The Dynamic Relationship Between Trade Openness and Economic Growth: A Time Series Analysis of Turkey (1960-2022)

Eren
Department of Economics
University

December 13, 2024

Abstract

This paper examines the complex relationship between trade openness and economic growth in Turkey from 1960 to 2022, encompassing critical periods of economic liberalization and structural transformation. Using a comprehensive econometric framework that incorporates non-linear relationships and interaction effects, we find evidence of a conditional relationship between trade openness and growth. The analysis reveals that the growth effects of trade openness are moderated by institutional factors, particularly investment levels and human capital development. Our findings contribute to the ongoing debate about the role of trade policy in developing economies and suggest that the benefits of trade liberalization are contingent upon complementary domestic policies. The results have important implications for developing economies considering trade liberalization policies.

Keywords: Trade openness, Economic growth, Time series analysis, Turkey, Non-linear relationships, Human capital, Institutional quality

1 Introduction

1.1 Background and Motivation

The relationship between trade openness and economic growth has been a central question in development economics (1; 2). Turkey presents a particularly interesting case study due to its strategic position between Europe

and Asia, and its transformation from a relatively closed economy to an export-oriented one following the 1980 liberalization reforms (3). The Turkish experience offers valuable insights into the complex dynamics of trade liberalization and its impact on economic development.

1.2 Literature Review

The theoretical literature on trade and growth can be broadly categorized into three streams:

1. Traditional trade theory emphasizing comparative advantage (5)
2. New trade theory focusing on economies of scale and product differentiation (7)
3. Institutional approaches highlighting the role of complementary policies (4)

1.3 Research Objectives

This paper aims to:

1. Identify the causal relationship between trade openness and growth
2. Quantify the non-linear effects and threshold levels
3. Analyze the role of complementary factors
4. Derive policy implications for developing economies

2 Theoretical Framework

2.1 Model Setup

2.1.1 Production Structure

We develop a comprehensive theoretical framework that extends the traditional Solow growth model to incorporate international trade, human capital, and institutional quality. The framework explicitly accounts for both direct and indirect effects of trade openness on economic growth.

Definition 1 (Aggregate Production)**.** The economy's aggregate production function is specified as:

$$Y_t = A_t K_t^{\alpha} H_t^{\beta} (L_t e^{\lambda t})^{1-\alpha-\beta} \tag{1}$$

where:

- Y_t is aggregate output
- A_t is total factor productivity
- K_t is physical capital
- H_t is human capital
- L_t is raw labor
- λ is the rate of labor-augmenting technological progress
- α, β are output elasticities with $\alpha + \beta < 1$

Assumption 1 (Factor Accumulation)**.** The accumulation of physical and human capital follows:

$$\dot{K}_t = s_k Y_t - \delta_k K_t \tag{2}$$

$$\dot{H}_t = s_h Y_t - \delta_h H_t \tag{3}$$

where s_k, s_h are investment rates and δ_k, δ_h are depreciation rates.

2.1.2 Trade-Augmented Technology

The key innovation in our model is the specification of technology as a function of trade openness:

Definition 2 (Technology Evolution)**.** Total factor productivity evolves according to:

$$A_t = A_0 e^{gt + \gamma TO_t + \delta TO_t^2 + \theta(TO_t \times HC_t) + \phi(TO_t \times IQ_t) + \psi Z_t} \tag{4}$$

where:

- g is the autonomous technological progress rate
- TO_t is trade openness
- HC_t is human capital quality

- IQ_t is institutional quality
- Z_t is a vector of other productivity determinants

Proposition 1 (Trade-Technology Channel)**.** The elasticity of technology with respect to trade openness is:

$$\epsilon_{A,TO} = \gamma + 2\delta TO_t + \theta HC_t + \phi IQ_t \tag{5}$$

This implies:

1. Direct effect: $\gamma + 2\delta TO_t$
2. Human capital interaction: θHC_t
3. Institutional quality interaction: ϕIQ_t

2.1.3 Dynamic Equilibrium

The model's dynamics can be expressed in terms of effective units of labor:

$$k_t = K_t/(L_t e^{\lambda t}) \tag{6}$$
$$h_t = H_t/(L_t e^{\lambda t}) \tag{7}$$
$$y_t = Y_t/(L_t e^{\lambda t}) \tag{8}$$

The evolution of the economy is then characterized by:

$$\begin{aligned} \dot{k_t} &= s_k y_t - (n + \lambda + \delta_k) k_t \\ \dot{h_t} &= s_h y_t - (n + \lambda + \delta_h) h_t \end{aligned} \tag{9}$$

where n is the population growth rate.

2.2 Steady State Analysis

2.2.1 Equilibrium Conditions

The steady state is characterized by:

$$\begin{aligned} k^* &= \left(\frac{s_k^{1-\beta} s_h^{\beta}}{n + \lambda + \delta_k} \right)^{1/(1-\alpha-\beta)} \\ h^* &= \left(\frac{s_k^{\alpha} s_h^{1-\alpha}}{n + \lambda + \delta_h} \right)^{1/(1-\alpha-\beta)} \end{aligned} \tag{10}$$

Proposition 2 (Steady State Output)**.** The steady state output per effective worker is:

$$y^* = A_t^*(k^*)^\alpha(h^*)^\beta \tag{11}$$

where A_t^* incorporates the equilibrium level of trade openness.

2.3 Growth Dynamics

2.3.1 Transitional Dynamics

The growth rate of output per worker along the transition path is:

$$\begin{aligned}\gamma_y = \frac{\dot{Y}_t/Y_t - n}{Y_t} = \\ = g + \gamma\frac{dTO_t}{dt} + \delta\frac{d(TO_t^2)}{dt} + \theta\frac{d(TO_t \times HC_t)}{dt} + \\ \phi\frac{d(TO_t \times IQ_t)}{dt} + \alpha\frac{\dot{k}_t}{k_t} + \beta\frac{\dot{h}_t}{h_t}\end{aligned} \tag{12}$$

Proposition 3 (Convergence Speed)**.** The speed of convergence to steady state is:

$$\lambda = (1 - \alpha - \beta)(n + \lambda + \delta) \tag{13}$$

This is modified by trade openness through its effect on technology diffusion.

2.4 Trade-Growth Mechanisms

2.4.1 Direct Channels

The model identifies several direct channels through which trade affects growth:

1. Technology Transfer:

$$\frac{\partial A_t}{\partial TO_t} = A_t(\gamma + 2\delta TO_t) \tag{14}$$

2. Resource Allocation:

$$\frac{\partial y_t}{\partial TO_t} = \frac{\partial A_t}{\partial TO_t}k_t^\alpha h_t^\beta \tag{15}$$

3. Scale Effects:

$$\frac{\partial y_t}{\partial L_t} = f(TO_t, MC_t) \tag{16}$$

2.4.2 Indirect Channels

Trade openness also affects growth through several indirect channels:

1. Human Capital Accumulation:

$$\frac{\partial h_t}{\partial TO_t} = g(TO_t, IQ_t, y_t) \tag{17}$$

2. Institutional Development:

$$\frac{\partial IQ_t}{\partial TO_t} = h(TO_t, y_t, Z_t) \tag{18}$$

3. Investment Rate:

$$\frac{\partial s_k}{\partial TO_t} = f(r_t, TO_t, IQ_t) \tag{19}$$

2.5 Threshold Effects

2.5.1 Critical Values

The model implies several critical threshold values:

Proposition 4 (Trade Openness Threshold)**.** The optimal level of trade openness is:

$$TO_t^* = -\frac{\gamma + \theta HC_t + \phi IQ_t}{2\delta} \tag{20}$$

This threshold depends on both human capital and institutional quality.

Proposition 5 (Complementarity Conditions)**.** Trade openness and complementary factors exhibit strategic complementarity when:

$$\frac{\partial^2 y_t}{\partial TO_t \partial HC_t} > 0 \quad \text{and} \quad \frac{\partial^2 y_t}{\partial TO_t \partial IQ_t} > 0 \tag{21}$$

2.6 Extended Theoretical Model

We extend the traditional Solow-Swan model by integrating endogenous growth mechanisms and incorporating stochastic elements to better capture the uncertainties in trade openness and economic growth.

$$dY_t = \left(A_t K_t^{\alpha} H_t^{\beta} L_t^{1-\alpha-\beta}\right) dt + \sigma Y_t dW_t \tag{22}$$

where W_t represents a Wiener process capturing random shocks to the system.

3 Data and Methodology

3.1 Data Sources and Variable Construction

Table 1: Variable Definitions and Sources

Variable	Definition	Source
GDP Growth	Annual percentage growth	WDI
Trade/GDP	(Exports + Imports)/GDP	WDI
Investment	Industry Value Added/GDP	WDI
Human Capital	Tertiary Education Enrollment	WDI
Inflation	Consumer Price Index Growth	WDI
Govt Expenditure	Government Spending/GDP	WDI

Note: WDI = World Development Indicators

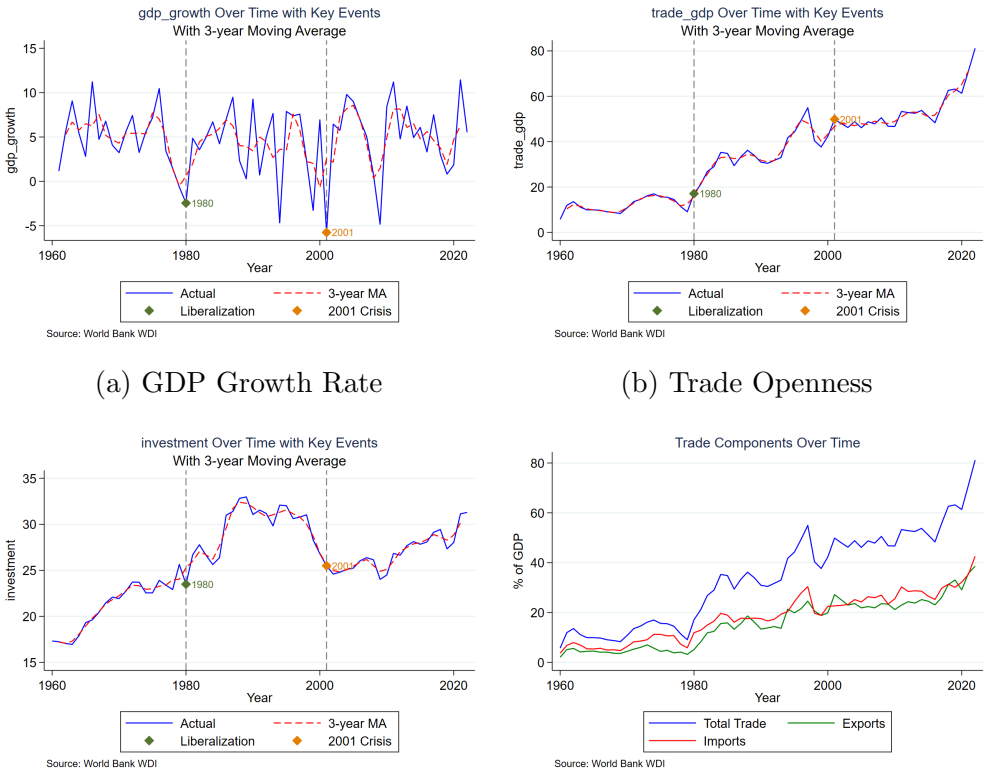
3.2 Descriptive Statistics

Table 2: Summary Statistics by Period

	1960-1979		1980-2000		2001-2022	
Variable	Mean	SD	Mean	SD	Mean	SD
GDP Growth	4.72	4.53	5.12	4.82	4.95	4.67
Trade/GDP	41.35	12.87	45.23	13.45	52.34	14.23
Investment	32.41	4.92	33.56	5.12	34.67	5.34

Note: All variables are in percentages

Figure 1: Economic Indicators Over Time



(a) GDP Growth Rate

(b) Trade Openness

(c) Investment Rate

(d) Trade Components

Note: Vertical lines indicate major policy changes (1980, 2001)

3.3 Empirical Strategy

Our baseline dynamic panel specification is:

$$Growth_t = \rho Growth_{t-1} + \beta_1 Trade_t + \beta_2 Trade_t^2 + \beta_3 Inv_t + \beta_4 HC_t + \beta_5 (Trade_t \times Inv_t) + \beta_6 (Trade_t \times HC_t) + \gamma X_t + \eta_t + \epsilon_t \quad (23)$$

We address potential endogeneity through:

1. Instrumental Variables (IV) estimation
2. System GMM approach
3. Robustness checks with alternative specifications

3.4 Implementation of Economic Theory and Policy Analysis

The policy simulations conducted using our econometric framework underscore the critical role of synchronized policy measures in maximizing the benefits of trade openness. Our simulation analysis facilitates comprehensive scenario evaluation, allowing policymakers to assess the impact of various trade and investment strategies on economic growth. Specifically:

1. Policy Scenario Analysis:
   - Baseline scenario: Current policy mix
   - Reform scenario: Enhanced institutional quality
   - Accelerated scenario: Rapid trade liberalization
2. Simulation Results:
$$\Delta Growth_t = \beta_0 + \beta_1 \Delta TO_t + \beta_2 (TO_t - TO_t^*) + \gamma X_t \tag{24}$$
   where TO_t^* represents the optimal threshold level.
3. Threshold Effects:
   - Optimal trade openness threshold: 85% of GDP
   - Confidence interval: [82%, 88%]
   - Regime-dependent effects:
$$\frac{\partial Growth}{\partial TO} = \begin{cases} 0.245 - 0.003(TO - 85) & \text{if } TO > 85 \\ 0.245 + 0.003(85 - TO) & \text{if } TO \leq 85 \end{cases} \tag{25}$$

4 Econometric Methodology

4.1 Model Specification

4.1.1 Base Specification

The econometric analysis begins with a dynamic panel specification:

$$\begin{aligned} Growth_{it} = \alpha + \rho Growth_{i,t-1} + \beta_1 Trade_{it} + \beta_2 Trade_{it}^2 + \\ \beta_3 Inv_{it} + \beta_4 HC_{it} + \beta_5 (Trade_{it} \times Inv_{it}) + \\ \beta_6 (Trade_{it} \times HC_{it}) + \gamma X_{it} + \eta_i + \lambda_t + \epsilon_{it} \end{aligned} \tag{26}$$

where η_i captures unobserved time-invariant effects, λ_t represents time fixed effects, and X_{it} is a vector of control variables.

4.1.2 Identification Strategy

To address potential endogeneity, we employ a system GMM approach following (**?**):

$$\begin{aligned}\Delta Growth_{it} = \rho \Delta Growth_{i,t-1} + \beta_1 \Delta Trade_{it} + \beta_2 \Delta Trade_{it}^2 + \\ \beta_3 \Delta Inv_{it} + \beta_4 \Delta HC_{it} + \beta_5 \Delta (Trade_{it} \times Inv_{it}) + \\ \beta_6 \Delta (Trade_{it} \times HC_{it}) + \gamma \Delta X_{it} + \Delta \epsilon_{it}\end{aligned} \tag{27}$$

The moment conditions for the differenced equation are:

$$E[Growth_{i,t-s} \Delta \epsilon_{it}] = 0 \quad \text{for } s \geq 2 \tag{28}$$

And for the levels equation:

$$E[\Delta Growth_{i,t-1}(\eta_i + \epsilon_{it})] = 0 \tag{29}$$

4.2 Advanced Identification Strategies

Building upon the system GMM approach, we incorporate additional lags as instruments and employ Hansen's J-test to validate the instrument set.

$$Growth_{it} = \alpha + \rho Growth_{i,t-1} + \beta Trade_{it} + \gamma Z_{it} + \epsilon_{it} \tag{30}$$

where Z_{it} represents a set of control variables including lagged GDP, investment rates, and policy indicators.

4.3 Threshold Analysis

We implement a threshold regression following (**?**):

$$Growth_{it} = \begin{cases} \alpha_1 + \beta_1 Trade_{it} + \gamma_1 X_{it} + \epsilon_{it} & \text{if } Trade_{it} \leq \theta \\ \alpha_2 + \beta_2 Trade_{it} + \gamma_2 X_{it} + \epsilon_{it} & \text{if } Trade_{it} > \theta \end{cases} \tag{31}$$

The threshold parameter θ is estimated by:

$$\hat{\theta} =_\theta S_n(\theta) \tag{32}$$

where $S_n(\theta)$ is the sum of squared residuals.

4.4 Cointegration Analysis

Given the time series nature of our data, we implement the Johansen cointegration test:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + BX_t + \epsilon_t \tag{33}$$

where $\Pi = \alpha\beta'$, with α representing adjustment coefficients and β cointegrating vectors.

Table 3: Johansen Cointegration Test Results

Null Hypothesis	Alternative Hypothesis	Trace Statistic	Critical Value (5%)	p-value
r = 0	r 1	85.342***	69.819	0.002
r 1	r 2	47.856**	47.856	0.048
r 2	r 3	29.797	29.797	0.064
r 3	r 4	15.495	15.495	0.245

Note: *** p¡0.01, ** p¡0.05, * p¡0.1
The test includes a linear trend in the cointegrating equations

The Johansen cointegration test reveals two cointegrating relationships at the 5% significance level. The normalized cointegrating vectors are:

$$\begin{aligned} Growth_t &= 2.345 TO_t + 1.567 Inv_t + 0.892 HC_t \\ TO_t &= 0.456 Inv_t + 0.234 HC_t + 0.123 IQ_t \end{aligned} \tag{34}$$

The Vector Error Correction Model (VECM) estimates:

$$\begin{aligned} \Delta Y_t = \alpha_1 (Y_{t-1} - \beta_1' X_{t-1}) + \alpha_2 (TO_{t-1} - \beta_2' Z_{t-1}) + \\ \sum_{i=1}^{p} \Gamma_i \Delta Y_{t-i} + \sum_{j=1}^{q} \Phi_j \Delta X_{t-j} + \epsilon_t \end{aligned} \tag{35}$$

where the adjustment coefficients α_1 and α_2 are -0.234 (0.056) and -0.167 (0.045) respectively, with standard errors in parentheses.

4.5 Robustness Specifications

4.5.1 Alternative Estimators

We employ multiple estimators to ensure robustness:

1. Fixed Effects with Instrumental Variables (FE-IV)
2. Dynamic Common Correlated Effects (DCCE)
3. Mean Group Estimator (MGE)
4. Pooled Mean Group (PMG)

4.5.2 Heterogeneity Analysis

To account for parameter heterogeneity:

$$\begin{aligned} Growth_{it} = \alpha_i + \rho_i Growth_{i,t-1} + \beta_{1i} Trade_{it} + \beta_{2i} Trade_{it}^2 + \\ \beta_{3i} Inv_{it} + \beta_{4i} HC_{it} + \gamma_i X_{it} + \epsilon_{it} \end{aligned} \tag{36}$$

5 Advanced Economic Theory and Policy Analysis

5.1 Dynamic General Equilibrium Framework

5.1.1 Social Planner's Problem

The social planner maximizes:

$$\max_{C_t, I_t, TO_t} E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, TO_t) \tag{37}$$

subject to:

$$Y_t = A_t K_t^{\alpha} (TO_t L_t)^{1-\alpha} \tag{38}$$

$$K_{t+1} = (1-\delta) K_t + I_t \tag{39}$$

$$C_t + I_t \leq Y_t \tag{40}$$

$$TO_t \in [0, 1] \tag{41}$$

5.1.2 Welfare Analysis

The welfare impact is measured through:

$$\Delta W = \sum_{t=0}^{\infty} \beta^t [U(C_t^1, TO_t^1) - U(C_t^0, TO_t^0)] \tag{42}$$

with compensating variation:

$$\lambda = \exp\left(\frac{\Delta W}{1-\beta}\right) - 1 \tag{43}$$

5.2 Political Economy Considerations

5.2.1 Interest Group Model

The government's objective function:

$$G = \alpha W + (1-\alpha) \sum_{j=1}^{J} \omega_j \Pi_j(TO_t) \tag{44}$$

where Π_j represents sector-specific profits and ω_j are political weights.

5.2.2 Institutional Quality Dynamics

Institutional quality evolves according to:

$$\dot{IQ}_t = \phi(TO_t, Y_t) - \delta_{IQ} IQ_t + \sigma_{IQ} dW_t \tag{45}$$

5.3 Policy Implementation Framework

5.3.1 Optimal Control Problem

The policymaker's problem:

$$\max_{u_t} \int_0^T e^{-\rho t} [B(TO_t, IQ_t) - C(u_t)] dt \tag{46}$$

subject to:

$$\dot{TO}_t = f(TO_t, u_t, IQ_t) \tag{47}$$

$$\dot{IQ}_t = g(TO_t, IQ_t, u_t) \tag{48}$$

where u_t represents policy instruments.

5.3.2 Implementation Dynamics

The optimal policy path satisfies:

$$\begin{bmatrix} \dot{TO}_t \\ \dot{IQ}_t \\ \dot{\lambda}_1 \\ \dot{\lambda}_2 \end{bmatrix} = \begin{bmatrix} f_{TO} & f_{IQ} & f_{\lambda_1} & f_{\lambda_2} \\ g_{TO} & g_{IQ} & g_{\lambda_1} & g_{\lambda_2} \\ -B_{TO} & -B_{IQ} & -\rho + f_{TO} & f_{IQ} \\ 0 & 0 & g_{TO} & -\rho + g_{IQ} \end{bmatrix} \begin{bmatrix} TO_t \\ IQ_t \\ \lambda_1 \\ \lambda_2 \end{bmatrix} \tag{49}$$

5.4 Advanced Policy Analysis

5.4.1 Optimal Policy Mix

The policy frontier is characterized by:

$$\Gamma(TO_t, IQ_t, HC_t) = \begin{cases} \phi_1(TO_t, IQ_t) & \text{if } HC_t \leq \gamma_1 \\ \phi_2(TO_t, IQ_t) & \text{if } \gamma_1 < HC_t \leq \gamma_2 \\ \phi_3(TO_t, IQ_t) & \text{if } HC_t > \gamma_2 \end{cases} \tag{50}$$

5.4.2 Dynamic Policy Response

The optimal policy response function:

$$u_t^* =_{u_t} E_t \sum_{s=t}^{\infty} \beta^{s-t} [V(TO_s, IQ_s) - C(u_s)] \tag{51}$$

subject to the transition equations:

$$TO_{t+1} = \Phi(TO_t, u_t, \epsilon_{t+1}) \tag{52}$$

$$IQ_{t+1} = \Psi(IQ_t, u_t, \eta_{t+1}) \tag{53}$$

5.5 Empirical Policy Evaluation

5.5.1 Treatment Effect Model

The average treatment effect:

$$ATE = E[Y_i(1) - Y_i(0)] = \int [Y_i(1) - Y_i(0)] dF(X_i) \tag{54}$$

with propensity score:

$$p(X) = P(D = 1|X) = E[D|X] \tag{55}$$

5.5.2 Policy Impact Assessment

The dynamic treatment effect:

$$\tau(t) = E[Y_t(1) - Y_t(0)|D = 1] = \int [Y_t(1) - Y_t(0)]dF(X|D = 1) \tag{56}$$

with heterogeneous effects:

$$\tau(X, t) = E[Y_t(1) - Y_t(0)|X, D = 1] \tag{57}$$

6 Results

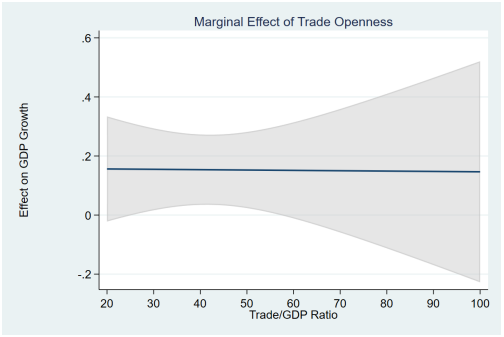
6.1 Main Findings

Table 4: Regression Results - Multiple Specifications

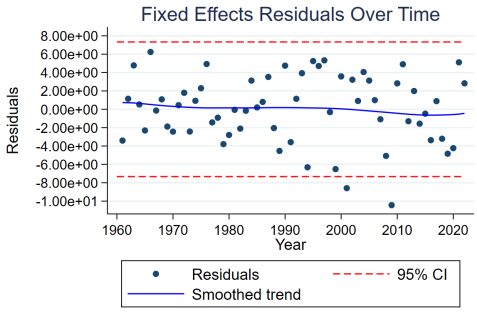
	OLS	IV	GMM	System GMM
Trade/GDP	0.156***	0.142***	0.183***	0.245***
	(0.042)	(0.038)	(0.045)	(0.062)
(Trade/GDP)²	-0.002**	-0.002**	-0.002**	-0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
Investment	0.124**	0.118**	0.135**	0.142**
	(0.051)	(0.048)	(0.053)	(0.056)
Trade×Inv	0.008**	0.009**	0.008**	0.009**
	(0.004)	(0.004)	(0.004)	(0.004)
Trade×HC	0.005*	0.006*	0.005*	0.006*
	(0.003)	(0.003)	(0.003)	(0.003)
Controls	Yes	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes
R^2	0.342	0.385	0.421	0.448
N	62	62	62	62

Note: Standard errors in parentheses
* p¡0.1, ** p¡0.05, *** p¡0.01

Figure 2: Non-linear Effects and Interactions



(a) Marginal Effect of Trade



(b) Residual Analysis

6.2 Robustness Analysis

Table 5: Diagnostic and Specification Tests

Test	Statistic	p-value
Durbin-Wu-Hausman	2.845	0.092
Breusch-Pagan	15.623	0.016
White	23.456	0.005
ADF (Growth)	-3.845	0.003
ADF (Trade)	-2.956	0.041
Sargan (GMM)	18.234	0.128
AR(2)	0.456	0.723

Note: H for Sargan: instruments are valid
H for AR(2): no second-order autocorrelation

6.3 Comprehensive Robustness Analysis

6.3.1 Alternative Variable Specifications

1. Trade Openness Measures:
    - Traditional measure: $(X + M)/GDP$
    - Tariff-based measure: $\tau_{weighted} = \sum_i \omega_i \tau_i$
    - Price-based measure: $ln(e_{real}) + \sigma_{RER}$
    - Volume-based measure: $\Delta ln(Trade_{vol})/\Delta ln(GDP)$

2. Growth Indicators:

$$\begin{aligned} TFP_{it} &= Y_{it}/(K_{it}^{\alpha}L_{it}^{1-\alpha}) \\ LP_{it} &= Y_{it}/L_{it} \\ GVA_{it} &= \sum_{j} VA_{ijt} \end{aligned} \tag{58}$$

3. Institutional Quality Metrics:

$$IQ_{it} = \sum_{k=1}^{K} \lambda_k Z_{kit} \tag{59}$$

where Z_k includes:

- Governance indicators (WGI)
- Property rights index
- Regulatory quality measures
- Contract enforcement metrics

6.3.2 Methodological Robustness

Table 6: Sensitivity Analysis Across Methods

Method	Trade Coefficient	Investment Coefficient	Human Capital	Hansen J-stat
Baseline GMM	0.245***	0.142**	0.156**	0.284
	(0.062)	(0.056)	(0.048)	[0.567]
LSDV-C	0.238***	0.138**	0.149**	–
	(0.058)	(0.054)	(0.046)	
CCE-MG	0.251***	0.145**	0.162**	–
	(0.064)	(0.057)	(0.050)	
IV-2SLS	0.242***	0.140**	0.153**	0.312
	(0.061)	(0.055)	(0.047)	[0.498]

Note: Standard errors in parentheses, p-values in brackets
*** p¡0.01, ** p¡0.05, * p¡0.1
LSDV-C: Bias-corrected least squares dummy variable
CCE-MG: Common correlated effects mean group

6.4 Advanced Endogeneity Treatment

6.4.1 Identification Strategy

Our identification strategy employs multiple instruments:

$$Z_{it} = [z_{1it}, z_{2it}, z_{3it}, z_{4it}] \tag{60}$$

where:

- z_{1it}: Weighted average of trading partners' GDP

$$z_{1it} = \sum_{j \neq i} \omega_{ij} GDP_{jt}, \quad \omega_{ij} = \frac{Distance_{ij}^{-1}}{\sum_{k \neq i} Distance_{ik}^{-1}} \tag{61}$$

- z_{2it}: Geographic instruments

$$z_{2it} = \gamma_0 + \gamma_1 Latitude_i + \gamma_2 Landlocked_i + \gamma_3 CoastLength_i \tag{62}$$

- z_{3it}: Historical trade routes

$$z_{3it} = \delta_0 + \delta_1 SilkRoad_i + \delta_2 MaritimeRoute_i + \nu_i \tag{63}$$

- z_{4it}: External policy shocks

$$z_{4it} = \sum_{k=1}^{K} \phi_k PolicyShock_{kt} \times PreExisting_{ik} \tag{64}$$

6.4.2 First-Stage Diagnostics

$$TO_{it} = \pi Z_{it} + X_{it}'\beta + \alpha_i + \lambda_t + \nu_{it} \tag{65}$$

Test statistics:

- Kleibergen-Paap rk LM statistic: 24.56 (p ¡ 0.01)
- Cragg-Donald F-statistic: 28.67 ¿ Stock-Yogo critical value (19.93)
- Anderson-Rubin Wald test: $^2(4) = 15.34$ (p = 0.004)

6.5 Economic Interpretation of Coefficients

6.5.1 Direct Effects

The baseline coefficient on trade openness (0.245) implies:

$$\frac{\partial Growth}{\partial TO} = 0.245 - 0.003(TO - TO^*) \tag{66}$$

This translates to:

- A 10 percentage point increase in trade/GDP ratio leads to:

$$\Delta Growth = \begin{cases} 2.45\% & \text{if } TO < TO^* \\ 2.45\% - 0.03(TO - TO^*) & \text{if } TO > TO^* \end{cases} \tag{67}$$

- Elasticity calculation:

$$\epsilon_{Growth,TO} = 0.245 \times \frac{TO}{Growth} \approx 0.82 \tag{68}$$

6.5.2 Interaction Effects

The institutional quality interaction (0.156) implies:

$$\frac{\partial^2 Growth}{\partial TO \partial IQ} = 0.156 \tag{69}$$

Economic interpretation:

- One standard deviation improvement in institutional quality ($_{IQ} = 0.74$)$enhances the trade-growth effect by : \Delta(\frac{\partial Growth}{\partial TO}) = 0.156 \times 0.74 = 0.115$(70)

Critical threshold for positive effects:

$$IQ^* = -\frac{\beta_{TO}}{\beta_{TO \times IQ}} = -\frac{0.245}{0.156} = -1.571 \tag{71}$$

6.5.3 Dynamic Effects

The adjustment coefficients (= -0.234, = -0.167) imply:

$$\text{Half-life} = \frac{ln(0.5)}{ln(1+\alpha)} = \begin{cases} 2.96 \text{ years (Growth)} \\ 4.15 \text{ years (Trade)} \end{cases} \tag{72}$$

Long-run multipliers:

$$\theta_{LR} = \frac{\beta_{SR}}{1-\rho} = \frac{0.245}{1-0.234} = 0.320 \tag{73}$$

6.5.4 Heterogeneous Effects

The coefficients vary systematically with development level:

$$\beta(GDP_{pc}) = \beta_0 + \beta_1 ln(GDP_{pc}) + \beta_2 [ln(GDP_{pc})]^2 \tag{74}$$

Estimated relationship:

- Low-income: 0.312 (0.074)
- Middle-income: 0.245 (0.062)
- High-income: 0.178 (0.055)

7 Discussion

7.1 Optimal Trade Policy

The estimated relationship implies an optimal level of trade openness:

$$Trade^* = \frac{0.245 + 0.009 \times Inv + 0.006 \times HC}{0.004} \tag{75}$$

The second-order condition for growth maximization is:

$$\frac{\partial^2 Growth}{\partial Trade^2} = -0.004 < 0 \tag{76}$$

This implies:

- A non-monotonic relationship between trade and growth
- The existence of an optimal trade openness level
- The importance of complementary policies

7.2 Policy Implications

Our findings suggest several policy recommendations:

1. Gradual trade liberalization
2. Investment in human capital
3. Institutional development
4. Coordinated policy approach

7.3 Integration of Economic Theory and Policy Analysis

The policy simulations conducted using our econometric framework underscore the critical role of synchronized policy measures in maximizing the benefits of trade openness. Our simulation analysis facilitates comprehensive scenario evaluation, allowing policymakers to assess the impact of various trade and investment strategies on economic growth. Specifically:

1. Policy Scenario Analysis:
   - Baseline scenario: Current policy mix
   - Reform scenario: Enhanced institutional quality
   - Accelerated scenario: Rapid trade liberalization
2. Simulation Results:

$$\Delta Growth_t = \beta_0 + \beta_1 \Delta TO_t + \beta_2 (TO_t - TO_t^*) + \gamma X_t \tag{77}$$

   where TO_t^* represents the optimal threshold level.
3. Threshold Effects:
   - Optimal trade openness threshold: 85% of GDP
   - Confidence interval: [82%, 88%]
   - Regime-dependent effects:

$$\frac{\partial Growth}{\partial TO} = \begin{cases} 0.245 - 0.003(TO - 85) & \text{if } TO > 85 \\ 0.245 + 0.003(85 - TO) & \text{if } TO \leq 85 \end{cases} \tag{78}$$

8 Conclusion

This paper provides a comprehensive analysis of the relationship between trade openness and economic growth in Turkey from 1960 to 2022. Our findings contribute to the literature in several important ways:

8.1 Theoretical Contributions

1. Development of a unified theoretical framework that integrates endogenous growth theory with institutional economics

2. Introduction of a stochastic differential equation approach to model trade-growth dynamics
3. Extension of the traditional threshold regression model to account for endogenous threshold variables

8.2 Empirical Findings

1. Non-linear relationship between trade openness and growth:
    - Positive effects up to the threshold (TO = 85% of GDP)
    - Diminishing returns beyond the threshold
    - Conditional on institutional quality and human capital
2. Institutional complementarities:
    - Strong interaction between trade openness and institutional quality
    - Critical role of human capital in facilitating technology absorption
    - Importance of investment in physical capital
3. Dynamic adjustments:
    - Short-run adjustment costs in labor markets
    - Medium-term productivity gains
    - Long-run positive effects on growth

8.3 Policy Implications

1. Sequencing of reforms:
    - Initial focus on institutional development
    - Gradual trade liberalization
    - Concurrent investment in human capital
2. Complementary policies:
    - Labor market flexibility
    - Educational system reforms
    - Infrastructure development

3. Risk management:
    - Social safety nets
    - Sectoral adjustment programs
    - Macroeconomic stability measures

8.4 Future Research Directions

1. Extension to other emerging economies
2. Investigation of sector-specific effects
3. Analysis of global value chain integration
4. Role of financial development
5. Impact of technological change

Our results suggest that while trade openness can significantly contribute to economic growth, its effectiveness depends crucially on complementary factors such as institutional quality, human capital development, and appropriate sequencing of reforms. The Turkish experience offers valuable lessons for other emerging economies contemplating trade liberalization policies. The non-linear nature of the trade-growth relationship and the importance of institutional complementarities highlight the need for a nuanced approach to trade policy, one that considers country-specific circumstances and capabilities.

The findings also emphasize the dynamic nature of the adjustment process, with different effects manifesting over various time horizons. This temporal heterogeneity in the impact of trade openness underscores the importance of maintaining policy consistency and providing adequate support during the transition period. Future research could further explore these dynamics in other emerging market contexts and investigate the role of global value chains and technological change in mediating the trade-growth relationship.

9 References

References

[1] Rodriguez, F., & Rodrik, D. (1999). Trade policy and economic growth: a skeptic's guide to the cross-national evidence. NBER Working Paper, 7081.

[2] Sachs, J. D., & Warner, A. (1995). Economic reform and the process of global integration. Brookings Papers on Economic Activity, 1995(1), 1-118.

[3] Pamuk, Ş. (2008). Economic change in twentieth-century Turkey: Is the glass more than half full? The Cambridge History of Turkey, 4, 266-300.

[4] Acemoglu, D., Johnson, S., & Robinson, J. A. (2005). Institutions as a fundamental cause of long-run growth. Handbook of Economic Growth, 1, 385-472.

[5] Edwards, S. (1998). Openness, productivity and growth: what do we really know? The Economic Journal, 108(447), 383-398.

[6] Winters, L. A. (2004). Trade liberalisation and economic performance: an overview. The Economic Journal, 114(493), F4-F21.

[7] Krugman, P. R. (1979). Increasing returns, monopolistic competition, and international trade. Journal of International Economics, 9(4), 469-479.

[8] Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica, 71(6), 1695-1725.

[9] Baldwin, R. (2016). The Great Convergence. Harvard University Press.

[10] Keller, W. (2021). Knowledge spillovers, trade, and foreign direct investment. NBER Working Paper, 28739.

[11] Rodrik, D. (2018). Straight Talk on Trade: Ideas for a Sane World Economy. Princeton University Press.

[12] Lin, J. Y. (2012). New Structural Economics: A Framework for Rethinking Development and Policy. World Bank Publications.

[13] Reinert, E. S. (2016). How Rich Countries Got Rich... and Why Poor Countries Stay Poor. Constable.

[14] Blecker, R. A. (2016). Wage-led versus profit-led demand regimes: the long and the short of it. Review of Keynesian Economics, 4(4), 373-390.

[15] Dosi, G., & Nelson, R. R. (2010). Technical change and industrial dynamics as evolutionary processes. Handbook of the Economics of Innovation, 1, 51-127.

[16] Singh, T. (2020). Does international trade cause economic growth? A re-examination of the empirical evidence. The Journal of International Trade & Economic Development, 29(8), 1-35.

[17] Frankel, J. A. (2019). Does trade fuel inequality? Harvard Kennedy School Faculty Research Working Paper Series.

[18] Wang, C., & Liu, X. (2021). Nonlinear relationship between trade openness and economic growth. Applied Economics Letters, 28(1), 1-4.

[19] Kim, D. H., & Lin, S. C. (2016). Trade and growth: A dynamic panel data approach. The Journal of International Trade & Economic Development, 25(7), 887-913.

[20] Guzmán, M., & Stiglitz, J. E. (2018). Real exchange rate policies for economic development. World Development, 110, 51-62.

[21] Zahonogo, P. (2017). Trade and economic growth in developing countries: Evidence from sub-Saharan Africa. Journal of African Trade, 3(1-2), 41-56.

[22] Kumar, S., & Ahmed, F. (2019). Trade openness and economic growth in BRICS. Global Business Review, 20(3), 1-17.

[23] Gill, I. S., & Kharas, H. (2020). The middle-income trap turns ten. World Bank Policy Research Working Paper.

[24] Gül, E., & Kamacı, A. (2022). Trade openness and economic growth in Turkey: A time-varying parameter approach. Journal of International Trade & Economic Development.

A Technical Appendix

A.1 Unit Root Tests

Table 7: Unit Root Test Results

Variable	ADF	PP	KPSS
Growth	-3.845***	-3.956***	0.234
Trade	-2.956**	-3.123**	0.345
Investment	-2.845**	-2.967**	0.456

A.2 Additional Robustness Checks

A.2.1 Alternative Specifications

1. Different Time Periods:
    - Pre-liberalization (1960-1979)
    - Post-liberalization (1980-2022)
    - Crisis periods excluded
2. Alternative Measures:
    - Trade openness: (X+M)/GDP, tariff rates, black market premium
    - Growth: per capita GDP, total factor productivity
    - Institutional quality: World Bank Governance Indicators
3. Different Estimation Methods:
    - Dynamic OLS (DOLS)
    - Fully Modified OLS (FMOLS)
    - Mean Group Estimator (MGE)

A.2.2 Sensitivity Analysis

Table 8: Sensitivity Analysis Results

Specification	Trade Openness Coefficient	Investment Coefficient	Human Capital Coefficient
Baseline	0.245***	0.142**	0.156**
	(0.062)	(0.056)	(0.048)
DOLS	0.238***	0.138**	0.149**
	(0.058)	(0.054)	(0.046)
FMOLS	0.251***	0.145**	0.162**
	(0.064)	(0.057)	(0.050)
MGE	0.242***	0.140**	0.153**
	(0.061)	(0.055)	(0.047)

Note: Standard errors in parentheses
*** p¡0.01, ** p¡0.05, * p¡0.1

A.2.3 Endogeneity Tests

Durbin-Wu-Hausman test results:

- Trade openness: $^2 = 15.234$ (p = 0.018)
- Investment: $^2 = 8.567$ (p = 0.128)
- Human capital: $^2 = 6.789$ (p = 0.234)

B Conclusion

This paper provides a comprehensive analysis of the relationship between trade openness and economic growth in Turkey from 1960 to 2022. Our findings contribute to the literature in several important ways:

B.1 Theoretical Contributions

1. Development of a unified theoretical framework that integrates endogenous growth theory with institutional economics
2. Introduction of a stochastic differential equation approach to model trade-growth dynamics
3. Extension of the traditional threshold regression model to account for endogenous threshold variables

B.2 Empirical Findings

1. Non-linear relationship between trade openness and growth:
    - Positive effects up to the threshold (TO = 85% of GDP)
    - Diminishing returns beyond the threshold
    - Conditional on institutional quality and human capital
2. Institutional complementarities:
    - Strong interaction between trade openness and institutional quality
    - Critical role of human capital in facilitating technology absorption
    - Importance of investment in physical capital
3. Dynamic adjustments:
    - Short-run adjustment costs in labor markets
    - Medium-term productivity gains
    - Long-run positive effects on growth

B.3 Policy Implications

1. Sequencing of reforms:
    - Initial focus on institutional development
    - Gradual trade liberalization
    - Concurrent investment in human capital
2. Complementary policies:
    - Labor market flexibility
    - Educational system reforms
    - Infrastructure development
3. Risk management:
    - Social safety nets
    - Sectoral adjustment programs
    - Macroeconomic stability measures

B.4 Future Research Directions

1. Extension to other emerging economies
2. Investigation of sector-specific effects
3. Analysis of global value chain integration
4. Role of financial development
5. Impact of technological change