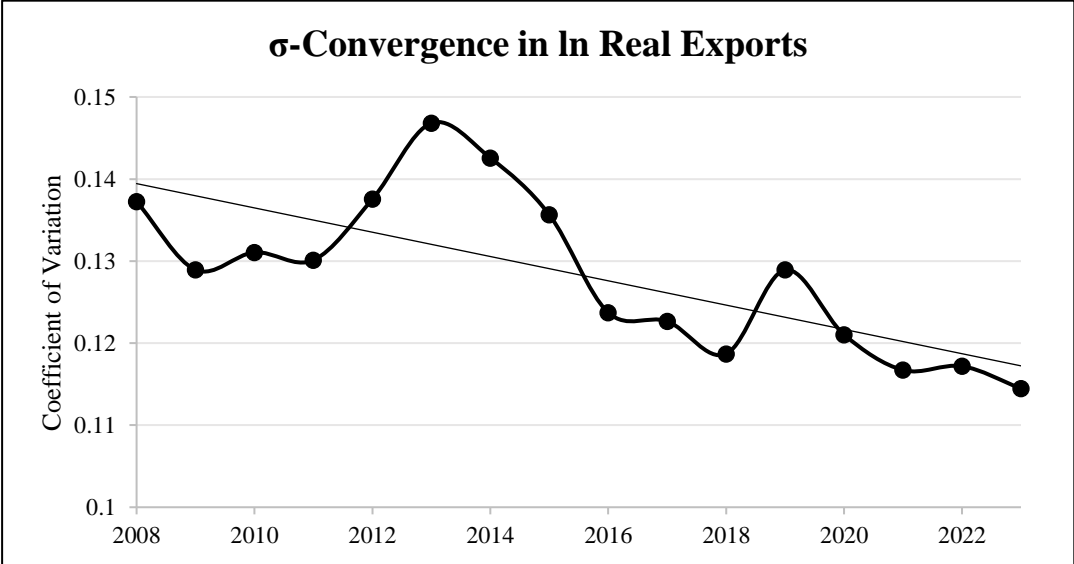


Figure 4.10. σ -Convergence in ln Real Exports (Levels), 2008–2023

Source: Created by Author, TURKSTAT (2025b)

¹³ Sigma convergence means the convergence in a specific variable (such as exports per capita) among a group of economies (like provinces) over time (Barro & Sala-i-Martin, 1992, 2004).

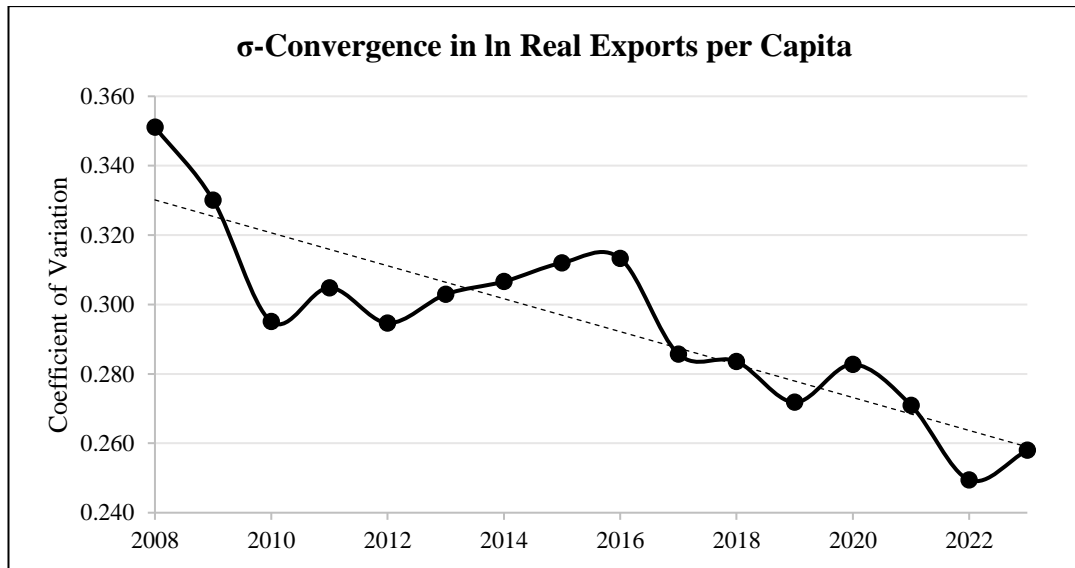


Figure 4.11. σ -Convergence in ln Real Exports per Capita, 2008–2024

Source: Created by Author, TURKSTAT (2025b)

Chapter 5 explains the variables which are used to explain spatial dependences of variables on exports of provinces and the spatial weight matrices. Chapter 3 and Chapter 6 presents the direct (own) and indirect (neighbour) effects and tests whether spillovers.

CHAPTER 5

DATA AND DESCRIPTIVE ANALYSIS

This chapter provide information about the provincial dataset used in this thesis. Firstly, general overview of data, data sources and period is presented. Then, the unit transformation of data is explained for every data used in the study. After explaining the economic data, spatial data (e.g. weight matrices) used in the spatial panel models is introduced. How the spatial data is collected and used explained. Finally, as set of descriptive statistics, graphics and maps is presented to explain how economic data spatially and graphically distributed. Preliminary tests are applied in Chapter 6.

5.1 Data Sources, Time Coverage, and Sample Design

The empirical analysis is based on an annual provincial panel dataset covering all 81 NUTS-3 provinces of Türkiye over the period 2008–2023. Data is collected for each province over each year and this means that the data is balanced. The period of the study is chosen between 2008-2023 because of data availability.

The core and dependent variable of this study is provincial export volume by origin of company (EXP). The data obtain from the database of Turkish Statistical Institute (TÜİK, extracted in 2025) in current US dollars. To be able to compare all of the variables nominal values are converted to real terms (2024 US dollars) by using the US annual average consumer price index. Then the data transformed into natural logarithms form. The same process is applied for provincial import value (IMP).

Provincial manufacturing activity is captured by manufacturing value added (MGDP). The data is also obtained from TÜİK (2025). As the data is reported in current Turkish lira, it is converted into US dollars by using the Central Bank of the Republic of Türkiye's annual average exchange rate. Later, the data is deflated to 2024 US dollars

with the US CPI. To be able to have more stable data, the data is transformed into logarithm form. A similar transformation is applied to provincial credit volumes (CRDT). CREDIT is the cash loans provided to market. The data obtained from the Banking Regulation and Supervision Agency (BDDK, obtained in 2025). These variables are used for proxy for the industrial structure and access to finance at provincial level.

To be able to capture common global shocks, external cost and supply/demand conditions that are common across provinces the dataset includes the international crude oil price (POIL), expressed as the log of the annual average price of a barrel of crude oil in real 2024 US dollars. The series is taken from the U.S. Energy Information Administration (EIA, 2025 extraction) in nominal US Dollar form and transformed into real prices by using US CPI index.

Human capital and innovation are represented by the ratio of women to men in higher education (GEN) and the number of patents granted in each province (PAT). The education ratio is calculated by data obtained from TÜİK while granted patent counts are taken from the Turkish Patent and Trademark Office (TÜRKPATENT, 2025 extraction). Patent numbers are converted into $\log(1+\text{num})$ form of logarithms to reduce while the education ratio is used in level form.

Demographic pressure and market potential within provinces are approximated by population density (POPD). The data is computed as the number of populations per square kilometer using TÜİK population dataset and provincial land areas information obtained from Directorate General for Mapping (HGM, 2025). It is also expressed in logarithms.

Connectivity and physical infrastructure are captured by two additional variables. The first one is the log of international air passengers (PSGR) flied from airports located in each province. The data is sourced from the General Directorate of State Airports Authority (DHMI, 2025). The second one is the log of total asphalt road length (ROAD). It is defined as the sum of state, provincial and motorway asphalt roads within the province. The data obtained from the General Directorate of Highways (KGM, 2025).

Overall, the dataset provides province-by-year balanced panel data. Also, all monetary variables are expressed in real 2024 US dollars while most variables are used in natural logarithms where it is applicable. More detailed definitions, transformations and expected signs of each variable are reported in Section 5.2.

5.2 Baseline Variables and Transformations

This section shows all the variables used in empirical analysis except spatial ones which is introduced in section 5.3. All series are used as an annual panel in 81 provinces over 2008-2023. Monetary variables are transformed from TL to US dollars, if necessary, by using the official average USD/TL exchange rate. Afterwards, the data is transformed into the logarithm of real 2024 US dollars by deflating by using the US CPI.

In the literature survey, variables that are used to explain provincial export are grouped into five broad blocks in Chapter 2. These are (i) economic size and industrial structure, (ii) institutional and policy environment, (iii) human capital, knowledge and innovation, (iv) infrastructure, accessibility and connectivity, and (v) external, market and trade linkages. The groups and variables are presented in Table 5.1.

Table 5.1 Variable Definitions and Data Sources

Variable	Description	Unit / Scale	Transformation	Source
<i>Economic Size and Industrial Structure</i>				
EXP	Provincial exports	real 2024 USD	ln()	TÜİK
MGDP	Provincial manufacturing GDP	real 2024 USD	ln()	TÜİK
IMP	Provincial imports	real 2024 USD	ln()	TÜİK
<i>Institutional and Policy Environment</i>				
CRDT	Provincial bank credit stock	real 2024 USD	ln()	BDDK
<i>External, Market and Trade Linkages</i>				
POIL	International crude oil price	avg. real 2024 USD per barrel	ln()	U.S. EIA

Table 5.1 (continued)

<i>Human Capital, Knowledge and Innovation</i>				
POPD	Population density	persons per km ²	Population/area ln()	TÜİK
GEN	Female-to-male higher-education ratio	ratio	none	TÜİK
PAT	Provincial patent grants	annual patent count	ln()	TURK PATENT
<i>Infrastructure, Accessibility and Connectivity</i>				
PSGR	International air passengers	annual num. of passengers	ln()	DHMİ
ROAD	Total asphalt road length	kilometers	ln()	KGM

5.3 Spatial Data and Distance Structures

The spatial dimension of the analysis is consisting of the 81 NUTS-3 provinces of Türkiye. Each province is treated as a spatial unit and spatial interaction is modelled through weight matrices. In weight matrices, provinces are considered as “neighbours”. The matrices are purely geographical and they are constructed from provincial boundaries. In addition, they do not depend on any economic variables which helps to avoid endogeneity concerns in the spatial structure itself.

Geographical information on provincial boundaries and centroids is taken from the website of Directorate General for Mapping and processed using one of the geographical information system software, QGIS. In software, by using the centroids of the province’s geometries, an 81×81 contiguity and distance matrices are computed. This contiguity and distance information, together with polygon data is then used to build several alternative spatial weight matrices that reflect different notions of proximity.

First, the analysis uses k-nearest-neighbour (k-NN) matrices with k=6. In these matrices, each province is connected to its k geographically closest neighbours regardless of whether they share an administrative border. This construction

emphasises connectivity rather than contiguity and ensures that even geographically peripheral provinces have a minimum number of links.

Second, distance-band matrix is obtained by combining the centroid distance information with 300-kilometer cut-off. For each cut-off, provinces whose centroids lie within the specified distance are linked, with raw weights based on inverse distance ($1/d_{ij}$) and zero weights for pairs beyond the cut-off.

All spatial weight matrices are row-standardised so that each row sums to one and the elements can be interpreted as relative weights assigned to neighbouring provinces. The diagonal is kept at zero in all cases as province cannot be a neighbor itself. The matrices are time-invariant over 2008–2023, reflecting the fact that provincial boundaries and physical geography do not change within the sample period.

5.4 Descriptive Statistics and Stylized Facts

This section provides summary information about the data used in this thesis. The aim is not Rather than estimating model or explaining the dependent variable, this section gives some general information about dependent variable of export and its covariates.

The summary statistics confirm that provincial exports are highly heterogeneous. The mean of log real exports masks a very wide range: the gap between the lowest and highest exporting provinces is several orders of magnitude in level terms, reflecting the dominance of a small number of large industrial and coastal provinces. A similar pattern holds for manufacturing GDP, imports and bank credit, where the upper tail is driven by major metropolitan areas, while many inland provinces operate at much smaller scales.

Table 5.2 shows that real provincial exports in log form (EXP) are highly heterogenous with a mean of about 19.1 and values ranging from 0 to 25.6. There some years that are not engage any export activities cause the zeros. While calculating the natural logarithm, $\ln(1+\ln)$ formulation is applied.

A similar pattern holds for manufacturing GDP, imports and bank credit, where the upper tail is consisting of major metropolitan areas while many inland provinces

operate much smaller scales. Manufacturing GDP (MGDP) and imports (IMP) have similar average levels (around 20.1 and 18.6), but imports are more dispersed (min 0, max 26.1).

Summary statistics

Table 5.2 Summary Statistics

	mean	sd	min	max
EXP	19.06614	2.570684	0	25.61573
MGDP	20.10028	1.804466	15.53495	24.78793
IMP	18.63013	2.950048	0	26.0885
CRDT	21.3714	1.322061	18.24498	26.48449
POIL	4.560427	.3436975	3.929077	5.04465
GEN	.701228	.1458778	.2572099	1.033115
PAT	1.300203	1.43566	0	7.372118
POPD	4.258465	.8508406	2.314112	7.976942
PSGR	4.507388	5.398215	0	18.16737
ROAD	6.516359	.544196	4.804021	8.016648
<i>N</i>	1296			

Bank credit (CRDT) is relatively high and even across provinces (mean 21.4, s.d 1.3), while the crude oil price (POIL), a common external factor, fluctuates only within a narrow band (mean 4.56). On the other hand, human-capital and innovation variables display strong heterogeneity. The female-to-male higher-education ratio (GEN) averages 0.70 (standard deviation, 0.15) and patent grants (PAT) range from 0 to 7.37. Finally, population density (POPD) and especially international passengers (PSGR, min 0, max 18.2) reveal a sharp metropolitan-peripheral divide, whereas road length (ROAD) is much less dispersed (mean 6.52).

Spatial Distribution of Variables

The graduated maps for 2008 and 2023 shows a clear spatial diffusion of economic activity over time. In 2008, it can be seen that exports (EXP) are concentrated in the Marmara region, Ankara, İzmir and a few specialized centers such as Denizli. On the other hand, in 2023, the map shows that high-export provinces have visibly multiplied and the darkest classes are clustered with neighbors. A similar pattern appears for imports (IMP) as well.

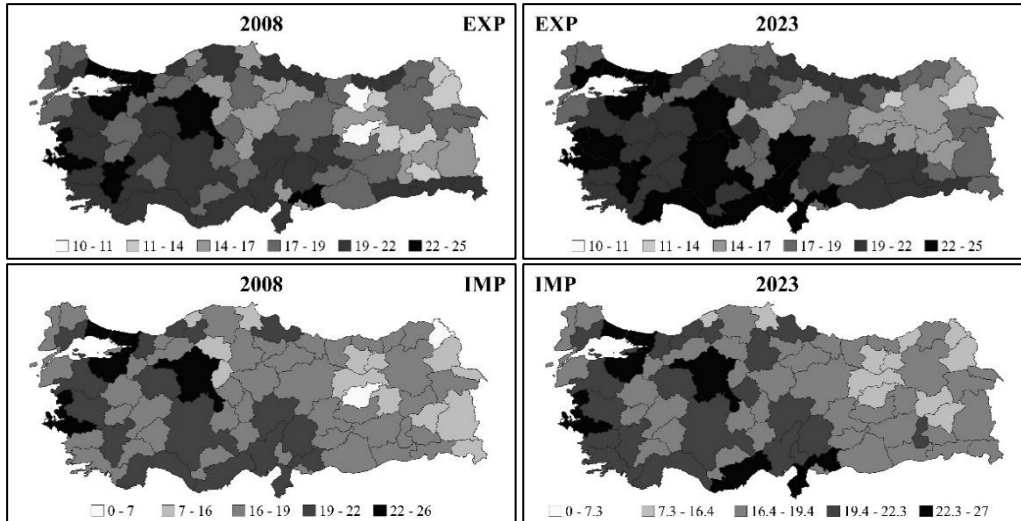


Figure 5.1. Choropleth Maps of Export and Import in Türkiye (2008-2023)

For MGDP, CREDIT and POPD, economic mass, financial depth, population density and transport infrastructure are again strongest around İstanbul, Ankara and İzmir in 2008 and clustering by 2023.

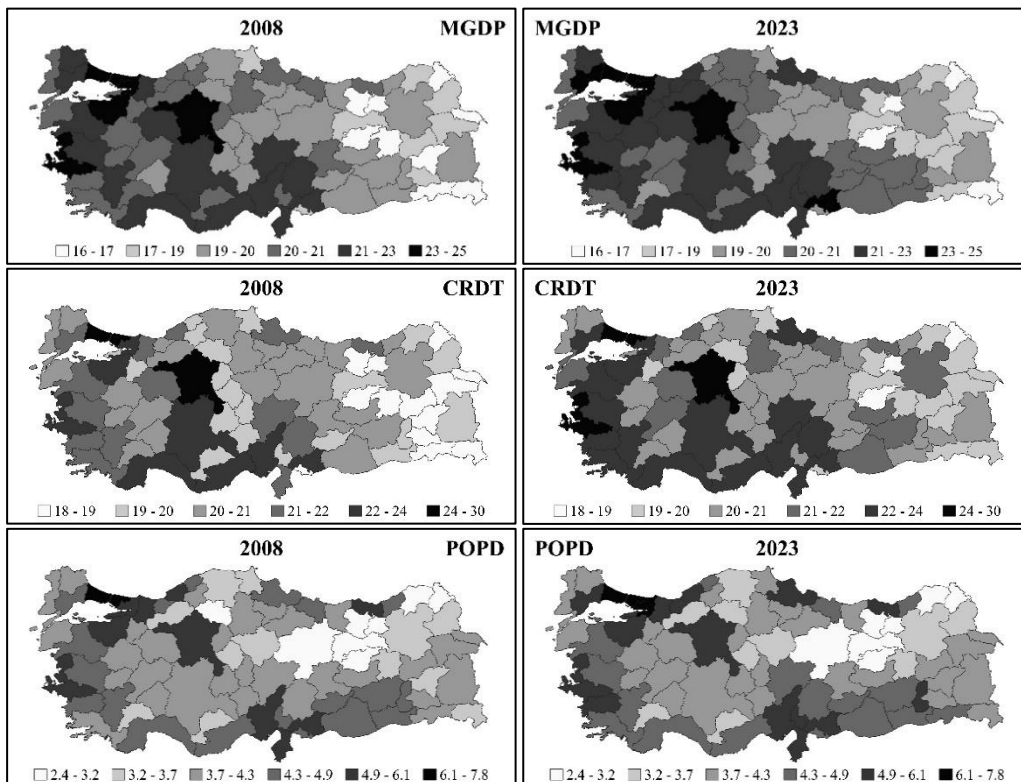


Figure 5.2. Choropleth Maps of MGDP, CRDT and POPD

ROAD, has the same pattern with MGDG, CRDT and POPD. However, it is not strong in İstanbul, Ankara and İzmir like others. Road density seems evenly distributed when it is compared with other variables.

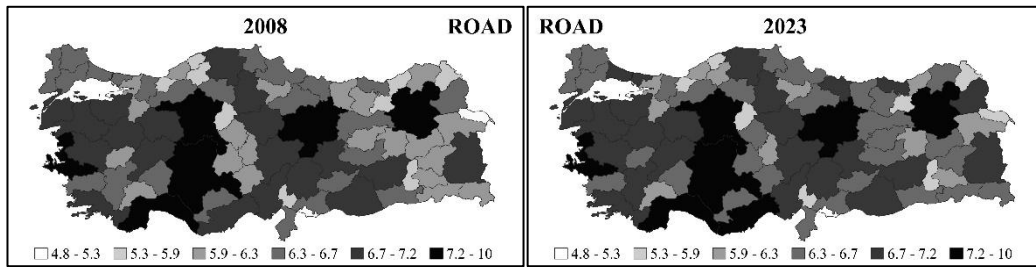


Figure 5.3. Choropleth Maps of Road Density in Türkiye (2008-2023)

Patent values (PAT) are close to zero in many provinces in 2008. However, patent activity becomes more widespread over time concentrating in provinces with strong manufacturing and export. On the other hand, maps illustrates that high educated women ratio (GEN) increase across almost all provinces. Finally, passenger numbers (PSGR) become more evenly distributed as new airports and routes open.

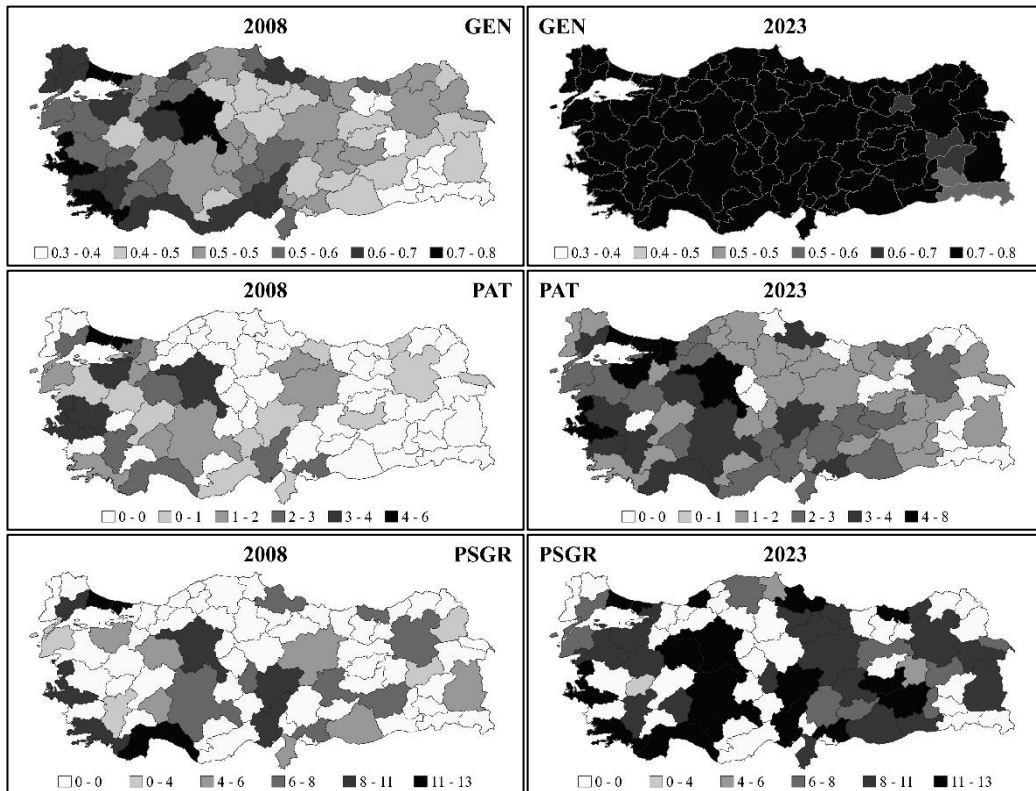


Figure 5.4. Choropleth Maps of WEDU, PAT and PSGR

Overall, It seems that EXP, IMP, MGDG, CREDIT, POPD and PSGR appear to follow a broadly similar spatial pattern, with initial cores around major metropolitan areas and gradual diffusion towards their hinterlands.

Correlation Structure of Variables

The cross-section plots (year 2023) confirm the patterns between variables and export visually (Figure 5.5). Log exports are tightly and positively related to log MGDG, log IMP and log CRDT. They follow linear upward clouds, while the relationship with POIL is flat because of being time series data rather than panel data. GEN and PAT also show clear positive slopes. It can be referred that provinces with a higher female-to-male higher-education ratio and more patent grants tend to have higher export levels for now. Similarly, POPD and PSGR display monotonic positive associations with exports. There is some dispersion on scatter plot of ROAD. Overall, the scatter plots provide some correlation evidence that economic size, imports, finance, human capital, innovation and connectivity are all empirically may be linked to provincial export performance.

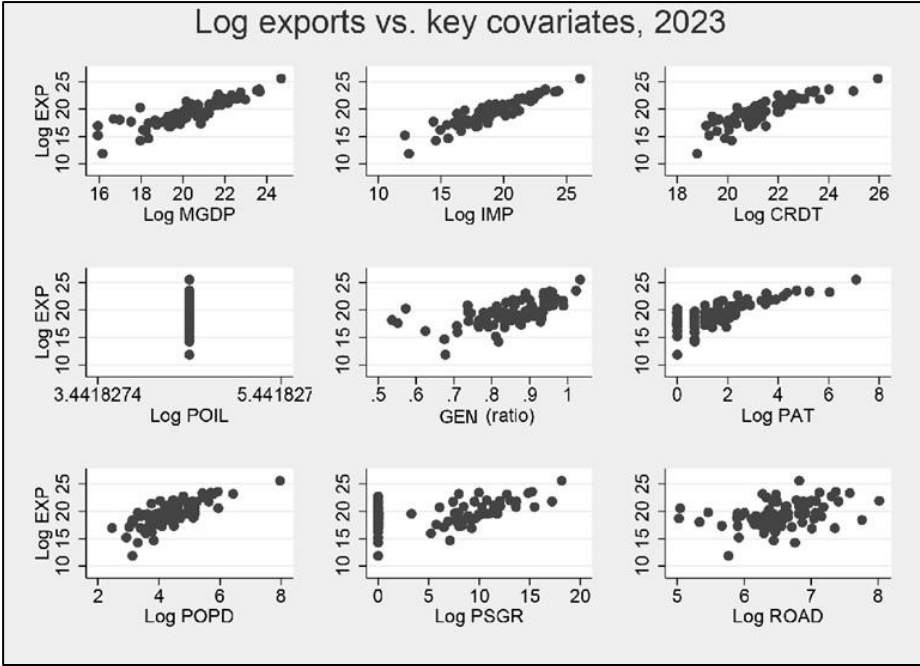


Figure 5.5. Pairwise Scatter Plots of Key Variable

CHAPTER 6

EMPIRICAL RESULTS

The previous chapters presented the literature, data and methodology. This chapter finally do the work and show how and why provincial exports in Türkiye move the way they do. The empirical analysis starts from documenting basic spatial and time-series patterns in exports and key covariates. Later, it moves to panel unit root and cointegration analysis, where cross-sectionally augmented error-correction models are used. The is to find whether there is a long-run relationships between exports and macro-financial, education-innovation and connectivity blocks. To achieve that non-spatial benchmark models are estimated and their residuals are checked for spatial dependence. Later on, the spatial error-correction models and explores are introduced. The question, how export shocks and provincial characteristics spill over across neighboring regions is answered with the help of the empirical analysis.

6.1 Preliminary Tests: Dependence, Stationarity and Cointegration

Before beginning to the model estimations and results, this section presents some preliminary diagnostic tests and their results. The aims of this section are to check the cross-sectional dependence, control the stationary condition and check if there is a long-run relationship that justifies an error-correction representation. The tests are flows the methodology presented in Section 6.1.2- 6.1.3 and provide empirical basis for the ECM terms and dynamic spatial specifications used later in the chapter.

6.1.1 Cross-Sectional Dependence (CD) Tests

For the period 2008–2023, cross-sectional dependence is examined using Pesaran's (2004) CD test for all main variables for 81 provinces and it can be seen at Table 6.1.

The results show that there is strong and highly significant dependence. All variables have very large CD statistics with p-values equal to 0.000.

Although, an average pairwise correlations are not very high for economic size and industrial structure variables (around 0.19–0.49), it becomes very high for other variables (0.5–1.0).

Table 6.1 Cross-sectional Dependence Test Results for Main Variables

<i>Variable</i>	<i>CD-test</i>	<i>p-value</i>	<i>corr</i>	<i>abs(corr)</i>
Economic Size and Industrial Structure				
EXP	60.020	0.000	0.264	0.449
MGDP	110.380	0.000	0.485	0.533
IMP	44.240	0.000	0.194	0.336
Institutional and Policy Environment				
CRDT	202.220	0.000	0.888	0.888
External, Market and Trade Linkages				
POIL	227.680	0.000	1.000	1.000
Human Capital, Knowledge and Innovation				
POPD	120.940	0.000	0.531	0.805
GEN	221.560	0.000	0.973	0.973
PAT
Infrastructure, Accessibility and Connectivity				
PSGR
ROAD	52.080	0.000	0.229	0.561

In addition, infrastructure, accessibility and connectivity variables such as asphalt road length is also significant but relatively lower dependence, CD statistics around 52 and average correlations near 0.23. Finally, patent and international air passenger variables (PAT and PSGR) is not reported due to missing observations for the nature of the variables as most of the provinces do not have airport or granted patents.

Overall, the CD test statistics clearly shows cross-sectional dependence in this panel series. This means that dependencies between provinces should take into considerations while creating econometric models and it should allow common shocks and spatial or economic linkages across provinces.

6.1.2 Panel Unit Root Tests

Pesaran's CADF/CIPS panel unit root tests are applied to check whether the data are stationary or non-stationary. The test is applied for the variables of the study over 2008-2023 period. The result shows that unit root cannot be rejected for log of exports and for most provincial fundamentals (CRDT, GEN, MGDP, PAT, POIL, POPD, PSGR, ROAD) except imports (IMP).

Table 6.2 Pesaran (2007) Unit Root Test Results for Main Variables

<i>Variable</i>	<i>Lags</i>	<i>Stationarity (5% level)</i>
EXP	1	Non-stationary
MGDP	1	Non-stationary
IMP	1	Stationary
CRDT	1	Non-stationary
POIL*	1	Non-stationary
POPD	1	Non-stationary
GEN	1	Non-stationary
PAT	1	Non-stationary
PSGR	1	Non-stationary
ROAD	1	Non-stationary

*Dickey Fuller Test is used for the data

The second test is applied to be able to understand that whether the non-stationary data are showing I(0) properties when their first differences estimated. The result is presented in Table 6.3.

For ΔEXP and almost all differenced covariates ($\Delta MGDP$, ΔIMP , $\Delta CRDT$, $\Delta POPD$, ΔGEN , ΔPAT , $\Delta ROAD$), the unit-root null is strongly rejected with second test. It means that most variables behave as I(1) element in models.

Table 6.3 Pesaran (2007) Unit Root Test Results for First Differenced Variables

<i>Variable</i>	<i>Lags</i>	<i>Stationarity (5% level)</i>
ΔEXP	1	Stationary
$\Delta MGDP$	1	Stationary
ΔIMP	1	Stationary
$\Delta CRDT$	1	Stationary
$\Delta POIL$ *	1	Stationary
$\Delta POPD$	1	Stationary

Table 6.3 (continued)

<i>ΔGEN</i>	1	Stationary
<i>ΔPAT</i>	1	Stationary
<i>ΔPSGR</i>	1	Stationary
<i>ΔROAD</i>	1	Stationary

*Dickey Fuller Test is used for the data

In the empirical work that follows, exports and the explanatory variables are I(1) form. It means they can enter the error-correction models in levels and in first differences. However, IMP may be used as persistent control variables rather than focus explanatory variable by means of the long-run relationships.

6.1.3 Treatment of Non-stationary Variables

The unit root results showed that most variables have I(1) characteristic while IMP is looking like stationary in levels. In line with the econometric framework presented in Section 6.1.2, exports and their potential explanatory variables can be estimated in first differences. This estimation gives us long-run information through an error-correction term.

For each variable block (macro-financial, education-innovation and connectivity) panel ECM is firstly estimated. In this estimation procedures, export and its explanatories enter into model in long-run part. At the same time, they join the model in the short-run part as well. When the cointegration occurs, this procedure gives as an error correction term which measures the deviation of exports from its long-run equilibrium with its explanatories.

In the regressions, ΔEXP (difference) is used as the dependent variable, the regressors enter the equations also mainly in their first differences. In the equations lagged error-correction term is also included as an additional regressor. The aim to include error correction term is to capture the speed of coming back to the long-run equilibrium. Variable which is stationary such as IMP are allowed to enter both the long-run relation and the short-run dynamics without differencing.

There are two variables either affect globally or affected by global. The international crude oil price (POIL) is a purely time-varying macro variable common to all provinces and it has global conditions. Also, international passengers (PSGR) are strongly may be affected by national and global shocks. For these variables, the reason by adding them into models is not identifying a cointegrating vector with provincial exports. The aim is to control the deviations from global demand and cost conditions.

Overall, this treatment of non-stationarity ensures that the models in Sections 6.2 and 6.3 respect the I(1) nature of the data, avoid spurious regression problems. By capturing global shocks and avoiding spurious regressions, they allow the dynamic spatial specifications to be interpreted truly while describing short-run adjustments around a cointegrated long-run relationship.

6.1.4 Panel Cointegration Tests

Almost all of the variable have I(1) structure and have cross-sectional dependencies. Long run equilibrium can be applied by cross-sectionally augmented error-correction model (CS-ECM). It is estimated dynamic common correlated effects estimator. The models are set in three different way and in each specification, provincial export growth lagged level of export and set of explanatory variables are both used in ECM model. Cross section averages which enter the model proxy the common shocks.

$$\Delta EXP_{it} = \alpha_i + \varphi_i(EXP_{it-1} - \beta_i'X_{i,t-1}) + \gamma_i'\Delta X_{it} + \delta_i'\bar{Z}_t + u_{it} \quad (22)$$

where X_{it} denotes long-run regressors, \bar{Z}_t are cross-section's averages that proxy for unobserved common factors. φ_i is the speed-of-adjustment parameter.

Three different CS-ECM models are estimated according to the literature survey presented in Chapter 2. The first estimation is made with macro-financial variable such as manufacturing value added (MGDP), imports (IMP) and cash credits (CRDT). The second model, education and innovation block, is estimated by using, higher educated women population ratio (GEN), granted patent numbers (PAT) and population density (POPD). And final block is infrastructure and connectivity, called connectivity in short

form. Asphalt road length, international air passenger number and population density enters into this model

Table 6.4 summarizes the main cointegration diagnostics from the CS-ECM estimations. For each of the three blocks, the adjustment coefficient on the lagged error-correction term is negative and significant. It provides us strong evidence of a stable long-run relationship between provincial exports and explanatory variables. All of three model has significant mean adjustment coefficient terms and the coefficients are about -1.08 for the macro–finance block, -1.10 for the education and innovation block and -0.59 for the connectivity block. These values imply very rapid error-correction. It means if there is some deviation from the long-run equilibrium it is adjusted within one year. The within-R-squared of the CS-ECMs ranges between 0.08 and 0.28. The root mean squared error is below 1 in all cases. These results are indicating a reasonable fit given the large cross-sectional dimension.

Cross-sectional dependence results shows that there is significant evidence that there is no cross-sectional dependence occurs in the macro-finance block as CD statistic is -0.97 and p value greater than 0.05 (0.33). On the other hand, some cross-sectional dependency occurs in the education-innovation and connectivity blocks (CD statistics between 2.1-2.3 with p-values of 0.033 and 0.020).

Table 6.4 Cointegration Results

	<i>Macro & Finance Block</i>	<i>Education & Innovation Block</i>	<i>Connectivity Block</i>
Adjustment Coefficient	-1.082 p-value=0.00	-1.099 p-value=0.00	-0.585 p-value=0.00
R-squared	0.09	0.08	0.28
R-squared MG	0.57	0.33	-0.14
Root MSE	0.56	0.70	0.90
CD Statistic	-0.97	2.11	2.32
p-value	0.3339	0.0351	0.0203

For each CS-ECM, the implied error-correction term

$$EC_{i,t} = EXP_{i,t-1} - \beta'_i X_{i,t-1} \quad (23)$$

subjected to Pesaran's CADF panel unit-root test.

To verify that this ECM representation is consistent after the model estimation error correction terms are expected to be $I(0)$. To be able to discover that the time-series properties of the estimated error-correction terms are tested.

When CADF tests results are checked on the error-correction terms, the unit-root is rejected for all three blocks. These results support the existence of panel cointegration between provincial exports and their macro-financial, human-capital and connectivity determinants.

CADF unit-root tests reject the null hypothesis that there is a unit root at the 5 per cent level for all three blocks. The p-values are 0.016 (macro-finance), 0.031 (education-innovation) and 0.006 (connectivity). The results show that error-correction terms are stationary $I(0)$. It confirms the presence of a stable long-run relationship between provincial exports and the regressors. The economic interpretation of the long-run coefficients and the adjustment speeds and as well as their spatial extensions are discussed in detail in Section 6.2 and Section 6.3.

6.2 Static Panel Estimation Results (Non-Spatial Benchmarks)

The results are organized into three groups of explanatory variable groups as these groups are discussed in Chapter 2. These determinants of exports are gathered into groups of macro-financial factors, human capital-knowledge and innovation (innovation shortly), and infrastructure-accessibility and connectivity (connectivity shortly). All models have the dependent variable of the first difference of log real exports ΔEXP . On the other hand, province and year fixed effects are included in the models. In order to capture unobserved common factors, cross-section averages of the main variables are added into models. Short-run effects are measured by coefficients on differenced regressors, while long-run relationships are summarized by the coefficients entering the error-correction term. The individual province error correction terms from these models are used both as regressors in the spatial models and as the basis for Moran's I tests in Section 6.2.5.

6.2.1 Model Specification

A main cross-sectionally augmented error-correction model (CS-ECM) is built and presented below.

$$\Delta EXP_{it} = \alpha_i + \varphi_i(EXP_{it-1} - \beta_i' X_{i,t-1}) + \gamma_i' \Delta X_{it} + \delta_i' \bar{Z}_t + u_{it} \quad (22)$$

where $i = 1, 2 \dots 81$ denotes provinces, $t = 2008, \dots 2023$ year

ΔEXP_{it} = denotes the growth rate of exports in province i at time t

$\varphi_i \overbrace{(EXP_{it-1} - \beta_i' X_{i,t-1})}^{EC_{i,t}}$ = the error-correction component, measuring how deviations of exports from their long-run equilibrium come back

φ_i = the province-specific error-correction (speed-of-adjustment) coefficient

ΔX_{it} = the vector of short-run effects of changes in province-specific fundamentals

\bar{Z}_t = the vector of coefficients on the cross-sectional averages

6.2.2 Macro and Finance Model Results

The results of dynamic common correlated effects ECM (dyn-CCE ECM) estimation results for the macro-finance block can be seen in Table 6.5. This model combines manufacturing value added (MGDP), imports (IMP) and bank credit (CRDT) variables to explain the short and long run relationship with export growth. The R-squared of 0.09 (within) is modest, while the MG R-squared of 0.57 indicates that the long-run component explains a sizeable share of cross-section variation. Finally, the CD statistic -0.97 p-value of 0.33 suggests that once common factors are controlled via cross-sectional averages there is no remaining significant cross-sectional dependence in the residuals.

The results show that in the short run, export growth responds positively to changes in imports. The coefficient on ΔIMP is positive (0.20) and statistically significant. This result indicates that provinces experiencing faster import growth tend to have higher export growth within the same year. This is consistent with the idea and presented

literature in Chapter 2 that global value-chain participation support export performance.

On the contrary, short-run changes in manufacturing value added is not statistically significant while explaining the export growth. It may be explained because of yearly fluctuations in manufacturing output do not translate immediately into export growth.

Table 6.5 Macro/Finance, Dyn-CCE ECM for Provincial Export Growth

<i>ΔEXP</i>	
Short Run Effects	
Manufacturing GDP growth (<i>ΔMGDP</i>)	-0.375 (0.615)
Import growth (<i>ΔIMP</i>)	0.196*** (0.075)
Adjust. Term	
Error Correction Term (<i>EC_{t-1}</i>)	-1.082*** (0.121)
Long Run Effects	
Log of Cash Loans (CRDT)	0.795 (1.535)
Log of Manufacturing GDP (MGDP)	2.491*** (0.901)
R-squared	0.09
R-squared (MG)	0.57
Root MSE	0.56
CD Statistic	-0.97
p-value	0.3339

Notes: Coefficients reported with robust standard errors in parentheses. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

In the dyn-CCE ECM macro model, the adjustment coefficient (φ_i) of the lagged error correction level (denoted EC_{t-1} in the model) is around -1.08 and highly significant. This implies rapid convergence towards the long-run equilibrium. It can be explained like that when exports are 1 percent above their equilibrium level, export growth declines by about 1.1 percentage points in the following year.

In the long-run part of the model, manufacturing value added has a positive (2.5) and statistically significant coefficient. This is indicating that provinces with larger manufacturing value added sustain higher export level. However, the long-run coefficient on credit is not statistically significant which is interesting finding. This finding shows that provincial credit depth does not have a clear additional long-run

effect on exports. Overall, the macro–finance block confirms a stable cointegrating relationship in which manufacturing activity anchors long-run exports, while import growth plays a supportive role in the short run.

6.2.3 Education and Innovation Model Results

ECM model is built to discover whether education and innovation block variables have long run relationship with export growth or not and reported in. The within R-squared value 0.08 is low and the MG R-squared is moderate 0.33. The CD statistic 2.11 with p-value 0.0351 suggests that there is some remaining cross-sectional dependence in the residuals even after controlling for common factors. It can be spatial dependence.

The results show that there is no significant long-run relationship between exports, patents (PAT), the female-to-male higher-education ratio (GEN) and population density (POPD). It is the unexpected result for most of the academicians. However, it is suggested to examine the exported good variety of Türkiye on conclusion part.

The result is the same with short-run dynamics which includes changes in imports and credit (ΔIMP , $\Delta CRDT$). In the short run, neither ΔIMP nor $\Delta CRDT$ is statistically significant to explain the export growth. This indicates that once innovation and education variables enter into the long-run part of the model, short-run macro fluctuations become less explaining to export growth.

Table 6.6 Education-Innovation, Dyn-CCE ECM for Provincial Export Growth

ΔEXP	
Short Run Effects	
Import growth (ΔIMP)	0.051 (0.103)
Credit growth ($\Delta CRDT$)	3.981 (4.352)
Adjust. Term	
Error Correction Term (EC_{t-1})	-1.099*** (0.167)
Long Run Effects	
Log of Cash Loans (PAT)	1.549 (1.614)

Table 6.6 (continued)

Log of High Educated Women Ratio (GEN)	27.390 (29.313)
Log of Population Density (POPD)	29.564 (26.520)
R-squared	0.08
R-squared (MG)	0.33
Root MSE	0.70
CD Statistic	2.11
p-value	0.0351

Notes: Coefficients reported with robust standard errors in parentheses. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

The good news is the error-correction coefficient of the long run equilibrium. It remains negative again with -1.1 and statistically significant. It can be explained as deviations from the long-run equilibrium are quickly corrected.

To sum up, although, none of the long-run coefficients (PAT, GEN or POPD) is statistically significant to explain export growth, this does not mean that human capital and innovation are irrelevant for export performance as adjustment coefficient adjust the shocks to come back to long run equilibrium. In practice, the error-correction term from this block mainly captures how exports adjust to set of innovation-related explanatory variables. On the other hand, separate contributions of patents, education and density should be interpreted with caution.

6.2.4 Infrastructure and Connectivity Model Results

Finally, Table 6.7 reports the ECM estimates for the infrastructure and connectivity block. Road length (ROAD), international air passengers (PSGR) and population density (POPD) are estimated to explain the short run and long run relationships with import growth (IMP). The within R-squared is relatively high at 0.28. However, the MG R-squared is negative -0.14. This indicates that the long-run component ROAD, PSGR, POPD have very limited explanatory power for cross-sectional differences.

The short-run part includes growth on import, international air passengers numbers, roads and density (ΔIMP , $\Delta PSGR$, $\Delta ROAD$, $\Delta POPD$). In the short run, only the positive coefficient (0.081) on import growth can be expressed almost significant with

p value 0.07. It may be suggested that import growth is again may be associated with higher short-run export growth, although the effect is less and not significant as it is in the macro–finance model. In short-run, growth in connectivity, international passengers variables and population density are not statistically significant.

Table 6.7 Connectivity, Dyn-CCE ECM for Provincial Export Growth

<i>ΔEXP</i>	
Short Run Effects	
Import Growth (<i>ΔIMP</i>)	0.081* (0.044)
Int. Air Passenger Growth (<i>ΔPSGR</i>)	0.010 (0.015)
Asphalt Road Length (<i>ΔROAD</i>)	-0.547 (2.749)
Population Density (<i>ΔPOPD</i>)	4.527 (3.053)
Adjust. Term	
Error Correction Term (<i>EC_{t-1}</i>)	-0.585*** (0.056)
Long Run Effects	
Log of Asphalt Road Length (<i>ROAD</i>)	4.550 (4.411)
Log of Int. Air Passenger (<i>PSGR</i>)	0.079 (0.101)
Log of Population Density (<i>POPD</i>)	2.654 (15.613)
R-squared	0.28
R-squared (MG)	-0.14
Root MSE	0.90
CD Statistic	2.32
p-value	0.0203

Notes: Coefficients reported with robust standard errors in parentheses. *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

When we come to crucial part for ECM models, the speed of adjustment parameter on the lagged export level is about -0.59, which is good being negative for adjustment towards long run equilibrium, and highly significant. Convergence speed towards a long-run equilibrium is lower compared to the previous blocks but it is significant.

The long-run coefficients of ROAD, PSGR and POPD are positive but not statistically significant at the 5% significance level. This indicates that, within the Dyn-CCE framework with rich common-factor controls, the panel does not deliver a consistent estimate for exports with respect to connectivity variables. However, the significant

error-correction term suggests that road infrastructure, international connectivity proxy (passengers) and population density help define a healthy long-run equilibrium for exports.

In summary, one of the main common findings from the non-spatial Dyn-CCE ECM is that provincial exports display strong connectivity towards long-run equilibria, while short-run dynamics are mainly driven by import growth.

In the next section, the residuals and error-correction terms from these benchmarks are used to test for remaining spatial dependence (Moran’s I). The presence of significant spatial autocorrelation in these residuals may motivate the spatial panel models estimated in Section 6.3.

6.2.5 Testing for Spatial Dependency: Moran's I

In the light of the literature explained in chapter 3, as a diagnostic step before estimating spatial panel models, application of Moran’s I statistics are suggested to determine whether there is spatially dependency or not. The residuals of the three Dyn-CCE error-correction models are computed to examine the spatial dependency.

To be able to do this calculation, the weight matrix of “six-nearest-neighbors” spatial weight matrix is created and used according to centroids of the provinces.

The global Moran’s I result in Table 6.8 indicate that the macro-finance ECM exhibits a positive and statistically significant Moran’s I of 0.027 with p value 0.045, while the residuals of connectivity ECM show an even stronger statistics 0.040 with the significant p value 0.005. In contrast, the Moran’s I for the education-innovation block ECM, residuals are smaller and statistically not significant Table 6.8.

Table 6.8 Global Moran’s I Test Before Spatial Models

ECM Residual	I	E(I)	sd(I)	z	p-value*
Macro–Finance	0.027	-0.001	0.016	1.693	0.045**
Education–Innovation	0.016	-0.001	0.017	1.027	0.152
Connectivity	0.040	-0.001	0.016	2.545	0.005***

**1-tail test

Overall, the non-spatial model reduces but do not fully remove the spatial dependencies. To be able to remove these dependencies in the residuals, spatial panel error-correction models is introduced and applied in Section 6.3.

6.3 Spatial Panel Estimation Results and Spillovers

The existence of spatial autocorrelation in the ECM residuals suggests that export dynamics cannot be explained only by the local characteristics. When a neighbor province experiences higher exports, imports or connectivity, this may tends to spill over into nearby provinces. To capture these interdependencies, this section estimates spatial panel error-correction models for provincial export growth.

The dependent variable which is the first difference of log real exports (ΔEXP) can be interpreted as the growth rate of provincial real exports. Short-run changes in the determinants enter in differenced form, while deviations from the long-run equilibrium are represented by the lagged error-correction terms ($EC_{MacFin_{t-1}}$, $EC_{EdIn_{t-1}}$ and $EC_{Con_{t-1}}$) obtained from non-spatial ECM equations

Spatial dependence is introduced through a six-nearest-neighbours matrix (K6), and modelled using spatial lags of the dependent variable. Spatially correlated errors also provide dynamic SC/SARAR-type structure (Figure 3.7). In some specifications, spatial lags of selected regressors are treated as potentially endogenous and instrumented and obtain dynamic SDM structure.

For each of the three conceptual blocks introduced in previous section, macro and finance, education and innovation, and infrastructure and connectivity, separately estimated spatially. The next three subsections present the specification for each block. In each case, results are summarized in a single table and discussed with emphasis on the sign and magnitude of the adjustment coefficient, the role of key covariates in explaining export growth, and the strength of spatial spillovers implied by the coefficient on the spatially lagged dependent variable.

6.3.1 Model Specification

The purpose of this subsection is to examine whether provincial export growth spatially spills over or not once macro-finance, human-capital and connectivity fundamentals are taken into account. In particular, the analysis asks two related questions. The first one is whether shocks on export growth in the province affect export growth of neighboring provinces or not. This theory is called endogenous spillovers. And the second one is the opposite, whether changes in neighbors' characteristic affect the export of the province or not.

A main spatial dynamic error-correction model is built and presented below.

$$\Delta EXP_{it} = \mu_i + \tau_t + \rho W \Delta EXP_{i,t} + \delta \Delta EXP_{i,t-1} + \phi EC_{i,t-1} + \beta' \Delta X_{i,t} + \theta' W \Delta X_{i,t} + u_{it}$$

$$u_{it} = \lambda (We)_{it} + \varepsilon_{it} \quad (23)$$

where

ΔEXP_{it} = export growth

$\rho W \Delta EXP_{i,t}$ = endogenous spillover (neighbors provincial export spillover)

$\delta \Delta EXP_{i,t-1}$ = lagged dependent variable to capture short-run dynamics

$\phi EC_{i,t-1}$ = lagged error-correction term obtained from ECM models

ϕ = the province-specific error-correction (speed-of-adjustment) coefficient

$\beta' \Delta X_{i,t}$ = vector of coefficients on changes in own-province fundamentals

$\theta' W \Delta X_{i,t}$ = exogenous spillover (spatial lags of these coefficients)

$\lambda (We)_{it}$ = spatial error component

6.3.2 Model I: The Impact of Macro-Financial Factors

In this section, the spatial macro-finance structure of export is modelled with dynamic spatial error correction model with fixed effects¹⁴. The Model I examines whether short-run changes in imports (ΔIMP), manufacturing value added ($\Delta MGDP$), bank

¹⁴ The Hausman test is applied to determine the appropriate model specification between fixed effects and random effects.

cash credit ($\Delta CRDT$) and lagged export growth (EXP_{t-1}) are associated with provincial export growth (EXP). In addition, the lagged macro–finance error-correction term ($EC_{MacFin_{t-1}}$) is included to capture the adjustment of exports towards the long-run equilibrium implied by these macro-financial fundamentals.

The overall Wald score is significant as p value is less than 0.001. This shows that the model is statistically significant as a whole. The log likelihood of -1223.53 indicates a better fit than random-effects specification. The pseudo R^2 is about 0.025, which is low but quite normal for growth-rate regressions with fixed effects and spatial terms, where much of the variation is left in province-specific shocks.

The coefficient of lagged export growth (ΔEXP_{t-1}) is negative (-0.36) and highly significant. It means that provinces that experience unusually rapid export growth in one year tend to slowdown in the following year (Table 6.9).

Short-run changes in imports and manufacturing are positively associated with export growth. A one percent increase in provincial imports lead to increase 0.06 export growth. It may show the import dependency of Türkiye’s export. At the same time, a 1 percent rise in manufacturing GDP is associated with around 0.66 percentage higher export growth. Both. On the other hand, the short-run coefficient on bank credit is positive but statistically insignificant. It can be commented as credits do not rapid effects on export growth.

Table 6.9 Spatial Error–Correction Model for Provincial Export Growth (1)

Dependent variable: ΔEXP	
Panel A. Short-run and error-correction effects	
Import growth (ΔIMP)	0.055*** (0.02)
Manufacturing GDP growth ($\Delta MGDP$)	0.66*** (0.169)
Credit growth ($\Delta CRDT$)	0.379 (0.232)
Lagged export growth (ΔEXP_{t-1})	-0.36***

Table 6.9 (continued)

Error-correction term ($EC_{MacFin_{t-1}}$)	-0.30*** (0.025)
Year trend	0.004 (0.012)
Panel B. Spatial parameters (K6 weight matrix)	
Spatial lag of ΔEXP ($W\Delta EXP$)	-0.570*** (0.120)
Spatial error term (We)	0.490*** (0.077)
Panel C. Model diagnostics	
Observations	1134
Provinces	81
Years	14
Log-likelihood	-1223.5
Wald χ^2 (model)	324.46(0.00)
Wald χ^2 (spatial terms, p-value)	44.9 (0.00)
Pseudo R ²	0.0248

Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 6-nearest neighbour weight matrix (K6). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

As expected, the lagged error-correction term for the macro-finance block ($EC_{MacFin_{t-1}}$) has negative sign (-0.3) with strong significance. This confirms the presence of a stable long-run relationship that when exports go up it is reduced by macro-financial fundamentals.

When we come to interesting point, spatial side, the spatial lag of export growth is negative and significant (-0.57), where the spatial error component is positive and significant (0.49). As the joint Wald test of the spatial terms is highly significant, spatial dependence is a crucial part of the model.

The impact decomposition¹⁵ shows that local macro shocks help to increase export growth but neighbours take it back. A 1% increase in provincial imports raises that

¹⁵ The impact decomposition tables are added into APPENDIX C.

province's export growth by about 0.06 percentage points directly while neighbors subtract almost 0.02 points from other provinces. Manufacturing has even stronger negative effect by neighbors.

Taken together, these results suggest that macro-financial conditions and long-run adjustment forces are key drivers of provincial export growth. On the other hand, while spatial linkages across neighbouring provinces are non-negligible and display elements of both common-shock propagation and competitive interactions.

6.3.3 Model II: The Impact of Education and Innovation

Dynamic spatial fixed-effect¹⁶ error-correction model for education and innovation block is estimated and reported in Table 6.10.

This specification examines whether short-run changes in population density ($\Delta POPD$), imports (ΔIMP), manufacturing value added ($\Delta MGDP$), bank cash credit ($\Delta CRDT$) are associated with provincial export growth (ΔEXP). In addition, the lagged education–innovation error-correction ($EC_{EdIn_{t-1}}$) term is included to capture the adjustment of exports towards the long-run equilibrium implied by these fundamentals.

The overall Wald chi² score is significant as p value is less than 0.001. This indicates that the model is statistically significant as a whole. The pseudo R² is low (about 0.0007) This is normal for a growth-rate dependent variable with province fixed effects and spatial components because most of the variation is left in idiosyncratic shocks rather than explained by the covariates.

The coefficient on lagged export growth is negative (around -0.29) and highly significant. This shows parallel results as presented in Model II. Unexpected rapid export growth tend to be followed by a slowdown in future.

¹⁶ The Hausman test is applied to determine the appropriate model specification between fixed effects and random effects. (APPENDIX A)

The lagged error-correction term ($EC_{EdIn_{t-1}}$) obtained by the ECM model is also negative (-0.12) and statistically significant. It confirms that deviations from the long-run equilibrium defined by education-innovation fundamentals are gradually corrected over time. In magnitude, the estimate shows that 12 percent of last year's deviation from the long-run equilibrium is adjusted within one year.

Table 6.10 Spatial Error–Correction Model for Provincial Export Growth (2)

Dependent variable: ΔEXP	
Panel A. Short-run and error-correction effects	
Population density growth ($\Delta POPD$)	3.060** (1.373)
Import growth (ΔIMP)	0.073*** (0.021)
Manufacturing GDP growth ($\Delta MGDP$)	0.388** (0.173)
Credit growth ($\Delta CRDT$)	0.428 (0.294)
Lagged export growth (ΔEXP_{t-1})	-0.289*** (0.03)
Error-correction term ($\Delta EC_{EdIn_{t-1}}$)	-0.121*** (0.015)
Year trend	-0.112*** (0.019)
Panel B. Spatial parameters (K6 weight matrix)	
Spatial lag of ΔEXP ($W\Delta EXP$)	-0.56*** (0.142)
Spatial lag of $\Delta CRDT$ ($W\Delta CRDT$)	-0.22 (0.391)
Spatial error term (We)	0.474*** (0.092)
Panel C. Model diagnostics	
Observations	1134
Provinces	81
Years	14
Log-likelihood	-1257.8064

Table 6.10 (continued)

Wald χ^2 (model)	220.13(0.00)
Wald χ^2 (spatial terms, p-value)	32.52(0.000)
Pseudo R ²	0.0007

Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 6-nearest neighbour weight matrix (K6). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

In the short-run regressors, several variables display economically meaningful and statistically significant effects. Increases in population density are associated with higher export growth. A 1 percent rise in density corresponds to roughly 3.1 percentage points higher export growth. It is expected result because provinces with higher population benefit from agglomeration and market-access advantages as presented in literature survey.

Import growth also enters with a positive (0.07) and significant coefficient. It can be explained again by import dependent export structure of Türkiye. pointing. Bank credit has a positive but insignificant direct effect. Manufacturing GDP growth is also positive and significant (0.388). It indicates that manufacturing increase exports. Bank credit has a positive but insignificant direct effect.

In the education–innovation block, the impact decomposition¹⁷ says that local characteristics are support provincial exports but their spillovers reduce the export. A 1% rise in provincial population density boosts local export growth by about 3.2 percentage points directly, but reduces neighbors’ growth by 1.2 points.

Import and manufacturing growth show the same pattern. They have negative indirect effects of -0.03 and -0.16 while their net impacts remain positive at around 0.05 and 0.25 points.

On the dynamic side, lagged export growth has negative total effect (-0.196) like Model II findings.

¹⁷ The impact decomposition tables are added into APPENDIX C.

Overall, education-innovation adjustment model variables strongly support local exports. However, neighbors have negative effect on provinces exports.

6.3.4 Model III: The Impact of Connectivity

In this section, the spatial infrastructure and connectivity structure of export is modelled with dynamic spatial error correction model with fixed effects¹⁸. The overall Wald chi-square is large with p value less than 0.001. This means they are jointly significant and the model is statistically valid.

The pseudo R² is about 0.04 which means that the specification explains roughly 4% of the variation in export growth which is reasonable for a growth-rate model with spatial effects.

This specification examines whether short-run changes in international oil prices ($\Delta POIL$), population density ($\Delta POPD$), imports (ΔIMP), manufacturing value added ($\Delta MGDP$), bank cash credit ($\Delta CRDT$) and lagged export growth (ΔEXP_{t-1}) are associated with provincial export growth (ΔEXP). In addition, the lagged connectivity error-correction term ($EC_{Con_{t-1}}$) is included to capture the adjustment of exports towards the long-run equilibrium implied by these connectivity-related fundamentals.

Table 6.11 reports the spatial dynamic error-correction panel model results for the infrastructure and connectivity block. Export growth depends on short-run changes in imports and international oil prices. The coefficient on lagged export growth is again negative -0.45, like Model I and Model II results.

The lagged error-correction term for the connectivity block ($EC_{Con_{t-1}}$) is also negative -0.39 and highly significant. This shows that 40 percent of deviations from the long-run connectivity equilibrium can be corrected in a year.

¹⁸ The Hausman test is applied to determine the appropriate model specification between fixed effects and random effects. (APPENDIX A)

Table 6.11 Spatial Error–Correction Model for Provincial Export Growth (3)Dependent variable: ΔEXP

Panel A. Short-run and error-correction effects		Panel B. Spatial parameters (K6 weight matrix)	
Oil price growth ($\Delta POIL$)	0.202** (0.080)	Spatial lag of ΔIMP ($W\Delta IMP$)	-0.098** (0.043)
Population density growth ($\Delta POPD$)	1.029 (1.391)	Spatial lag of $\Delta POPD$ ($W\Delta POPD$)	-2.894 (0.043)
Import growth (ΔIMP)	0.050** (0.207)	Spatial lag of $\Delta MGDP$ ($W\Delta MGDP$)	0.150 (0.263)
Manufacturing GDP growth ($\Delta MGDP$)	0.239 (0.172)	Spatial lag of ΔEXP ($W\Delta EXP$)	0.012 (0.121)
Credit growth ($\Delta CRDT$)	0.137 (0.154)	Spatial error term (We)	-0.209 (0.152)
Lagged export growth (ΔEXP_{t-1})	-0.45*** (0.030)	Panel C. Model diagnostics	
		Observations	1134
Error-correction term (EC_{cont-1})	-0.39*** (0.029)	Provinces	81
		Years	14
Year trend	-0.005 (0.005)	Log-likelihood	-1188.78
		Wald χ^2 (model)	360.08 (0.00)
		Wald χ^2 (spatial terms, p-value)	9.00 (0.109)
		Pseudo R ²	0.04
Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 6-nearest neighbour weight matrix (K6). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.			

Increases in imports are associated with higher export growth. 1 per cent rise in imports lead to 0.05 percentage higher export growth. International oil prices affect export

growth positively. The estimated results are significant and suggesting that higher global oil prices tend to support stronger provincial exports. It is possibly via energy-related exports. Manufacturing GDP and short-run changes in bank credit are not statistically significant. Spatial spillovers side has interesting findings. When indirect effects are presented, POIL has positive indirect effect (0.097) at 95% interval. On the other hand, POPD and IMP has -4.5 and -0.1 points negative effects significant effect at %90 level.

When the total effects¹⁹ are considered, it is obvious that at price of oil has an significant and positive effect with 0.31 points while lagged export and lagged error correction term of connectivity has negative (-0.063 and -0.39) and significant effect.

6.4 Main Findings

After the CS-ECM and spatial ECM SDM estimations, a coherent picture of provincial export dynamics is delivered by using three different (macro-finance, education-innovation and infrastructure-connectivity) perspective to explain it. All non-spatial CS-ECM models shows that imports have crucial short run contribution to export growth. On the other hand, bank loans (credits) remains weak and unstable to explain export growth. In the macro-financial CS-ECM model discover that 1% increase in import growth led around 0.2% higher export growth while the long run elasticity of exports with respect to manufacturing GDP is around 2.5. It is an important founding that %100 increase in manufacturing GDP may cause %250 export. By contrast, the long-run coefficients on credit are insignificant so we can consider that finance cannot boost export in long run. Lastly, education-innovation and connectivity blocks have the same result that explanatory variables do not have any power to explain export individually. Models including patents, hig educated women ratio and population density as a whole significant. This explanation is valid also for connectivity variables.

¹⁹ The impact decomposition tables are added into APPENDIX C.

All CS-ECM models confirm stable long-run relationships between exports and the variables used in the models. In addition to that all models have negative and statistically significant error-correction terms. The results of the estimations of adjustment speeds differ. The adjustment coefficient is close to -1.1 (in a year almost %110 correction of deviation) for macro-finance block, around also -1.1 in a year %110 correction of deviation for education-innovation block and close to -0.59 (in a year almost %60 correction of deviation) for connectivity block. It means that in the related model estimated and confirmed long run equilibrium, if there is a deviation from the long run equilibrium occurs, export comes back to the equilibrium, for macro-finance and education-innovation blocks less than a year and for connectivity block in almost 3 years.

The spatial ECMs confirm these findings and add geographical dimension. In the macro-financial spatial ECM, the direct impact²⁰ of import growth on export growth is about 0.08 and the direct impact of manufacturing GDP growth is close to 0.48, with total effects of roughly 0.05 and 0.30, respectively. In the education-innovation spatial model, population density growth has strong direct impact around 3.2 percentage and under 2 percentage total effect. It means 1% increase in population density directly increase 3.2% export growth but almost 2 % totally. The findings of connectivity model interesting as well as the others. Increase in crude oil price growth has positive effect with 0.2 while import has positive significant around 0.05 point. In all three spatial ECMs, error correction terms are negative and significant. Around %30 of macro financial disequilibrium, 12% of education-innovation and about 40% of connectivity related disequilibrium are adjusted within a year.

The spatial models show that these variables are not spatially same. The spatial lag of export growth is negative and significant in the macro-financial and education innovation models (around -0.56 to -0.57). This can be explained in a way that export growth increases of neighbors have negative effect of home province.

²⁰ The detailed results of the impact decomposition are provided in Appendix C.

The impact decompositions are also important even spatially lagged variables are not significant. While import, manufacturing GDP and population density has positive and economically meaningful direct effects, the indirect effects from the growth of these elements are negative. For example, in the macro-financial block, the import growth of the neighbor has -0.03 indirect effect while increase in manufacturing has -0.18. In the education-innovation model, the indirect effect of population density growth is almost -1.2 and in the connectivity model it is even larger around -4.5. These results are pointing strong crowding-out effects from dens populated better connected provinces.

Overall, the results suggest that provincial export growth in Türkiye has strong relations with real economic fundamentals such as manufacturing capacity, integration into global value chains, agglomeration and connectivity rather than financial deepening. Provinces has different adjustment mechanisms with different speeds in long run equilibria defined by these fundamentals. At the same time, the spatial ECMs shows that improvement in these fundamentals may led to generate strong local growths but often negative spillovers on neighborhoods. This can be defined as regional competition rather than shared growth. From a policy perspective, as Türkiye is a developing country, these findings claim that industrial, innovation and infrastructure policies can boost local economies while can harm neighbor provinces without complementary mechanisms to support them.

CHAPTER 7

CONCLUSION

Economies do not recognize borders. The aim of this study to open the door to a new wave of spatially aware inter-provincial studies for Türkiye. This study asks a simple question: why do some Turkish provinces export more than others even they share the same national policies and shocks? The thesis examines whether exports are spatially dependent between each other by using a province level balanced panel of all 81 provinces of Türkiye from 2008-2023. The empirical design is built around three blocks which are economic structure and finance, knowledge and innovation, and connectivity. These are directly grounded in the trade and spatial theories discussed in the thesis. The empirical strategy combines cross-sectionally augmented dynamic CCE error-correction models with dynamic spatial panel specifications to capture both long-run relationships and short-run spatial spillovers.

In the literature about province level exports of Türkiye, exports either explained by static spatial models without any long run equations or by panel ARDL/ECM methods where export is not the central dependent variable. This thesis estimates a dedicated provincial export function with an error-correction term and then connects the findings with a spatial framework. It contributes to the literature by being one of the first studies modelling provincial exports of Türkiye jointly short-run and long dynamics together with spatial spillovers. This makes the thesis a useful reference point for future provincial and regional exports studies in Türkiye.

The findings of this thesis are consistent with earlier empirical work on Turkish provincial exports. The results indicate that provincial exports in Türkiye are linked to the macro-financial environment and trade and production network capacities of provinces. Similar to non-spatial and spatial analysis studies for Türkiye(Abar & Tekmanlı, 2018; Doğan, 2022; Gençosmanoğlu & Yamanoğlu, 2023; Solmaz, 2024),

empirical results of this thesis show that, in the short run, provinces that expand their imports and manufacturing activity tend to see faster export growth. This finding fits with the idea of an import-dependent, value-chain-driven export structure of Türkiye. In the long run, manufacturing activity determines the level of exports while credit conditions do not have significant contributions. Companies may be encouraged to produce rather than providing credit or incentives. Across all three estimations, the error-correction terms are negative and clearly significant which means that when exports converge to or diverge from their long-run path, they do not move indefinitely. Instead, export growth adjusts to its long-run equilibrium.

Once dynamics and spatial spillovers are taken into account, unlike previous non-spatial Turkish regional studies by using for 2009–2021 (Türkcan, 2018), which find long-run cointegration between exports and innovation indicators such as patents, trademarks and utility models, our results do not show any strong individual long-run relationship of innovation or education proxies. The results on education and innovation indicates that model confirms the existence of a stable equilibrium but individual proxies such as patent counts, the female-to-male higher-education ratio or population density are not strong long-run predictors of export growth individually. In the short run, once these variables are in the system, additional macro shocks like changes in imports or credit lose much of their explanatory power. This finding suggests that education and innovation may play an important role as a bundle rather than individual indicator.

When we come to the connectivity block, the non-spatial model suggest that road density, international passengers and population density do not deliver a significant long-run effect unlike the results of spatial and non-spatial studies for Türkiye (Abar & Tekmanlı, 2018; Solmaz, 2024). However, the spatial error-correction estimates finds out that changes in connectivity and density are clearly part of the equilibrium to which exports adjust. At the same time, speed of adjustment in the connectivity block is slower than in the macro-financial and education–innovation blocks. In the short run, addition of connectivity into model shows that connectivity support local export growth when combined with some macro-financial conditions. Moreover, higher global oil prices are also associated with stronger exports. It may reflect the structure

of Türkiye's export basket and the role of energy-related activities. Another interesting finding is that provinces that experience unusually strong export growth in one year are systematically more likely to slow down in the following year.

Perhaps the most striking findings come from the spatial spillover patterns. For all three blocks, local characteristics/determinants generally support the province's own exports. However, neighbours' export do not always share the gains. Positive shocks to imports, manufacturing or population density raise export growth in the province where they occur. On the other hand, the corresponding indirect effects on neighbouring provinces are often negative to neighbors. This finding is indicating competitive or crowding-out spillovers rather than a spillover in benefit. By contrast, some common shocks, such as higher international oil prices, tend to generate positive spillovers across provinces. Overall, the thesis presents that provinces are strongly tied to their own structural characteristics has strong export growth pattern. However, local improvements on industrial depth or connectivity can sometimes harm exports of nearby regions.

Overall, this study shows that increasing in provincial exports is not only about expanding activity within a single province. It is related also how macro-financial conditions, human capital and connectivity are organized across region. The strong role of imports and manufacturing shows the importance of designed regional industrial and upgrading policies. On the other hand, finding on education and innovation indicate that policy should focus on the quality and long-term consistency of education rather than on "more patents" or "more graduates". The presence of negative spatial spillovers of neighbors also shows that uncoordinated transport and logistics investments can create harmful competition between neighboring provinces instead of a shared regional improvement. Although these conclusions are subject to limitations of province-level annual and linear spatial panel data, the thesis provides a framework and useful starting point for future works on products, sectors, free zones and value-chain networks in Türkiye's provincial and regional export system.

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APPENDICES

A. ROBUSTNESS TESTS

MODEL 1 – FIXED EFFECTS

Table Appendix A. 1 Estimation Results of the Model I - Fixed Effects

Dependent variable: ΔEXP

Panel A. Short-run and error-correction effects

Import growth (ΔIMP)	0.055*** (0.02)
Manufacturing GDP growth ($\Delta MGDP$)	0.66*** (0.169)
Credit growth ($\Delta CRDT$)	0.379 (0.232)
Lagged export growth (ΔEXP_{t-1})	-0.36*** (0.03)
Error-correction term ($EC_{MacFin_{t-1}}$)	-0.30*** (0.025)
Year trend	0.004 (0.012)

Panel B. Spatial parameters (K6 weight matrix)

Spatial lag of ΔEXP ($W\Delta EXP$)	-0.570*** (0.120)
Spatial error term (We)	0.490*** (0.077)

Panel C. Model diagnostics

Observations	1134
Provinces	81
Years	14
Log-likelihood	-1223.5
Wald χ^2 (model)	324.46
Wald χ^2 (spatial terms, p-value)	44.9 (0.00)
Pseudo R ²	0.0248

Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 6-nearest neighbour weight matrix (K6). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

MODEL 1 – RANDOM EFFECTS

Table Appendix A. 2 Estimation Results of the Model I - Random Effects

Dependent variable: ΔEXP

Panel A. Short-run and error-correction effects

Import growth (ΔIMP)	0.075*** (0.02)
Manufacturing GDP growth ($\Delta MGDP$)	0.465*** (0.165)
Credit growth ($\Delta CRDT$)	0.274 (0.234)
Lagged export growth (ΔEXP_{t-1})	-0.55*** (0.18)
Error-correction term ($EC_{MacFin_{t-1}}$)	-0.44*** (0.104)
Year trend	0.003 (0.012)

Panel B. Spatial parameters (K6 weight matrix)

Spatial lag of ΔEXP ($W\Delta EXP$)	-0.548 (0.157)
Spatial error term (We)	0.442 (0.104)

Panel C. Model diagnostics

Observations	1134
Provinces	81
Years	14
Log-likelihood	-1349.9
Wald χ^2 (model)	19.91
Wald χ^2 (spatial terms, p-value)	142.96 (0.00)
Pseudo R ²	0.087

Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 6-nearest neighbour weight matrix (K6). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

MODEL 1 – HAUSMAN TEST STATISTICS

Table Appendix A. 3 Hausman Test Results of Model I

	FE	RE	B-b	Std.err
ΔEXP_{t-1}	-0.37	-0.23	-0.13	0.00
ΔIMP	0.05	0.74	-0.19	.
$\Delta MGDP$	0.65	0.46	0.19	0.04
$\Delta CRDT$	0.37	0.27	0.10	.
EC_{MacFin}_{t-1}	-0,30	-0.02	-0.27	0.02
YEAR	0.00	0.00	0.00	0.00
Chi2	63.06			
p-value	0.0000			

MODEL 2 – FIXED EFFECTS

Table Appendix A. 4 Estimation Results of the Model II - Fixed Effects

Dependent variable: ΔEXP

Panel A. Short-run and error-correction effects	
Population density growth ($\Delta POPD$)	3.060** (1.373)
Import growth (ΔIMP)	0.073*** (0.021)
Manufacturing GDP growth ($\Delta MGDP$)	0.388** (0.173)
Credit growth ($\Delta CRDT$)	0.428 (0.294)
Lagged export growth (ΔEXP_{t-1})	-0.289*** (0.03)
Error-correction term (ΔEC_{EdIn}_{t-1})	-0.121*** (0.015)
Year trend	-0.112*** (0.019)
Panel B. Spatial parameters (K6 weight matrix)	
Spatial lag of ΔEXP ($W\Delta EXP$)	-0.56*** (0.142)
Spatial lag of $\Delta CRDT$ ($W\Delta CRDT$)	-0.22 (0.391)
Spatial error term (We)	0.474*** (0.092)
Panel C. Model diagnostics	
Observations	1134
Provinces	81
Years	14
Log-likelihood	-1257.8064
Wald χ^2 (model)	220.13
Wald χ^2 (spatial terms, p-value)	32.52(0.000)
Pseudo R ²	0.0007

MODEL 2 – RANDOM EFFECTS

Table Appendix A. 5 Estimation Results of the Model II - Random Effects

Dependent variable: ΔEXP	
Panel A. Short-run and error-correction effects	
Population density growth ($\Delta POPD$)	2.41* (1.30)
Import growth (ΔIMP)	0.077*** (0.021)
Manufacturing GDP growth ($\Delta MGDP$)	0.45** (0.176)
Credit growth ($\Delta CRDT$)	0.408 (0.301)
Lagged export growth (ΔEXP_{t-1})	-0.23*** (0.03)
Error-correction term ($\Delta EC_{Edm_{t-1}}$)	0.000 (0.03)
Year trend	-0.002 (0.019)
Panel B. Spatial parameters (K6 weight matrix)	
Spatial lag of ΔEXP ($W\Delta EXP$)	-0.37 (0.384)
Spatial lag of $\Delta CRDT$ ($W\Delta CRDT$)	-0.39 (0.299)
Spatial error term (We)	0.32 (0.022)
Panel C. Model diagnostics	
Observations	1134
Provinces	81
Years	14
Log-likelihood	-1354.1880
Wald χ^2 (model)	4.90
Wald χ^2 (spatial terms, p-value)	119.37(0.000)
Pseudo R ²	0.082

MODEL 2 – HAUSMAN TEST STATISTICS

Table Appendix A. 6 Hausman Test Results of Model II

	FE	RE	B-b	Std.err
<i>ΔPOPD</i>	3.06	2.41	0.64	0.43
<i>ΔIMP</i>	0.73	0.78	-0.00	.
<i>ΔMGDP</i>	0.39	0.45	-0.06	.
<i>ΔCRDT</i>	0.43	0.40	0.02	.
<i>ΔEXP_{t-1}</i>	-0.29	-0.23	-0.06	.
<i>EC_{EC_Edln_{t-1}}</i>	-0.12	0.00	-0.12	0.02
YEAR	-0.11	-0.00	-0.11	0.16
Chi2	69.00			
p-value	0.000			

MODEL 3 – FIXED EFFECTS

Table Appendix A. 7 Estimation Results of the Model III - Fixed Effects

Dependent variable: ΔEXP

Panel A. Short-run and error-correction effects		Panel B. Spatial parameters <i>(K6 weight matrix)</i>	
Oil price growth ($\Delta POIL$)	0.202** (0.080)	Spatial lag of ΔIMP ($W\Delta IMP$)	-0.098** (0.043)
Population density growth ($\Delta POPD$)	1.029 (1.391)	Spatial lag of $\Delta POPD$ ($W\Delta POPD$)	-2.894 (0.043)
Import growth (ΔIMP)	0.050** (0.207)	Spatial lag of $\Delta MGDP$ ($W\Delta MGDP$)	0.150 (0.263)
Manufacturing GDP growth ($\Delta MGDP$)	0.239 (0.172)	Spatial lag of ΔEXP ($W\Delta EXP$)	0.012 (0.121)
Credit growth ($\Delta CRDT$)	0.137 (0.154)	Spatial error term (We)	-0.209 (0.152)
Lagged export growth (ΔEXP_{t-1})	-0.45*** (0.030)	Panel C. Model diagnostics	
		Observations	1134
Error-correction term ($EC_{Con_{t-1}}$)	-0.39*** (0.029)	Provinces	81
		Years	14
Year trend	-0.005 (0.005)	Log-likelihood	-1188.78
		Wald χ^2 (model)	360.08
Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 6-nearest neighbour weight matrix (K6). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.		Wald χ^2 (spatial terms, p-value)	9.00 (0.109)
		Pseudo R ²	0.04

MODEL 3 – RANDOM EFFECTS

Table Appendix A. 8 Estimation Results of the Model III - Random Effects

Dependent variable: ΔEXP

Panel A. Short-run and error-correction effects		Panel B. Spatial parameters <i>(K6 weight matrix)</i>	
Oil price growth ($\Delta POIL$)	0.211*** (0.073)	Spatial lag of ΔIMP ($W\Delta IMP$)	-0.102** (0.042)
Population density growth ($\Delta POPD$)	2.961** (1.375)	Spatial lag of $\Delta POPD$ ($W\Delta POPD$)	-4.147** (1.982)
Import growth (ΔIMP)	0.078*** (0.022)	Spatial lag of $\Delta MGDP$ ($W\Delta MGDP$)	-0.146 (0.256)
Manufacturing GDP growth ($\Delta MGDP$)	0.355 (0.182)	Spatial lag of ΔEXP ($W\Delta EXP$)	0.325*** (0.126)
Credit growth ($\Delta CRDT$)	0.082 (0.137)	Spatial error term (We)	-0.445** (0.18)
Lagged export growth (ΔEXP_{t-1})	-0.26*** (0.029)	Panel C. Model diagnostics	
Error-correction term (EC_{Cont-1})	-0.04*** (0.009)	Observations	1134
Year trend	-0.000 (0.994)	Provinces	81
		Years	14
		Log-likelihood	-1334.13
		Wald χ^2 (model)	193.85
		Wald χ^2 (spatial terms, p-value)	14.83 (0.01)
		Pseudo R ²	0.1135
Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 6-nearest neighbour weight matrix (K6). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.			

MODEL 3 – HAUSMAN TEST STATISTICS

Table Appendix A. 9 Hausman Test Results of the Model III - Fixed Effects

	FE	RE	B-b	Std.err
<i>ΔPOIL</i>	0.20	0.21	-0.00	0.03
<i>ΔPOPD</i>	1.03	2.96	-1.93	0.21
<i>ΔIMP</i>	0.05	0.08	-0.03	.
<i>ΔMGDP</i>	0.24	0.36	-0.12	.
<i>ΔCRDT</i>	0.14	0.08	0.06	0.71
<i>ΔEXP_{t-1}</i>	-0.45	-0.26	-0.19	0.00
<i>EC_{EC_Con_{t-1}}</i>	-0.39	-0.04	-0.36	0.27
YEAR	-0.00	-0.00	-0.00	0.00
Chi2	163,28			
p-value	0.000			

MODEL 3 – FIXED EFFECT ROBUSTNESS TEST STATISTICS

Table Appendix C. 1 Robustness Test for Model III – FE- Distance Matrix

Dependent variable: ΔEXP

Panel A. Short-run and error-correction effects		Panel B. Spatial parameters (K6 weight matrix)	
Oil price growth ($\Delta POIL$)	0.1840** (0.080)	Spatial lag of ΔIMP ($W\Delta IMP$)	-0.123** (0.060)
Population density growth ($\Delta POPD$)	0.937 (1.402)	Spatial lag of $\Delta POPD$ ($W\Delta POPD$)	-3.019 (2.640)
Import growth (ΔIMP)	0.477** (0.020)	Spatial lag of $\Delta MGDP$ ($W\Delta MGDP$)	0.209 (0.292)
Manufacturing GDP growth ($\Delta MGDP$)	0.246 (0.176)	Spatial lag of ΔEXP ($W\Delta EXP$)	0.145 (0.141)
Credit growth ($\Delta CRDT$)	0.110 (0.147)	Spatial error term (We)	-0.361* (0.20)
Lagged export growth (ΔEXP_{t-1})	-0.46*** (0.297)	Panel C. Model diagnostics	
Error-correction term (EC_{Cont-1})	-0.40*** (0.03)	Observations	1134
Year trend	-0.006 (0.005)	Provinces	81
		Years	14
		Log-likelihood	-1187.57
		Wald χ^2 (model)	369.5
		Wald χ^2 (spatial terms, p-value)	11.56 (0.04)
		Pseudo R ²	0.039
Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 300 km inverse distance weight matrix (I300). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.			

B. ADDITIONAL FIGURES AND TABLES

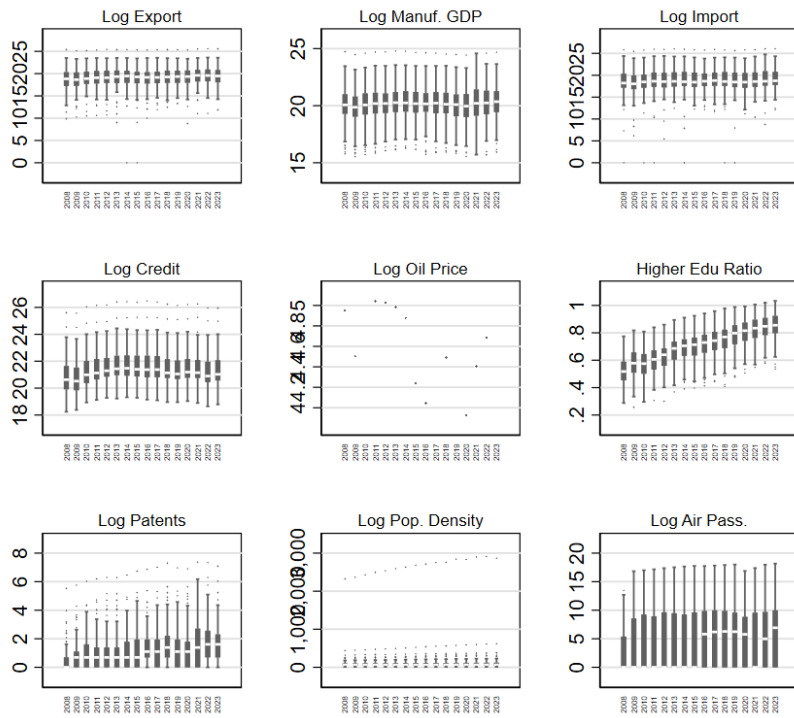


Figure Appendix B. 1 Time-series Boxplots

Table Appendix B. 1 Pairwise Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) EXP	1.00									
(2) MGDP	0.80 (0.00)	1.00								
(3) IMP	0.84 (0.00)	0.84 (0.00)	1.00							
(4) CRDT	0.78 (0.00)	0.87 (0.00)	0.80 (0.00)	1.00						
(5) POIL	-0.02 (0.40)	0.01 (0.70)	-0.02 (0.50)	-0.03 (0.23)	1.00					
(6) GEN	0.45 (0.00)	0.53 (0.00)	0.43 (0.00)	0.53 (0.00)	-0.38 (0.00)	1.00				
(7) PAT	0.69 (0.00)	0.77 (0.00)	0.68 (0.00)	0.82 (0.00)	-0.10 (0.00)	0.57 (0.00)	1.00			
(8) POPD	0.72 (0.00)	0.74 (0.00)	0.71 (0.00)	0.74 (0.00)	-0.03 (0.32)	0.40 (0.00)	0.66 (0.00)	1.00		
(9) PSGR	0.46 (0.00)	0.48 (0.00)	0.45 (0.00)	0.66 (0.00)	-0.10 (0.00)	0.38 (0.00)	0.54 (0.00)	0.45 (0.00)	1.00	
(10) ROAD	0.34 (0.00)	0.42 (0.00)	0.35 (0.00)	0.58 (0.00)	-0.03 (0.23)	0.21 (0.00)	0.43 (0.00)	0.01 (0.76)	0.49 (0.00)	1.00

C. DIRECT/INDIRECT/TOTAL EFFECTS

Model I

Table Appendix C. 2 The Impact of Macro-Financial Factors (K6 Matrix)

Effects	Variable	Marginal Effect
Direct Effects	ΔEXP_{t-1}	-0.240*** (0.028)
	ΔIMP	0.078 *** (0.021)
	$\Delta MGDP$	0.484 *** (0.171)
	$\Delta CRDT$	0.285 (0.245)
	$EC_{MacFin_{t-1}}$	-0.028*** (0.008)
Indirect Effects	ΔEXP_{t-1}	0.091 *** (0.020)
	ΔIMP	-0.030*** (0.010)
	$\Delta MGDP$	-0.184** (0.071)
	$\Delta CRDT$	-0.108 (0.102)
	$EC_{MacFin_{t-1}}$	0.011 *** (0.004)
Total Effects	ΔEXP_{t-1}	-0.149*** (0.027)
	ΔIMP	0.048*** (0.014)
	$\Delta MGDP$	0.300*** (0.116)
	$\Delta CRDT$	0.177 (0.148)
	$EC_{MacFin_{t-1}}$	-0.017*** (0.005)

Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 6-nearest neighbour weight matrix (K6). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Model II

Table Appendix C. 3 The Impact of Education and Innovation (K6 Matrix)

Effects	Variable	Marginal Effect
Direct Effects	$\Delta POPD$	3.196** (1.433)
	ΔIMP	0.076*** (0.021)
	$\Delta MGDP$	0.406** (0.176)
	$\Delta CRDT$	0.464 (0.326)
	$EC_{Edm_{t-1}}$	-0.302*** (0.029)
	ΔEXP_{t-1}	-0.126*** (0.016)
Indirect Effects	$\Delta POPD$	-1.234** (0.597)
	ΔIMP	-0.029*** (0.010)
	$\Delta MGDP$	-0.157** (0.070)
	$\Delta CRDT$	-0.331 (0.361)
	$EC_{Edm_{t-1}}$	0.117*** (0.022)
	ΔEXP_{t-1}	0.049*** (0.011)
Total Effects	$\Delta POPD$	1.961** (0.905)
	ΔIMP	0.047*** (0.014)
	$\Delta MGDP$	0.249** (0.118)
	$\Delta CRDT$	0.133 (0.204)
	$EC_{Edm_{t-1}}$	-0.185*** (0.030)
	ΔEXP_{t-1}	-0.077*** (0.012)

Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 6-nearest neighbour weight matrix (K6). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Model III

Table Appendix C. 4 The Impact of Connectivity (K6 Matrix)

Effects	Variable	Marginal Effect
Direct Effects	$\Delta POIL$	0.216*** (0.072)
	$\Delta POPD$	2.752** (1.325)
	ΔIMP	0.074*** (0.021)
	$\Delta MGDP$	0.353** (0.176)
	$\Delta CRDT$	0.084 (0.139)
	$EC_{cons_{t-1}}$	-0.269*** (0.028)
	ΔEXP_{t-1}	-0.043*** (0.009)
Indirect Effects	$\Delta POIL$	0.097** (0.049)
	$\Delta POPD$	-4.510* (2.408)
	ΔIMP	-0.108* (0.057)
	$\Delta MGDP$	-0.043 (0.363)
	$\Delta CRDT$	0.038 (0.065)
	$EC_{cons_{t-1}}$	-0.121* (0.064)
	ΔEXP_{t-1}	-0.019* (0.011)
Total Effects	$\Delta POIL$	0.313*** (0.095)
	$\Delta POPD$	-1.757 (2.318)
	ΔIMP	-0.034 (0.065)
	$\Delta MGDP$	0.310 (0.280)
	$\Delta CRDT$	0.122 (0.201)
	$EC_{cons_{t-1}}$	-0.390*** (0.071)
	ΔEXP_{t-1}	-0.063*** (0.017)

Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 6-nearest neighbour weight matrix (K6). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Model III

Table Appendix C. 5 The Impact of Connectivity (300 km Matrix)

Effects	Variable	Marginal Effect
Direct Effects	$\Delta POIL$	0.237*** (0.078)
	$\Delta POPD$	2.837** (1.328)
	ΔIMP	0.070*** (0.022)
	$\Delta MGDP$	0.400** (0.180)
	$\Delta CRDT$	0.104 (0.138)
	$EC_{Cons_{t-1}}$	-0.280*** (0.028)
	ΔEXP_{t-1}	-0.044*** (0.009)
Indirect Effects	$\Delta POIL$	0.109* (0.063)
	$\Delta POPD$	-6.610** (3.089)
	ΔIMP	-0.129 (0.082)
	$\Delta MGDP$	-0.208 (0.360)
	$\Delta CRDT$	0.048 (0.066)
	$EC_{Cons_{t-1}}$	-0.129 (0.091)
	ΔEXP_{t-1}	-0.020 (0.015)
Total Effects	$\Delta POIL$	0.346*** (0.094)
	$\Delta POPD$	-3.773 (2.809)
	ΔIMP	-0.059 (0.083)
	$\Delta MGDP$	0.192 (0.327)
	$\Delta CRDT$	0.152 (0.198)
	$EC_{Cons_{t-1}}$	-0.409*** (0.098)
	ΔEXP_{t-1}	-0.065*** (0.019)

Notes: Coefficients reported with robust standard errors in parentheses. Spatial dependence modelled using a row-standardised 300 km inverse distance weight matrix (I300). *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively.

D. TURKISH SUMMARY / TÜRKE ÖZET

Bu çalışma, Türkiye’de aynı para politikasına, aynı kur rejimine ve benzer ulusal şoklara maruz kalan seksen bir ilin neden bu kadar farklı ihracat performansları sergilediğini anlamaya yönelik bir çabanın ürünü temsil etmektedir. Temel çıkış noktası olarak, aynı ulusal politika çerçevesi altında yaşayan illerin ihracat düzeyleri ve ihracat büyüme patikalarının belirgin biçimde ayrıştığı olgusu alınmaktadır. İlave olarak, bu ayrışmanın arkasında hangi yerel özelliklerin ve hangi mekânsal etkileşim kanallarının bulunduğu da araştırılmaktadır. Çalışmada, özellikle iki ana kavram etrafında bir çerçeve kurulmaktadır: “yerel kapasite” ve “ağ bağlantıları”. Yerel kapasite, ölçek ve imalat sanayi derinliği, beşerî sermaye, yenilik kapasitesi, finansal derinlik ve yerel kurumsal yapı gibi il içi faktörleri kapsamaktadır. Ağ bağlantıları ise, iller arası ulaştırma koridorları, tedarik zinciri ilişkileri, liman ve sınır kapısı erişimi, uluslararası uçuş ve yolcu akımları ile komşu illerle kurulan ekonomik ve lojistik bağları ifade etmektedir. Bu bakış açısıyla, il ihracatının yalnızca il içi özelliklerden ibaret bir fonksiyon olmadığı, mekânsal olarak birbirine bağlı, çoğu zaman birbirinden etkilenen ve bazen de rekabet eden bir ağ yapısı içinde şekillendiği varsayılmaktadır.

Çalışmada, küresel üretim ve ticaret dinamikleri kısaca özetlenmekte, dünya mal ihracatının son yıllarda ulaştığı düzey ve büyük ekonomilerin bu yapı içindeki ağırlığı gösterilmektedir. Küresel ölçekte ihracat hacmi genişlerken, bu artışın ülkeler ve bölgeler arasında eşit dağılmadığı, üretim, lojistik ve değer zinciri ağlarının belirli çekirdek alanlarda yoğunlaşma eğilimi gösterdiği tespit edilmektedir. Bu genel fotoğrafın ardından Türkiye ekonomisinin yeri tartışılmakta; ülkenin nüfusu, ekonomik büyüklüğü ve dünya ihracatındaki payı çerçevesinde orta ölçekli, imalat ağırlıklı bir ekonomi olarak konumlandığı belirtilmektedir.

2008 sonrasında Türkiye’nin ihracat hacmini artırdığı, aynı zamanda küresel ihracattaki payını da sınırlı da olsa yükselttiği gözlenmektedir. Ancak bu artış ülke içinde homojen bir şekilde dağılmamakta, iller arasında hem ihracat düzeyi hem de kişi başına ihracat bakımından önemli farklılıklar devam etmektedir. Çalışma, tam da

bu noktada, “hangi illerin neden daha çok ve daha hızlı ihracat yaptığı” ve “bu sürecin mekânsal olarak nasıl bir desen izlediği” sorularını birlikte yanıtlamaya çalışmaktadır.

Çalışmanın kuramsal arka planı, klasik dış ticaret teorilerinden başlayarak yeni dış ticaret teorisi, yeni ekonomik coğrafya ve çekim modelleri üzerinden mekânsal ekonometrik yaklaşımlara doğru adım adım genişletilmektedir. Ricardo’nun karşılaştırmalı üstünlük yaklaşımı ile Heckscher–Ohlin modelinin, ülkeler ve bölgeler arasındaki üretkenlik ve faktör donanımı farklılıklarına dayanan uzmanlaşma mekanizmasını açıkladığı; faktör fiyat eşitlenmesi, Stolper–Samuelson ve Rybczynski teoremlerinin bu çerçeveyi tamamladığı hatırlatılmaktadır. Ancak aynı faktör donanımına sahip ya da benzer beşerî sermaye düzeyine sahip bölgeler arasındaki ticaret hacmi farklarının ve üretim coğrafyasındaki yoğunlaşmanın yalnızca bu çerçeveye tam olarak açıklanamadığı vurgulanmaktadır. Bu nedenle, artan getiriler, ürün farklılaştırması ve eksik rekabet üzerine kurulu yeni dış ticaret teorisinin ve yığılma ekonomileri, pazar erişimi ve taşıma maliyetleri üzerine odaklanan yeni ekonomik coğrafyanın sağladığı araçlar devreye girmektedir. Böylece imalat sanayinin yapı ve derinliğinin, il düzeyi gelir ve ölçek göstergelerinin, ulaştırma altyapısı ve erişilebilirliğin, pazar potansiyeli ve beşerî sermaye birikiminin il ihracatını neden yakından ilgilendirdiği kuramsal olarak temellendirilmektedir.

Çalışmada ayrıca çekim modeli literatürü ve mekânsal bağımlılık tartışmaları ele alınmakta, klasik yerçekimi denkleminde çok taraflı direnç terimleri içeren mikro temelli modellere ve oradan mekânsal otoregresif yapılara uzanan teorik ve ampirik dönüşüm özetlenmektedir. Ticaret akımlarının mekânsal etkileşimli doğasının ihmal edilmesinin, parametre tahminlerinde sistematik yanlılıklara yol açabileceği belirtilmektedir. Anselin, LeSage & Pace ve Elhorst’un katkıları çerçevesinde, mekânsal gecikme ve mekânsal hata modellerinin panel bağlamda nasıl geliştirildiği aktarılmakta; böylece ilerleyen bölümlerde kurulacak dinamik mekânsal panel hata düzeltme modeline hem teorik meşruiyet hem de yöntemsel zemin sağlanmaktadır.

Ampirik literatür, illerin ve bölgelerin ihracatını açıklamaya yönelik çalışmalar üzerinden sistematik biçimde incelenmektedir. Farklı ülke örneklerinde kullanılan değişken setlerinin çoğu zaman parçalı ve örtüşen bir yapı sergilediği saptanmakta; bu da kimi zaman değişkenler arasında nedensel ilişki kurulmasını güçleştirmektedir.

Çalışmada, bu dağılık görünüm toparlanmakta ve ihracatın belirleyicileri beş ana kanal altında yeniden sınıflandırılmaktadır: ekonomik büyüklük ve sanayi yapısı; altyapı, erişilebilirlik ve bağlantısallık; beşerî sermaye, bilgi ve inovasyon; kurumsal ve politik ortam; dış pazar ve ticaret bağlantıları. Bu sayede, literatürde farklı çalışmalarda kullanılan nüfus, kişi başına gelir, toplam faktör verimliliği, imalat payı, altyapı göstergeleri, liman ve kapı erişimi, lojistik performans endeksleri, patent ve marka sayıları, yükseköğrenim oranı, kamu harcamaları, hukukun üstünlüğü, doğrudan yabancı yatırım ve dış talep göstergeleri gibi değişkenler ortak bir çerçeveye oturtulmaktadır.

Türkiye'ye odaklanan çalışmalar incelendiğinde, liman ve sınır kapılarına yakınlığın, yığılma ekonomilerinin, ithalat kompozisyonunun ve lojistik altyapının il ihracatını güçlendirdiği bulguları öne çıkmaktadır. Ancak söz konusu çalışmaların önemli bir kısmının statik mekânsal modellere dayandığı; uzun dönem ihracat denklemleri kurmadığı, mekânsal modellerde eşbütünleşme ilişkilerini ve hata düzeltme dinamiklerini içermediği görülmektedir. Panel ARDL ve hata düzeltme modellerini kullanan çalışmalar ise genellikle ihracat–GSYH ilişkisine odaklanmakta, il ihracatının çok boyutlu belirleyicilerini ve mekânsal etkileşim kanallarını kapsamlı biçimde ele almamaktadır. Bu çalışma, tam da bu noktada, seksen bir il için hem uzun dönem eşbütünleşme ilişkilerini hem kısa dönem dinamikleri hem de mekânsal bağımlılığı dikkate alan dinamik bir mekânsal hata düzeltme modeli önermekte ve uygulamaktadır. Bu yönüyle, Türkiye'de il ihracatını doğrudan bağımlı değişken olarak alan, hata düzeltme terimiyle uzun dönem ilişkiyi açıkça tanımlayan ve bunu dinamik mekânsal panel modellerle birleştiren ilk örneklerden biri olma iddiası taşımaktadır.

Çalışmanın veri seti, 2008–2023 döneminde seksen bir ilin tamamını kapsayan dengeli bir yıllık panelden oluşmaktadır. Bağımlı değişken, firmanın kayıtlı olduğu ile göre tanımlanan mal ihracatıdır. İlgili Kurum ve Kuruluşlardan temin edilen ihracat, ithalat, imalat katma değeri ve nakdi kredi stoku gibi parasal seriler, gerekli durumlarda Türk lirasından ABD dolarına çevrilmekte; sonrasında ABD TÜFE endeksi kullanılarak 2024 yılı sabit dolarına deflate edilmekte ve doğal logaritma formuna dönüştürülmektedir. Böylece serilerin hem zaman içi hem de iller arası

karşılaştırılabilirliği artırılmakta, uç gözlemlerin etkisi yumuşatılmaktadır. İnsan sermayesi ve yenilik kapasitesi, il düzeyinde yükseköğretimde kadın/erkek oranı ve tescilli patent sayısı ile temsil edilmekte; patentler için $\log(1+PAT)$ dönüşümü kullanılmaktadır. Nüfus baskısı ve yerel pazar potansiyeli, kilometrekare başına düşen nüfus yoğunluğu ile; fiziksel altyapı ve bağlantısallık ise uluslararası yolcu sayısı ve toplam asfalt yol yoğunluğu ile ölçülmektedir. Tüm bu değişkenler, çalışmanın kuramsal çerçevesine uygun biçimde beş kavramsal blok altında yeniden gruplanmaktadır.

Mekânsal boyutun kurulabilmesi için, Türkiye'nin seksen bir ilinin her biri bir mekânsal birim olarak ele alınmakta; Harita Genel Müdürlüğü'nden temin edilen sınır ve merkez noktası bilgileri coğrafi bilgi sistemlerinde işlenerek seksen bir çarpı seksen bir boyutunda bitişiklik ve mesafe matrisleri elde edilmektedir. Bu bilgilerden hareketle iki temel mekânsal ağırlık matrisi tanımlanmaktadır. Birincisi, her ilin en yakın altı komşusuna bağlandığı k-en yakın komşu matrisi; ikincisi ise il merkezleri arası mesafenin üç yüz kilometreyi aşmadığı komşu çiftlerini içeren, mesafenin tersine dayalı mesafe bandı matrisidir. Her iki matriste de köşegen elemanlar sıfır alınmakta, satır standartlaştırma yoluyla her ilin komşu ağırlıklarının toplamının bire eşit olması sağlanmaktadır. Coğrafyanın çalışma dönemi boyunca değişmez olduğu varsayımı altında, bu matrisler zamana göre sabit kabul edilmektedir.

Betimsel analizler, Türkiye'nin ihracat coğrafyasının belirgin bir çekirdek-çevre yapısı sergilediğini göstermektedir. Log reel ihracatın ortalaması yaklaşık on dokuz düzeyinde iken, bazı illerde belirli yıllarda hiç ihracat yapılmaması nedeniyle minimum değer sıfıra kadar düşmekte, maksimum değer ise yirmi beşin üzerine çıkmaktadır. Dağılımın üst kuyruğu İstanbul ve birkaç büyük sanayi ve liman kentinde yoğunlaşmakta; imalat katma değeri ve ithalatta da benzer bir yoğunlaşma örüntüsü dikkat çekmektedir. Kredi stokları daha dengeli bir dağılım sergilerken, patent ve eğitim göstergelerinin özellikle birkaç teknoloji merkezinde toplandığı görülmektedir. Nüfus yoğunluğu ve uluslararası yolcu trafiği büyük metropollerde yüksek seviyelere ulaşmakta, yol yoğunluğu ise görece daha homojen bir örüntü sunmaktadır. İki bin sekiz ve iki bin yirmi üç yıllarına ait ihracat haritaları, Marmara-Ege-İç Anadolu eksenli büyük merkezlerin ağırlığını koruduğunu; ancak zamanla bazı Anadolu

illerinin de tonunun koyulaştığını, yani görece daha hızlı büyüyen yeni ihracat odaklarının ortaya çıkmakta olduğunu göstermektedir. Sigma yakınsama analizi, özellikle kişi başına reel ihracatta iller arası farklılıkların belirgin biçimde azaldığını, yani sigma yakınsaması bulunduğunu ortaya koymaktadır. Bu bulgular, her ne kadar çekirdek-çevre yapısı devam etse de, bazı çevre illerin görece konumunu iyileştirmeye başladığına işaret etmektedir.

Yöntemsel çerçevede, öncelikle veri setinin zaman serisi ve panel özellikleri test edilmektedir. Pesaran'ın yatay kesit bağımlılık testi, hemen tüm ana değişkenlerde güçlü bir yatay kesit bağımlılığı bulunduğunu göstermekte; bu durum illerin birbirinden bağımsız olduğunun düşünülmemeyeceğini, ortak şoklar ve mekânsal etkileşimler nedeniyle bir ilde yaşanan gelişmelerin diğer illeri de etkileyebileceğini ortaya koymaktadır. Pesaran'ın CADF ve CIPS panel birim kök testleri, ihracat ve ithalat (durağan) hariç diğer değişkenlerin düzeyde birinci dereceden bütünleşik (I(1)), birinci farklarda ise durağan olduğunu göstermektedir. Bu tespit, sahte regresyon riskini azaltmak ve uzun dönem ilişkileri sağlıklı biçimde modellemek için panel hata düzeltme yaklaşımlarının kullanılmasını zorunlu kılmaktadır.

Bu çerçevede çalışma, üç kavramsal blok için ayrı ayrı "cross-sectionally augmented" hata düzeltme modelleri tahmin etmektedir. Makro-finans bloğunda, imalat katma değeri, ithalat ve kredi stokunun düzey değerleri ile gecikmeli ihracat üzerinden uzun dönem denge denklemi kurulmakta; bu denge ilişkisinin sapmalarını temsil eden hata düzeltme terimi modele dâhil edilmektedir. Eğitim-inovasyon bloğunda, yükseköğretimde kadın/erkek oranı, patent sayısı ve nüfus yoğunluğu uzun dönem bileşenini oluşturmaktadır. Altyapı-erişilebilirlik-bağlantısallık bloğunda ise yol yoğunluğu, uluslararası yolcu sayısı ve yine nüfus yoğunluğu uzun dönem kısmına alınmaktadır. Her üç blokta da, bağımlı değişken olarak ihracatın büyüme oranı (ΔEXP) kullanılmakta; açıklayıcı değişkenlerin farkları kısa dönem etkileri temsil etmektedir. Yatay kesit ortalamalarının modele eklenmesiyle, ülkedeki ortak şokların ve gözlemlenemeyen faktörlerin etkisinin sınırlandırılması amaçlanmaktadır.

Elde edilen sonuçlar, ihracatın makro-finans ve eğitim-inovasyon bloklarında tanımlanan uzun dönem dengeye doğru hızlı bir uyum sergilediğini, bağlantısallık bloğunda ise uyum hızının daha yavaş olduğunu göstermektedir. Makro-finans ve

eđitim–inovasyon bloklarında hata düzeltme katsayıları birin mutlak deęerine yakın, negatif ve istatistikî olarak son derece anlamlı bulunmakta; bu durum denge sapmalarının bir yıl içinde büyük ölçüde giderildiđine işaret etmektedir. Baęlantısallık bloęunda ise hata düzeltme katsayısı mutlak deęerce daha düşük olmakta, uyumun iki–üç yıla yayılan kademeli bir süreç olduđu anlaşılmaktadır. Kısa dönem tarafında, ithalat büyümesinin üç blokta da ihracat büyümesini desteklediđi; imalat büyümesinin özellikle makro–finans bloęunda anlamlı bir etkisi bulunduđu; kredi stokundaki deęişimlerin ise genellikle zayıf ve kararsız bir ilişki sergilediđi tespit edilmektedir. Eđitim–inovasyon ve baęlantısallık bloklarında tek tek deęişkenlerin uzun dönem katsayıları her zaman net ve istikrarlı olmayabilmektedir. Buna karşın hata düzeltme terimlerinin büyüklüğü, bu blokların birlikte tanımladıđı bileşik bir denge seviyesine doęru uyumu doęrulamaktadır.

Mekânsal modele geçilmeden önce, hata düzeltme modellerinin kalıntıları üzerinde Moran'ın I istatistiđi hesaplanmakta ve özellikle makro–finans ve baęlantısallık bloklarında anlamlı mekânsal baęımlılık izleri bulunduđu görülmektedir. Bu bulgu, mekânsal olmayan modellerin coęrafi baęımlılıđı bütünüyle ortadan kaldırmadıđını, iller arası etkileşimlerin model dışında bırakılamayacađını göstermekte ve dinamik mekânsal hata düzeltme modellerine geçişi gerekçelendirmektedir.

Çalışmanın temel ampirik aracı, gecikmeli ihracatı, ihracatın mekânsal gecikmesini, belirli açıklayıcı deęişkenlerin mekânsal gecikmelerini ve ilgili bloklara ait hata düzeltme terimlerini birlikte içeren dinamik bir mekânsal hata düzeltme modelidir. Bu yapı, Spatial Durbin ve SARAR tipi modellerin özelliklerini birleştirmektedir. Böylelikle, hem baęımlı deęişken hem açıklayıcı deęişkenler tarafında mekânsal etkileşimleri hem de hata terimlerinde mekânsal ilişkiyi model dâhilinde tutmaktadır. Model, il ve yıl sabit etkileri içermekte; böylece gözlemlenemeyen, zamana göre deęişmeyen il özellikleri ile ortak dönem şoklarının etkisi kontrol altında tutulmaktadır. Tahmin sürecinde, paneldeki sabit etkilerin varlıđı ve örneklem büyüklüğü dikkate alınarak, Lee ve Yu tarafından geliştirilen ve sabit etkilerin uygun dönüşümlerle temizlenmesini saęlayan bir Quasi-Maksimum Olabilirlik yaklaşımı kullanılmaktadır. Mekânsal katsayıların doğrudan yorumlanmasının yanıltıcı olabileceđi bilindiđinden, LeSage ve Pace tarafından önerilen çerçeveye paralel olarak

doğrudan (il içi), dolaylı (komşu illere taşan) ve toplam etkiler hesaplanmakta, politika yorumları bu ayrıştırma üzerinden yapılmaktadır.

Dinamik mekânsal hata düzeltme sonuçları, üç blok için benzer yapıda ancak tonları farklı bulgular ortaya koymaktadır. Makro–finans modelinde, kısa dönemde ithalat ve imalat büyümesinin il ihracat büyümesini anlamlı ve pozitif biçimde desteklediği; gecikmeli ihracat büyümesi katsayısının ise negatif bulunduğu tespit edilmektedir. Bu durum, bir yıl olağanüstü hızlı büyüyen illerin ertesi yıl kısmi bir normalleşme, yani ortalamaya dönüş eğilimi sergilediğine işaret etmektedir. Hata düzeltme teriminin katsayısı, makro–finans dengesinden sapmaların yaklaşık üçte birinin her yıl giderildiğini göstermektedir. Mekânsal tarafta, komşu illerin ihracat büyümesini temsil eden mekânsal gecikmeli değişkenin katsayısı negatif ve istatistikî olarak anlamlı bulunmakta; bu da komşu illerdeki hızlı ihracat artışının ilgili ilin büyümesini kısmen frenleyebildiğini göstermektedir. Buna karşılık mekânsal hata bileşeni pozitif ve anlamlı olup, ortak şokların mekânda yayılmasıyla uyumlu bir yapı ortaya koymaktadır.

Eğitim–inovasyon modelinde, nüfus yoğunluğu, ithalat ve imalat büyümesinin kısa dönemde kendi ilinin ihracatını anlamlı biçimde artırdığı; buna karşılık komşu illere yönelik dolaylı etkilerin çoğu zaman negatif yönlü olduğu görülmektedir. Yoğunluk artışı, il içinde yığılma ekonomileri ve pazar erişimi kanalıyla ihracat büyümesini desteklerken, yakın çevrede kısmi bir çekim merkezi etkisi yaratarak komşu illerin görece konumunu zayıflatabilmektedir. Bu blokta hata düzeltme katsayısı mutlak değer itibarıyla daha düşük olup, eğitim ve yenilik göstergelerinin tanımladığı dengeye uyumun daha yavaş ve kademeli bir biçimde gerçekleştiğine işaret etmektedir.

Altyapı–bağlantısallık modelinde, gecikmeli ihracat büyümesi katsayısı daha yüksek mutlak değere sahip negatif bir değer almakta, bu da ortalamaya dönüş eğiliminin bu blokta daha güçlü olduğuna işaret etmektedir. Bağlantısallık bloğuna ait hata düzeltme katsayısı, connectivity kaynaklı sapmaların her yıl yaklaşık yüzde kırkının telafi edildiğini göstermektedir. Kısa dönemde ithalat büyümesi ve petrol fiyatlarındaki artışın il ihracatını desteklediği; imalat, kredi ve nüfus yoğunluğundaki yıllık değişimlerin ise anlamlı bir kısa dönem etkisi olmadığı tespit edilmektedir. Petrol fiyatının ihracatı destekleyici yönde çalışması, Türkiye'nin enerjiyle ilişkili ihracat

bileşenleri ve fiyat–miktar dengesi üzerinden yorumlanmaktadır. Mekânsal tarafta, komşu illerin ithalat ve nüfus yoğunluğu artışları, ilgili ilin ihracat büyümesini negatif yönde etkileyebilmekte; bu bulgu, güçlü ve iyi bağlantılı komşuların bir noktadan sonra rekabet baskısı yaratabildiğine işaret etmektedir.

Tüm modeller birlikte değerlendirildiğinde, kısa dönemde ithalat büyümesinin üç blokta da en istikrarlı pozitif belirleyici olduğu sonucuna varılmaktadır. Uzun dönemde ise imalat katma değeri, ihracatın düzeyini belirleyen temel reel değişken olarak öne çıkmaktadır. Eğitim–inovasyon ve bağlantısallık göstergeleri, çoğu zaman tek tek katsayılar üzerinden değil, hata düzeltme terimleri aracılığıyla, ihracatın oturduğu denge seviyesinin bileşik bileşenleri şeklinde çalışmaktadır. Mekânsal etkileşimler açısından en dikkat çekici bulgu, komşu illerin ihracat büyümesini temsil eden mekânsal gecikmeli değişkenlerin özellikle makro–finans ve eğitim–inovasyon bloklarında negatif katsayılarla sahip olmasıdır. Bu durum, komşu illerin ihracatı arttıkça ilgili ilin büyüme hızının bir miktar frenlendiğini; dolayısıyla “paylaşılan büyüme”den çok “bölgesel rekabet” deseninin öne çıktığını düşündürmektedir. İthalat, imalat ve nüfus yoğunluğu gibi temel değişkenlerin komşu illerdeki artışları da çoğu kez negatif dolaylı etkilere yol açmakta; özellikle yoğun ve iyi bağlantılı büyük merkezlerin çevresinde bu dışlayıcı etkiler daha belirgin hale gelmektedir.

Çalışmanın sonuç kısmında, elde edilen bulgular hem yöntemsel katkı hem de politika önerileri çerçevesinde yeniden ele alınmaktadır. Yöntemsel açıdan, il bazında ihracatı doğrudan bağımlı değişken alan, hata düzeltme terimiyle uzun dönem ilişkiyi açıkça tanımlayan ve bunu dinamik mekânsal panel modellerle birleştiren bir çerçeve sunulmakta; böylece kısa dönem dinamikleri, uzun dönem uyarılma süreci ve mekânsal taşmalar aynı model içinde birlikte incelenebilmektedir. Bu yapı, Türkiye’de ve benzer ülke örneklerinde il ve bölge düzeyindeki ihracat çalışmalarına referans olabilecek esnek ve genişletilebilir bir iskelet sunmayı amaçlamaktadır.

Politika perspektifinden bakıldığında, üç temel mesaj öne çıkmaktadır. Birincisi, il düzeyinde ihracat büyümesinin güçlü biçimde reel temellere dayandığı; imalat kapasitesi, ithalat üzerinden küresel değer zincirlerine entegrasyon, yığılma ekonomileri ve bağlantısallığın bu süreçte başat rol oynadığı anlaşılmaktadır. Finansal derinleşme ise bu resimde tamamlayıcı ama ikincil bir rol üstlenmekte; kredi hacmini

geniřletmeye yönelik politikaların tek başına kalıcı bir ihracat artışı yaratmasının beklenmemesi gerektiđi ortaya konulmaktadır. İkincisi, hata düzeltme mekanizmalarının varlığı ve gücü, sistemin uzun dönem dengesinden sapmalar karşısında dağılmadığını, tersine dengeye dönme eğiliminde olduğunu göstermekte; bu durum, uzun vadeli sanayi, eğitim ve altyapı politikalarının etkilerinin zaman içinde birikerek görünür hâle gelebileceğine işaret etmektedir. Üçüncüsü, mekânsal taşmaların yönü, yerel kapasiteyi güçlendiren adımların her zaman komşu iller için pozitif dışsallık üretmediğini, aksine bölgesel rekabeti keskinleştirebildiğini göstermektedir. Bu nedenle sanayi, inovasyon ve altyapı politikalarının yalnızca tek tek illeri değil, fonksiyonel bölgeleri ve komşu iller arasındaki tamamlayıcılığı hedefleyecek şekilde, eşgüdümlü ve bütüncül bir anlayışla tasarlanması gerektiđi vurgulanmaktadır.

Çalışma, kendi sınırlarının da farkında olarak, kullanılan veri setinin yıllık ve il düzeyinde olduğunu; firmalar arası heterojenlik, sektör içi yapı ve ürün kompozisyonu gibi unsurların bu çerçevede doğrudan izlenemediğini belirtmektedir. Yöntemsel açıdan doğrusal mekânsal panel yapılar tercih edilmekte; olası doğrusal olmayan dinamikler, eşik etkileri veya çok katmanlı ağ yapıları analiz dışında kalmaktadır. Buna rağmen, geliştirilen çerçevenin gelecekte ürün grupları, sektörler, serbest bölgeler veya değer zinciri ağları düzeyinde yapılacak arařtırmalar için güçlü ve kullanılabilir bir başlangıç noktası sunabileceđi düşünölmektedir. Sonuç olarak çalışma, Türkiye'nin ihracatını yalnızca toplam değerler üzerinden okunan tek boyutlu bir zaman serisi olarak değil, seksen bir ilin etkileşimiyle oluşan, mekânsal ve zamansal katmanları iç içe geçmiş, dinamik bir süreç olarak ele almakta; bu sürecin daha iyi anlaşılmasının, daha dengeli ve sürdürülebilir bir bölgesel kalkınma ve ihracat stratejisi için vazgeçilmez olduđu değerlendirilmesini yapmaktadır.

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