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REAL EXCHANGE RATE EFFECTS ON THE BILATERAL MANUFACTURING TRADE BALANCE BETWEEN THE US AND TÜRKİYE: A BOUNDS TESTING APPROACH WITH STRUCTURAL BREAKS

Assoc. Prof. Derya HEKİM (Ph.D.)*

ABSTRACT

The exchange rate–trade balance relationship occupies a central place in open-economy macroeconomics, yet empirical evidence on whether currency depreciation generates a J-curve adjustment remains sensitive to the level of aggregation at which trade data are measured. Sector-level analysis is particularly informative in this regard, as it avoids the aggregation bias that arises when opposing dynamics across different product categories cancel each other out in country-level trade balance series. This paper investigates dynamics in the bilateral manufacturing trade balance between the United States and Türkiye using monthly sector-level data over the period 2013M01–2025M12. The trade balance is defined as the ratio of Türkiye's manufacturing exports to the US to Türkiye's manufacturing imports from the US. Structural breaks are identified endogenously through the Lee–Strazicich (2003) unit root test, and a step dummy variable controls for the permanent level shift associated with the COVID-19 shock from March 2020 onward. The ARDL bounds test confirms a stable long-run cointegrating relationship, and the error correction estimates reveal a net negative short-run exchange rate effect that reverses to a positive and significant long-run effect, consistent with the J-curve hypothesis. The findings suggest that real depreciation of the Turkish lira improves the bilateral manufacturing trade balance in the long run, though a temporary deterioration should be anticipated before the competitiveness gains materialize.

Keywords: *ARDL, J-Curve, Manufacturing Trade Balance, Disaggregated Trade Data, Structural Breaks, Türkiye–US Trade.*

JEL Codes: *F14, F31, C22.*

* Bursa Uludag University, Faculty of Economics and Administrative Sciences, Türkiye, E-mail: deryay@uludag.edu.tr

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1. INTRODUCTION

Whether exchange rate movements improve the trade balance - and if so, how quickly - has been debated in the international economics literature for decades. The Marshall–Lerner condition says yes in the long run, provided export and import demand are sufficiently elastic. In practice, though, the adjustment takes time. Magee (1973) noted that pre-existing trade contracts cause volumes to respond slowly to price changes, so the trade balance often deteriorates before it improves. This is the J-curve. Whether it shows up empirically depends substantially on the level of aggregation at which trade data are measured: aggregate trade balance series tend to hide the adjustment because gains in one sector offset losses in another (Rose & Yellen, 1989).

The United States and Türkiye maintain a substantial and growing bilateral trade relationship that makes this country pair a particularly relevant case for examining exchange rate dynamics. Bilateral merchandise trade between the two countries has exceeded 30 billion US dollars annually in recent years, with Türkiye consistently running a trade surplus in manufactured goods. Manufacturing accounts for the dominant share of Türkiye's exports to the US, covering a wide range of products from machinery and automotive parts to textiles, chemicals, and defense-related goods. On the exchange rate side, the Turkish lira depreciated by approximately 44 percent against the US dollar in 2018 alone, and by more than 80 percent in cumulative terms between 2018 and 2023, generating extraordinary variation in the real bilateral exchange rate. These episodes of sharp and sustained depreciation make the US–Türkiye bilateral manufacturing relationship an ideal setting for testing whether the J-curve mechanism operates at the sector level, and whether the magnitude of exchange rate changes that Türkiye has experienced is sufficient to produce measurable improvements in the bilateral manufacturing trade balance.

This paper focuses on the bilateral manufacturing trade balance between the United States and Türkiye, using sector-level monthly manufacturing export data rather than total bilateral trade flows. The sample period runs from January 2013 to December 2025, which means it covers the Turkish currency crisis of 2018, the COVID-19 disruptions of 2020, and the sharp depreciation of the lira during the unconventional monetary policy period of 2021–2023.

The bilateral US–Türkiye manufacturing relationship has received limited attention. Most studies on Türkiye either use aggregate trade data, focus on European partners, or disaggregate to individual commodity lines individual commodity lines. Halicioglu (2008a, 2008b) found a positive long-run exchange rate effect at the aggregate bilateral level for the US, but his data ended in 2005. Bahmani-Oskooee and Karamelikli (2021) covered the US bilateral relationship at the commodity level using NARDL, but their interest is in individual product categories, not the manufacturing sector as a whole. Sector-level evidence comparable to what has been produced for Türkiye–Germany manufacturing (Hekim, 2026) is missing for the US relationship.

The research question is whether the bilateral manufacturing trade balance between the United States and Türkiye follows a J-curve pattern. Two things make this study different from what already exists in the literature. First, sector-level manufacturing data are used rather than aggregate bilateral flows, which directly addresses the aggregation bias problem. Second, the sample is more recent and covers major structural shocks that previous bilateral studies on this country pair have not included.

The results support the J-curve for bilateral manufacturing trade: the net short-run exchange rate effect is negative, while the long-run effect is positive and significant. Section 2 reviews the relevant literature. Section 3 describes the data and methodology. Section 4 presents the results. Section 5 discusses the findings, and Section 6 concludes.

2. LITERATURE REVIEW

The J-curve literature has evolved considerably since Magee (1973) first described the adjustment lag. Early work relied on aggregate trade data and generally found weak or mixed evidence. Bahmani-Oskooee (1985) documented J-curve patterns for developing countries; Bahmani-Oskooee and Malixi (1992) found no such pattern for Türkiye; Bahmani-Oskooee and Alse (1994) did find evidence for Türkiye using cointegration. Kale (2001) concluded that real depreciation improves Türkiye's aggregate trade balance in the long run with roughly a one-year lag, and Akbostanci (2004) reached a similar conclusion using VECM models. These aggregate results provide some baseline, but they are vulnerable to the criticism that summing across heterogeneous sectors and partners may cancel out genuine adjustment dynamics.

Rose and Yellen (1989) made this criticism explicit and proposed shifting to bilateral trade data. Their own bilateral results for the US and six partners were negative — no J-curve — but the methodological framework gained traction. Bahmani-Oskooee and Brooks (1999) applied the same approach and found more supportive results for most US bilateral relationships. Wilson (2001) found evidence for Korea but not Malaysia or Singapore. For Türkiye, Halicioglu (2007) examined nine bilateral partners using a VECM and found no clear J-curve, though long-run effects were detectable in impulse responses. Halicioglu (2008a) used the ARDL bounds test for 13 bilateral partners and found that the US and UK were the only cases where real depreciation had a statistically significant positive long-run effect on the trade balance. Brada et al. (1997) found no exchange rate effect before 1980 but a positive long-run effect after 1980. Çelik and Kaya (2010) found an inverse J-curve pattern for Germany and the US using panel cointegration.

A natural next step was to disaggregate further, to the industry or commodity level. Yazici and Klasra (2010) looked at mining and manufacturing separately for Türkiye and found patterns that did not fit the standard J-curve. Durmaz (2015) examined 58 bilateral industries between Türkiye and the EU and found favorable long-run exchange rate effects in 13 of them. Yazgan and Öztürk (2019) used panel error correction across 33 countries. Bahmani-Oskooee and Karamelikli (2021) disaggregated to

the commodity level for US–Türkiye bilateral trade using NARDL and found exchange rate effects in the majority of the 58 commodity lines studied. The general pattern from disaggregated work is that more evidence for J-curve dynamics emerges once aggregation bias is removed — which is precisely the motivation for using manufacturing sector data here.

The fourth strand introduced asymmetry into the analytical framework. Shin et al. (2014) proposed the NARDL model, which separates the effects of depreciations and appreciations. Bahmani-Oskooee and Fariditavana (2015, 2016) showed that asymmetric specifications often reveal effects that symmetric models miss. For Türkiye, this has become a productive area. Bahmani-Oskooee et al. (2017) found significant depreciation effects on the trade balance with five EU partners. Ari et al. (2019) confirmed J-curve effects with several EU countries. Bahmani-Oskooee and Durmaz (2020) found more J-curve support at the commodity level with the EU once asymmetry is allowed. Karamelikli (2016) showed that nonlinear dynamics dominate for Türkiye's aggregate trade balance. Yilmaz (2024) found stronger asymmetric adjustment in non-EU bilateral relationships, and Keskin and Şengönül (2024) documented similar patterns with EU-28 partners. Hekim (2026) found pronounced asymmetry specifically in Türkiye–Germany bilateral manufacturing trade, with depreciations improving the manufacturing balance while appreciations had little effect.

Koçoğlu and Kula (2025) approach the question from a different angle, jointly examining monetary policy, exchange rates, and the trade balance over 2000–2024. Their finding that contractionary monetary policy improves the trade balance while simple exchange rate increases do not suggests that pass-through is uneven and context-dependent. This is consistent with the idea that whether exchange rate effects are symmetric or not depends on the specific bilateral relationship and sector being examined.

This paper sits in the disaggregated bilateral strand but differs from existing work in its unit of analysis. Rather than disaggregating to individual commodity lines, the manufacturing sector is treated as a whole—a level of aggregation that lies between total bilateral trade and individual product-level trade.

3. DATA AND METHODOLOGY

3.1. Model Specification

The model follows the reduced-form bilateral trade balance framework of Rose and Yellen (1989), applied to manufacturing trade data. The long-run relationship is:

$$lnTB_t = \alpha + \beta_1 lnY_{US,t} + \beta_2 lnY_{TR,t} + \beta_3 REX_t + \beta_4 DUM_t + \varepsilon_t \quad (1)$$

TB is the bilateral manufacturing trade balance, defined as the ratio of Türkiye's manufacturing exports to manufacturing imports from the US. Using manufacturing-specific export data rather than total bilateral trade flows is the key feature of this specification: it removes the aggregation across sectors

that tends to obscure adjustment dynamics in country-level models. Following Bahmani-Oskooee (1991), the trade balance is expressed in logarithmic ratio form to avoid negative-value problems and yield elasticity interpretations.

Y_{US} and Y_{TR} are seasonally adjusted industrial production indices for the United States and Türkiye, used as monthly proxies for economic activity. In a manufacturing trade model, industrial production is a natural scale variable because it tracks manufacturing output capacity directly (Rose & Yellen, 1989). REX is the real bilateral TL/USD exchange rate, defined so that an increase means a real depreciation of the lira. DUM is a step dummy equal to one from 2020M03 onward to capture the COVID-19 shock to manufacturing trade flows.

The expected sign on β_3 is positive: depreciation lowers the dollar cost of Turkish manufactured goods and should improve the manufacturing TB in the long run. The sign on β_1 is expected to be positive as the increase in US output leads to an increase in US imports and Türkiye's exports to the US. β_2 is expected to be negative as the increase in Türkiye's output leads to an increase in imports.

3.2. Data

The sample covers January 2013 to December 2025, giving 156 monthly observations. The 2013 start date reflects data availability: consistent monthly bilateral manufacturing trade statistics between Türkiye and the United States are available from this year without major definitional breaks. The manufacturing trade balance is constructed from bilateral manufacturing export and import data from TURKSTAT. The real bilateral exchange rate uses nominal TL/USD rates and CPI data from the CBRT, TURKSTAT, and the US Bureau of Labor Statistics. Industrial production indices for both countries are obtained from TURKSTAT and FRED. GDP would be the natural measure of income, but it is only available quarterly; industrial production is the standard monthly proxy used in this literature precisely because it tracks real economic activity at the frequency needed for the ARDL model (Halicioglu, 2008b). All variables are expressed in natural logarithms. Both industrial production series are seasonally adjusted with the X-13 ARIMA-SEATS (Findley et al., 1998) procedure before estimation.

3.3. Econometric Methodology

The ARDL bounds testing approach of Pesaran et al. (2001) is used because it handles mixtures of I(0) and I(1) regressors without requiring all variables to be integrated of the same order, and it yields an error correction model that separates short-run dynamics from the long-run relationship. The only requirement is that no variable be I(2), since this would invalidate the critical values (Ouattara, 2004).

Unit root tests begin with standard ADF and PP tests. Because these tests are known to have low power in the presence of structural breaks — failing to reject the unit root null even when the series is stationary around a broken trend — the Lee and Strazicich (2003) minimum LM test is also used. The Crash model (Model A), which allows for a break in the intercept, is selected because the main shocks

in the sample period (the 2018 currency crisis and COVID-19) manifests as level shifts in the manufacturing trade data rather than changes in trend. The break date identified for the dependent variable, 2020M03, is then incorporated as a step dummy in the ARDL model.

The ARDL error correction model takes the form:

$$\Delta lnTB_t = \alpha_0 + \sum_{j=1}^{n} \alpha_{1j} \Delta\, lnTB_{t-j} + \sum_{j=0}^{n} \alpha_{2j} \Delta\, lnY_{US,t-j} + \sum_{j=0}^{n} \alpha_{3j} \Delta\, lnY_{TR,t-j} + \sum_{j=0}^{n} \alpha_{4j} \Delta\, lnREX_{t-j} + \theta_1 lnTB_{t-1} + \theta_2 lnY_{US,t-1} + \theta_3 lnY_{TR,t-1} + \theta_4 lnREX_{t-1} + DUM_t + \mu_t \quad (2)$$

Cointegration is tested via the F-statistic on the lagged level terms, with critical values from Narayan (2005). Lag lengths are chosen by AIC over a maximum of twelve lags.

4. EMPIRICAL RESULTS

4.1. Unit Root Tests

Table 1 reports ADF and PP test results. For three of the four variables (LNTB, LNIPTR, and LNREX) the unit root null cannot be rejected in levels but but is rejected at the 1% level in first differences, indicating they are I(1). LNIPUS is an exception: both ADF (−3.17, p = 0.02) and PP (−3.60, p = 0.01) reject the unit root in levels, making it I(0). The sample therefore already contains a mixture of I(0) and I(1) variables before any structural break correction is applied, which is precisely the setting the ARDL bounds test is designed for. No I(2) variable is present, satisfying the prerequisite for the Pesaran et al. (2001) procedure.

Table 1. ADF and PP Unit Root Test Results

Variable	ADF Level	ADF 1st Diff.	PP Level	PP 1st Diff.	Conclusion
LNTB	-1.68 (0.44)	-8.79*** (0.00)	-1.52 (0.52)	-18.63*** (0.00)	I(1)
LNIPUS	-3.17** (0.02)	-11.43*** (0.00)	-3.60*** (0.01)	-10.37*** (0.00)	I(0)
LNIPTR	-1.30 (0.62)	-10.18*** (0.00)	-1.54 (0.51)	-14.37*** (0.00)	I(1)
LNREX	-1.90 (0.33)	-7.57*** (0.00)	-1.83 (0.36)	-8.86*** (0.00)	I(1)

Note: *** denotes significance at 1% and ** denotes significance at 5%.

The Lee–Strazicich results in Table 2 tell a somewhat different story. Once breaks are accounted for, the manufacturing trade balance (LNTB) is stationary in levels at the one percent level, with a break in March 2020. Turkish industrial production (LNIPTR) is also stationary at five percent, with a break in January 2020. US industrial production and LNREX remain I(1). The July 2018 break in LNREX coincides with the Turkish currency crisis, when the lira lost around 30 percent of its value in a matter of weeks. The sample thus has a mix of I(0) and I(1) variables, which the ARDL framework handles without difficulty. The early 2020 breaks in the manufacturing trade balance and industrial production indices are consistent with the COVID-19 shock.

Table 2. Lee and Strazicich (2003) Unit Root Test Results (Model A)

Variable	Test Stat. (τ)	1% Critical	5% Critical	Break Date	Conclusion
LNTB	-5.544***	-4.017	-3.418	2020M03	I(0) with break
LNIPUS	-3.167	-4.017	-3.418	2020M02	I(1)
LNIPTR	-3.547**	-4.017	-3.418	2020M01	I(0) with break
LNREX	-2.156	-4.017	-3.418	2018M07	I(1)

Note: *** and ** denote significance at 1% and 5%. Model A (Crash model) allows for a break in the intercept.

4.2. ARDL Estimation

AIC selects ARDL(2,1,2,2) as the optimal specification over a maximum of twelve lags. The full results are reported in Table 3. The bounds test F-statistic (Table 3 Panel D) of 8.78 exceeds the one percent upper critical bound, confirming that the bilateral manufacturing trade balance, the real exchange rate, and the industrial production indices share a stable long-run cointegrating relationship.

Table 3. Estimated Long and Short-run Results in ARDL(2,1,2,2)

	Coefficient	Std. Error	t-Statistic	p-Value
Panel A: Long-run Coefficients				
LNIPUS	-2.30*	1.42	-1.60	0.09
LNIPTR	0.24	0.65	0.38	0.70
LNREX	0.75***	0.22	3.36	0.00
Panel B: Short-run Coefficients				
D(LNTB(-1))	-0.15**	0.07	-2.07	0.04
D(LNIPUS)	1.19	1.51	0.79	0.43
D(LNIPTR)	-0.30	0.53	-0.56	0.57
D(LNIPTR(-1))	-1.31***	0.37	-3.48	0.00
D(LNREX)	0.79**	0.38	2.09	0.04
D(LNREX(-1))	-1.08***	0.37	-2.90	0.00
DUM	0.13**	0.05	2.48	0.01
C	3.54***	0.58	6.09	0.00
@TREND	-0.01***	0.01	-2.88	0.00
ECM	-0.57***	0.09	-5.99	0.00
Panel C: Diagnostic Tests				
		Test Statistic	**p-Value**	
Serial Correlation (Breusch-Godfrey)		F=0.40	0.66	
Heteroskedasticity (Breusch-Pagan-Godfrey)		F=1.12	0.34	
Model specification (Ramsey RESET)		F=0.26	0.61	
Normality of Residuals (Jarque-Bera)		JB=0.17	0.9	
Panel D: Bounds Test for Cointegration				
F-statistic (k=3)		F=8.78	Greater than the 1% upper critical value	

Note: ***, ** and * denote significance at 1%, 5% and 10% respectively. Critical values from Narayan (2005) for bounds test.

The error correction term of - 0.57 is negative and strongly significant, indicating that around 57 percent of any deviation from long-run equilibrium in the manufacturing trade balance is corrected within a single month- a fairly fast adjustment speed that is consistent with the monthly frequency of the data.

In the long run, the real exchange rate carries a positive and significant coefficient of 0.75, confirming that real lira depreciation improves the bilateral manufacturing trade balance. A 1% depreciation is associated with roughly a 0.75 percent improvement in the manufacturing trade balance

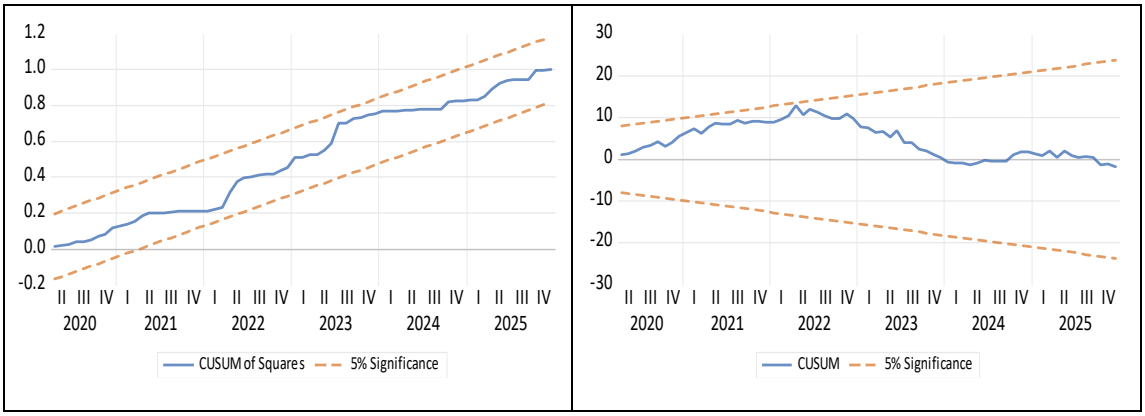
over the long run. US industrial production has a negative coefficient, significant at the ten percent level. This reflects the supply-side channel: higher US manufacturing output expands US export capacity to Türkiye, increasing the denominator of the trade balance ratio. Turkish industrial production is positive but insignificant, suggesting that Türkiye's manufacturing export performance toward the US is driven more by price competitiveness than by domestic output levels.

The short-run dynamics show the J-curve pattern clearly. The contemporaneous exchange rate coefficient D(LNREX) is positive (0.79) while the one-period lag is larger in absolute value and negative (-1.08), so that the net short-run effect (-0.29) is negative. Combined with the positive long-run coefficient (0.75), the implied dynamic adjustment is consistent with the J-curve: an initial net deterioration in the manufacturing balance that reverses to a long-run improvement. The first lag of Turkish industrial production D(LNIPTR(-1)) is negative and significant at -1.31, consistent with the high intermediate import content of Turkish manufacturing: a rise in domestic production in one month tends to be followed by an increase in imported inputs in the next, temporarily widening the import side of the bilateral manufacturing trade balance before any export-side response materializes. The COVID-19 dummy (DUM) enters with a positive and significant coefficient, indicating that the manufacturing trade balance shifted upward from March 2020 onward even after controlling for the exchange rate and output variables.[1]

All four diagnostic tests confirm model adequacy. The Breusch-Godfrey test finds no serial correlation ($F = 0.40$, $p = 0.66$), the Breusch-Pagan-Godfrey test finds no heteroskedasticity ($F = 1.12$, $p = 0.34$), the Ramsey RESET test shows no functional form misspecification ($F = 0.26$, $p = 0.61$), and the Jarque-Bera test does not reject residual normality ($JB = 0.17$, $p = 0.90$). Parameter stability is confirmed throughout the sample by both the CUSUM and CUSUM of squares tests (Figure 1).

[1] To assess whether the linear ARDL specification is appropriate or whether exchange rate changes exert asymmetric effects on the bilateral manufacturing trade balance, the model is extended to the Nonlinear ARDL (NARDL) framework proposed by Shin et al. (2014). In this specification, changes in the real exchange rate are decomposed into positive partial sums capturing depreciation episodes (REX_POS) and negative partial sums capturing appreciation episodes (REX_NEG), allowing depreciation and appreciation to have separate short-run and long-run impacts on the trade balance. Wald-based coefficient symmetry tests are then applied to assess whether the estimated coefficients on these two components are statistically equal. The long-run symmetry test yields $F(1,137) = 1.305$ ($p = 0.255$), the short-run symmetry test yields $F(1,137) = 0.243$ ($p = 0.623$), and the joint test yields $F(2,137) = 0.705$ ($p = 0.496$). None of the three tests reject the null hypothesis of coefficient equality between REX_POS and REX_NEG at any conventional significance level, indicating that real depreciations and appreciations of the Turkish lira exert statistically equivalent effects on the bilateral manufacturing trade balance in both the short and long run. These results confirm the appropriateness of the linear ARDL specification for this bilateral relationship.

Figure 1. CUSUM and CUSUM of Squares Tests



5. DISCUSSION

The J-curve result for bilateral manufacturing trade is consistent with prior findings in the bilateral trade literature on Türkiye. The pattern of initial deterioration followed by long-run improvement matches the Rose and Yellen (1989) definition and extends the finding of Halicioglu (2008b) to the manufacturing sector and to a more recent, more volatile sample. The confirmation of the J-curve is consistent with Brada et al. (1997) and Kale (2001), both of whom found positive long-run exchange rate effects for Türkiye, and with the broader summary in Bahmani-Oskooee and Ratha (2004). The adjustment speed of around 57 percent per month is higher than typical estimates obtained from quarterly data, which makes sense given that monthly data better capture the timing of contracts and shipment decisions in manufacturing.

The symmetric result is more interesting, because most of the recent Turkish trade balance literature finds asymmetry. Studies like Bahmani-Oskooee et al. (2017), Ari et al. (2019), Bahmani-Oskooee and Durmaz (2020), and Hekim (2026) all document asymmetric exchange rate effects in Türkiye's bilateral trade, particularly with European partners. The US case diverges from this pattern. One likely reason is the composition of US–Türkiye bilateral manufacturing trade, which is more diverse across product categories than, for instance, the capital-goods-heavy Türkiye–Germany relationship. The mechanisms that generate asymmetry in bilateral manufacturing trade-sunk market entry costs, pricing-to-market by exporters, price-inelastic import demand for specific intermediate goods- are more pronounced when bilateral trade is concentrated in a narrow set of products. Another factor is invoicing: a larger share of US–Türkiye bilateral manufacturing trade is denominated in US dollars, which tends to transmit exchange rate changes more symmetrically to both sides of the trade account. The finding is consistent with Koçoğlu and Kula (2025), who suggested that exchange rate pass-through in Türkiye is heterogeneous across contexts.

The negative long-run coefficient on US industrial production warrants further discussion, as it departs from the standard income-effect prediction that a more prosperous trading partner should absorb greater imports from Türkiye. The most plausible interpretation is that industrial production functions

as a dual proxy in bilateral trade balance models, capturing domestic manufacturing supply capacity as much as aggregate income. In a trade balance defined as the ratio of Türkiye's manufacturing exports to the US to its manufacturing imports from the US, an expansion of US manufacturing output raises the denominator through the export-capacity channel: as US productive capacity grows, the country's ability to supply manufactured goods to Türkiye expands, increasing Türkiye's bilateral imports. This supply-side interpretation aligns with the original treatment of industrial production as a scale variable in Rose and Yellen (1989) and is consistent with the negative partner-country coefficients reported in Halicioglu (2008b) for several of Türkiye's bilateral relationships.

Two structural features of the US–Türkiye relationship reinforce this channel. First, Turkish manufacturing exports to the US are concentrated in product categories — machinery, transportation equipment, base metals, and chemicals — where the United States maintains substantial domestic capacity, so US production expansions disproportionately generate goods that substitute for, rather than complement, Turkish exports. Second, periods of strong US manufacturing growth tend to coincide with deepening regional supply linkages within USMCA, where intermediate inputs are sourced primarily from Canada, Mexico, and domestic US suppliers, limiting the spillover to Turkish exporters. Taken together, these mechanisms imply that supply-side, substitution, and value-chain effects dominate the conventional income effect over the long run, producing the observed negative coefficient — a pattern consistent with broader evidence from disaggregated bilateral trade studies in which partner-country production variables often display non-standard signs once cross-sector aggregation is removed (Bahmani-Oskooee & Ratha, 2004; Bahmani-Oskooee & Karamelikli, 2021).

6. CONCLUSION

This paper examined trade balance dynamics in the bilateral manufacturing trade between Türkiye and the United States using monthly sector-level data from January 2013 to December 2025. The use of manufacturing-specific trade data is the central methodological feature: it addresses the aggregation bias problem that has undermined many aggregate trade balance studies (Bahmani-Oskooee & Ratha, 2004; Rose & Yellen, 1989) and puts the analysis on a comparable footing with sector-level studies for other bilateral manufacturing relationships.

The ARDL bounds test confirms cointegration, and the error correction estimates support the J-curve: a negative net short-run exchange rate effect that reverses to a positive and significant long-run effect. These results extend the earlier findings of Halicioglu (2008b) and complement the commodity-level evidence of Bahmani-Oskooee and Karamelikli (2021) with a sector-level perspective over a more recent sample.

The Wald symmetry tests find no evidence of asymmetric exchange rate effects. This is a different result from Türkiye–Germany manufacturing trade, where Hekim (2026) documented pronounced asymmetry, and from several other bilateral contexts where NARDL models reveal differential effects

of depreciations and appreciations (Ari et al., 2019; Bahmani-Oskooee et al., 2017). The contrast suggests that whether exchange rate effects are symmetric depends on partner-specific factors-especially trade composition and invoicing practices- rather than being a universal feature of Türkiye's manufacturing trade relationships.

For policy, the findings indicate that exchange rate depreciation improves Türkiye's manufacturing trade balance with the US in the long run, but not immediately. The J-curve implies a short-term worsening before the competitiveness gains materialize.

A few limitations of the analysis simultaneously define directions for future research. First, although the sector-level manufacturing aggregate substantially reduces the aggregation bias associated with total bilateral trade, residual heterogeneity remains within manufacturing itself; industry-level disaggregation across product groups — machinery, textiles, chemicals, and automotive — would reveal which categories drive the aggregate J-curve and whether the symmetry result holds uniformly. Second, while the linear specification's symmetry assumption is formally tested and not rejected within the NARDL framework reported in the footnote, a comparative panel analysis covering multiple bilateral manufacturing relationships simultaneously would allow a more systematic test of whether the US result is genuinely different from the European asymmetric cases. Finally, given Türkiye's growing participation in global value chains, future work that accounts for intermediate goods content in bilateral manufacturing trade flows may provide deeper insight into how exchange rate changes transmit to measured export and import values.

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