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# Export Elasticity to Exchange Rates Revisited: Application of Rolling ARDL Estimation to Japanese Exports

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# Export Elasticity to Exchange Rates Revisited: Application of Rolling ARDL Estimation to Japanese Exports*

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Abstract

This study applies the rolling regression technique to an auto-regressive distributed lag (ARDL) model to investigate how the Japanese export *quantity* and *price* equations responded to the yen's effective exchange rate over the sample period from the mid-1990s to December 2023. We reveal that the Japanese export quantity was unlikely to respond positively to yen depreciation, except for the Transport Equipment exports. Such unresponsiveness in export quantity likely changed in 2021 when the yen depreciated rapidly and prices in natural resources and energy rose globally. We also demonstrate that Japanese exporters tended to stabilize the export price by around 50 percent in destination markets, which is a typical PTM behavior. More intriguingly, we observe the complete PTM from around 2022 in response to the sharp yen depreciation. Thus, Japanese exporters have not exploited the yen depreciation to increase their export quantity. Instead, the exporters have raised the degree of PTM in the yen depreciation period to enjoy larger foreign exchange gains.

*Keywords*: Japanese exports; exchange rates; autoregressive distributed lag (ARDL) model; rolling regression; exchange rate pass-through

*JEL Classification*: F14; F31; F32

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## 1. Introduction

The effect of exchange rate changes on the economy is not an outdated research question. In recent research, numerous studies have analyzed the impact of exchange rate changes (e.g., devaluation) on the trade balance. For instance, Walter *et al.* (2012) theoretically and empirically investigated the macroeconomic linkages between exchange rates and U.S. bilateral trade with other G-7 countries. Baek (2013), using an auto-regressive distributed lag (ARDL) model, examined the short- and long-run impacts of exchange rate changes on bilateral trade between Korea and Japan at a disaggregated industry level. The estimated results indicate that the two countries' real income had significant impacts on the bilateral trade flows in both the short- and long-run. Similarly, Sato *et al.* (2013) scrutinized how industry-specific real effective exchange rates (REERs) affected Japanese exports in three electrical machinery industries (office machinery, electrical apparatuses, communication equipment) and the transportation equipment industry. Employing a structural near-vector autoregression (near-VAR) model from 2001 to 2013, they presented impulse-response functions indicating that a positive exchange rate shock (yen appreciation) led to long-lasting declines in Japanese exports across sectors. Fukui *et al*. (2023) examined how exchange rate depreciation impacts the economy and whether these effects differ under various exchange rate regimes. Gani (2024) studied the elasticities of Tunisian exports during the COVID-19 pandemic using the ARDL model, indicating that an appreciation of the real effective exchange rate negatively impacted industrial exports. These studies underscore the relevance of analyzing exchange rate dynamics and their impacts on exports and imports.

Japanese exporters have faced substantial exchange rate fluctuations over the past decades, while the country's trade balance has remained deficits in recent years. While Japan maintained a trade surplus up to 2010, the trade balance turned into a deficit in 2011 for the first time since the second energy crisis in 1979. Japanese trade deficits became very large in 2022 even though the yen depreciated substantially against the U.S. dollar (USD), reaching around 151 in October 2022. Notably, the Japanese export quantity has not shown any clear increase and has gradually declined in response to the yen's substantial depreciation. In 2023, the yen further depreciated from around 130 to 150 per U.S. dollar and reached 160 in 2024, making the REER most depreciated over 50 years. Despite this real effective depreciation, the quantity of Japanese exports continued to decline between 2023 and 2024.

A natural question is why the yen depreciation did not cause an increase in export quantity. Shimizu and Sato (2015) argued that a weaker yen no longer stimulated machinery exports as it once had because Japanese firms relocated their production bases strategically: Low-end products are increasingly produced overseas, while domestic production focuses on high-end products since the historical appreciation period, aligning with Japan's specialization in sophisticated machinery exports. Some other studies have examined the stagnation of export *quantities* by different export destinations in greater detail. As demonstrated by the Japan External Trade Organization in 2023 [1], the majority of its exports, 52.1 percent, were directed to Asian countries, followed by 21.6 percent directed towards North America and 13.6 percent to Europe. Thorbecke (2024) explored that after the global financial crisis, the yen fluctuations did not impact Japan's machinery exports to Asian countries but did impact these exports to non-Asian countries. Furthermore, Thorbecke (2024) suggested that the yen depreciation after the Covid-19 pandemic might not benefit firms in Asian countries that depended on Japanese capital goods. However, it has helped many Japanese machinery companies increase their profitability and exports to non-Asian countries.

[Insert Figure 1 around here.]

The pricing behavior of exporters is another key focus of exchange rate studies, particularly in the exchange rate pass-through (ERPT) literature. Parsons and Sato (2008) observed that Japanese exporters frequently adopt a pricing-to-market (PTM) strategy, stabilizing export prices in the local currency even at the expense of reduced profit margins during the yen appreciation periods. Nguyen and Sato (2019, 2020) demonstrated that PTM was more pronounced during yen depreciation before the 2000s. Still, this trend diminished from the 2000s, likely due to intensified global competition and increased intra-firm trade. Liu and Sato (2024), employing a non-linear ARDL (NARDL) model with multiple thresholds, highlighted significant asymmetry in the degree of ERPT or PTM between unexpected yen depreciation and appreciation periods. They found that PTM becomes more evident during appreciation periods.

The rolling regression approach has been widely used in empirical studies to capture the time-varying nature of economic relationships. This method involves estimating regression parameters over a fixed data window that rolls through the sample period, allowing for an examination of stability and trends. López and Thilwall (2006) applied the balance-of-payment-constrained growth model to 17 Latin American countries from 1977 to 2002 to estimate the income elasticity of demand for imports. They employed a rolling regression model to investigate whether trade liberalization led to a discernible trend increase in income elasticity over time. Hossain (2011) employed a rolling regression approach to estimate export elasticities to the exchange rate, indicating a declining sensitivity of real exports vis-à-vis the exchange rate over time. Shahbaz *et al.* (2015) combined the ARDL model with a rolling window approach to analyze the Pakistan economy. Shahzad *et al*. (2017) applied a modified bootstrap-rolling window

[1] See the website of the Japan External Trade Organization (https://www.jetro.go.jp/world/japan/stats/trade/).

approach to investigate oil volatility's impact on credit default swap spreads. Diebold and Yilmaz (2012) and Lyu *et al*. (2024) used a rolling window-based VAR (RW-VAR) model to investigate price volatility and spillovers.

Our study focuses on the recent experience of Japanese exports in response to the substantial yen depreciation. The novel contribution of this study is to apply the rolling regression approach to the ARDL model to investigate how the response of Japanese export *quantity* to the yen's real effective exchange rate has changed over the sample period from June 1992 to December 2023. Additionally, we apply the rolling ARDL model to the export *price* equation to examine the time-varying ERPT or PTM in Japanese exports from July 1995 to December 2023. Using industry-specific export quantity and price indices from the Japanese trade statistics provided by the Ministry of Finance, Japan, we explore differences in export *quantity* and *price* responses across industries. Focusing on the recent experience of Japanese exports amid significant yen depreciation, our findings provide insights into the apparent decline in export quantity responsiveness to exchange rate changes and the evolving nature of ERPT or PTM. This study builds on Nguyen and Sato (2020), which used a threshold autoregressive (TAR) model with a four-year rolling window approach to analyze differing ERPT behavior during yen appreciation and depreciation periods, and Forbes *et al*. (2017, 2020), which used distributed lag regression models to estimate pass-through coefficients across varying time windows of six, seven, eight, and 10 years.

The rolling ARDL estimation results reveal that Japanese export quantity is unlikely to respond positively to exchange rate changes. Only in the Transport Equipment exports did the export quantity respond positively (negatively) to exchange rate depreciation (appreciation) up to the early 2000s. Other industries indicate the unresponsiveness of export quantity to exchange rates during the same period. Such unresponsiveness in export quantity likely changed in 2021 when the yen depreciated rapidly and prices in natural resources and energy rose globally. We also demonstrate that Japanese exporters tended to stabilize the export price in destination markets, which is a typical PTM behavior, and the degree of PTM was about 50 percent from the mid-2000s. More interestingly, we reveal the complete PTM from around 2022 in response to the sharp yen depreciation. Thus, Japanese exporters have not exploited the yen depreciation to increase their export quantity. Instead, the exporters have raised the degree of PTM in the yen depreciation period to enjoy larger foreign exchange gains. Given such unresponsive export quantity and the strong tendency of PTM, the Japanese trade balance would unlikely improve despite further yen depreciation.

The remainder of this paper is structured as follows: Section 2 elaborates on the empirical model, Section 3 describes the data for empirical analysis, Section 4 presents the empirical results, and Section 5 concludes this study.

## 2. Empirical Model

### 2.1 Export Quantity Equation

*2.1.1 Export Demand Elasticity*

We employ the conventional export demand function to assess the degree of export quantity responses to exchange rate changes (e.g., Chinn, 2013).

$$x_t = \gamma_0 + \gamma_1 q_t + \gamma_2 y_t^* + \upsilon_t \tag{1}$$

where $x_t$ denotes export quantity, $q_t$ denotes bilateral real exchange rate, $y_t^*$ denotes foreign demand, $\upsilon_t$ denotes an error term, a single asterisk (*) denotes a foreign variable, and lowercase letters are assumed to be natural logarithmic. By extending the above "bilateral export" specification to the "export to the world" specification, we obtain:

$$x_t = \beta_0 + \beta_1 q_t^w + \beta_2 y_t^w + \varepsilon_t \tag{2}$$

where $q_t^w$ denotes the reciprocal of the yen's REER $(reer_t)$ obtained from the Bank for International Settlements (BIS), indicating that an increase in $q_t^w$ represents real effective depreciation of the yen. $y_t^w$ denotes a weighted average of the importing country's demand, and $\varepsilon_t$ denotes the error term.

*2.1.2 ARDL Model*

We extend equation (2) to the ARDL model, developed by Pesaran *et al*. (2001), to estimate both short-run and long-run responses of Japanese export quantity to exchange rate changes. A conditional error-correction model (ECM) can be shown as:

$$\Delta x_t = \rho_0 + \rho_1 x_{t-1} + \rho_2 q_{t-1}^w + \rho_3 y_{t-1}^w + \sum_{i=1}^{k} \gamma_{1i} \Delta x_{t-i} + \sum_{i=0}^{l} \gamma_{2i} \Delta q_{t-i}^w + \sum_{i=0}^{m} \gamma_{3i} \Delta y_{t-i}^w + \upsilon_t \tag{3}$$

Pesaran *et al*. (2001) proposed to conduct the bounds *F*-test, the joint null hypothesis of which is H$_0$: $\rho_1 = \rho_2 = \rho_3 = 0$. If the null hypothesis is rejected, a long-run equilibrium relationship is found between the variables. Specifically, in Equation (3), the long-run export elasticity to exchange rate changes is calculated as $\beta_1 = -\rho_2 / \rho_1$ and $\rho_1$ is called the coefficient for the error-correction term (ECT), which represents the speed of adjustment to equilibrium. To ensure the long-run relationship between the variables, Pesaran *et al*. (2001) also proposed to perform another bounds test for cointegration, i.e., the bounds $t$-test, where the null hypothesis is $H_0$: $\rho_1 = 0$. We conduct both bounds testing procedures using the rolling approach to the ARDL model.

*2.1.3 Rolling Regression of the ARDL Model*

We employ the rolling window approach, where the total sample period comprises 379 months. The rolling window size is fixed, i.e., five years.[2] For each sub-sample, the five-year window is advanced sequentially until the final observation is included. The first estimation uses the data from June 1992 to May 1997. The rolling ARDL model can be shown as follows:

$$\Delta x_t = \rho_{0,t} + \rho_{1,t} x_{t-1} + \rho_{2,t} q_{t-1}^{w} + \rho_{3,t} y_{t-1}^{w} + \sum_{i=1}^{k} \gamma_{1i,t} \Delta x_{t-i} + \sum_{i=0}^{l} \gamma_{2i,t} \Delta q_{t-i}^{w} + \sum_{i=0}^{m} \gamma_{3i,t} \Delta y_{t-i}^{w} + v_t \qquad (4)$$

where $\rho_{0,t}$, $\rho_{1,t}$, $\rho_{2,t}$, $\rho_{3,t}$, $\gamma_{1i,t}$, $\gamma_{2i,t}$, $\gamma_{3i,t}$ are the time-varying parameters estimated for each window. Since there are unusually large outliers for export quantity indices and the crisis period, we include dummy variables to avoid unusually large estimates of coefficients.[3] To consider possible misspecification or omitted explanatory variables, we include a trend term in a long-run level regression. The conditional ECM for the export quantity equation can be written as:

$$\Delta x_t = \rho_{0,t} + \rho_{1,t} x_{t-1} + \rho_{2,t} q_{t-1}^{w} + \rho_{3,t} y_{t-1}^{w} + \sum_{i=1}^{k} \gamma_{1i,t} \Delta x_{t-i} + \sum_{i=0}^{l} \gamma_{2i,t} \Delta q_{t-i}^{w} + \sum_{i=0}^{m} \gamma_{3i,t} \Delta y_{t-i}^{w} + D_t + v_t \qquad (5)$$

**2.2 Export Price Equation**

We extend the rolling ARDL model by replacing the export quantum index with the export unit price index. The total number of months in the entire sample period is 342, and the rolling window size is five years. The equation (4) can be modified as:

$$\Delta p_t = \rho_{0,t} + \rho_{1,t} p_{t-1} + \rho_{2,t} s_{t-1}^{w} + \rho_{3,t} y_{t-1}^{w} + \sum_{i=1}^{k} \gamma_{1i,t} \Delta p_{t-i} + \sum_{i=0}^{l} \gamma_{2i,t} \Delta s_{t-i}^{w} + \sum_{i=0}^{m} \gamma_{3i,t} \Delta y_{t-i}^{w} + v_t \qquad (6)$$

where $p_t$ denotes export unit price, $s_t^w$ denotes the reciprocal of the yen's NEER ($neer_t$)

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[2] This is a somewhat arbitrary choice. We tried different window sizes, such as a six-year window, but the conclusion is the same.

[3] Pesaran *et al*. (2001) included dummies to allow for unusual estimates of coefficients.

obtained from the BIS, which means that an increase in $s_t^w$ stands for the yen's nominal effective depreciation. $y_t^w$ denotes a weighted average of the importing country's demand, and $v_t$ denotes the error term. Similarly, $\rho_{0,t}$, $\rho_{1,t}$, $\rho_{2,t}$, $\rho_{3,t}$, $\gamma_{1i,t}$, $\gamma_{2i,t}$, $\gamma_{3i,t}$ are the time-varying parameters estimated for each window. The first estimation uses data from July 1995 to June 2000. Also, we include dummy variables to account for unusually large estimates of coefficients, as we did for the export quantity equation. We include a trend term in a long-run level regression to consider possible misspecification or omitted explanatory variables. The conditional ECM for the export unit price can be written as:

$$\Delta p_t = \rho_{0,t} + \rho_{1,t} p_{t-1} + \rho_{2,t} s_{t-1}^w + \rho_{3,t} y_{t-1}^w + \sum_{i=1}^{k} \gamma_{1i,t}\, \Delta p_{t-i}$$
$$+ \sum_{i=0}^{l} \gamma_{2i,t}\, \Delta s_{t-i}^w + \sum_{i=0}^{m} \gamma_{3i,t}\, \Delta y_{t-i}^w + D_t + v_t \qquad (7)$$

This study builds on the existing body of research by introducing a dynamic perspective. It uses rolling estimation to capture the evolving strategies of Japanese exporters. By analyzing export quantity and price-setting behavior, this research provides new insights into how Japanese exporters respond to exchange rate changes by adjusting export quantity and prices.

## 3. Data

This study uses the monthly series of the Japanese export quantum (quantity) index by industry, the Japanese export unit price index by industry, the REER and NEER of the yen, and the world industrial production index. The sample period for export quantity analysis spans from June 1992 to December 2023, while the sample period for export price analysis ranges from July 1995 to December 2023. Considering that more than a half of Japan's exports consists of machinery and equipment, electronics, and automobiles, we examine the four industries: All Manufacturing, General Machinery, Electrical and Electronic Equipment, and Transport Equipment.

The monthly Japanese export quantity index series by industry ($x_t$) and the Japanese export unit price index by industry ($p_t$) are obtained from the Ministry of Finance, Japan. We obtained the yen's REER ($reer_t$) and the yen's NEER ($neer_t$) from the BIS to calculate the reciprocal of the REER and NEER, $q_t^w$ and $s_t^w$, respectively. The world industrial production index (IPI), $y_t^w$, is constructed by taking a weighted average of the IPI series for Japan's 20 major trading partner countries, which is a proxy for world import demand. The IPI series are obtained from the CEIC Database. The 20 partner countries are selected based on the criteria that the destination country's share equals one percent or larger of Japan's total exports. Seasonality is adjusted using the Census X12 method.

# 4. Empirical Results

## 4.1 Benchmark Results

### *4.1.1 Results of Export Quantity Elasticity*

We have conducted the rolling ARDL estimation using the export quantity equation (5). While we can obtain information on both the long-run equilibrium relationship and short-run interactions between variables, our main objective is to investigate the time-varying nature of the long-run export quantity elasticity, i.e., the level response of export quantity to the real effective exchange rate. An increase in the real effective exchange rate is defined as yen depreciation. We present a graphical representation of the rolling estimates of export quantity responses to yen depreciation.

Figure 2 presents the results of rolling ARDL estimation for four industries: All Manufacturing, General Machinery, Electrical Equipment, and Transport Equipment. As shown in Figure 1, the quantity of Japanese exports has not responded to the yen depreciation since 2013. Shimizu and Sato (2015) revealed that the Japanese trade balance did not improve in response to exchange rates from the mid-2010s, likely due to drastic changes in Japanese firms' production and sales strategy. Specifically, after experiencing a historically high level of the yen against the USD (around 75–79 yen vis-à-vis the USD) for more than one year in 2011–12, Japanese export firms shifted their production base, especially for production of export goods with higher price elasticity, to Asia and other destination countries. Thus, even though the yen started to depreciate substantially in 2013 and after, most export goods produced in Japan became less elastic to yen depreciation.

This subsection attempts to assess whether Japanese export quantity responses to the exchange rate have changed, as suggested by previous studies. It conducts the rolling estimation of the ARDL model over the sample period from June 1992 to December 2023.

[Insert Figure 2 around here]

First, according to Figure 2a, where significantly positive responses of export quantity to exchange rates are shaded in pink, the estimated results of All Manufacturing exports are not significantly positive up to the mid-2000s. After that, we observed short-lived positive and significant responses several times. This means there is little evidence that the Japanese export quantity responds positively to exchange rate changes (yen depreciation). It must be noted, however, that Japanese export quantity responded positively and significantly to yen depreciation from February 2023 to December 2023. This may indicate a likely change in Japanese exporters' quantity-setting behavior.

Second, export quantity responses to the exchange rate differ across industries. Figure 2c shows insignificant export quantity responses for the Electrical Equipment industry in most sample periods. We can observe several short-lived positive and significant responses, but the degree of responses was unusually large in the late 2000s. In the General Machinery industry (Figure 2b), we cannot observe significantly positive responses in export quantity up to the early 2010s. However, two periods indicate significantly positive responses of export quantity: one is from November 2013 to May 2016, and the other is from January 2021 to December 2023, when the yen depreciated substantially against the USD and other currencies.

More intriguingly, we found positive and significant responses of export quantity to the exchange rate in the Transport Equipment industry from May 1997 to June 2000 (Figure 2d). After that, we could not observe significantly positive responses of export quantity to exchange rate changes except for several short-lived periods. This suggests that Japanese firms tended to export more (less) in response to yen depreciation (appreciation) up to 2000, and such positive responses weakened from the early 2000s. From April 2023, we can observe a positive and significant response of export quantity to yen depreciation, consistent with what we found in the General Machinery industry.

Finally, we present the bounds $F$-test and $t$-test results obtained from the rolling ARDL estimation in Appendix Figures A1 and A2. These results suggest that we could not find a cointegrating relationship for all the periods when the export quantity response was significantly positive to yen depreciation. Thus, the cointegration analysis weakly supports our findings from the export quantity analysis.

#### *4.1.2 Results of Export Price Elasticity*

Next, we conducted the rolling ARDL estimation using equation (7) to investigate the degree of ERPT or PTM. We aim to explore to what extent Japanese exporters stabilized their export prices in destination markets.

Figure 3 presents the results of long-run export price responses to yen depreciation. First, we cannot find significant responses in All Manufacturing exports in the early 2000s (Figure 3a). However, from the mid-2000s, especially from January 2009 to December 2023, the export price responses were positive and statistically significant in most periods. The magnitude of responses was around 0.5 during that period, which suggests that about 50 percent of exchange rate changes were passed on to importers. From around 2021, the degree of export price responses to yen depreciation rose to 1.5 and then gradually declined to 1.0. This result suggests that Japanese exporters raised the degree of local price stability in destination markets in response to a sharp and large depreciation of the yen.

[Insert Figure 3 around here]

Turning to the Electrical Equipment industry (Figure 3c), we can observe significantly positive responses to exchange rate changes in shorter periods: one is from April 2013 to January 2019, and the other is from May 2021 to December 2023. However, both periods do not necessarily show significant responses all the time. In the latter period, the degree of positive responses increased to around 2.0 and gradually decreased toward 1.0. Surprisingly, we cannot find significantly positive responses of export prices to the exchange rate from 2000 to early 2013 except for a few shorter periods. As Ito *et al*. (2018) demonstrated, Japanese electric machinery exporters tend to invoice their exports in USD, which leads to PTM, at least in the short-run. However, the insignificant responses we found above are inconsistent with the strong tendency of USD invoicing in the Electrical Equipment industry.

We can observe similar responses of export prices for both the General Machinery and Transport Equipment industries. The degree of positive responses is somewhat higher in the Transport Equipment industry (Figure 3d) than in the General Machinery industry (Figure 3b). From late 2021, both industries show a rise in export price responses to the exchange rate, suggesting an increase in PTM in response to a sharp yen depreciation.

Finally, we also present the bounds *F*-test and *t*-test results obtained from the rolling ARDL estimation in Appendix Figures A3 and A4, suggesting that a cointegrating relationship cannot be found for all the periods when the export price response was significantly positive to yen depreciation. Thus, the cointegration analysis weakly supports our findings from the export price analysis.

### 4.2 Additional Analysis

*4.2.1 Analysis of the World Industrial Production Index*

So far, we have analyzed the elasticity of exports in response to exchange rate changes. For an additional analysis, we show the time-varying responses of export quantity to the World IPI, which reflects global demand. According to the World Trade Summary 2022[4], Japan was the 4th largest merchandise exporter in 2022.

*4.2.1.1 Export Quantity Elasticity*

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[4] See the website of the World Integrated Trade Solution (https://wits.worldbank.org/Default.aspx?lang=en).

Figure 4 presents the results of rolling ARDL estimation for four industries: All Manufacturing, General Machinery, Electrical Equipment, and Transport Equipment.

[Insert Figure 4 around here]

First, according to Figure 4a, where significantly positive responses of export quantity to World IPI are shaded in pink, the estimated results for All Manufacturing exports are not significantly positive until September 2008. From 2008 to 2013, the Japanese export quantity responded positively to World IPI, which likely reflects the strong negative impacts of the global financial crisis and the subsequent Euro area sovereign debt crisis on international trade. After 2013, we observed short-lived positive and significant responses several times. However, this indicates little consistent evidence that the Japanese export quantity responds positively to World IPI.

Second, focusing on the General Machinery and Electrical Equipment industries, we can observe similar positive and significant responses starting from 2008 (Figures 4b and 4c), consistent with the result for the All Manufacturing industry. We can also observe positive and significant responses from 2020 or 2021, which likely captures the decline in export quantity caused by the economic slowdown during and after the COVID-19 pandemic. In contrast, the Transport Equipment industry does not exhibit positive and significant responses to the world IPI from 2020; rather, it indicates significantly negative responses (Figure 4d), which suggests that Japanese automobile firms increased their export quantities even though world demand did not recover due to the prolonged negative impact of the pandemic.

The bounds *F*-test and *t*-test results obtained from the rolling ARDL estimation in Appendix Figures A1 and A2 suggest that for the General Machinery and the Transport Equipment industries, cointegrating relationships cannot be found for all the periods when the export quantity responses were significantly positive to World IPI increases from 2008 to 2013. For All Manufacturing and General Machinery industries, we could find a cointegrating relationship when the export quantity response was significantly positive to World IPI increases in 2020. For the Electrical Machinery and the Transport Equipment industries, the cointegration analysis weakly supports our findings from the export price analysis.

*4.2.1.2 Export Price Elasticity*

Let us next discuss whether Japanese export prices significantly respond to world demand by estimating the Japanese export price elasticities to world IPI.

[Insert Figure 5 around here]

Figure 5 presents the results of industry export price responses to World IPI increases. Only a few short-lived positive and significant responses were observed during the sample period. This indicates that Japanese exporters' pricing behavior is unlikely to be affected by world demand.

The bounds *F*-test and *t*-test results obtained from the rolling ARDL estimation in Appendix Figures A3 and A4 suggest that a cointegrating relationship cannot be found for all the periods when the export price response was significantly positive to World IPI. Thus, the cointegration analysis weakly supports our findings from the export price analysis.

### *4.2.2 Sectoral Analysis*

So far, we have analyzed the export quantity- and the price-setting behavior of Japanese exports at the industry level. For the robustness check, we use alternative export quantity and price indices at the sectoral level. Because more than half of Japan's exports are composed of machinery, electronic devices, and automobiles, we first chose three industries, General Machinery, Electrical Equipment, and Transport Equipment, and second chose 28 sectors from the three industries.

For the General Machinery industry, we selected 12 sectors: (i) Power Generating Machinery, (ii) Internal Combustion Engines, (iii) Agricultural Machinery, (iv) Office Machines, (v) Other Office Machines, (vi) Metal Working Machines, (vii) Textile Machines, (viii) Construction Machines, (ix) Heating or Cooling Equipment, (x) Pump Centrifuges, (xi) Mechanical Handling Equipment, and (xii) Bearings. For the Electrical Equipment industry, we selected 13 sectors: (i) Electric Power Machinery, (ii) Insulated Wire, Cable, (iii) Visual Apparatus, (iv) T.V. Receivers, (v) Video Tape Recorder, (vi) Telecommunications Equipment, (vii) Domestic Electrical Equipment, (viii) Batteries and Accumulators, (ix) Thermionic Valves, Tubes, Transistors, etc., (x) Transistors and Diodes, (xi) Electronic Integrated Circuits, (xii) Electrical Measuring & Controlling Instrument and (xiii) Condensers. For the Transport Equipment industry, we selected three sectors: (i) Motor Vehicles, (ii) Passenger Motor Car, and (iii) Parts of Motor Vehicles.

Appendix Figures A5 to A13 present the estimated results for export quantity elasticity at the sectoral level, while Appendix Figures A14 to A22 illustrate the corresponding results for export price elasticity. These findings show the robustness of the empirical results for the industry-level analysis. However, for the General Machinery and Electrical Machinery, we obtained inconsistent results for some sectors, which must be interpreted cautiously.

## 5. Concluding Remarks

The main objective of this paper is to explore whether and how the yen exchange rate has affected the quantity and price of Japanese exports. We conducted the rolling ARDL estimation to investigate the time-varying long-run responses of export quantities and prices to the yen exchange rates.

Although export quantity is generally considered to respond positively to the exchange rate depreciation, we found little evidence that Japanese export quantity responded positively to the yen depreciation in real effective terms over the sample period from June 1992 to December 2023. Only in the Transport Equipment exports did the export quantity respond positively (negatively) to exchange rate depreciation (appreciation) up to the early 2000s. Other industries indicate the unresponsiveness of export quantity to exchange rates in the 1990s and 2000s. Such unresponsiveness in export quantity likely changed in 2021 when the yen depreciated rapidly and substantially.

We also estimated the export price equation using the rolling ARDL model to examine the time-varying ERPT or PTM. We demonstrated that Japanese exporters tended to stabilize the export price in destination markets, and the degree of PTM was around 50 percent from the mid-2000s to 2020. Although it is an incomplete PTM behavior, the estimated long-run PTM is consistent with the Japanese exporters' invoice currency choice: more than 60 percent of Japanese exports are invoiced in foreign currencies (Ito *et al*., 2018). More intriguingly, we observed the complete PTM from around late 2021 with the overresponse to the sharp yen depreciation in mid-2022.

Thus, Japanese exporters could not exploit the yen depreciation to increase their export quantity. Instead, they have raised the degree of PTM in the recent yen depreciation period to enjoy larger foreign exchange gains. The unresponsive export quantity to the exchange rate and the strong tendency of PTM have likely prevented the improvement of the Japanese trade balance. This conclusion is supported by additional empirical analysis investigating export quantity- and price-setting behavior with more disaggregated sectoral data.

Whereas we have revealed the time-varying responses of Japanese export quantity and price to exchange rate changes, we have not explored what determines such behavior in Japanese exports. This additional empirical work is left for our future research.

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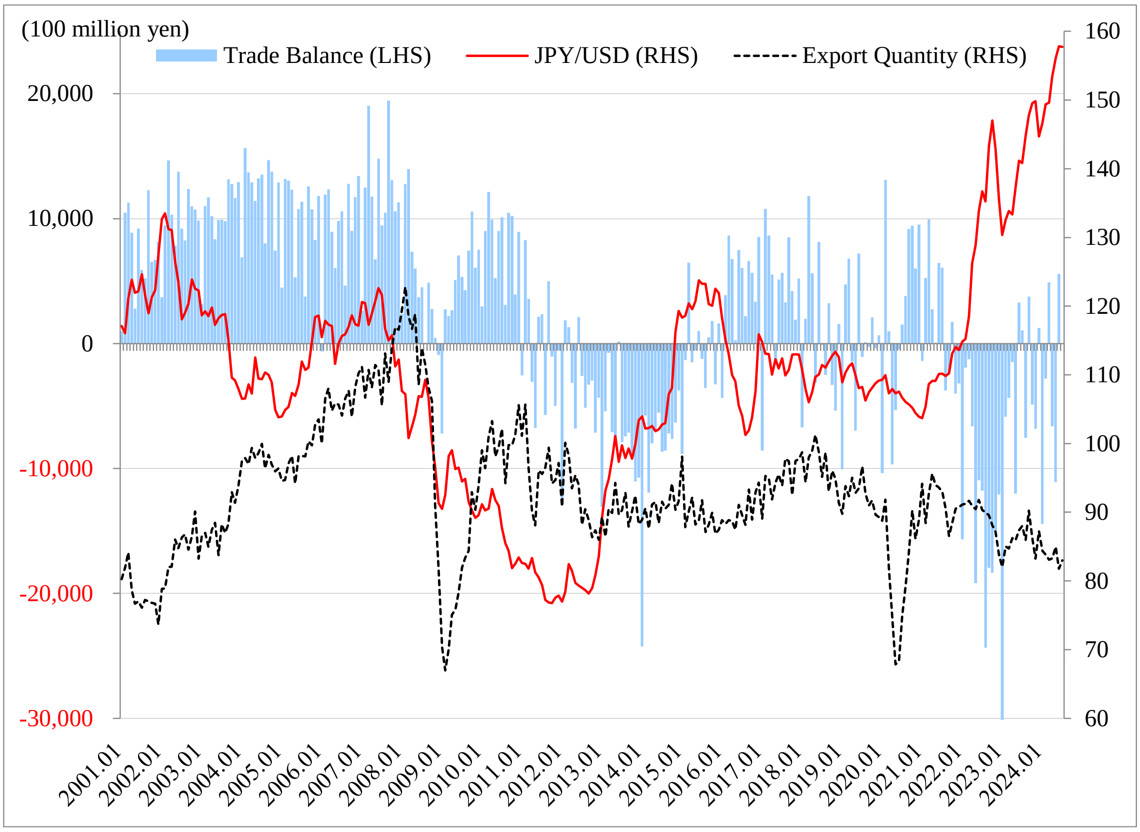
**Figure 1**. Japan's Trade Balance, Yen's Exchange Rate, and Export Quantity

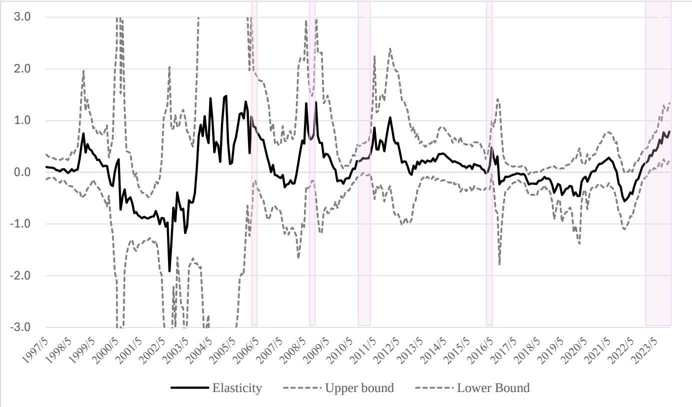



*Note*: The monthly data spans from January 2001 to July 2024. Japan's trade balance is in terms of 100 million yen (left-hand side axis). The bilateral nominal exchange rate of the yen vis-à-vis the U.S. dollar and the Japan's export quantity index (2010 = 100) are measured by the right-hand side axis.

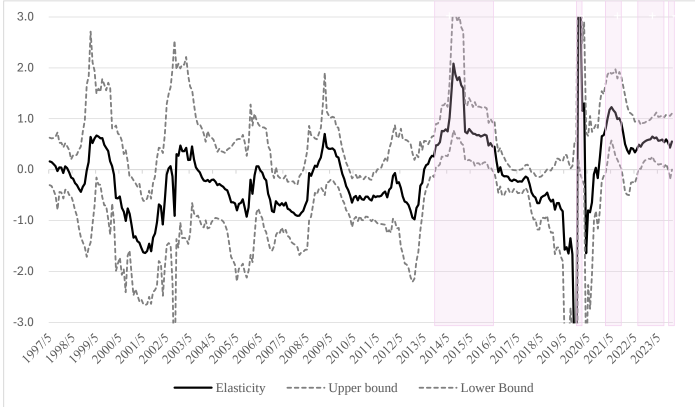
*Source*: IMF, International Financial Statistics (IFS); Japan's Ministry of Finance website.

**Figure 2.** Japanese Export Quantity Elasticity to Exchange Rates

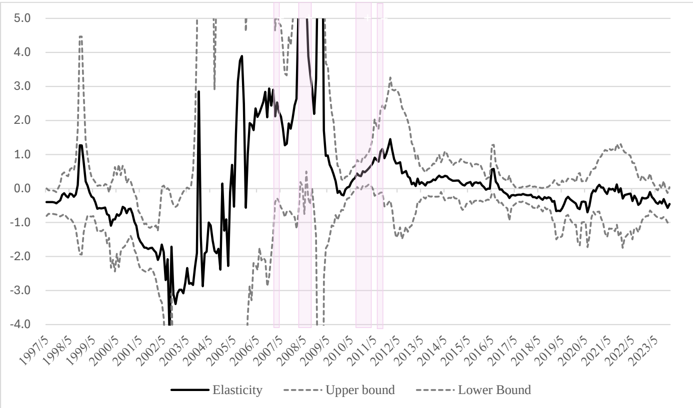
2a. All Manufacturing



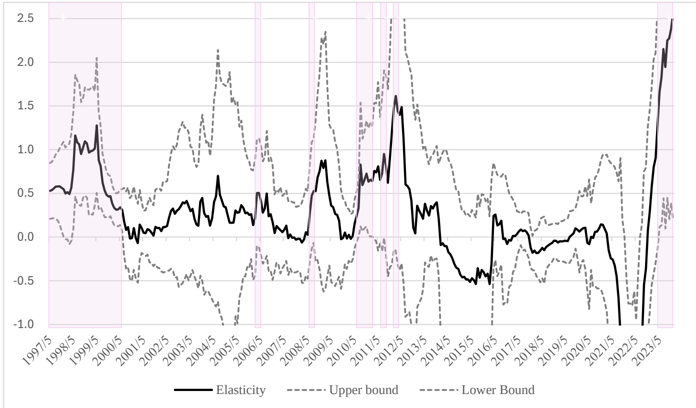

2b. General Machinery




2c. Electrical Equipment




2d. Transport Equipment

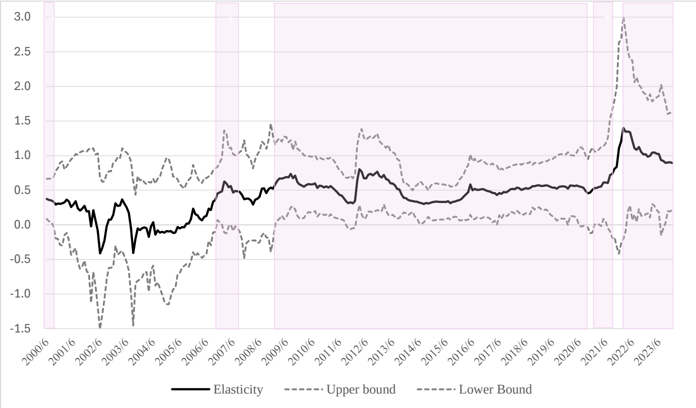



*Note*: The upper and lower bounds denote plus and minus two standard errors. Shaded areas in pink show the statistical significance at least at the 5% level.

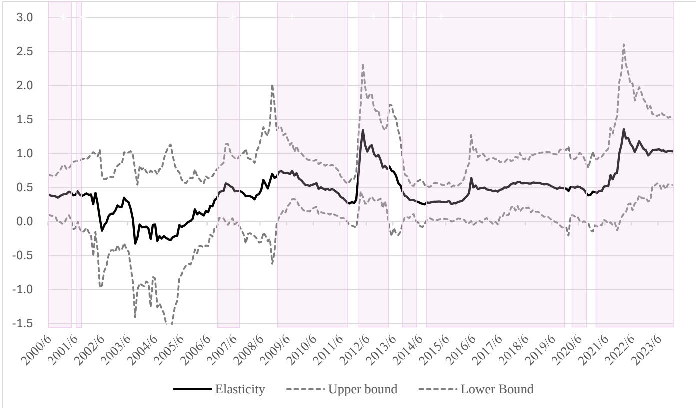
*Source*: Authors' estimation.

**Figure 3.** Japanese Export Price Elasticity to Exchange Rates

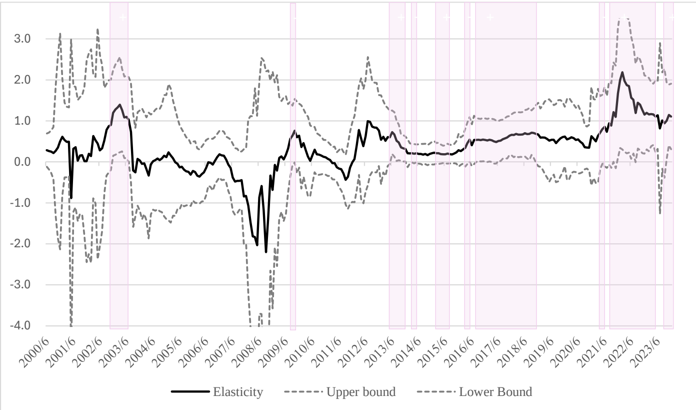
3a. All Manufacturing



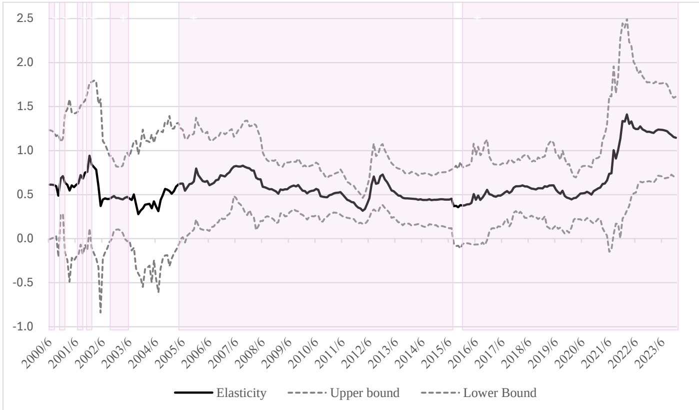

3b. General Machinery




3c. Electrical Equipment




3d. Transport Equipment

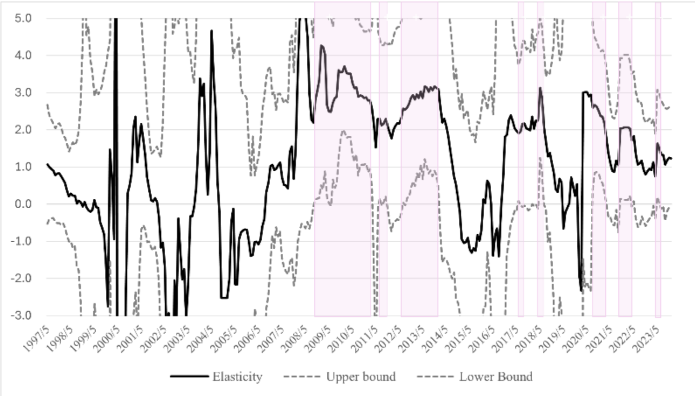



*Note*: The upper and lower bounds denote plus and minus two standard errors. Shaded areas in pink show the statistical significance at least at the 5% level.

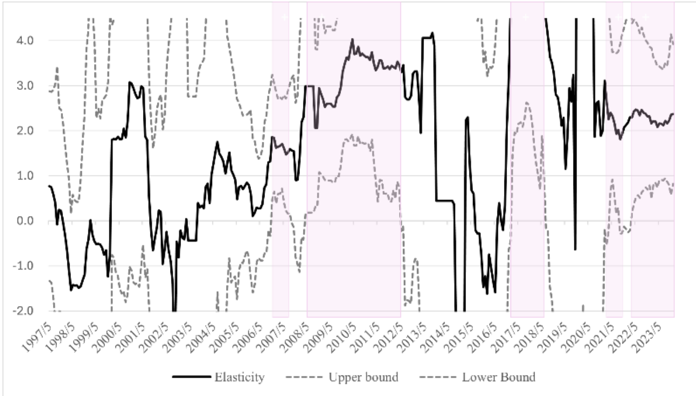
*Source*: Authors' estimation.

**Figure 4.** Japanese Export Quantity Elasticity to World IPI

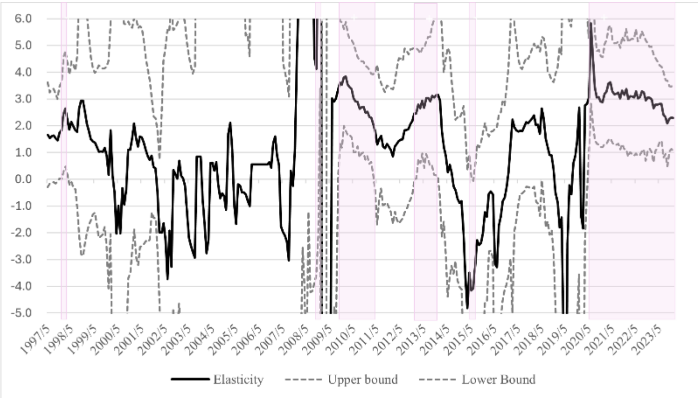
4a. All Manufacturing



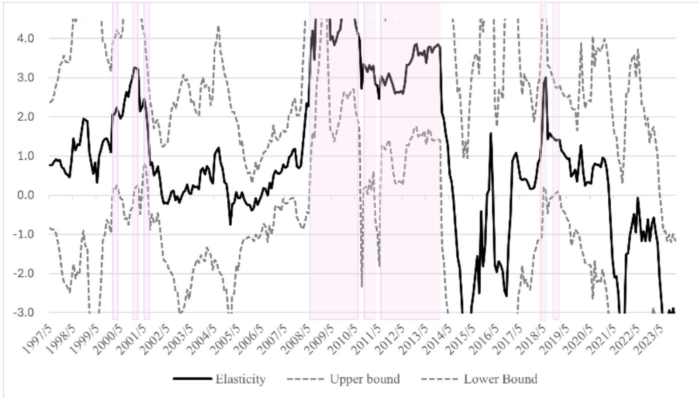

4b. General Machinery




4c. Electrical Equipment




4d. Transport Equipment

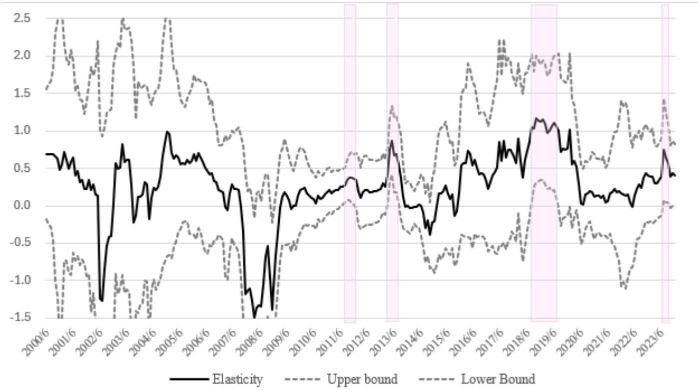



*Note*: The upper and lower bounds denote plus and minus two standard errors. Shaded areas in pink show the statistical significance at least at the 5% level.

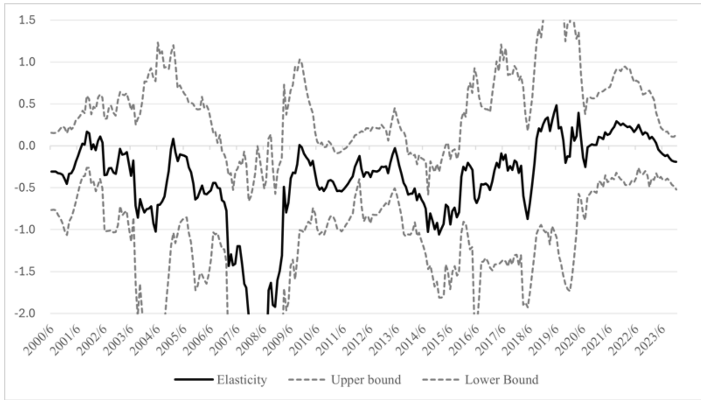
*Source*: Authors' estimation.

**Figure 5.** Japanese Export Price Elasticity to World IPI

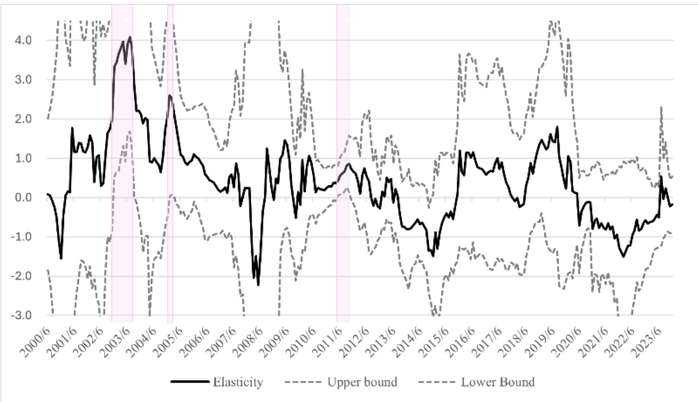
5a. All Manufacturing



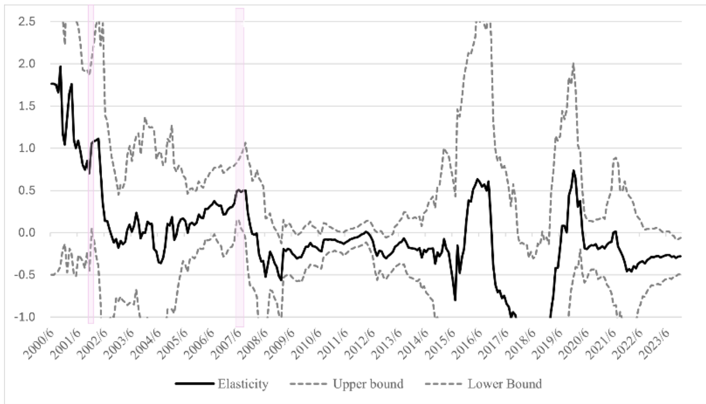

5b. General Machinery




5c. Electrical Equipment




5d. Transport Equipment

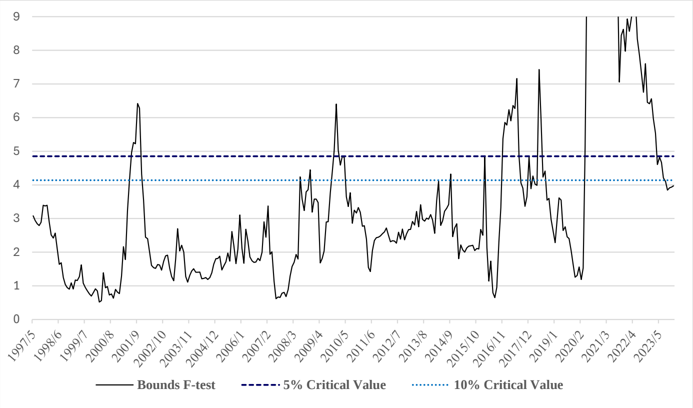



*Note*: The upper and lower bounds denote plus and minus two standard errors. Shaded areas in pink show the statistical significance at least at the 5% level.

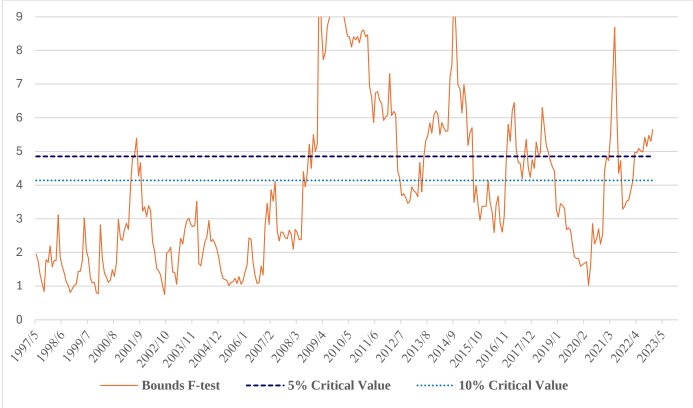
*Source*: Authors' estimation.

**Appendix Figure A1.** Bounds *F*-Test for Rolling ARDL Estimation of Japanese Export Quantity

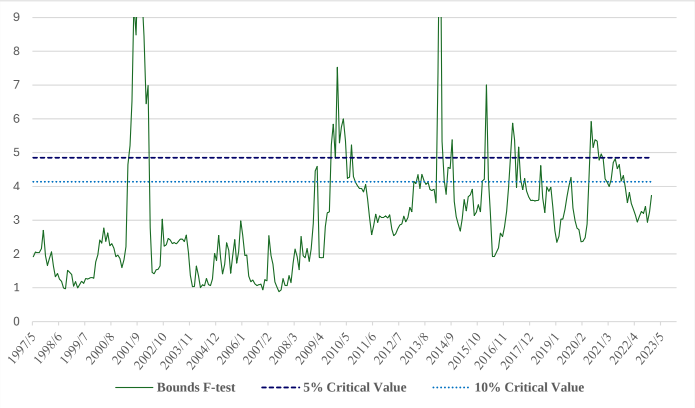
A1a. All Manufacturing



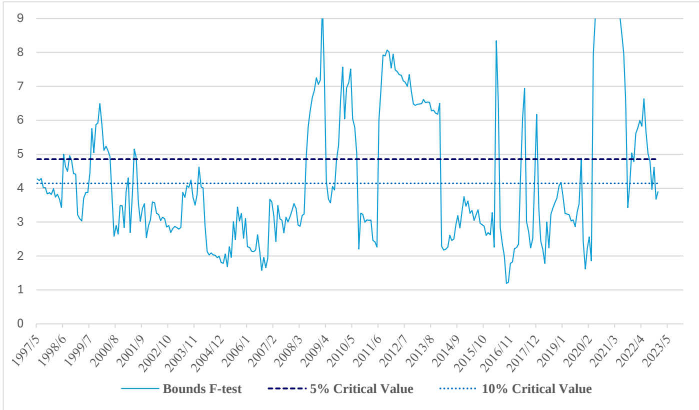

A1b. General Machinery




A1c. Electrical Equipment




A1d. Transport Equipment

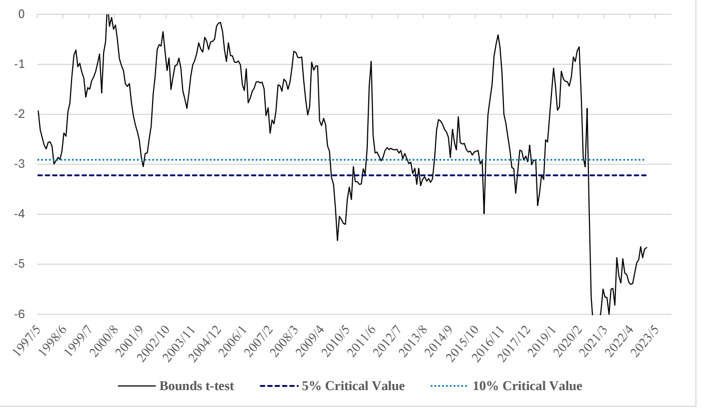



*Note*: The estimated bounds *t*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

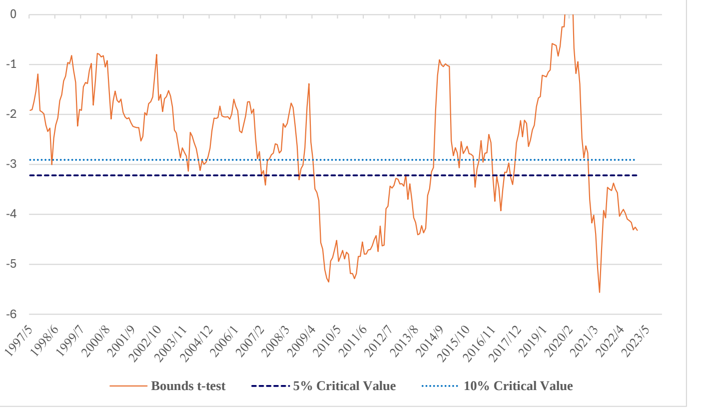
*Source*: Authors' estimation.

**Appendix Figure A2.** Bounds *t*-Test for Rolling ARDL Estimation of Japanese Export Quantity

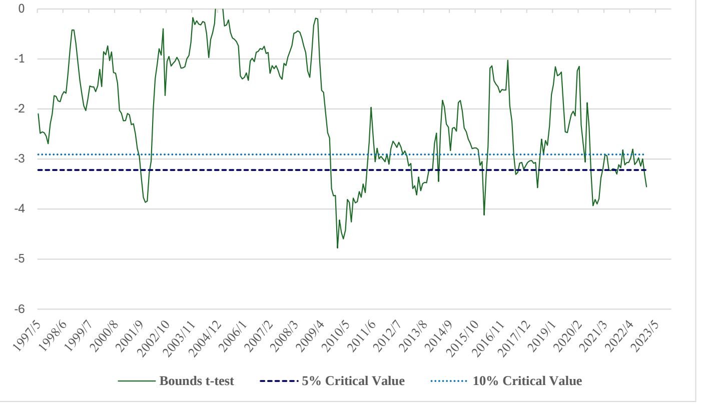
A2a. All Manufacturing



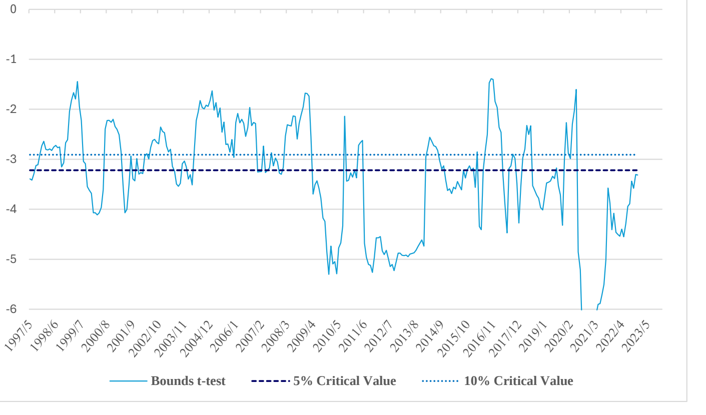

A2b. General Machinery




A2c. Electrical Equipment




A2d. Transport Equipment

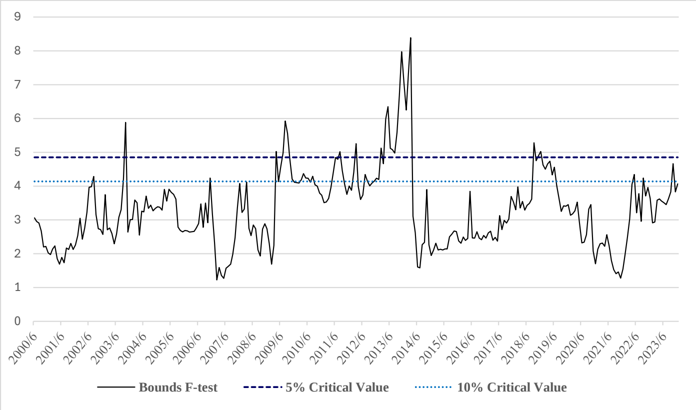



*Note*: The estimated bounds *t*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

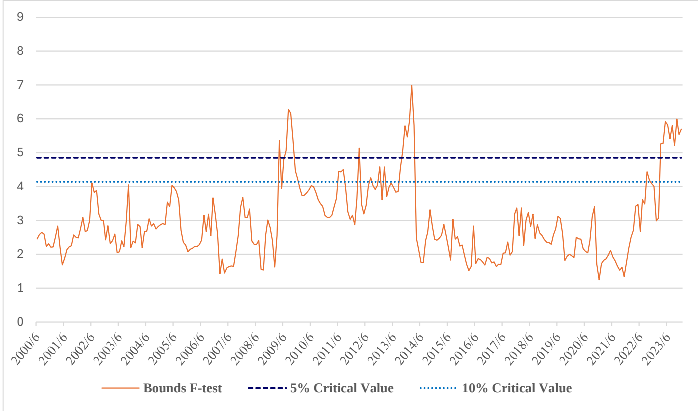
*Source*: Authors' estimation.

**Appendix Figure A3.** Bounds $F$-Test for Rolling ARDL Estimation of Japanese Export Prices

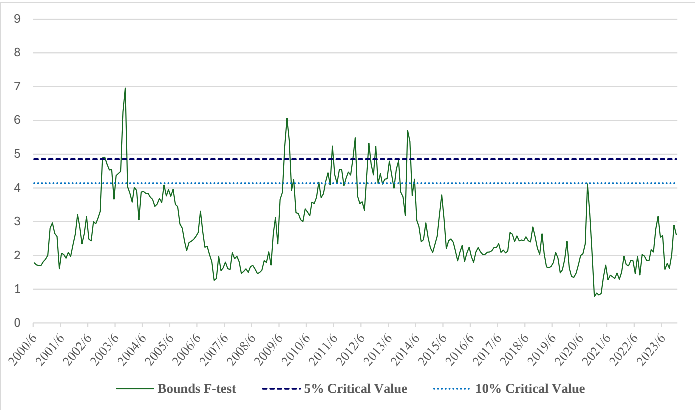
A3a. All Manufacturing



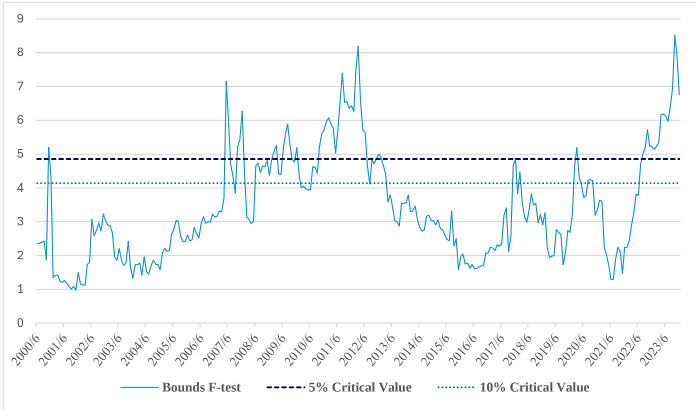

A3b. General Machinery




A3c. Electrical Equipment




A3d. Transport Equipment

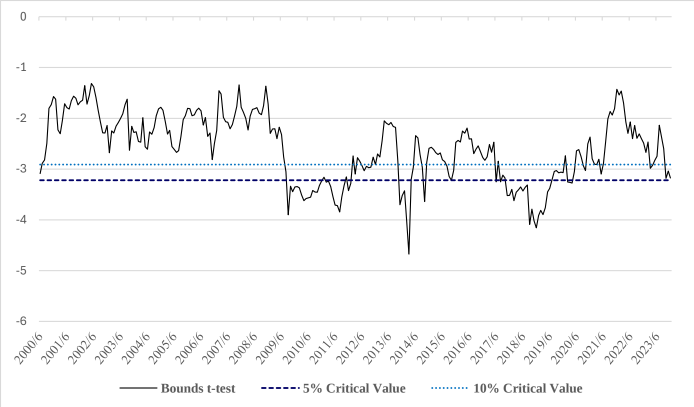



*Note*: The estimated bounds $F$-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

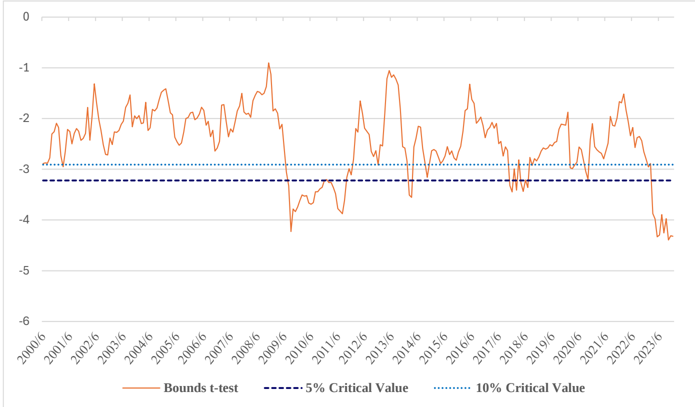
*Source*: Authors' estimation.

**Appendix Figure A4.** Bounds *t*-Test for Rolling ARDL Estimation of Japanese Export Prices

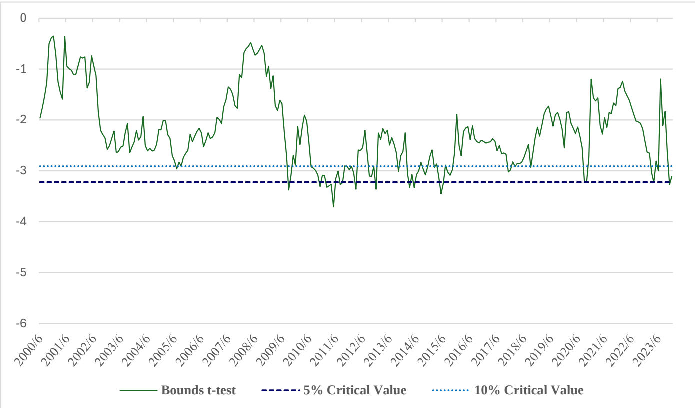
A4a. All Manufacturing



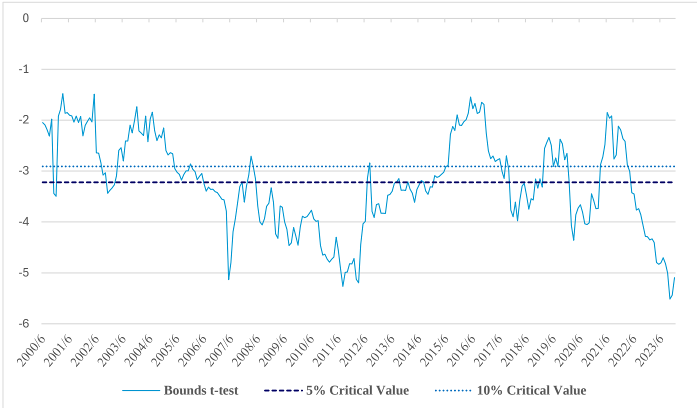

A4b. General Machinery




A4c. Electrical Equipment




A4d. Transport Equipment

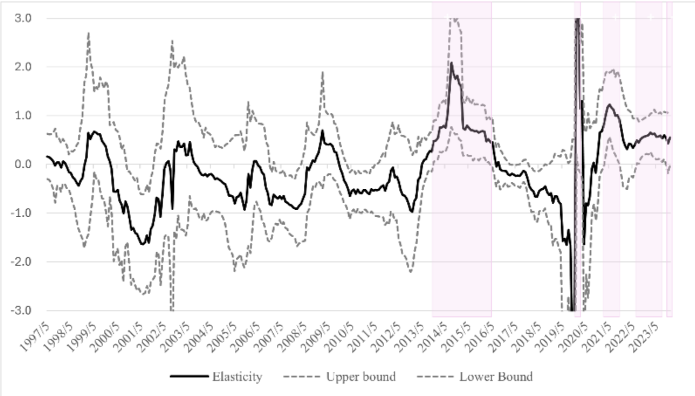



*Note*: The estimated bounds *t*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

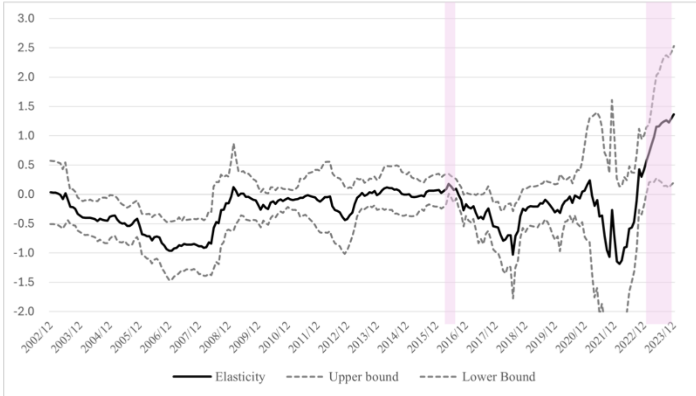
*Source*: Authors' estimation.

**Appendix Figure A5.** Export Quantity Elasticity to Exchange Rates for General Machinery

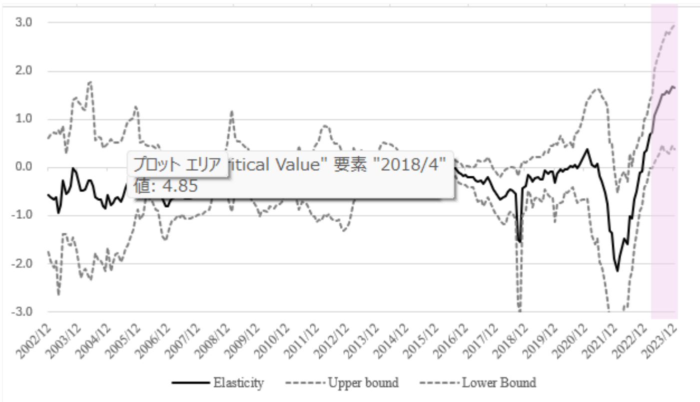
A5a. General Machinery



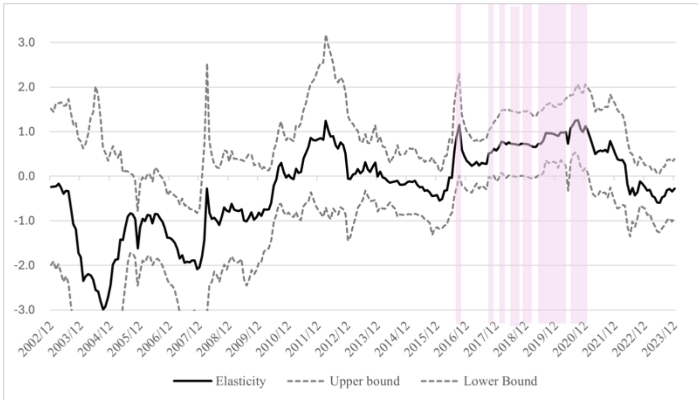

A5b. Power Generating Machinery



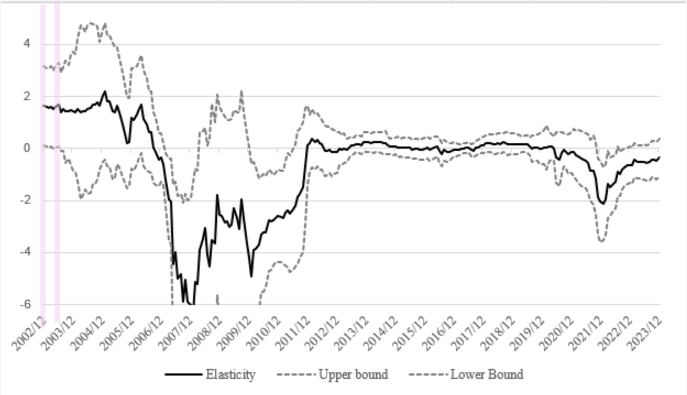

A5c. Internal Combustion Engines



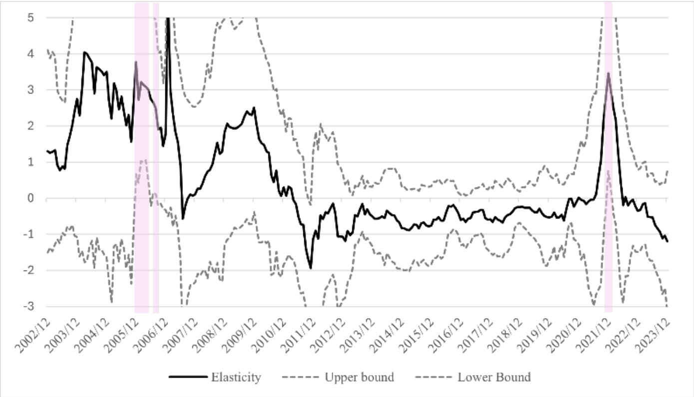

A5d. Agricultural Machinery



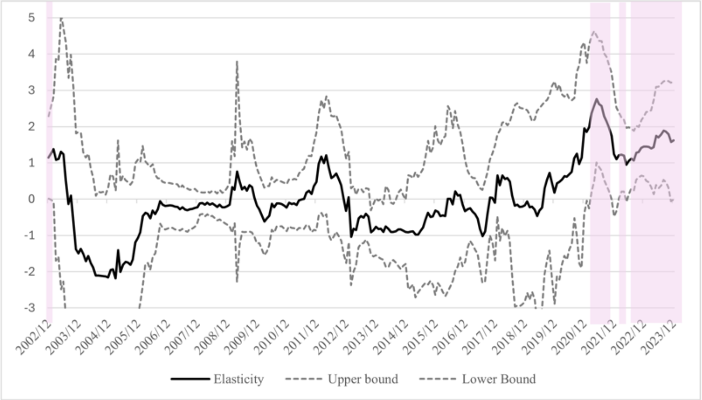
A5e. Office Machines



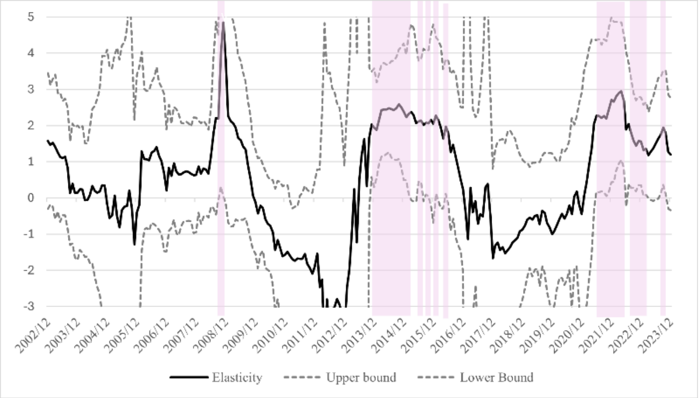

A5f. Other Office Machines



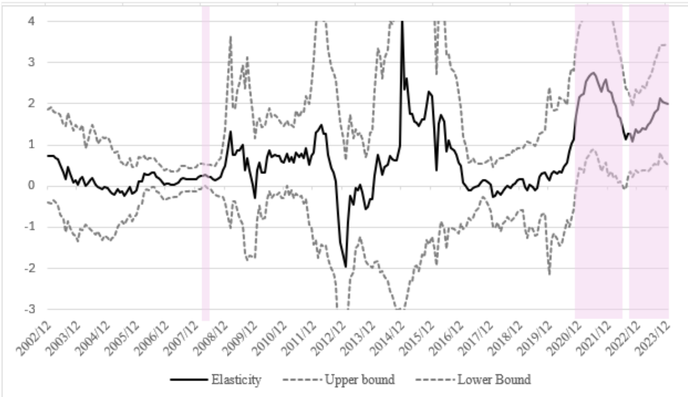

A5g. Metal Working Machines



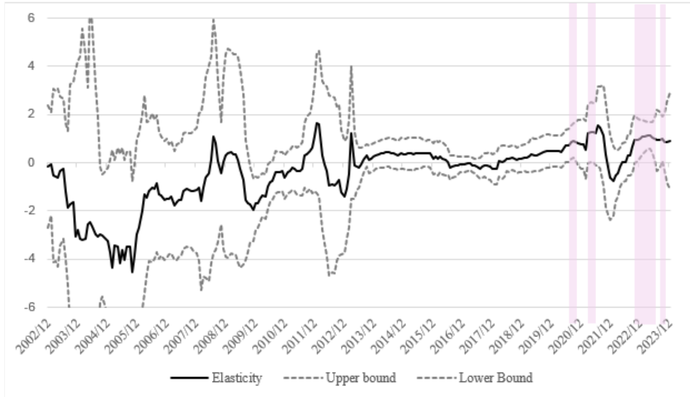

A5h. Textile Machines



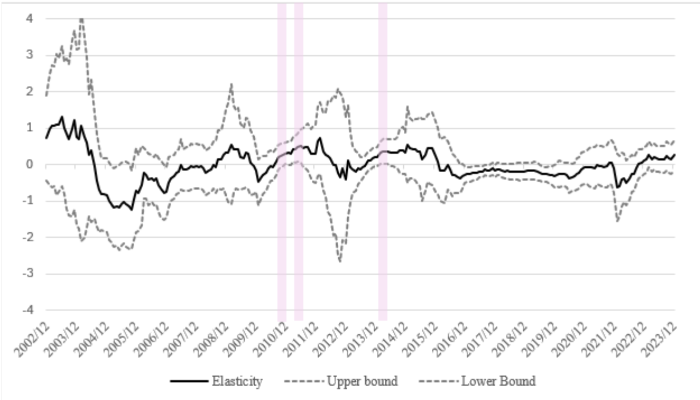
A5i. Construction Machines



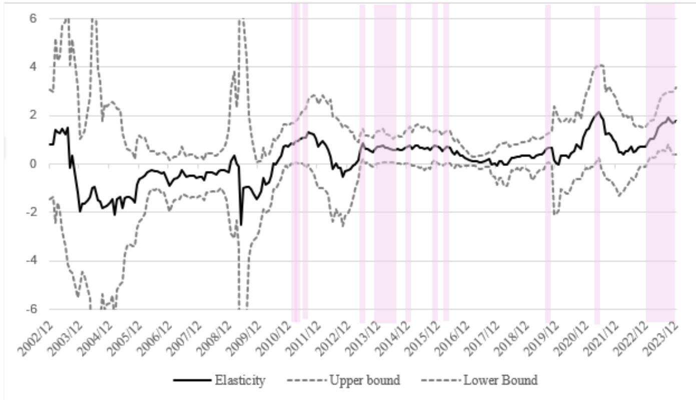

A5j. Heating or Cooling Equipment



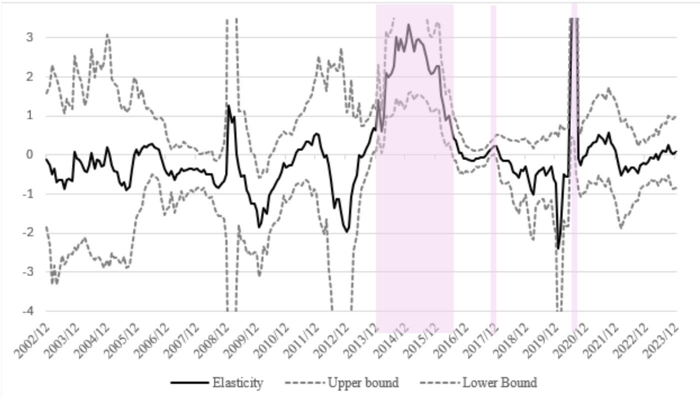

A5k. Pump Centrifuges




A5l. Mechanical Handling Equipment



A5m. Bearings

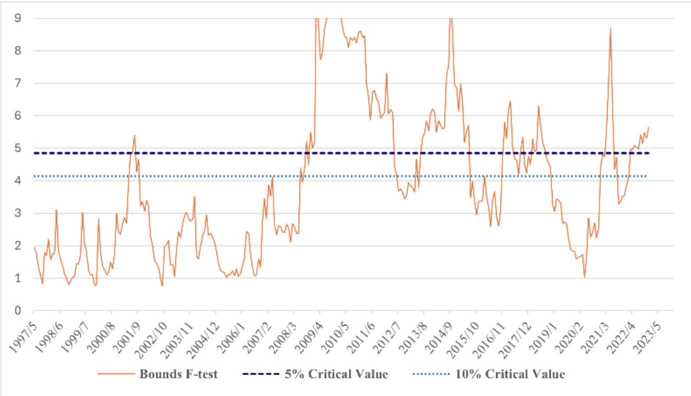



*Note*: The upper and lower bounds denote plus and minus two standard errors. Shaded areas in pink show the statistical significance at least at the 5% level.

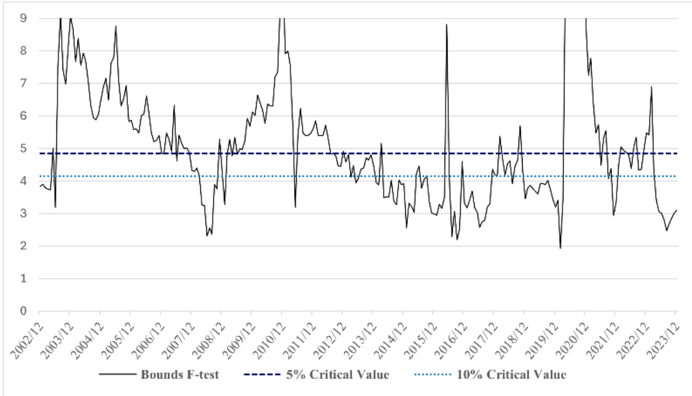
*Source*: Authors' estimation.

**Appendix Figure A6.** Bounds *F*-Test for Rolling ARDL Estimation of Japanese Export Quantity for General Machinery

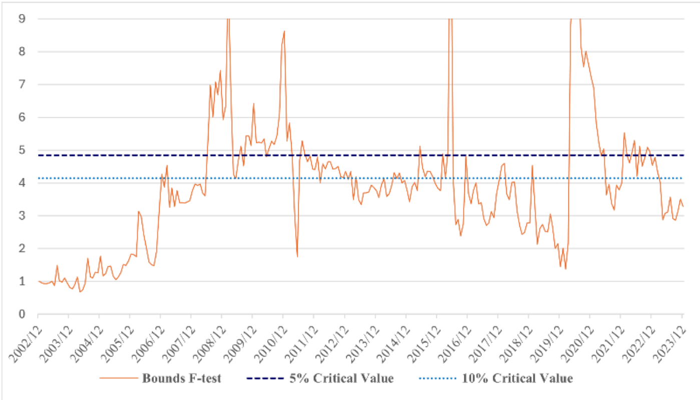
A6a. General Machinery



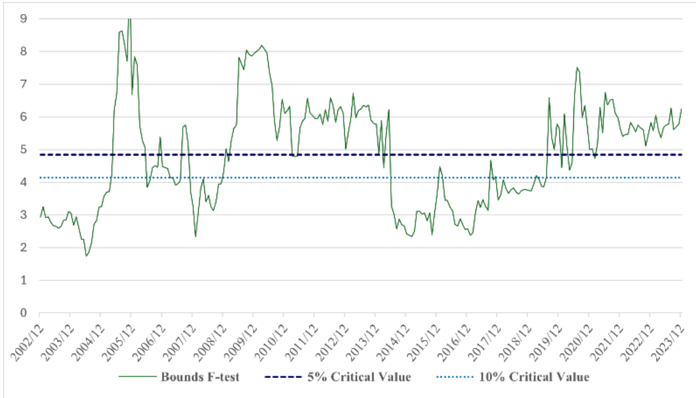

A6b. Power Generating Machinery



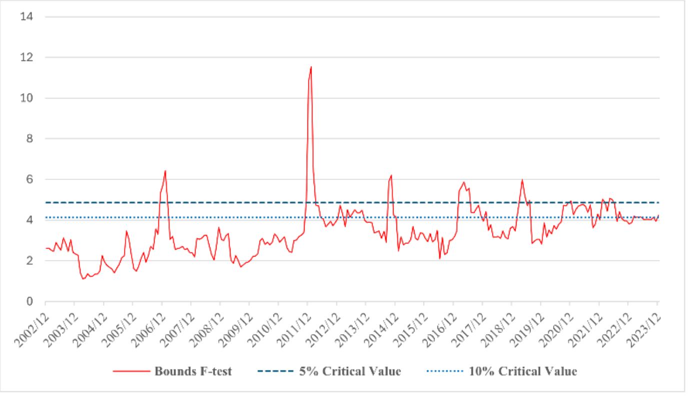

A6c. Internal Combustion Engines



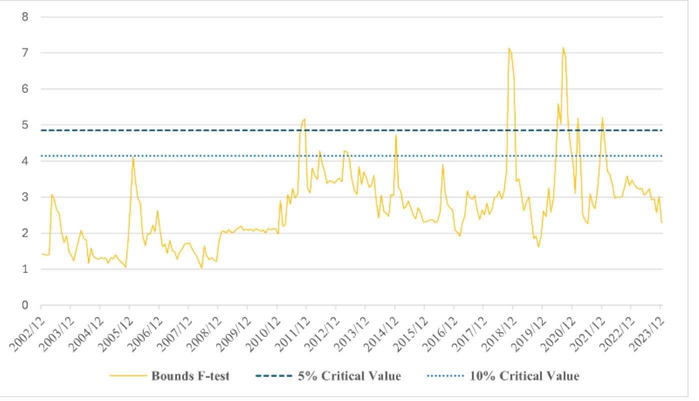

A6d. Agricultural Machinery



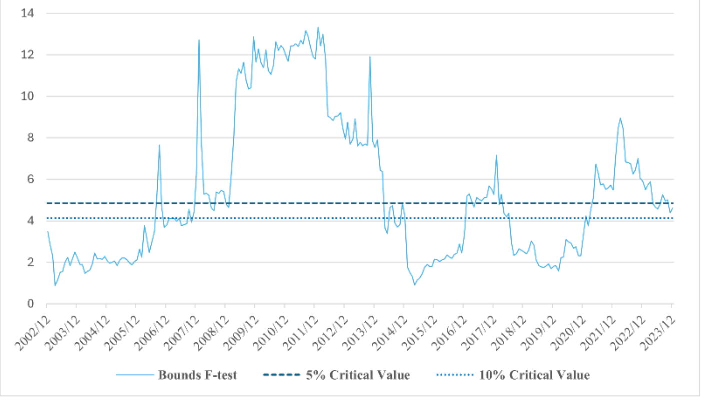
A6e. Office Machines



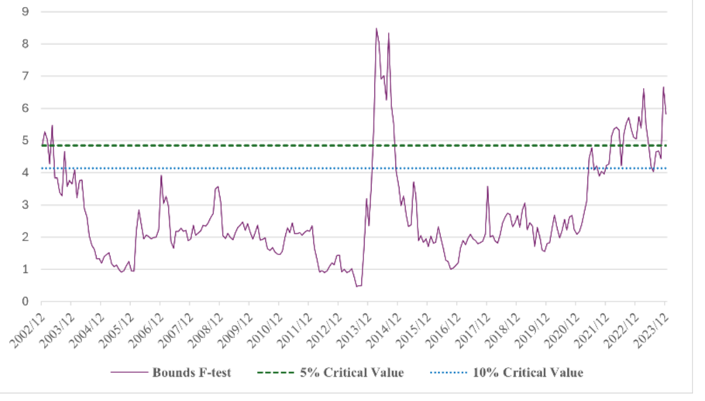

A6f. Other Office Machines



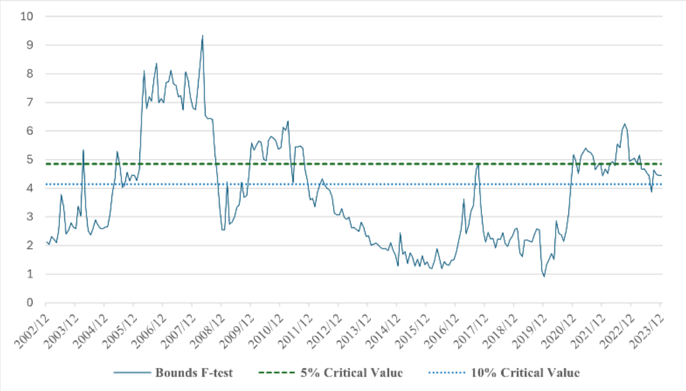

A6g. Metal Working Machines



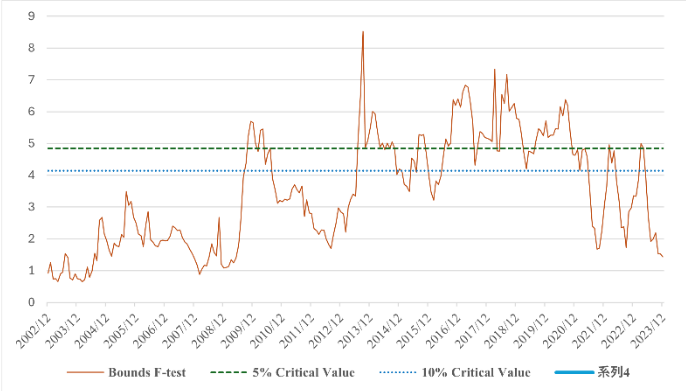

A6h. Textile Machines



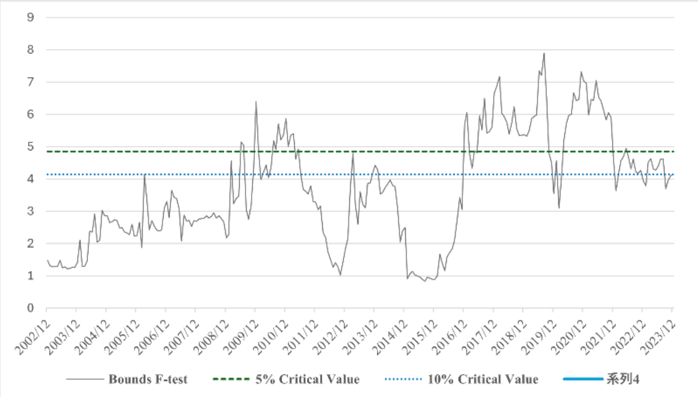
A6i. Construction Machines



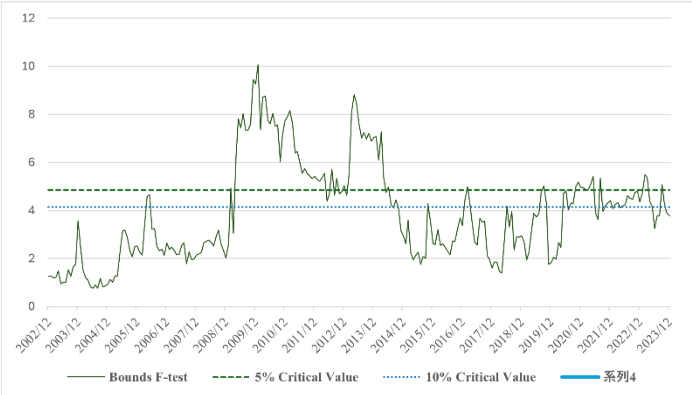

A6j. Heating or Cooling Equipment



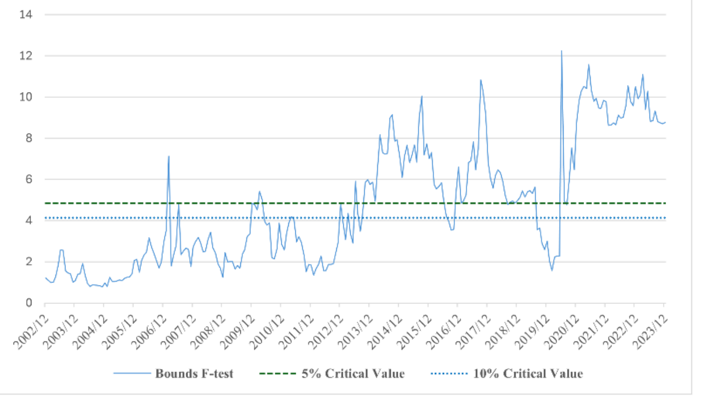

A6k. Pump Centrifuges




A6l. Mechanical Handling Equipment



A6m. Bearings

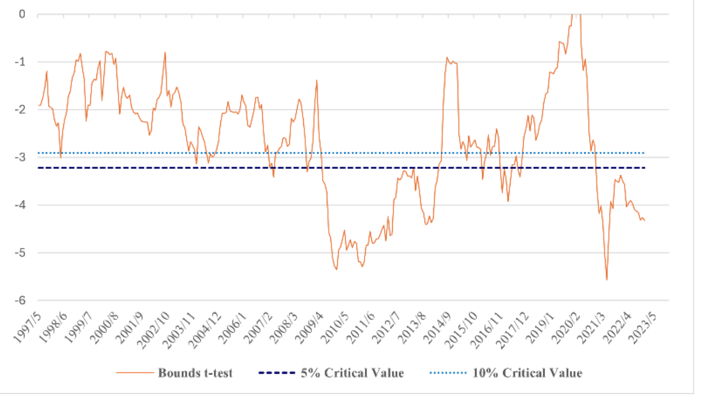



*Note*: The estimated bounds *F*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

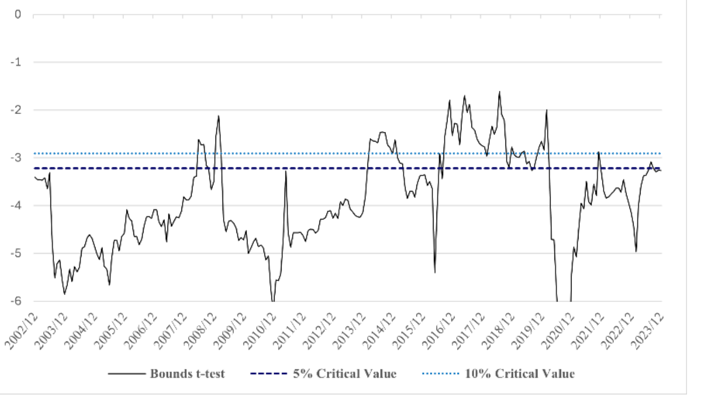
*Source*: Authors' estimation.

**Appendix Figure A7.** Bounds *t*-Test for Rolling ARDL Estimation of Japanese Export Quantity for General Machinery

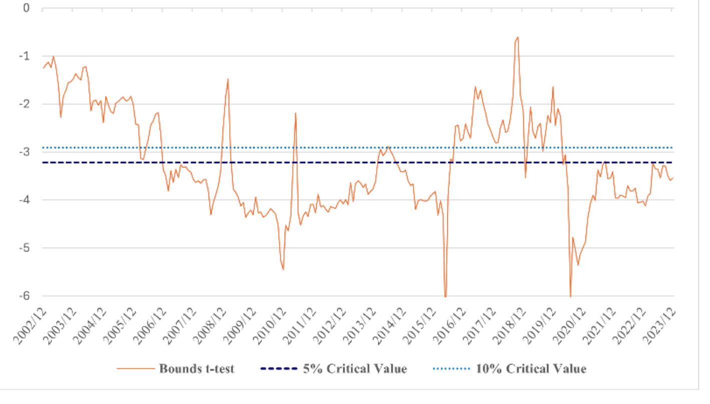
A7a. General Machinery



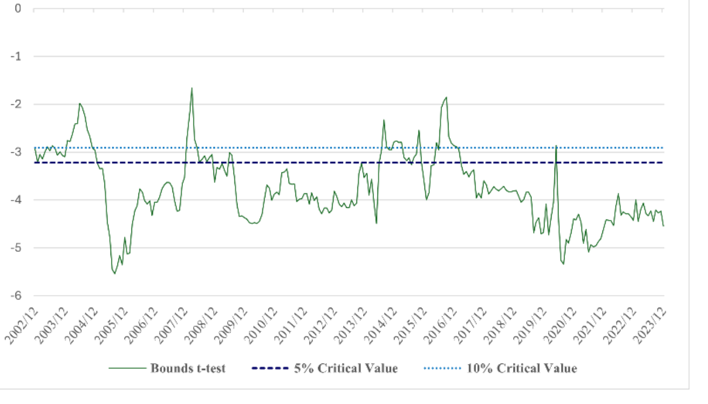

A7b. Power Generating Machinery



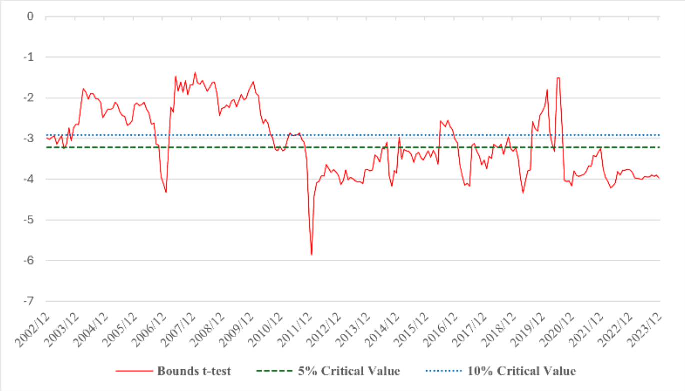

A7c. Internal Combustion Engines



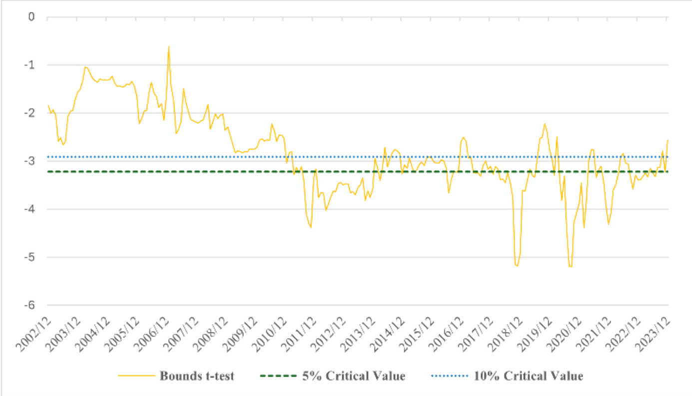

A7d. Agricultural Machinery



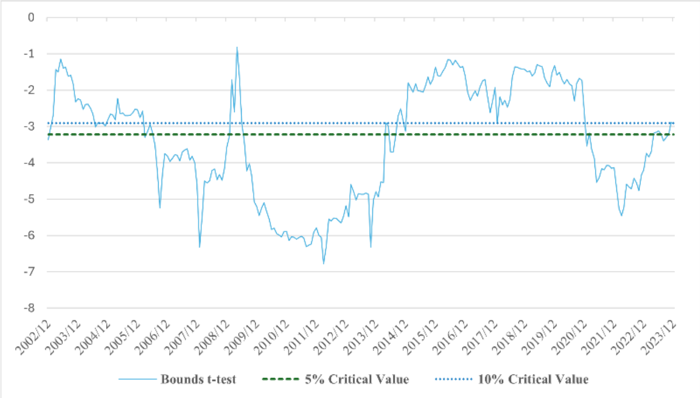
A7e. Office Machines



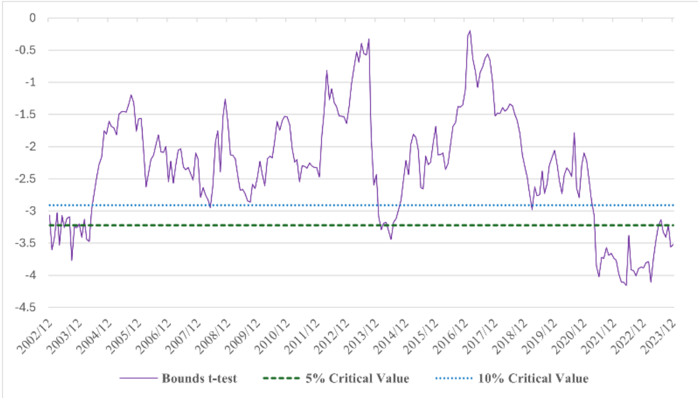

A7f. Other Office Machines



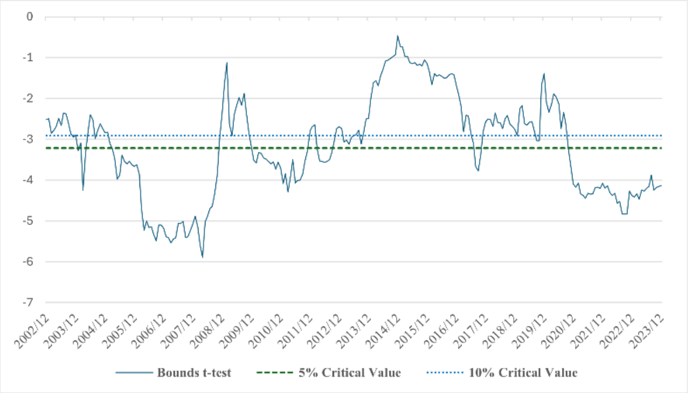

A7g. Metal Working Machines



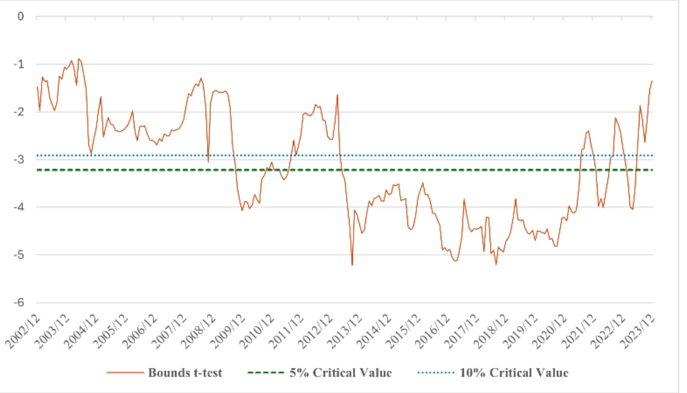

A7h. Textile Machines



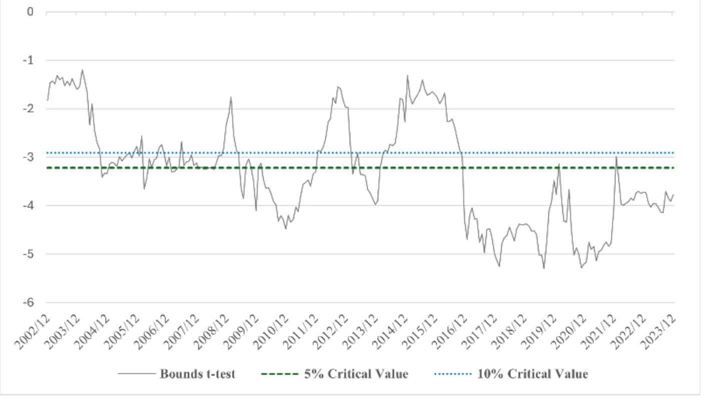
A7i. Construction Machines



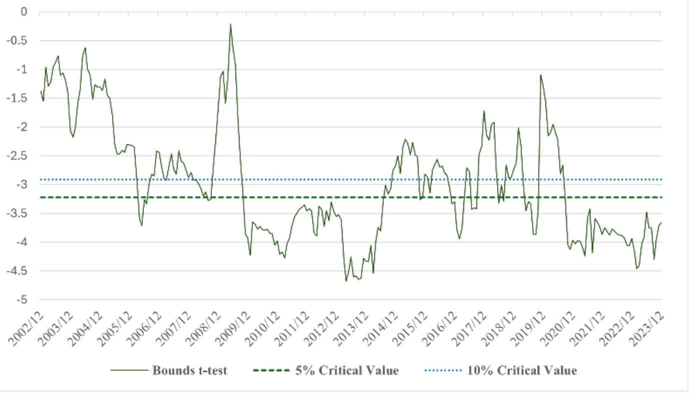

A7j. Heating or Cooling Equipment



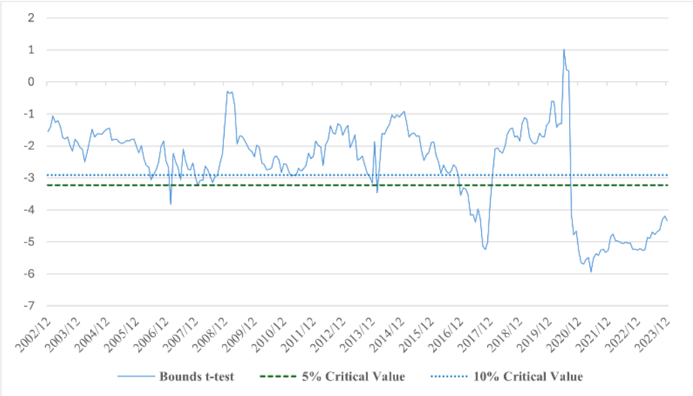

A7k. Pump Centrifuges




A7l. Mechanical Handling Equipment



A7m. Bearings

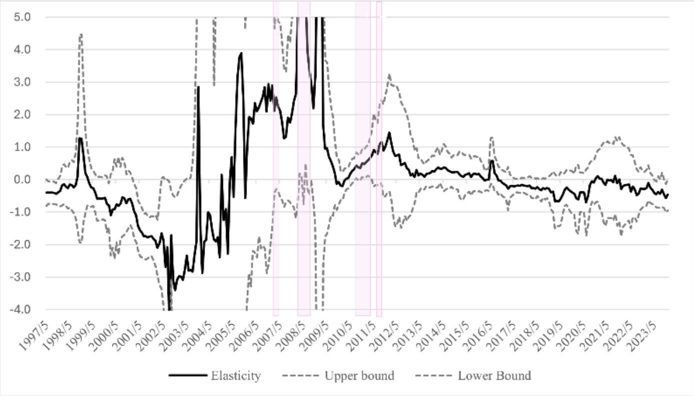



*Note*: The estimated bounds *t*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

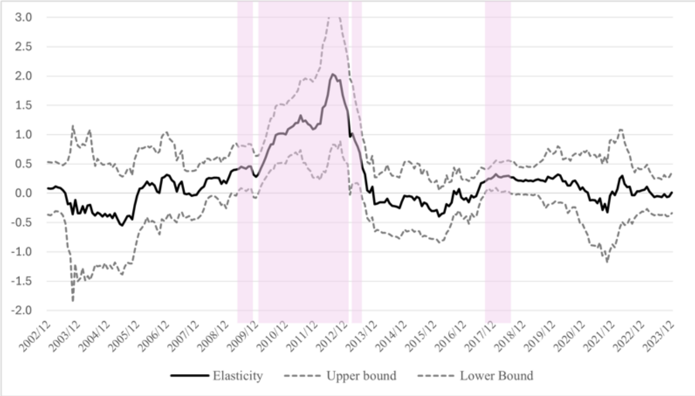
*Source*: Authors' estimation.

**Appendix Figure A8.** Export Quantity Elasticity to Exchange Rates for Electrical Equipment

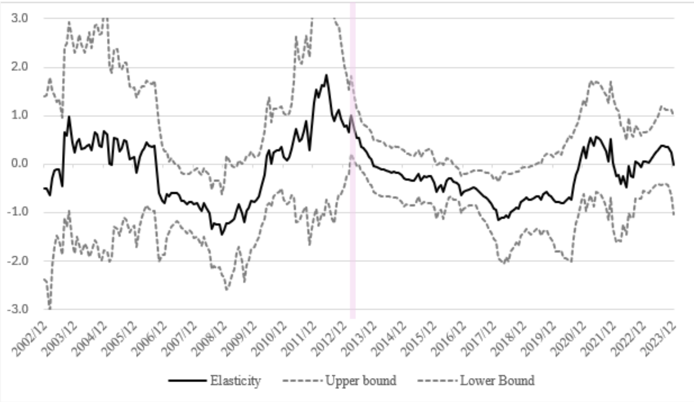
A8a. Electrical Equipment



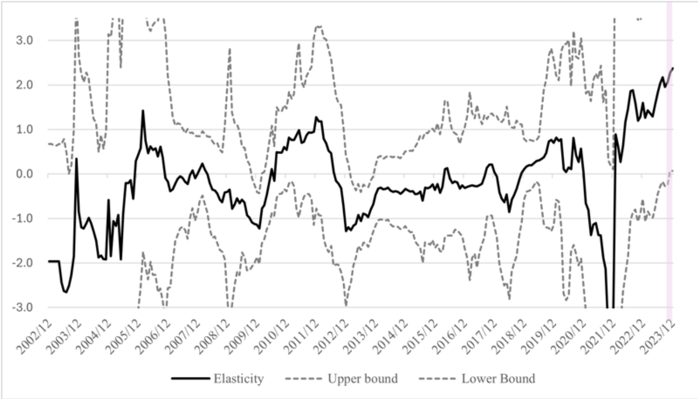

A8b. Electric Power Machinery



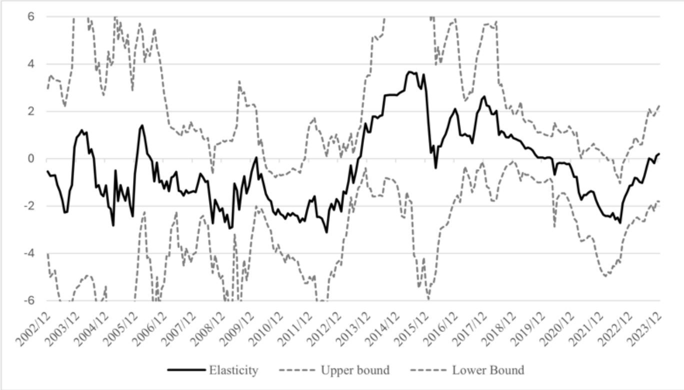

A8c. Insulated Wire and Cable



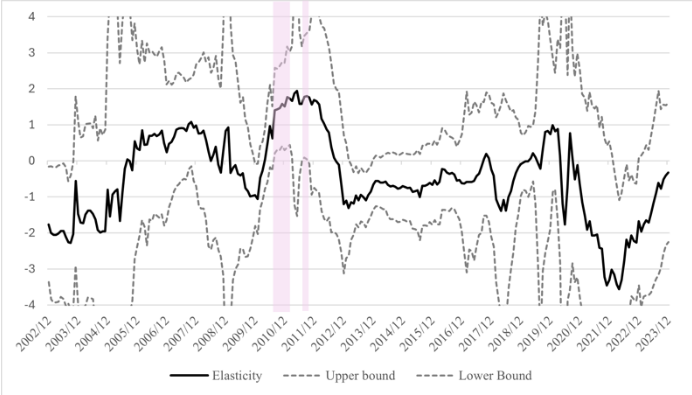

A8d. Visual Apparatus



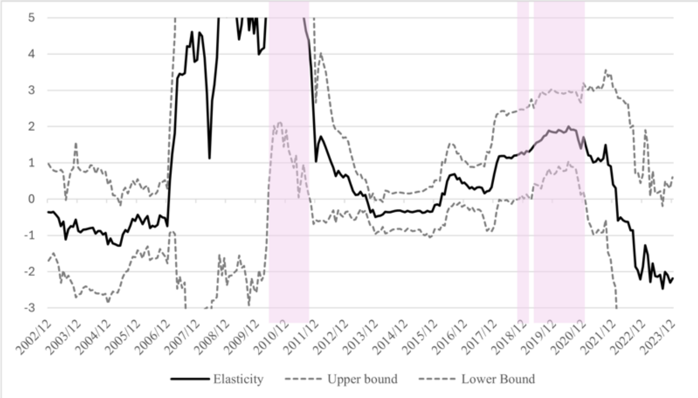
A8e. T.V. Receivers



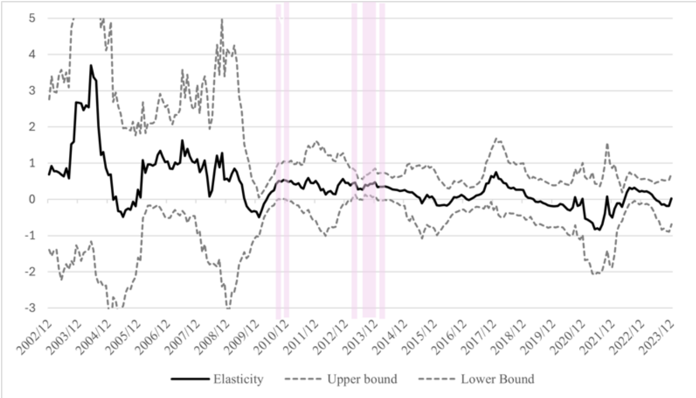

A8f. Video Tape Recorder



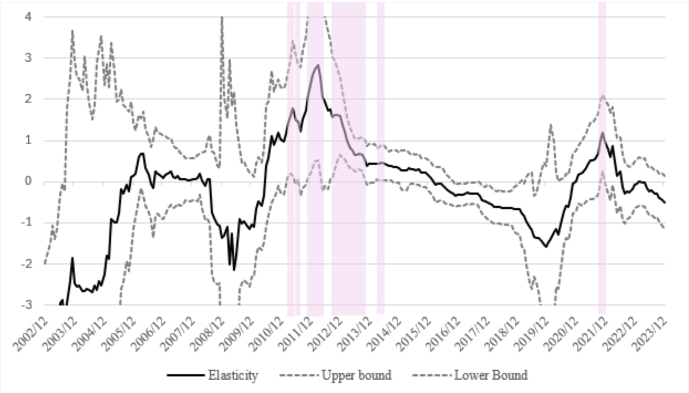

A8g. Telecommunication Equipment



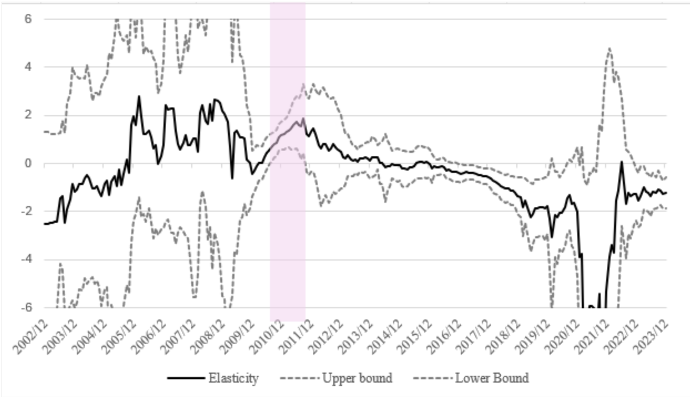

A8h. Domestic Electrical Equipment



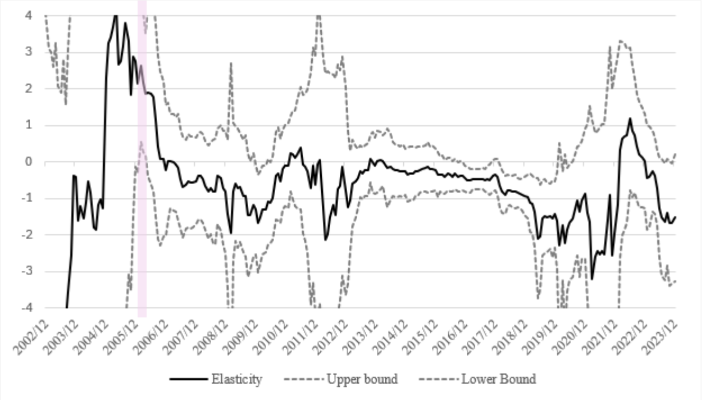
A8i. Batteries and Accumulators



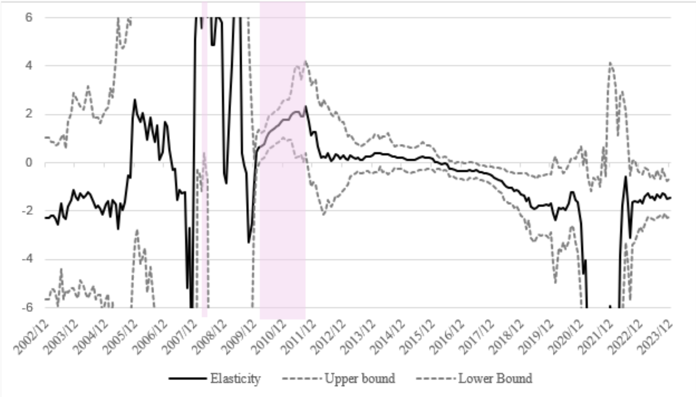

A8j. Thermionic Valves, Tubes, Transistors, etc.



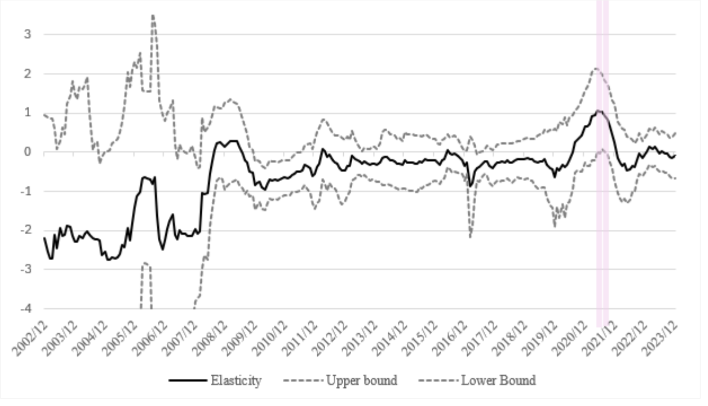

A8k. Transistors and Diodes



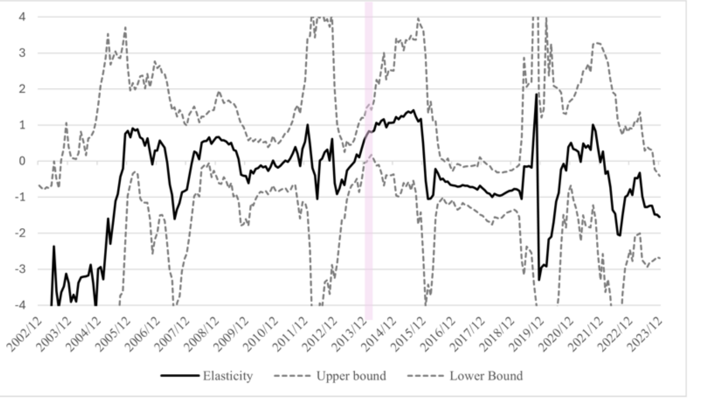

A8l. Electronic Integrated Circuits



A8m. Electronic Measuring & Controlling Instrument




A8n. Condenser

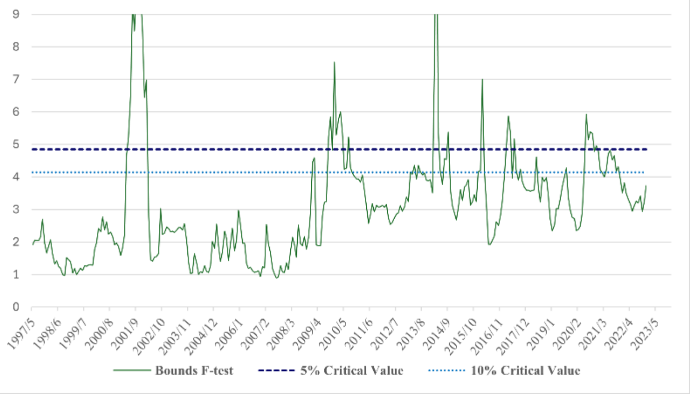



*Note*: The upper and lower bounds denote plus and minus two standard errors. Shaded areas in pink show the statistical significance at least at the 5% level.

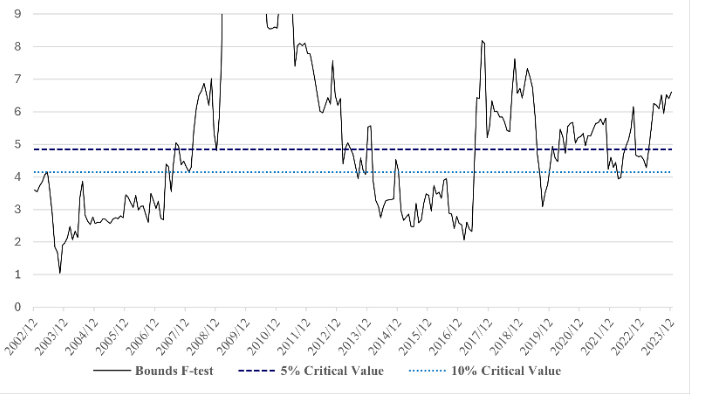
*Source*: Authors' estimation.

**Appendix Figure A9.** Bounds *F*-Test for Rolling ARDL Estimation of Japanese Export Quantity for Electrical Equipment

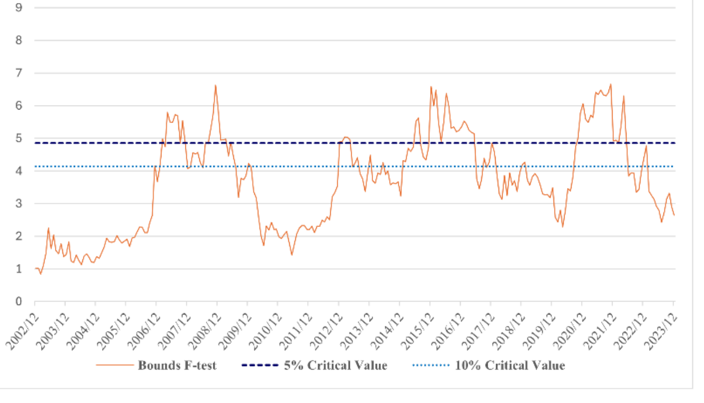
A9a. Electrical Equipment



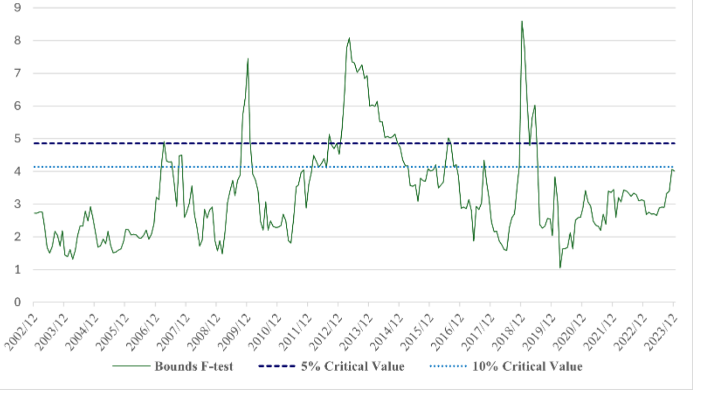

A9b. Electric Power Machinery



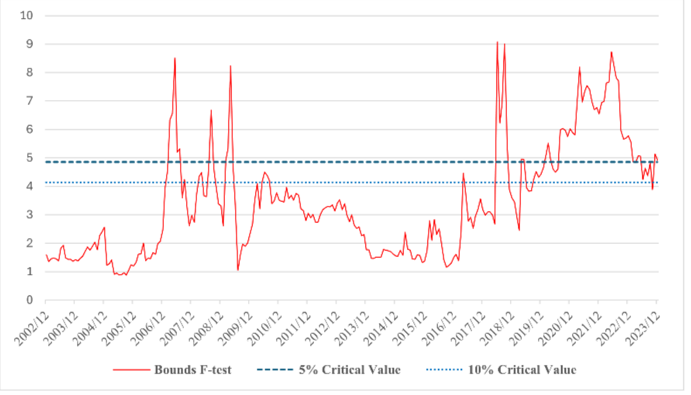

A9c. Insulated Wire, Cable



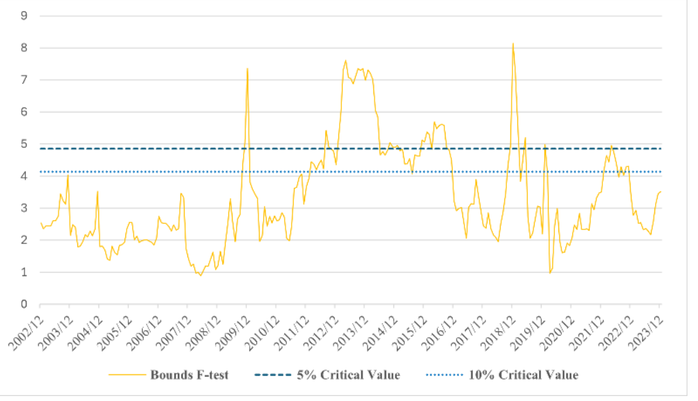

A9d. Visual Apparatus



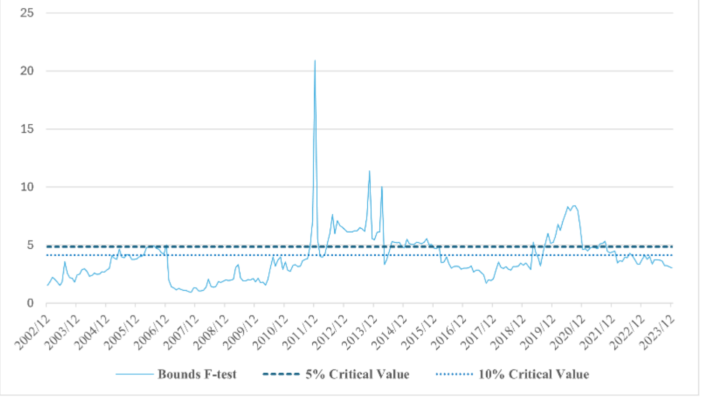
A9e. T.V. Receivers



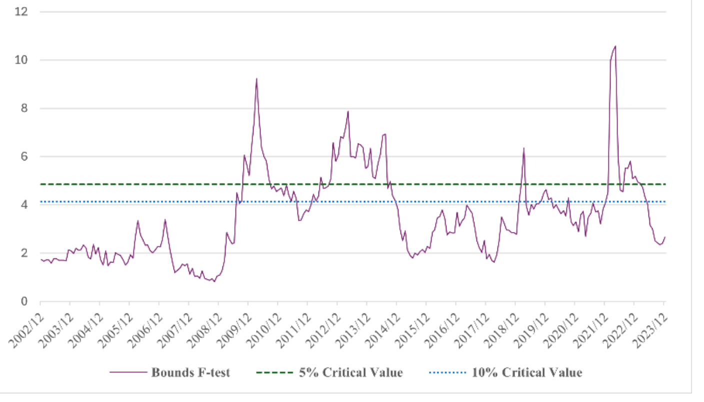

A9f. Video Tape Recorder



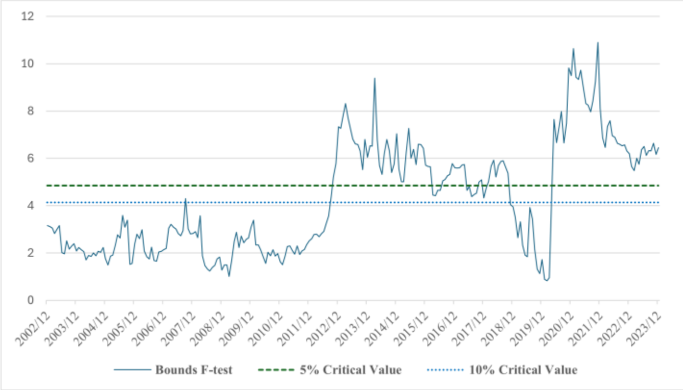

A9g. Telecommunication Equipment



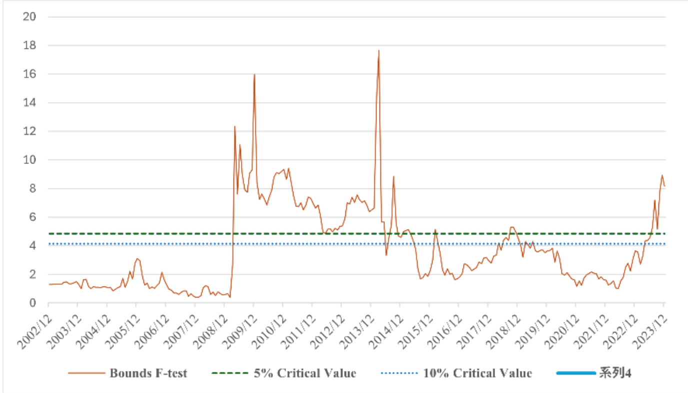

A9h. Domestic Electrical Equipment



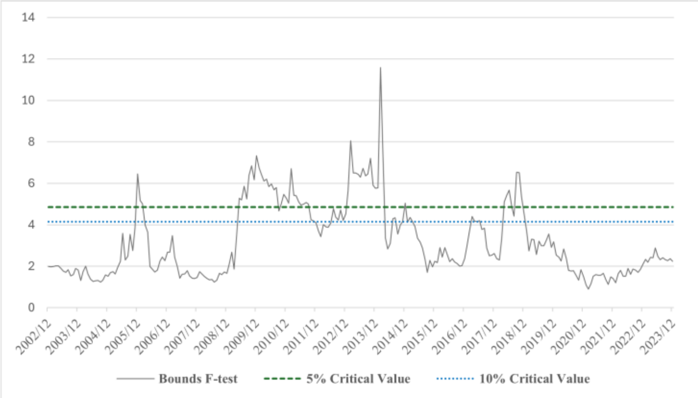
A9i. Batteries and Accumulators



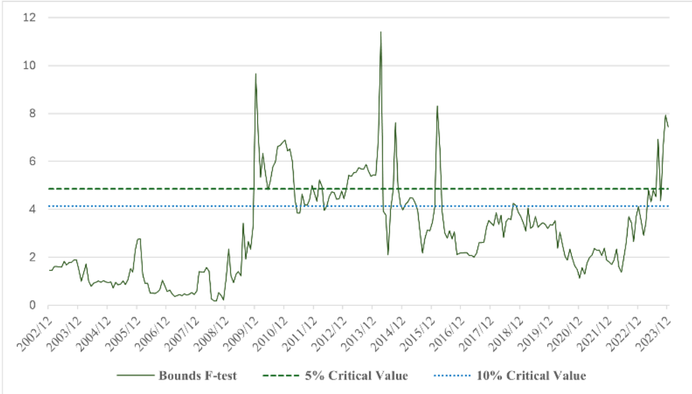

A9j. Thermionic Valves, Tubes, Transistors, etc.



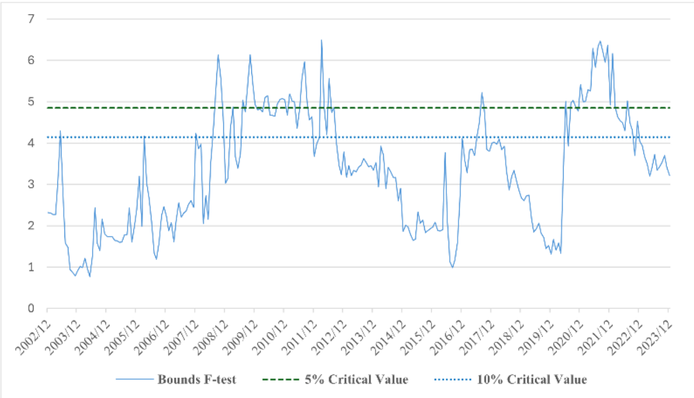

A9k. Transistors and Diodes



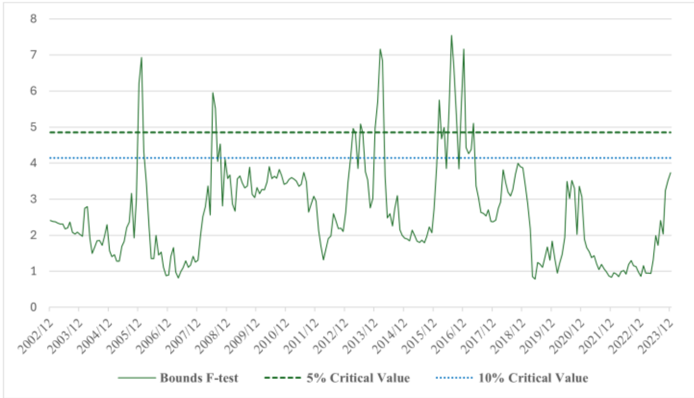

A9l. Electronic Integrated Circuits



A9m. Elect. Measuring & Controlling Instrument




A9n. Condenser

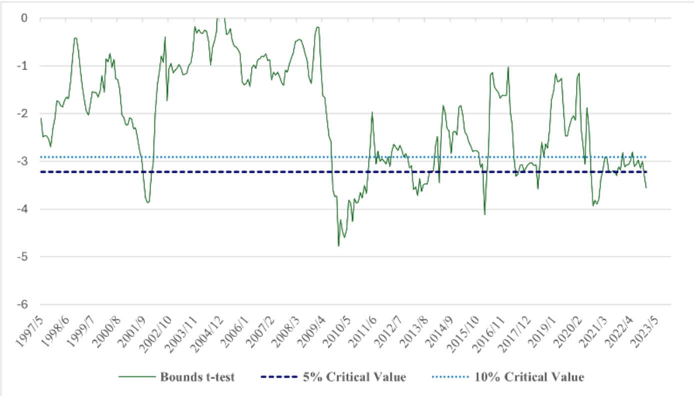



*Note*: The estimated bounds *F*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

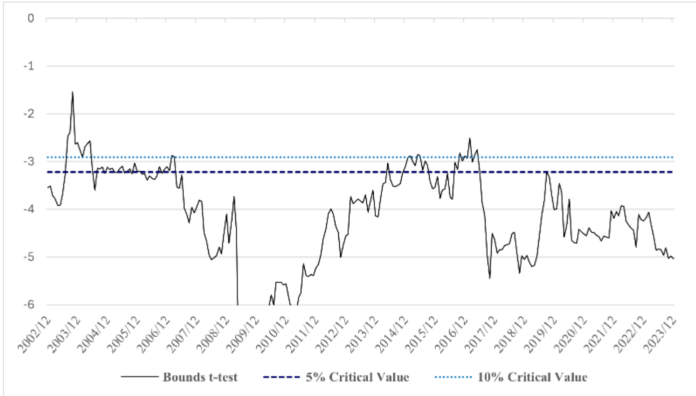
*Source*: Authors' estimation.

**Appendix Figure A10.** Bounds *t*-Test for Rolling ARDL Estimation of Japanese Export Quantity for Electrical Equipment

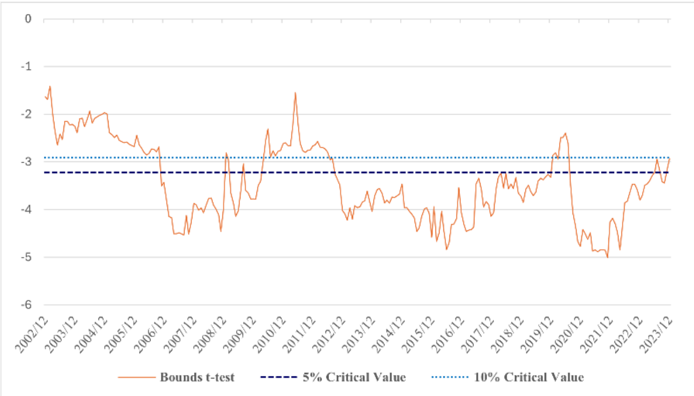
A10a. Electrical Equipment



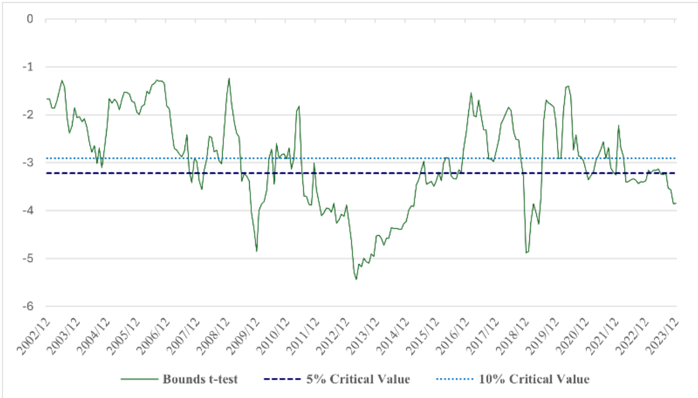

A10b. Electric Power Machinery



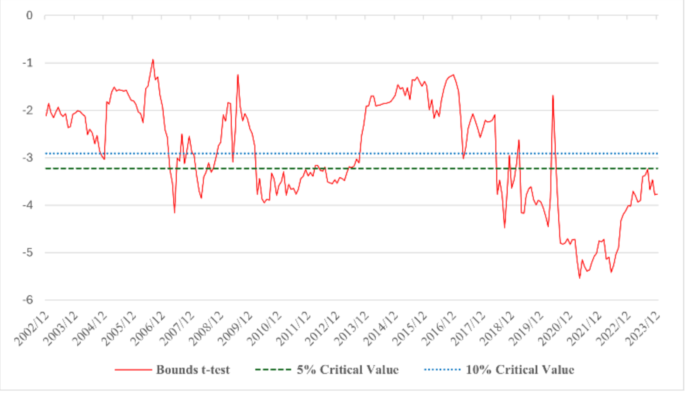

A10c. Insulated Wire, Cable



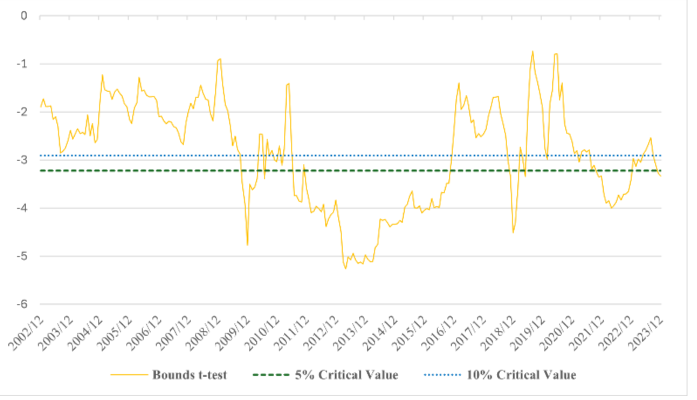

A10d. Visual Apparatus



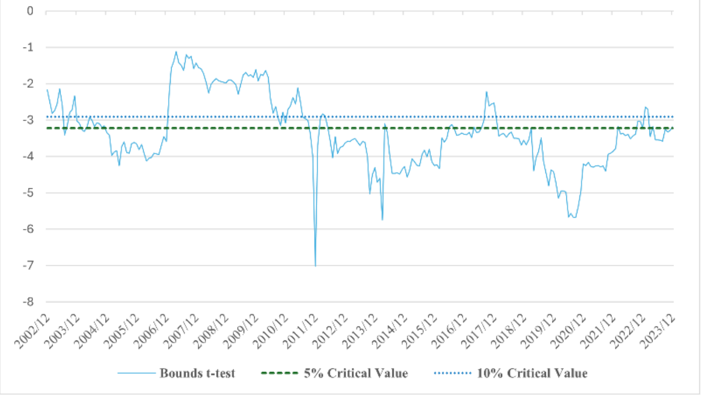
A10e. T.V. Receivers



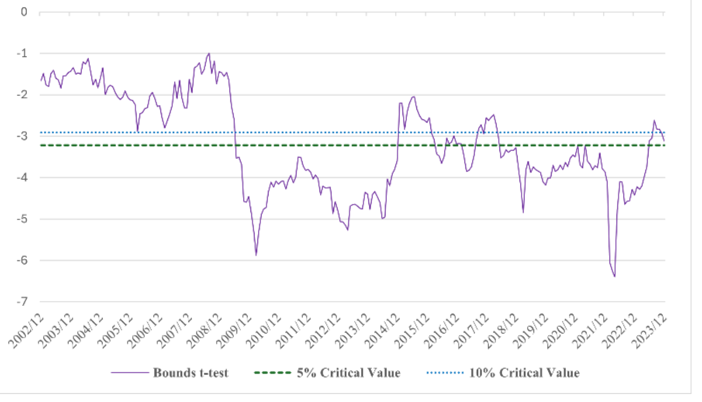

A10f. Video Tape Recorder



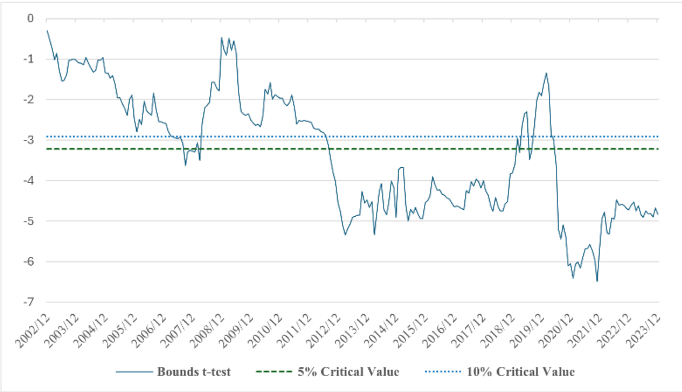

A10g. Telecommunication Equipment



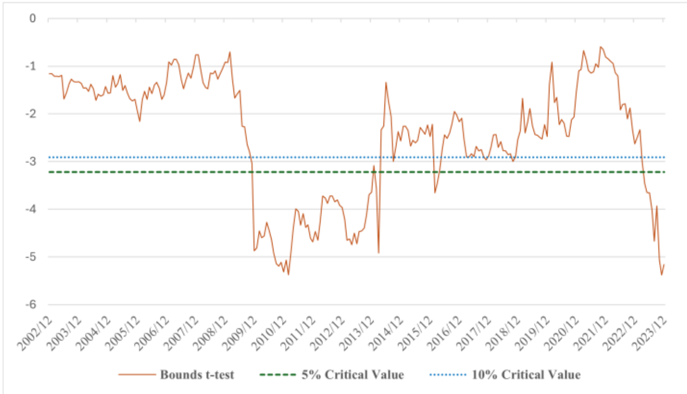

A10h. Domestic Electrical Equipment



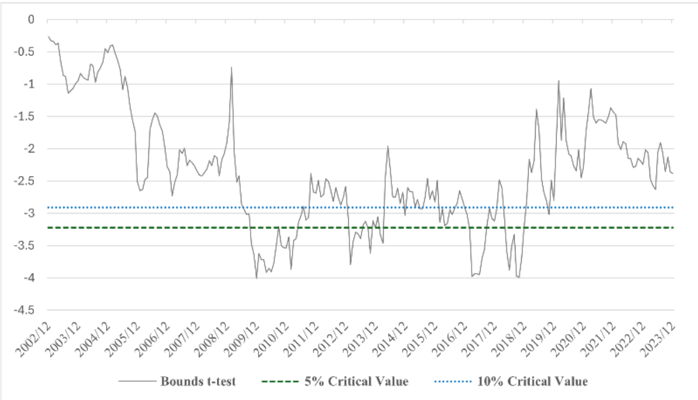
A10i. Batteries and Accumulators



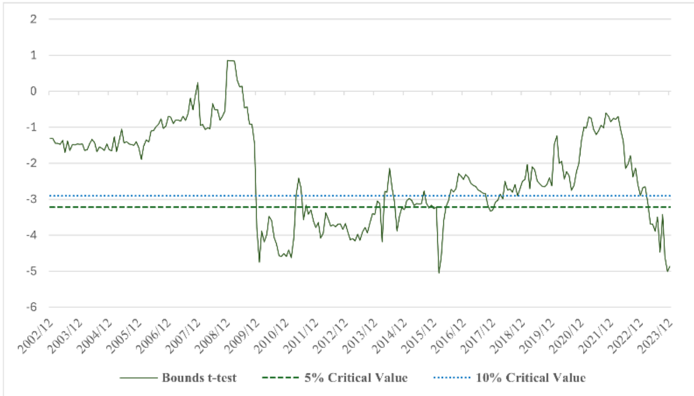

A10j. Thermionic Valves, Tubes, Transistors, etc.



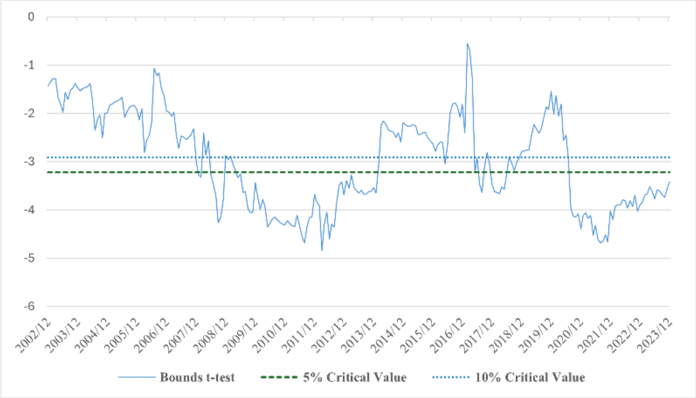

A10k. Transistors and Diodes



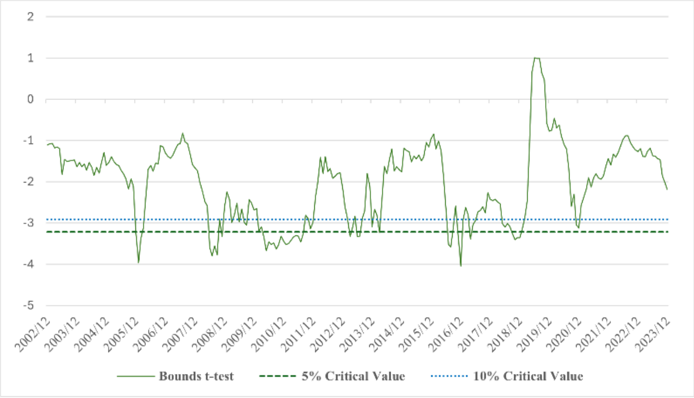

A10l. Electronic Integrated Circuits



A10m. Electronic Measuring & Controlling Instrument




A10n. Condenser

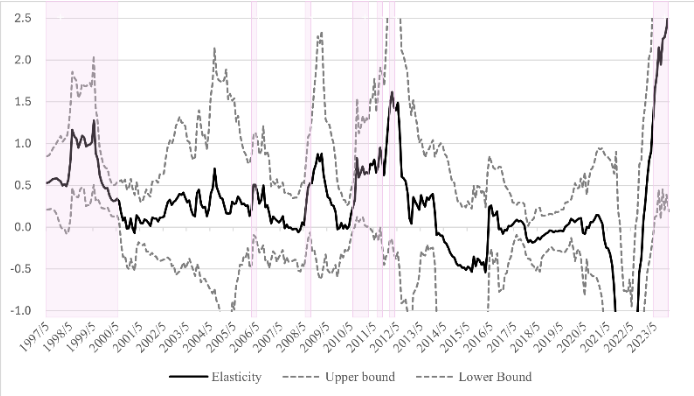



*Note*: The estimated bounds *t*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

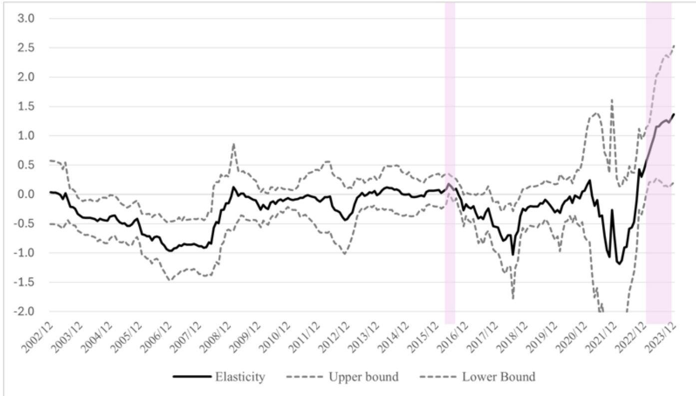
*Source*: Authors' estimation.

**Appendix Figure A11.** Export Quantity Elasticity to Exchange Rates for Transport Equipment

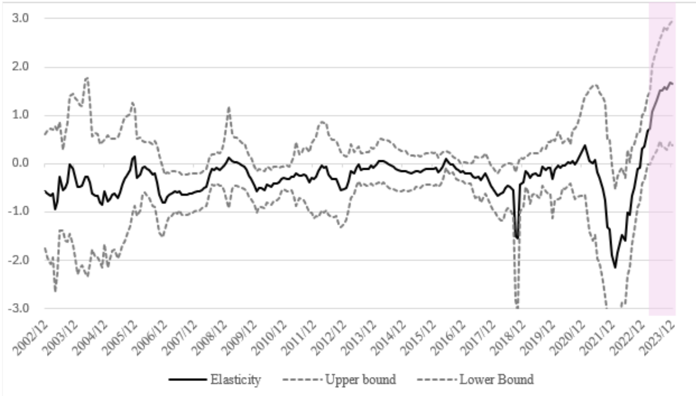
A11a. Transport Equipment



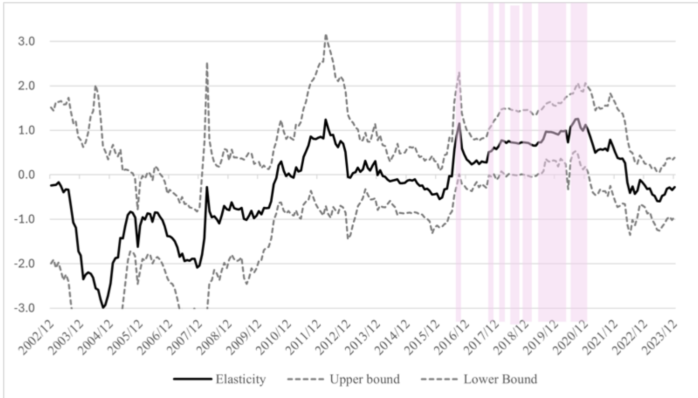

A11b. Motor Vehicles




A11c. Passenger Motor Car




A11d. Parts of Motor Vehicles

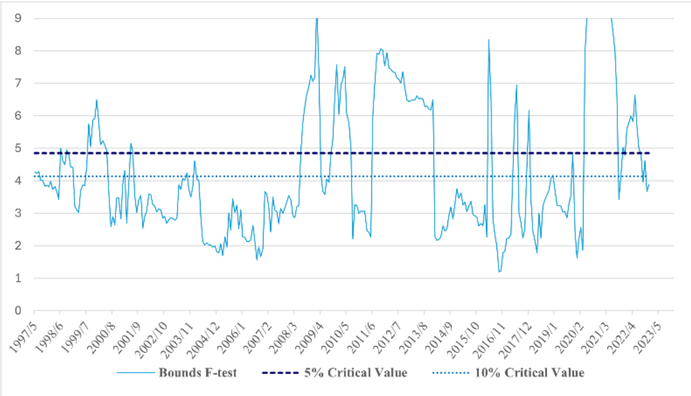



*Note*: The upper and lower bounds denote plus and minus two standard errors. Shaded areas in pink show the statistical significance at least at the 5% level.

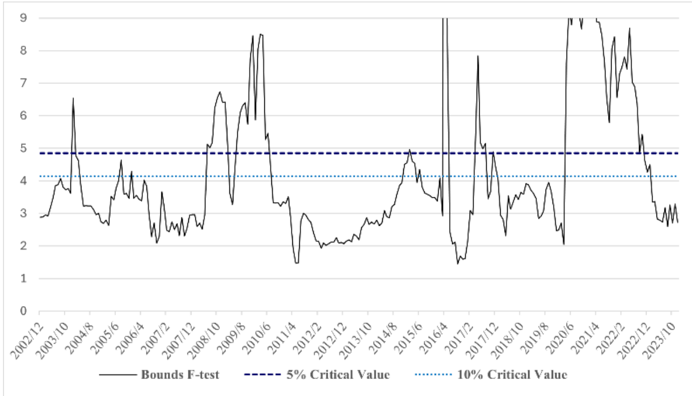
*Source*: Authors' estimation.

**Appendix Figure A12.** Bounds *F*-Test for Rolling ARDL Estimation of Japanese Export Quantity for Transport Equipment

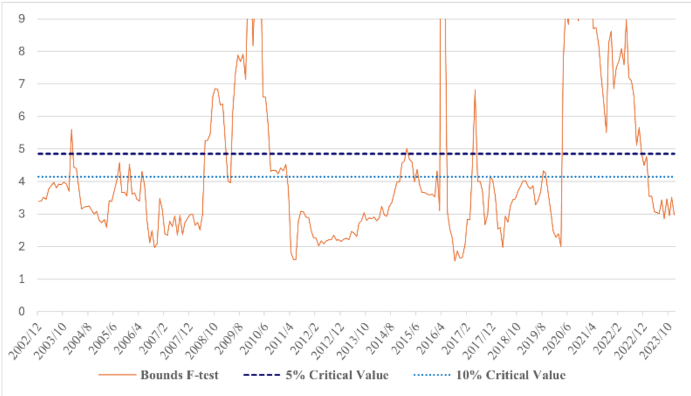
A12a. Transport Equipment



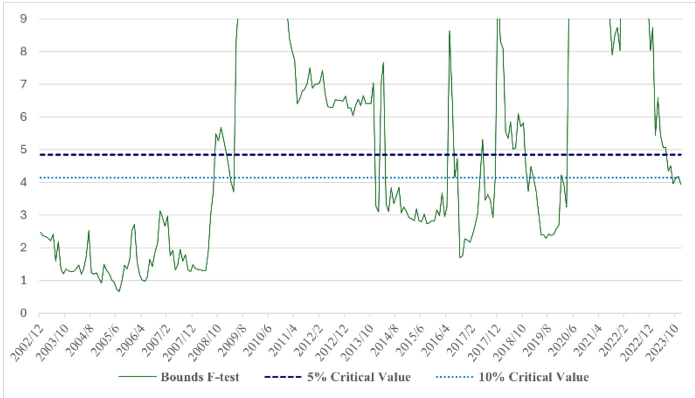

A12b. Motor Vehicles




A12c. Passenger Motor Car




A12d. Parts of Motor Vehicles

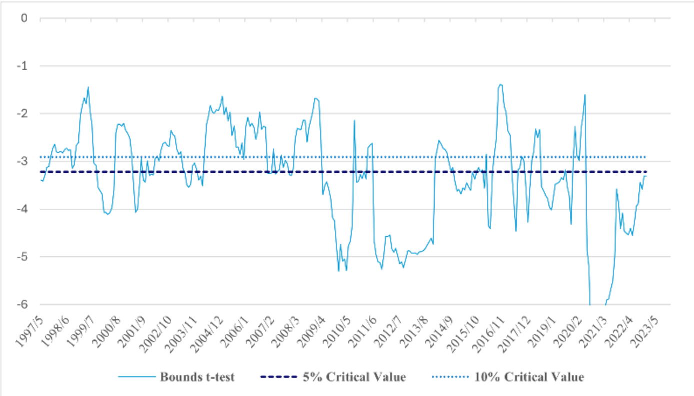



*Note*: The estimated bounds *F*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

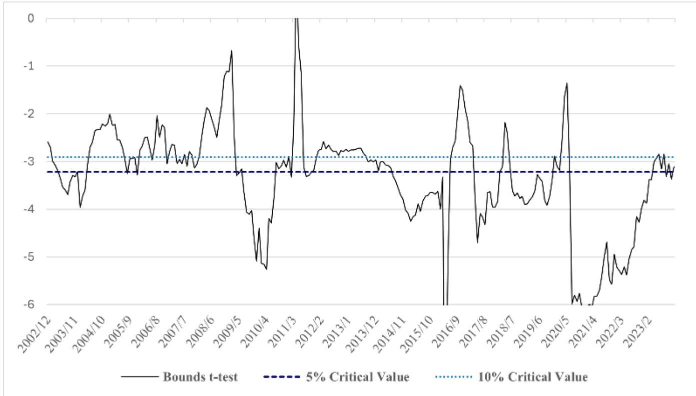
*Source*: Authors' estimation.

**Appendix Figure A13.** Bounds *t*-Test for Rolling ARDL Estimation of Japanese Export Quantity for Transport Equipment

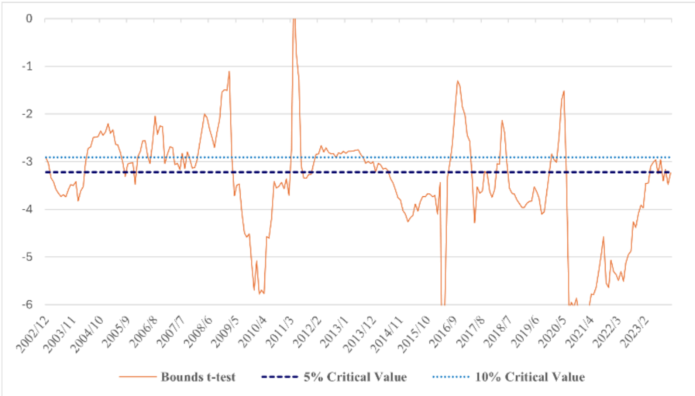
A13a. Transport Equipment



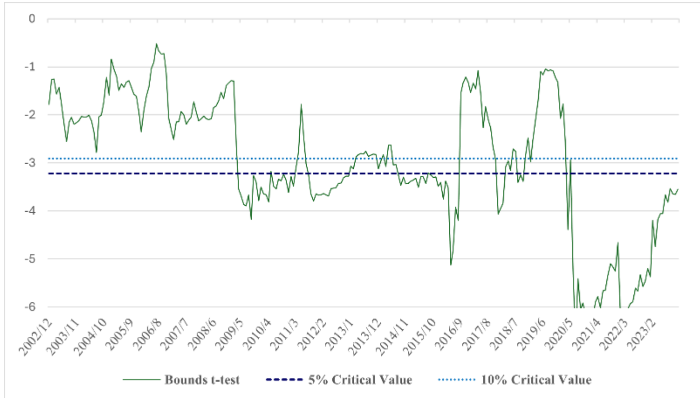

A13b. Motor Vehicles




A13c. Passenger Motor Car




A13d. Parts of Motor Vehicles

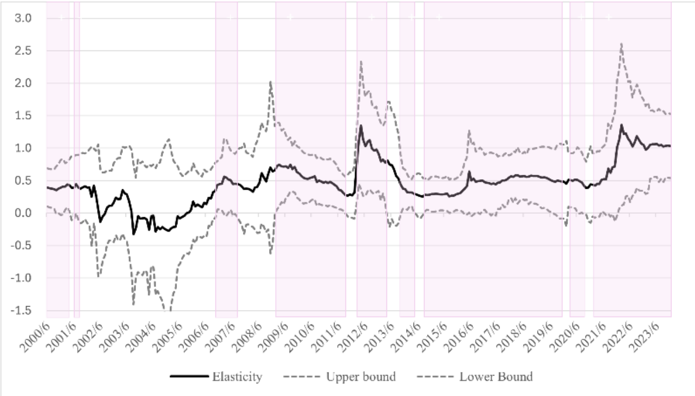



*Note*: The estimated bounds *t*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

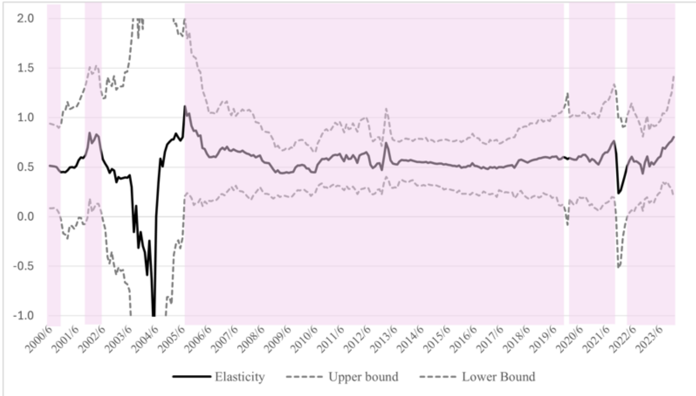
*Source*: Authors' estimation.

**Appendix Figure A14.** Export Price Elasticity to Exchange Rates for General Machinery

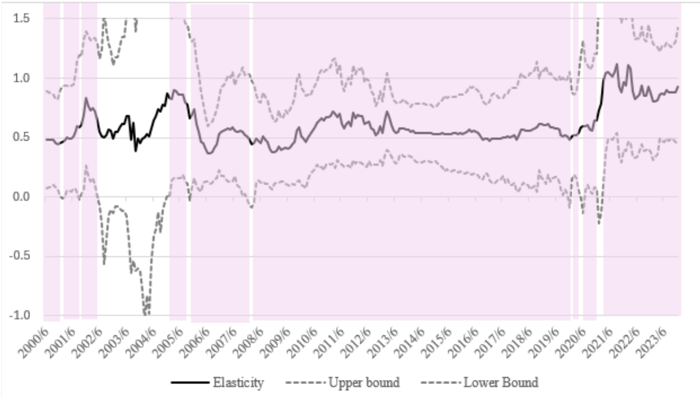
A14a. General Machinery



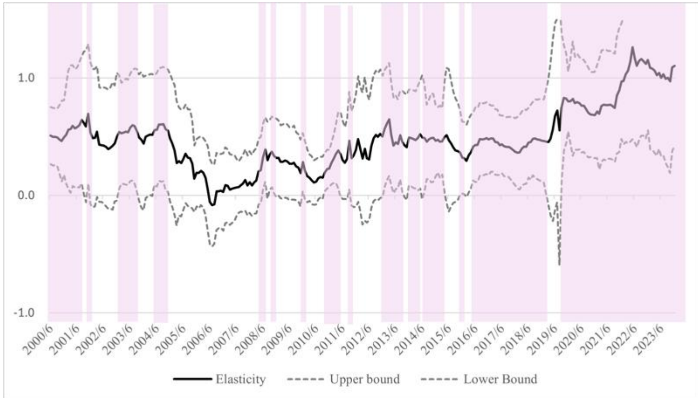

A14b. Power Generating Machinery



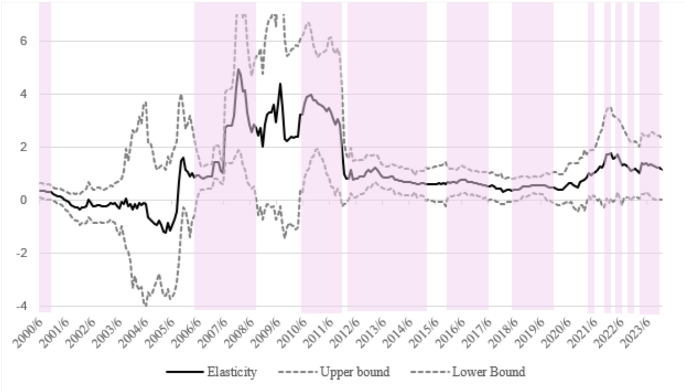

A14c. Internal Combustion Engines



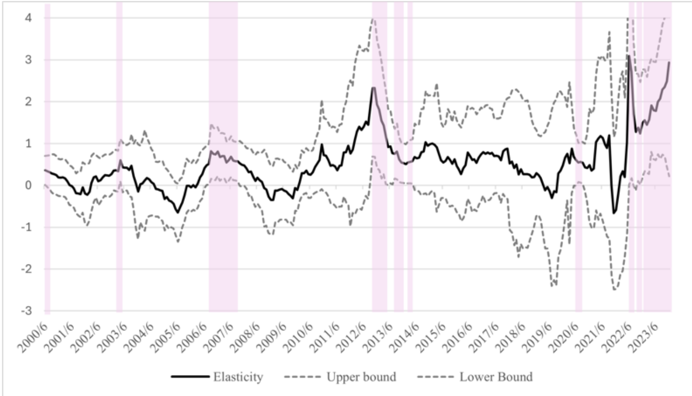

A14d. Agricultural Machinery



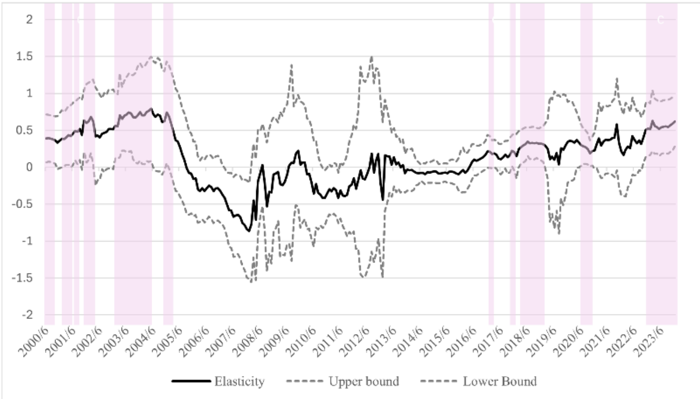
A14e. Office Machines



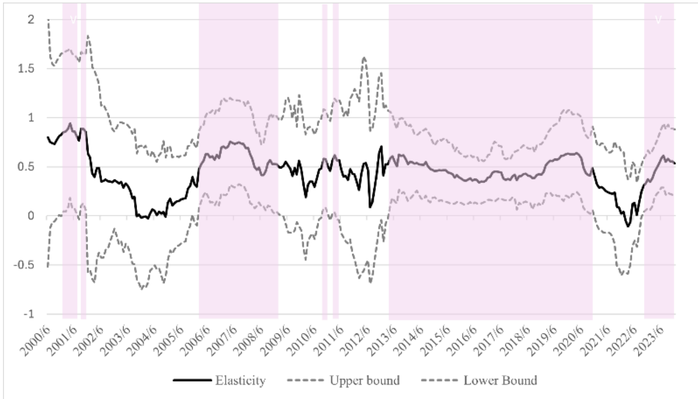

A14f. Other Office Machines



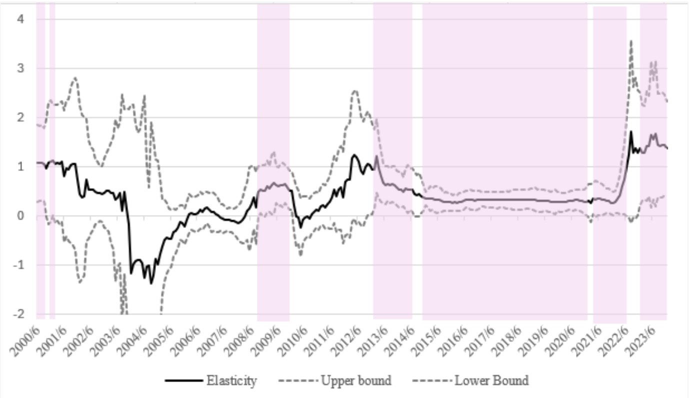

A14g. Metal Working Machines



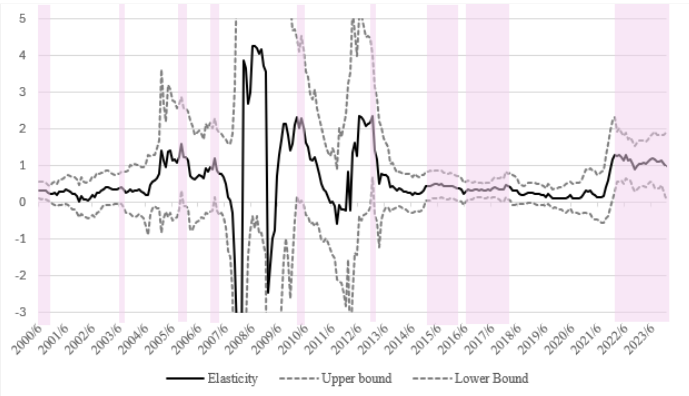

A14h. Textile Machines.



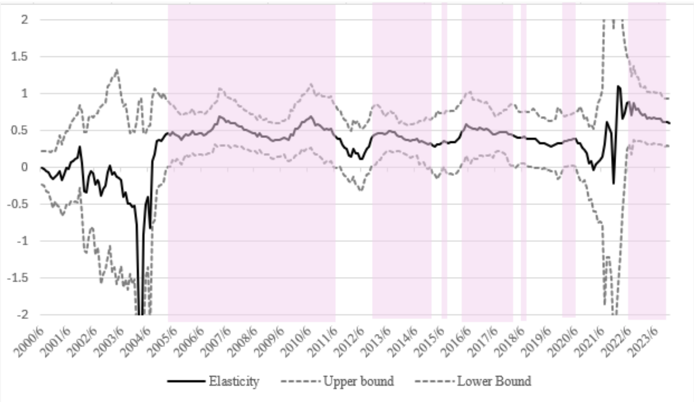
A14i. Construction Machines



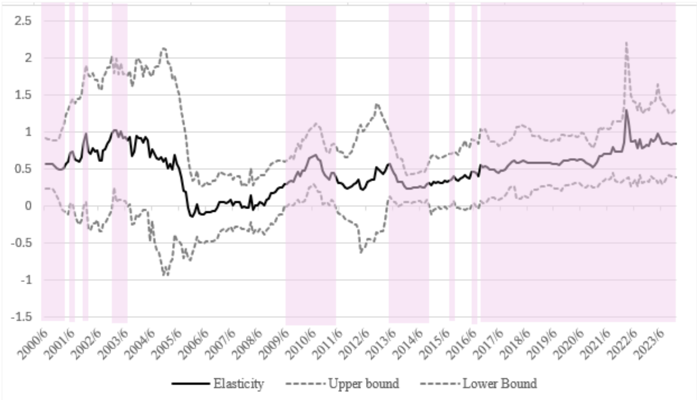

A14j. Heating or Cooling Equipment



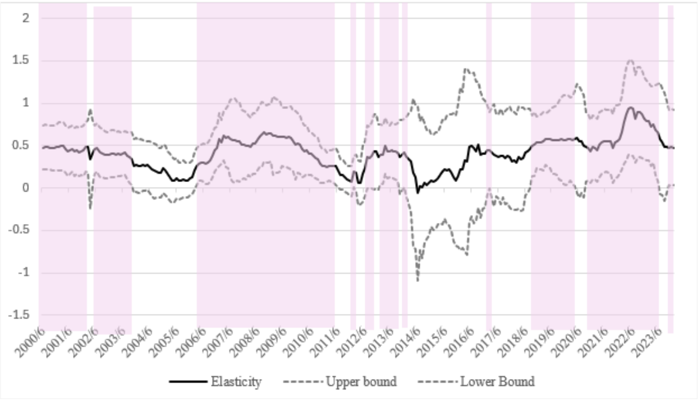

A14k. Pump Centrifuges




A14l. Mechanical Handling Equipment



A14m. Bearings

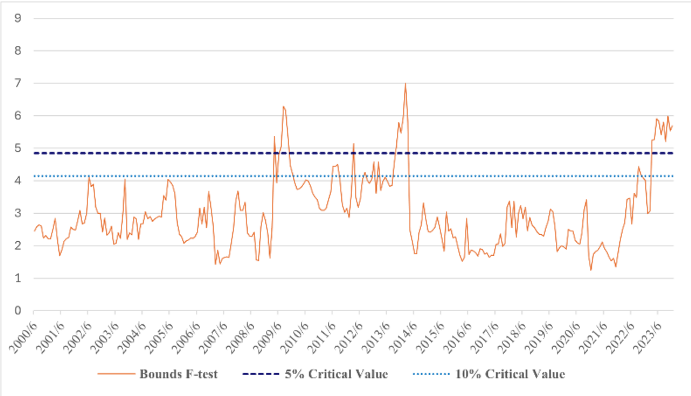



*Note*: The upper and lower bounds denote plus and minus two standard errors. Shaded areas in pink show the statistical significance at least at the 5% level.

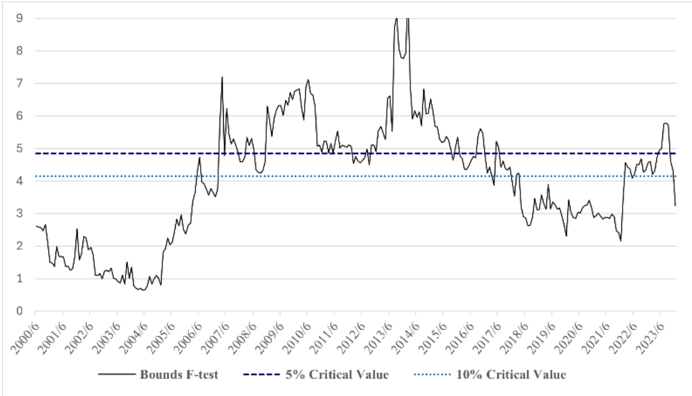
*Source*: Authors' estimation.

**Appendix Figure A15.** Bounds *F*-Test for Rolling ARDL Estimation of Japanese Export Price for General Machinery

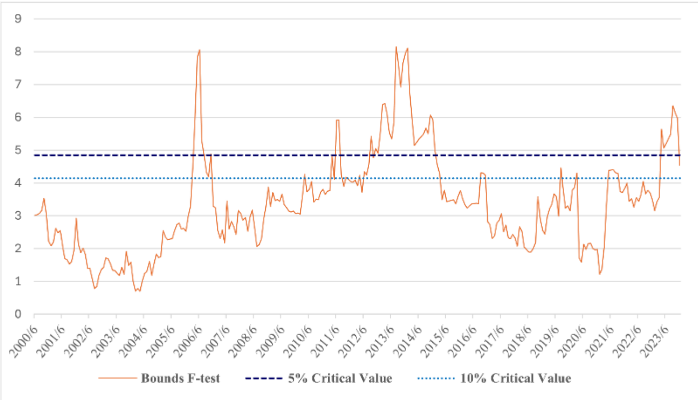
A15a. General Machinery



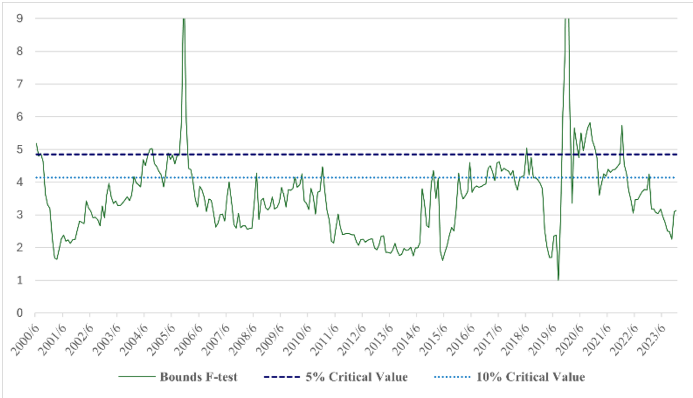

A15b. Power Generating Machinery



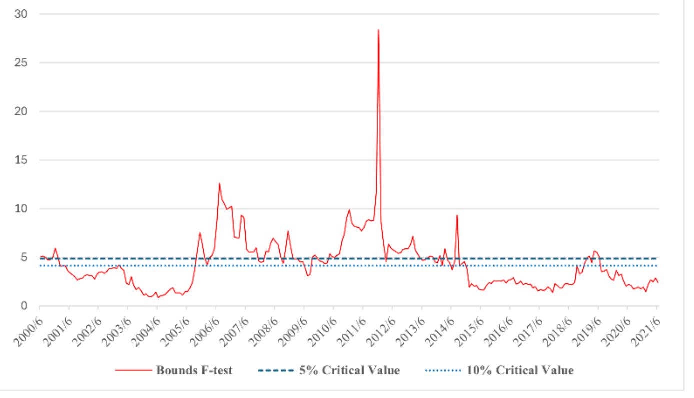

A15c. Internal Combustion Engines



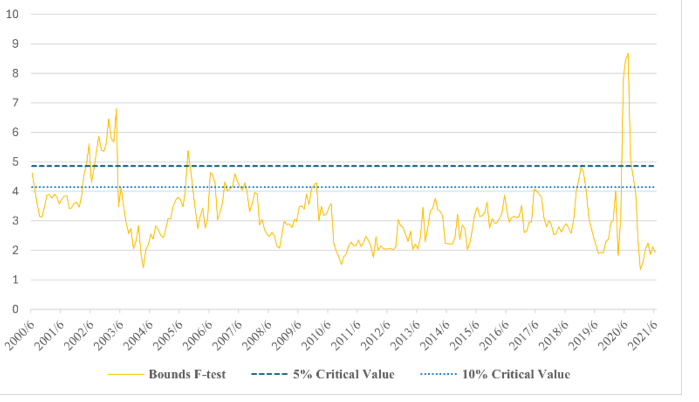

A15d. Agricultural Machinery



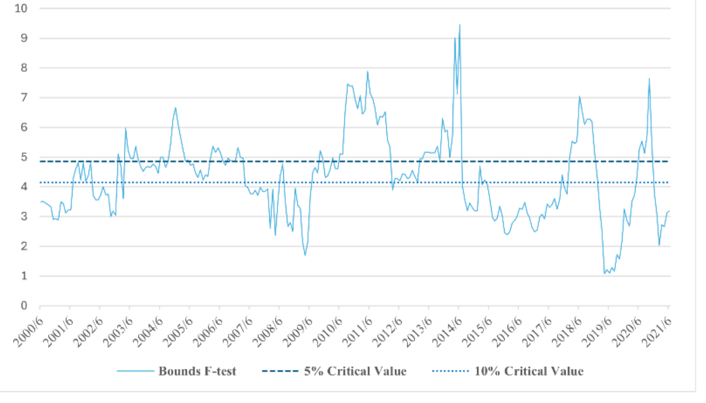
A15e. Office Machines



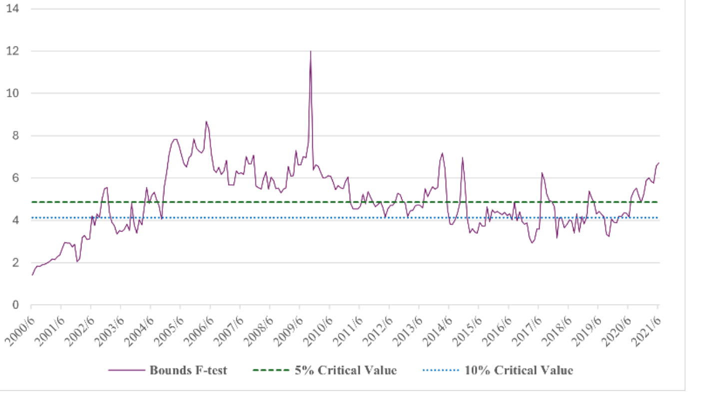

A15f. Other Office Machines



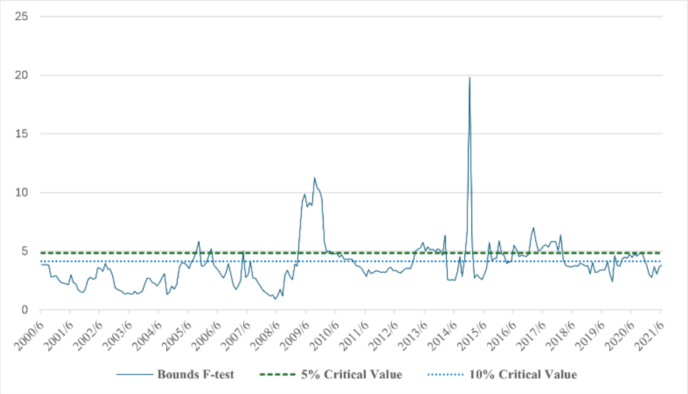

A15g. Metal Working Machines



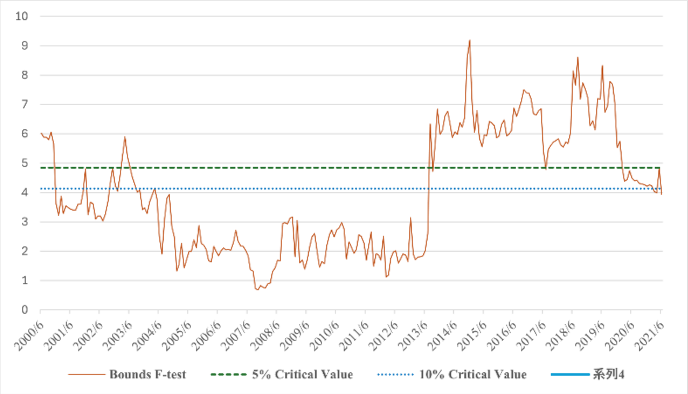

A15h. Textile Machines



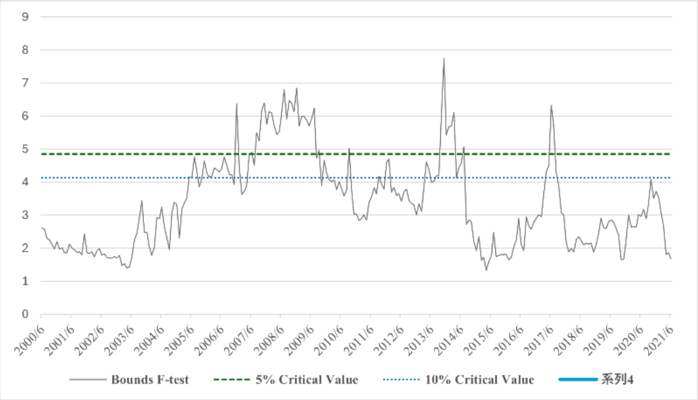
A15i. Construction Machines



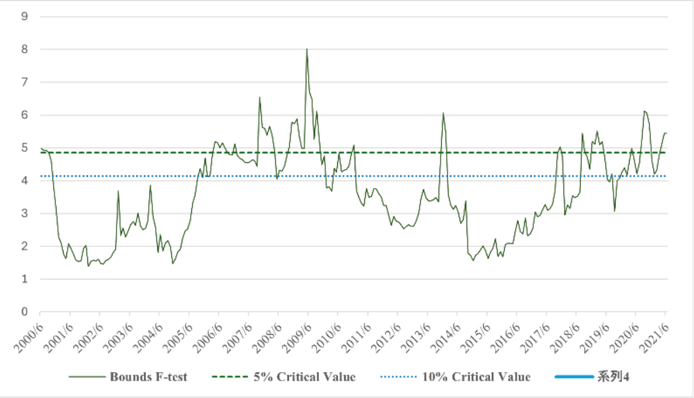

A15j. Heating or Cooling Equipment



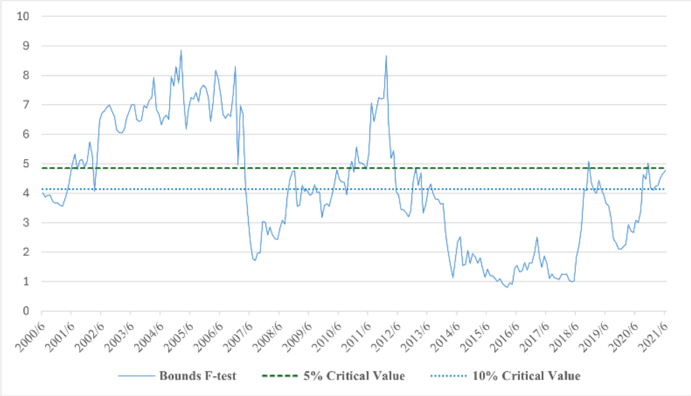

A15k. Pump Centrifuges




A15l. Mechanical Handling Equipment



A15m. Bearings

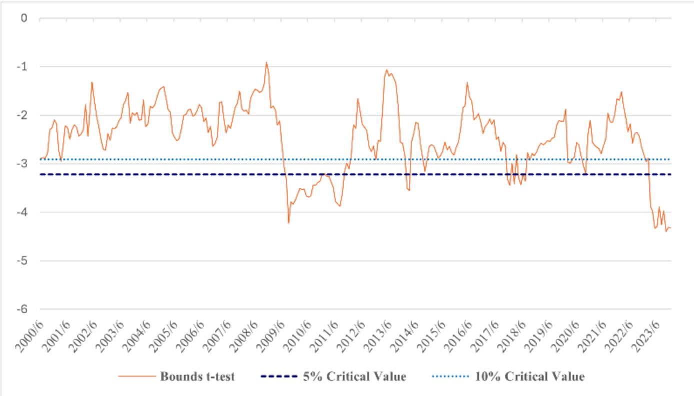



*Note*: The estimated bounds *F*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

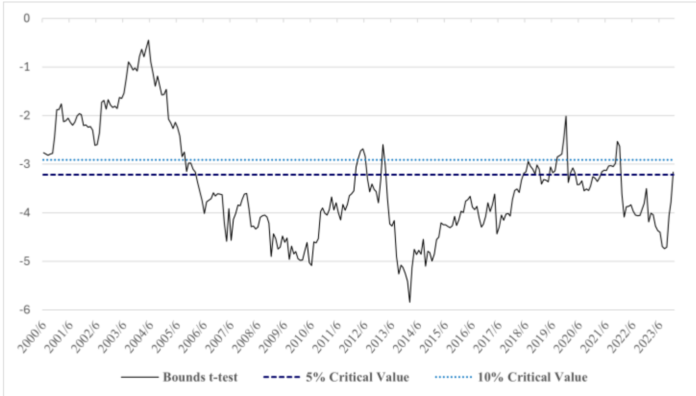
*Source*: Authors' estimation.

**Appendix Figure A16.** Bounds *t*-Test for Rolling ARDL Estimation of Japanese Export Price for General Machinery

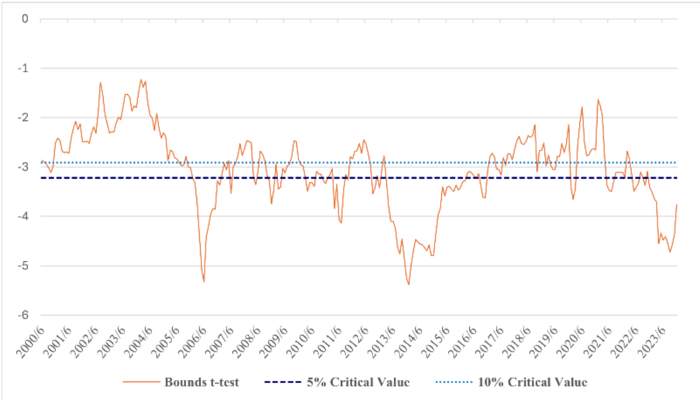
A16a. General Machinery



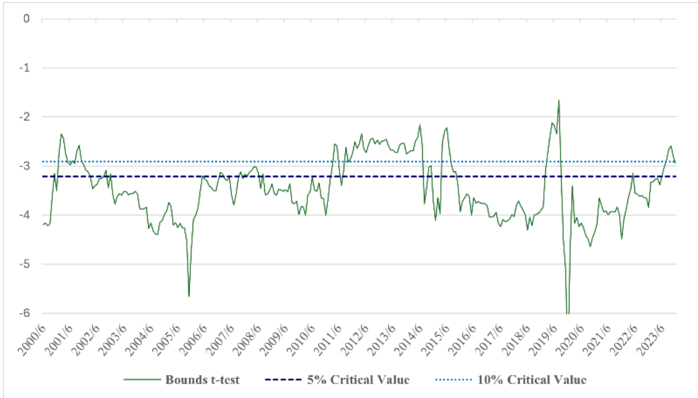

A16b. Power Generating Machinery



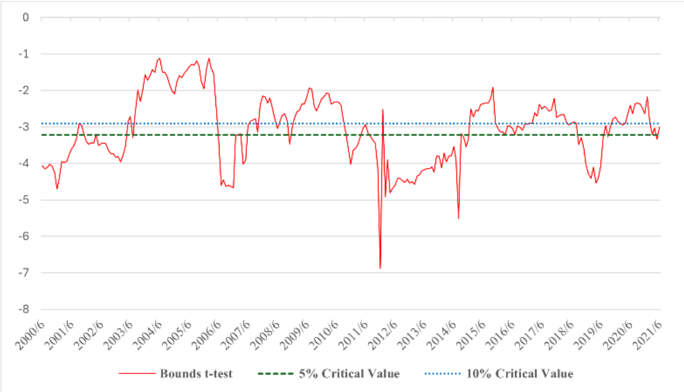

A16c. Internal Combustion Engines



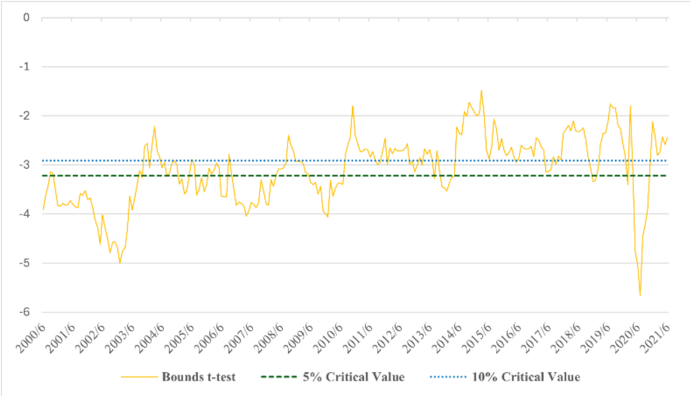

A16d. Agricultural Machinery



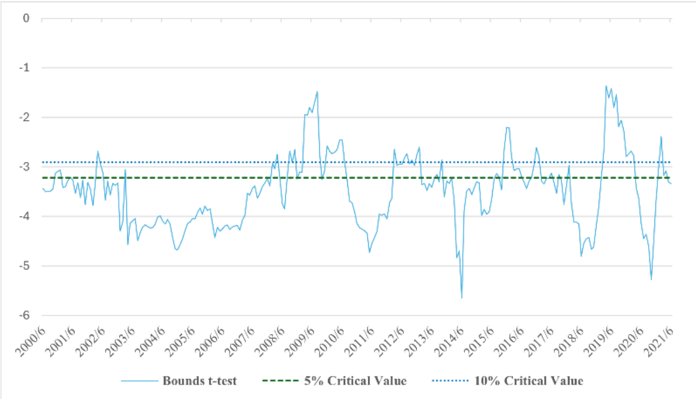
A16e. Office Machines



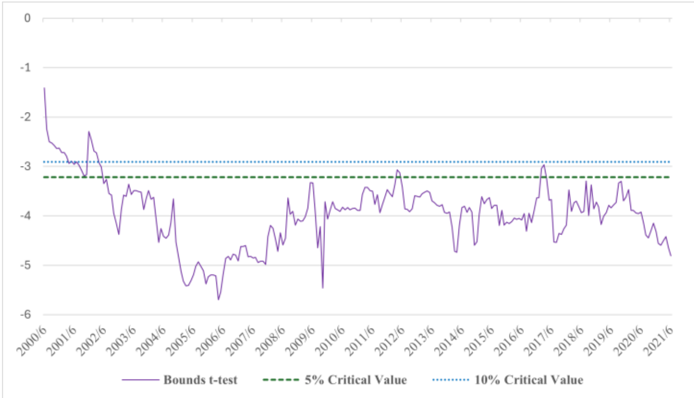

A16f. Other Office Machines



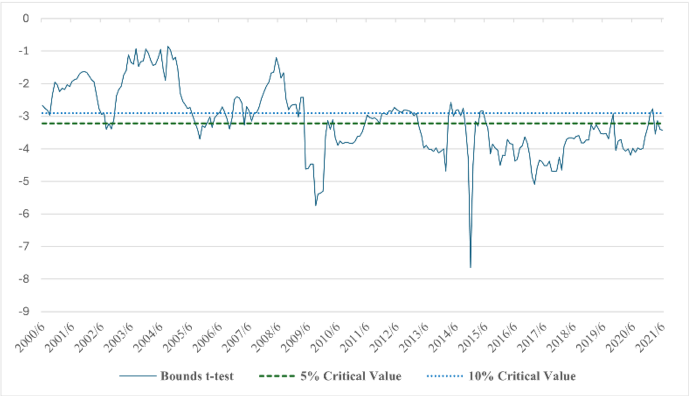

A16g. Metal Working Machines



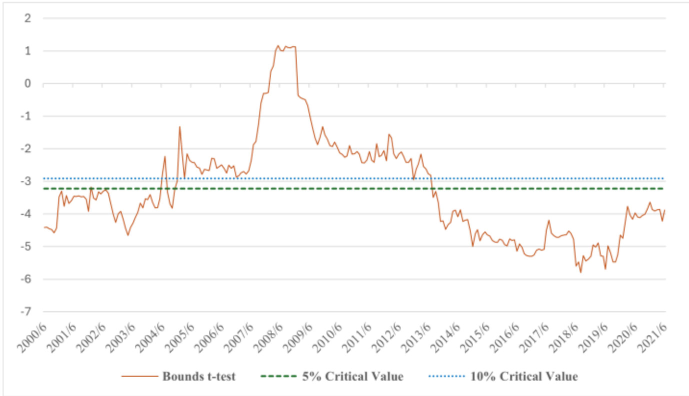

A16h. Textile Machines



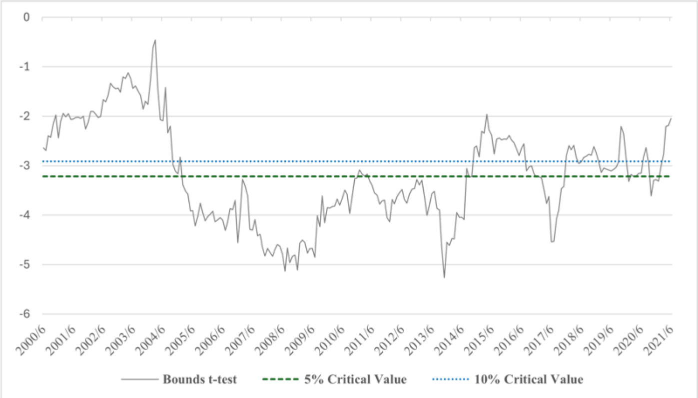
A16i. Construction Machines



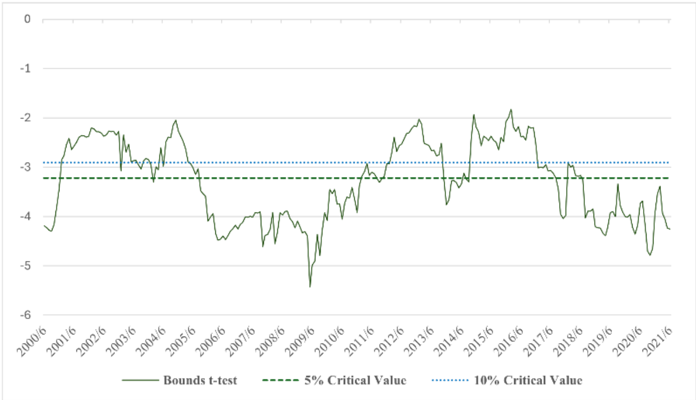

A16j. Heating or Cooling Equipment



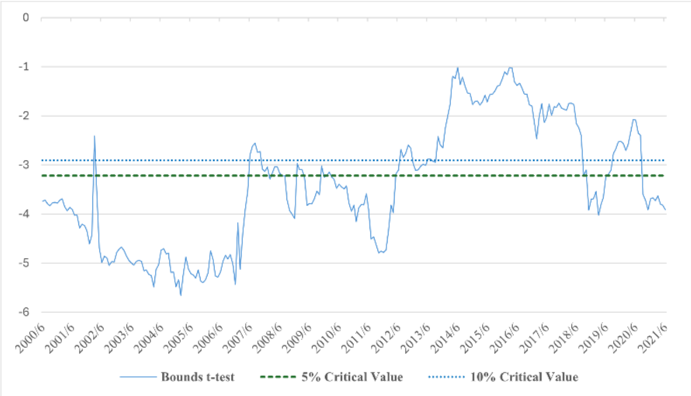

A16k. Pump Centrifuges




A16l. Mechanical Handling Equipment



A16m. Bearings

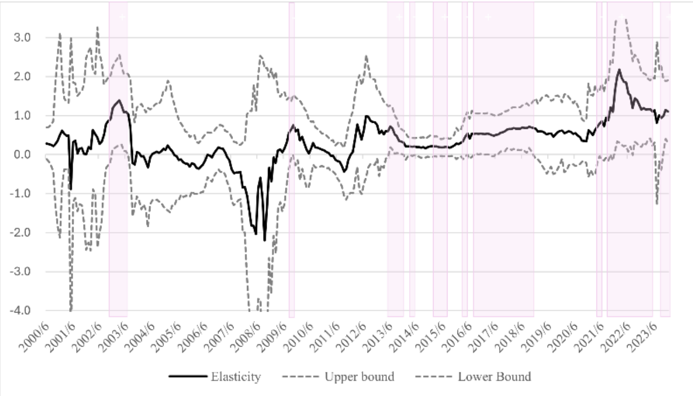



*Note*: The estimated bounds *t*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

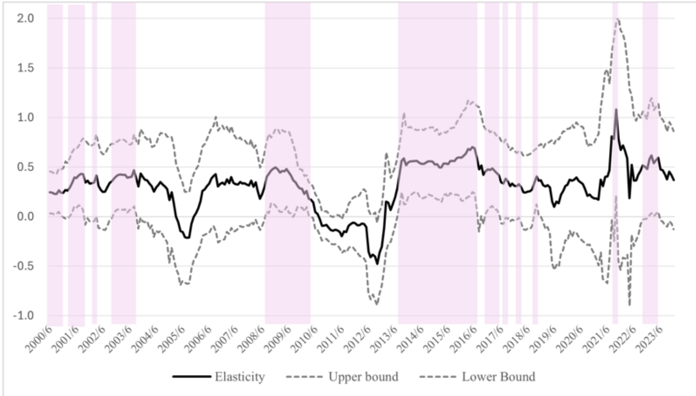
*Source*: Authors' estimation.

**Appendix Figure A17.** Export Price Elasticity to Exchange Rates for Electrical Equipment

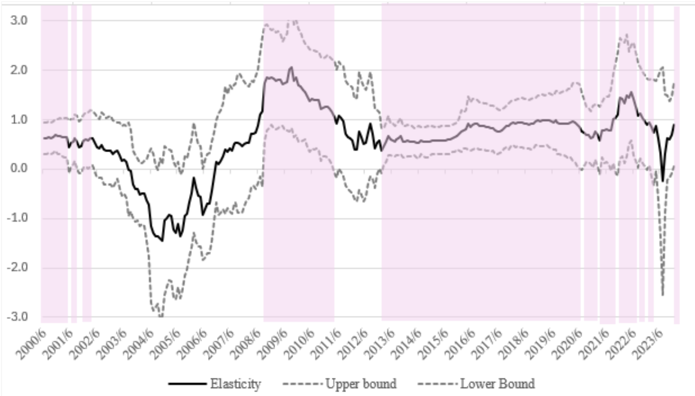
A17a. Electrical Equipment



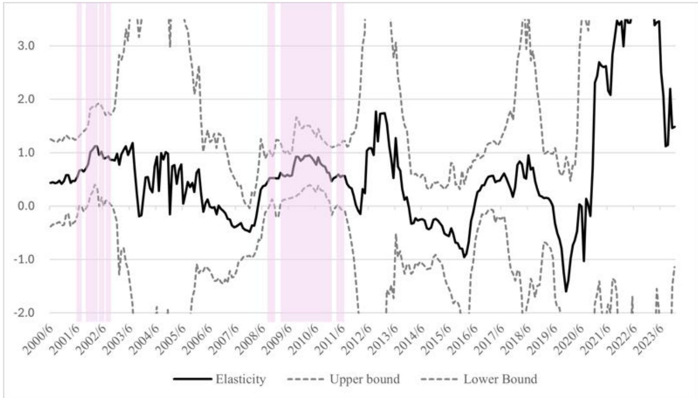

A17b. Electric Power Machinery



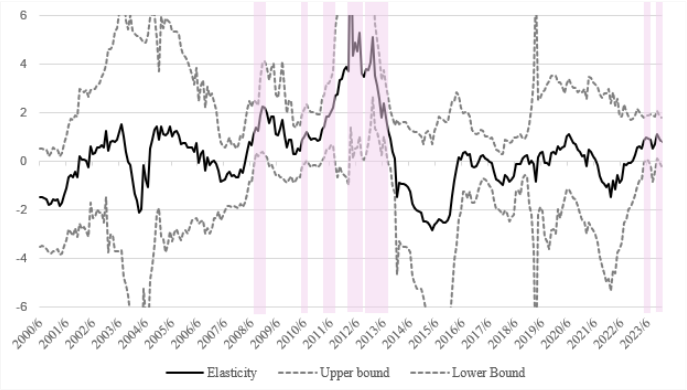

A17c. Insulated Wire and Cable



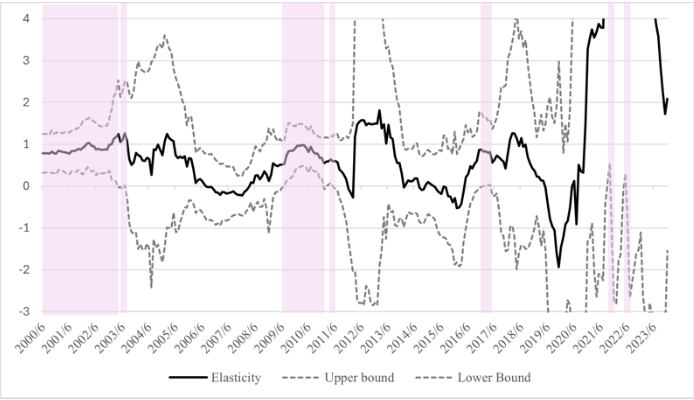

A17d. Visual Apparatus



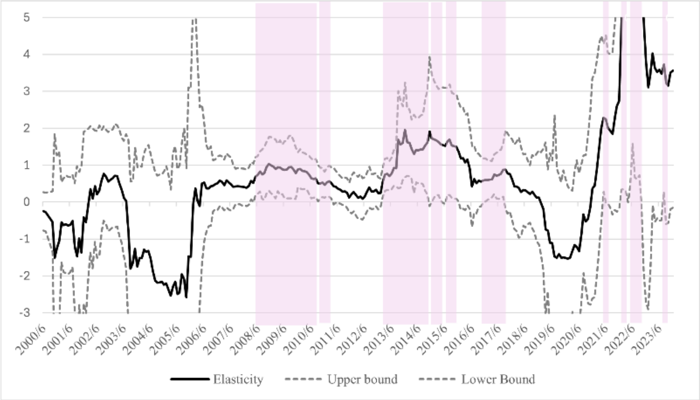
A17e. T.V. Receivers



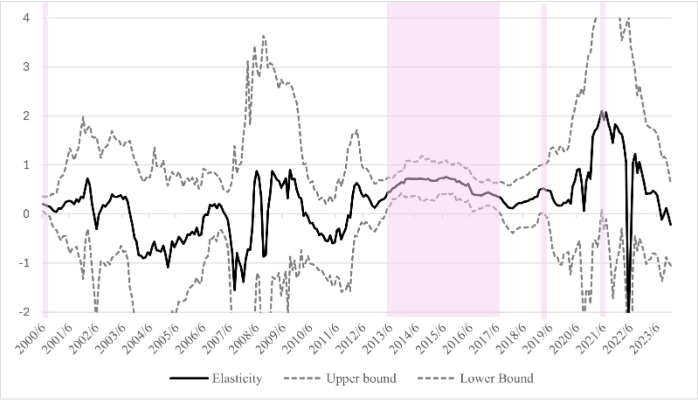

A17f. Video Tape Recorder



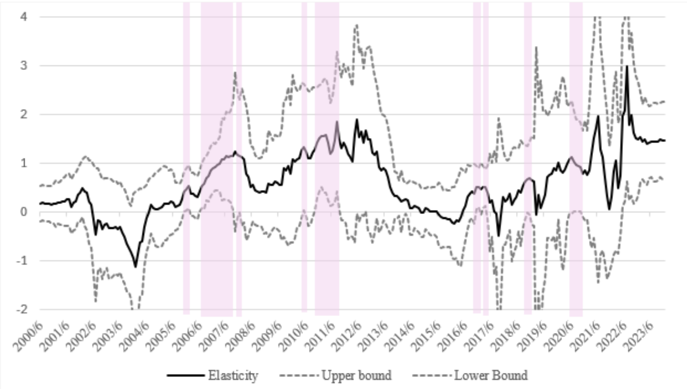

A17g. Telecommunication Equipment



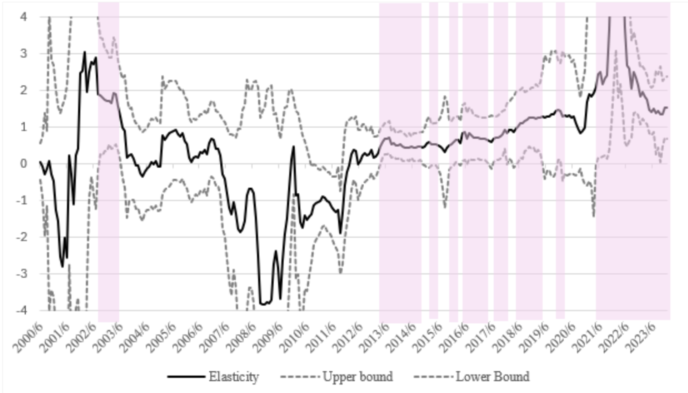

A17h. Domestic Electrical Equipment



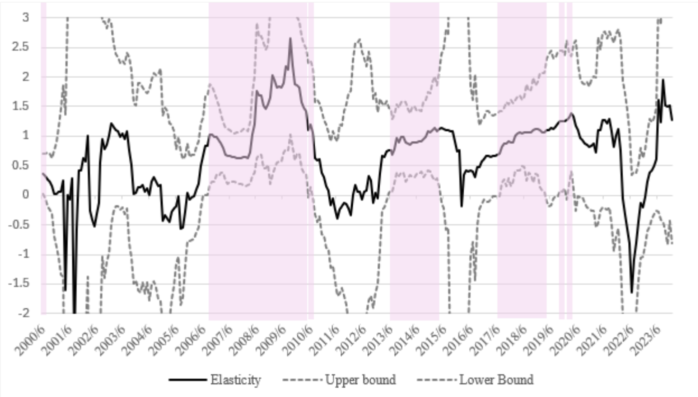
A17i. Batteries and Accumulators



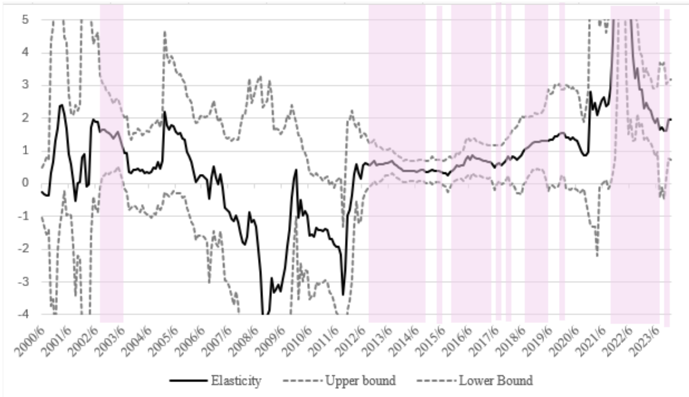

A17j. Thermionic Valves, Tubes, Transistors, etc.



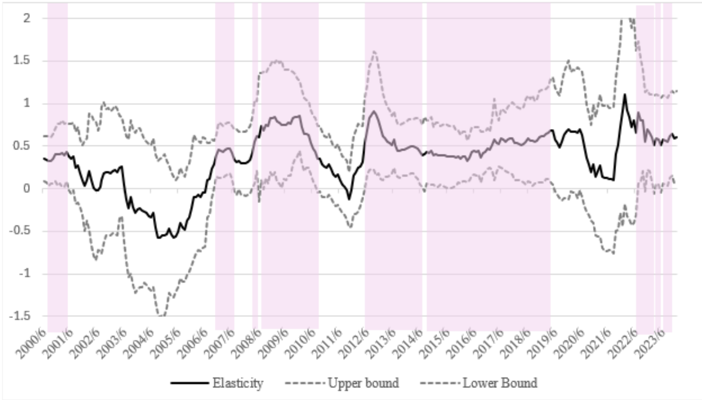

A17k. Transistors and Diodes



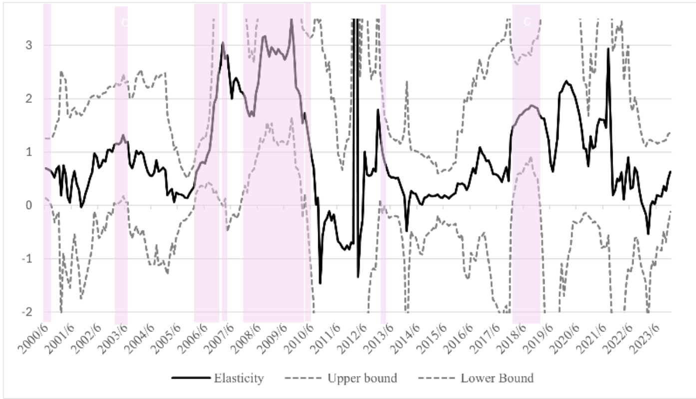

A17l. Electronic Integrated Circuits



A17m. Electronic Measuring & Controlling Instrument




A17n. Condenser

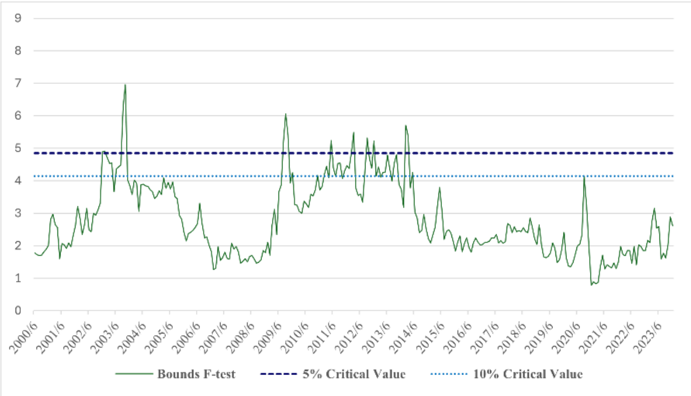



*Note*: The upper and lower bounds denote plus and minus two standard errors. Shaded areas in pink show the statistical significance at least at the 5% level.

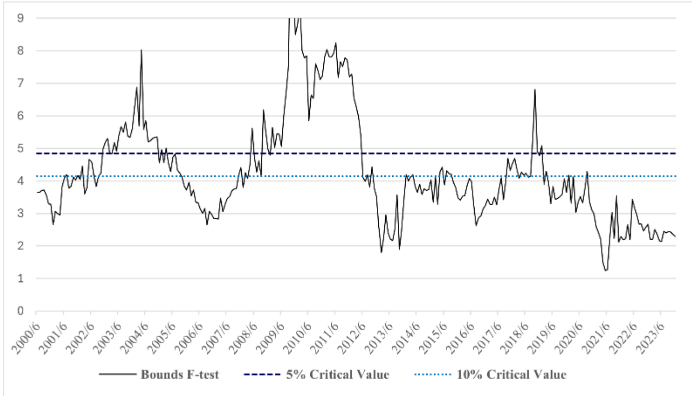
*Source*: Authors' estimation.

**Appendix Figure A18.** Bounds *F*-Test for Rolling ARDL Estimation of Japanese Export Price for Electrical Equipment

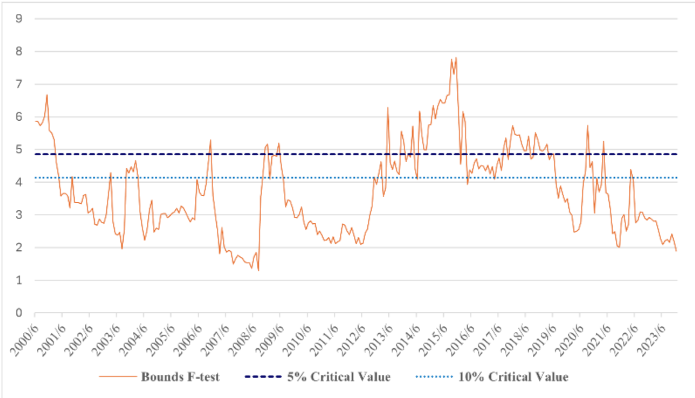
A18a. Electrical Equipment



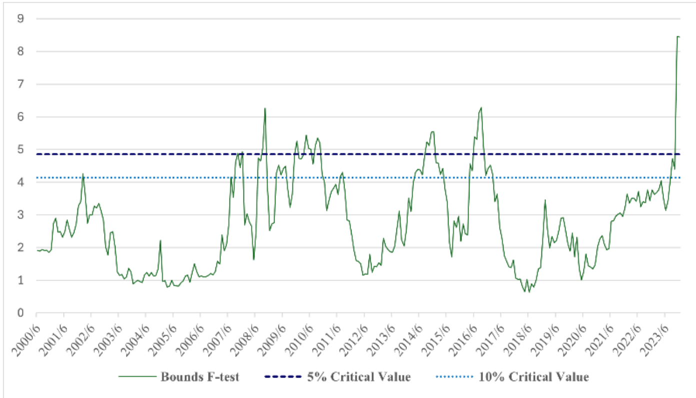

A18b. Electric Power Machinery



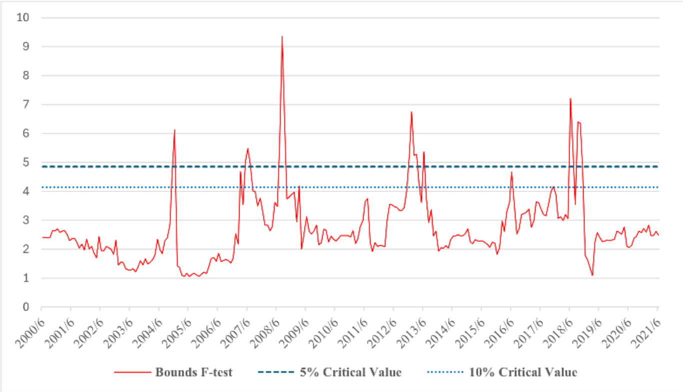

A18c. Insulated Wire, Cable



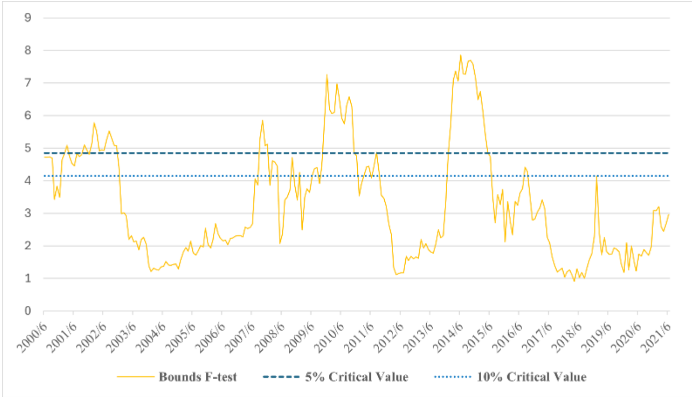

A18d. Visual Apparatus



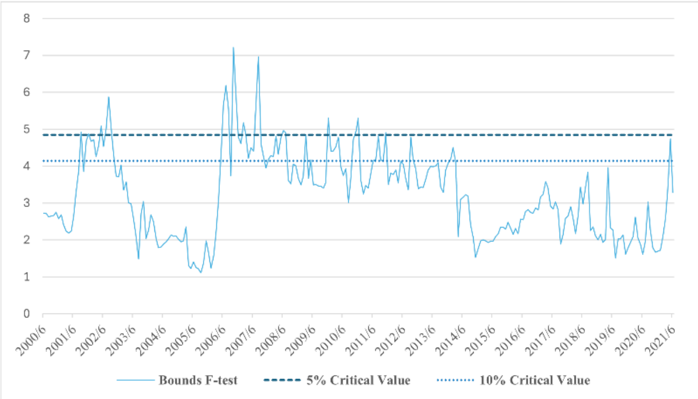
A18e. T.V. Receivers



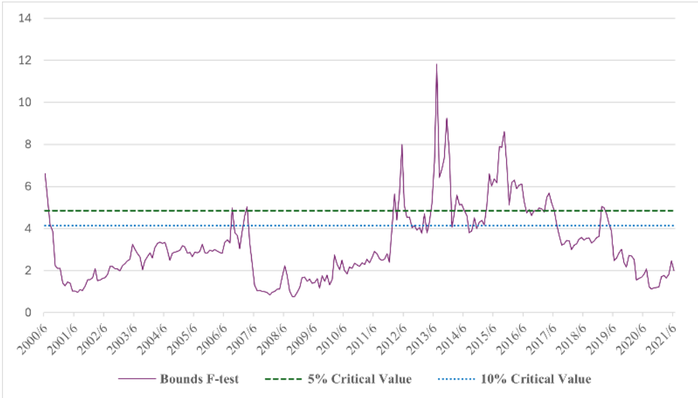

A18f. Video Tape Recorder



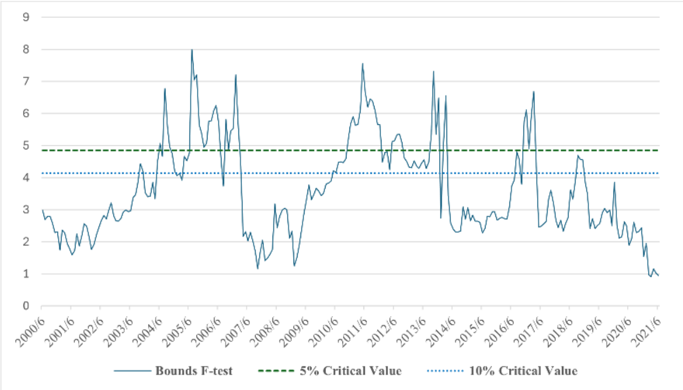

A18g. Telecommunication Equipment



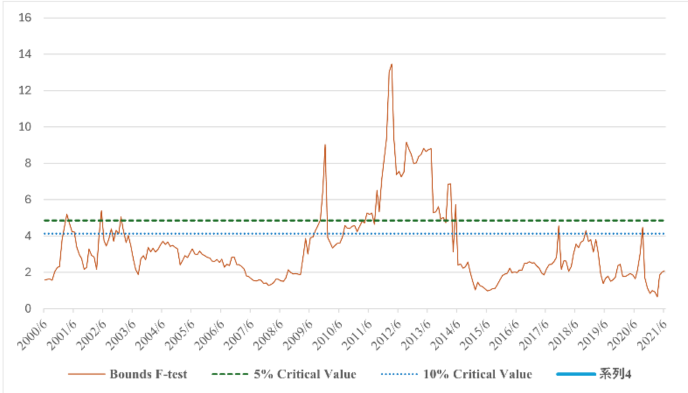

A18h. Domestic Electrical Equipment



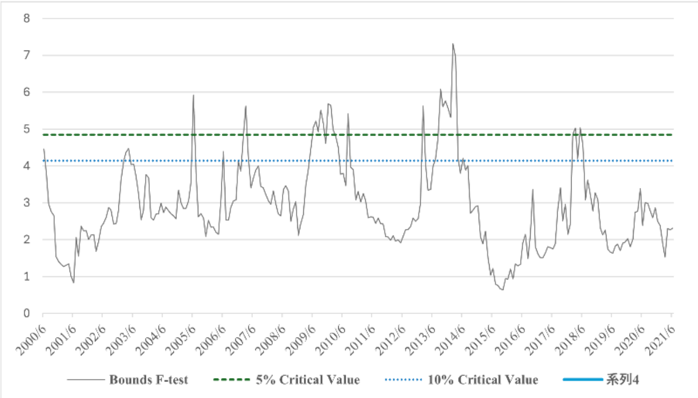
A18i. Batteries and Accumulators



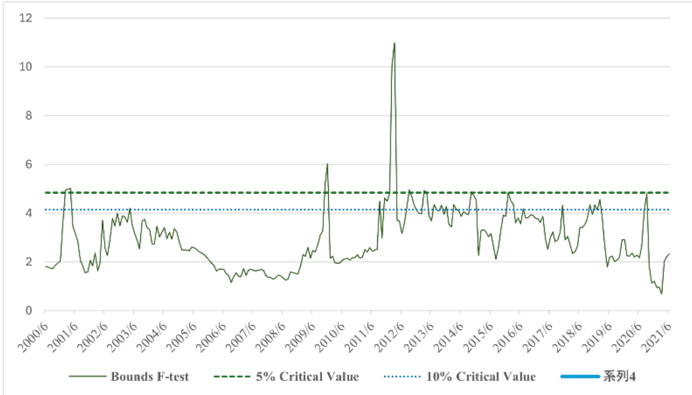

A18j. Thermionic Valves, Tubes, Transistors, etc.



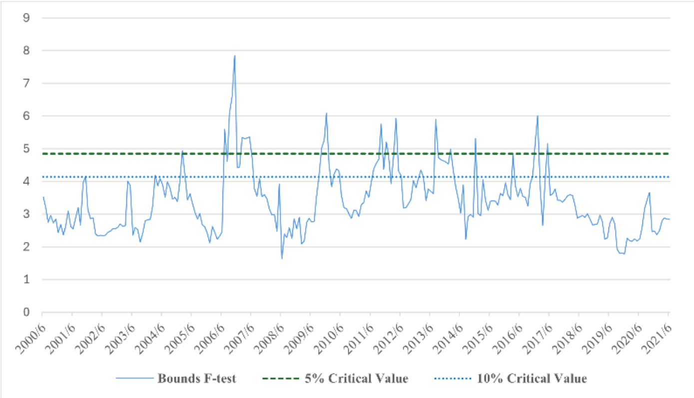

A18k. Transistors and Diodes



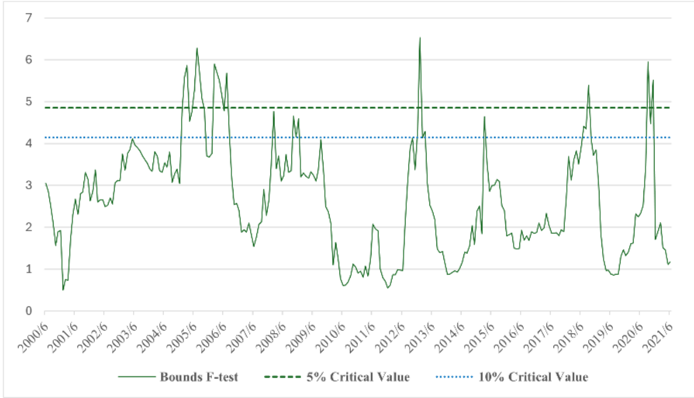

A18l. Electronic Integrated Circuits



A18m. Elect. Measuring & Controlling Instrument




A18n. Condenser

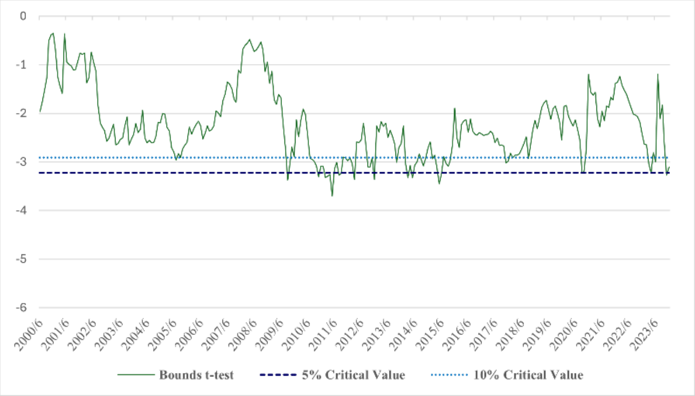



*Note*: The estimated bounds *F*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

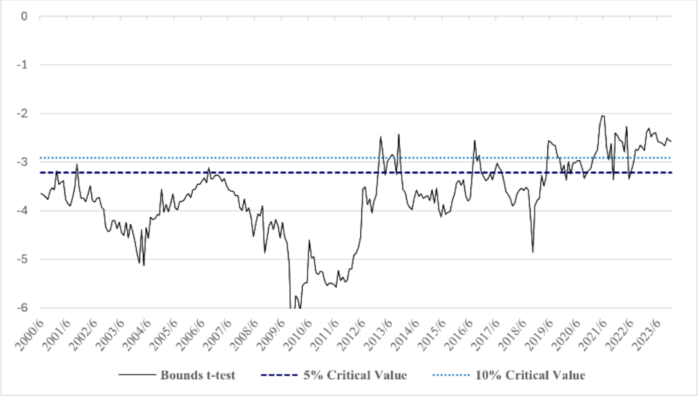
*Source*: Authors' estimation.

**Appendix Figure A19.** Bounds *t*-Test for Rolling ARDL Estimation of Japanese Export Price for Electrical Equipment

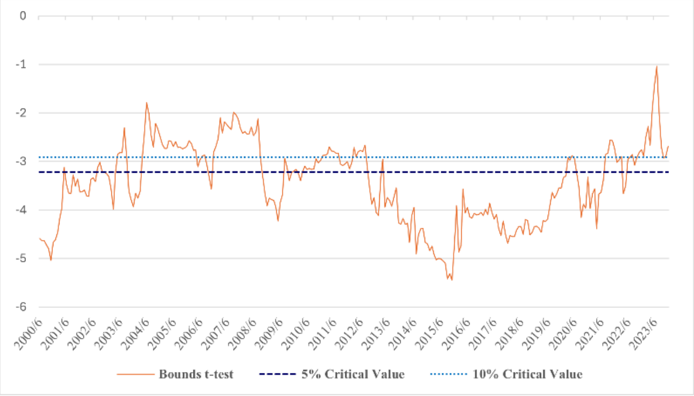
A14a. Electrical Equipment



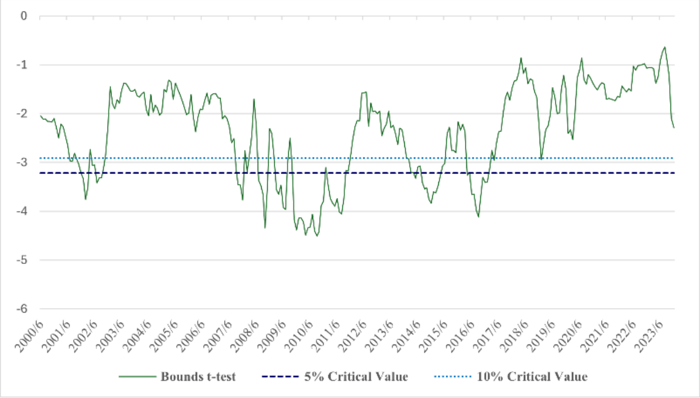

A14b. Electric Power Machinery



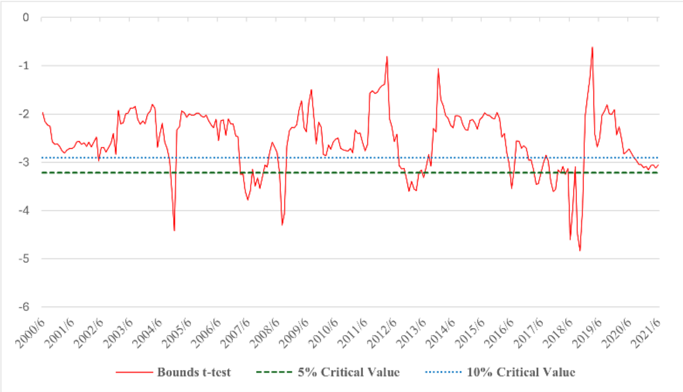

A19c. Insulated Wire, Cable



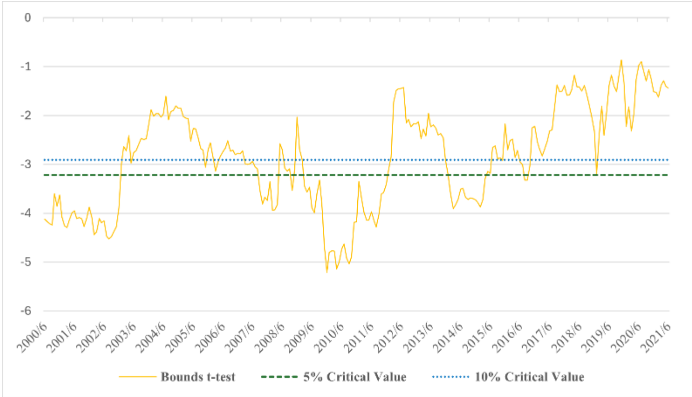

A19d. Visual Apparatus



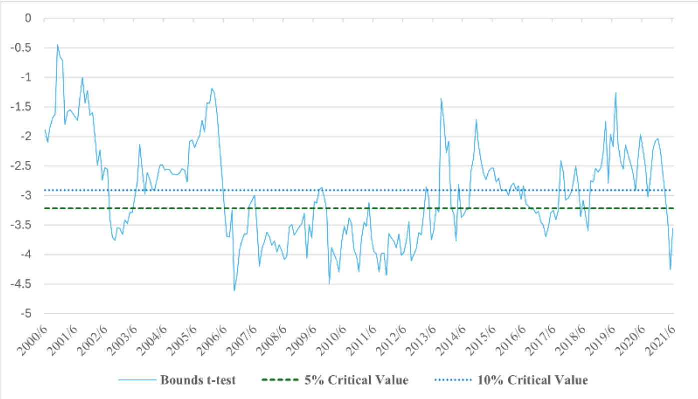
A19e. T.V. Receivers



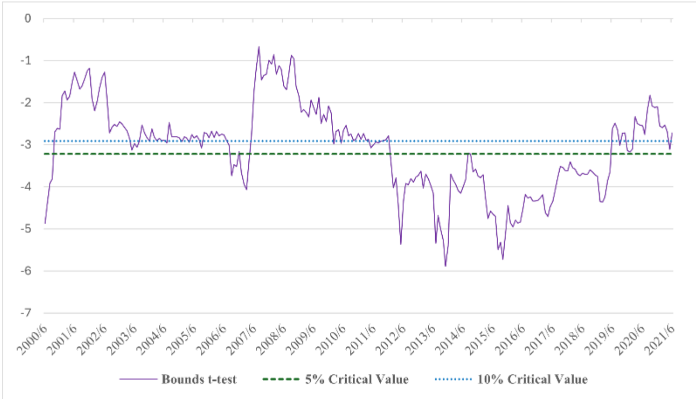

A19f. Video Tape Recorder



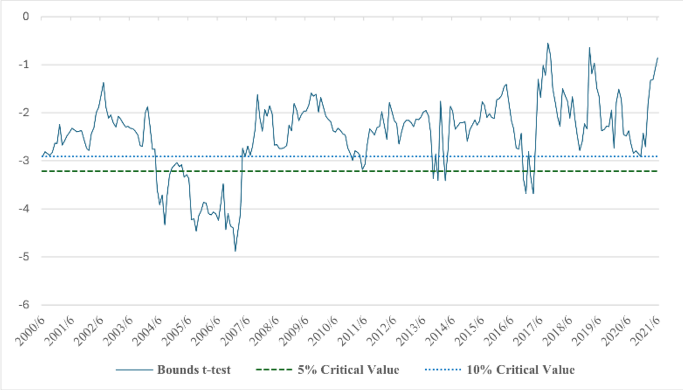

A19g. Telecommunication Equipment



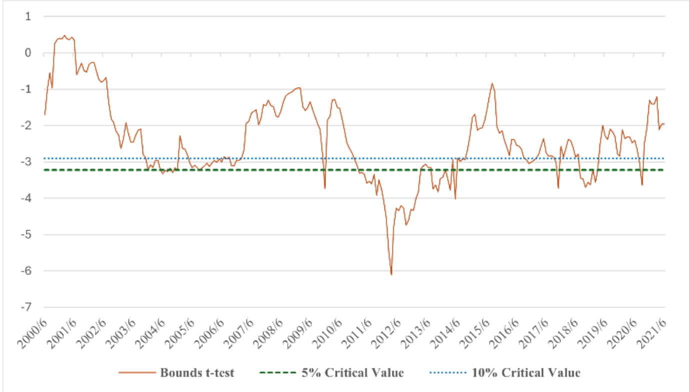

A19h. Domestic Electrical Equipment



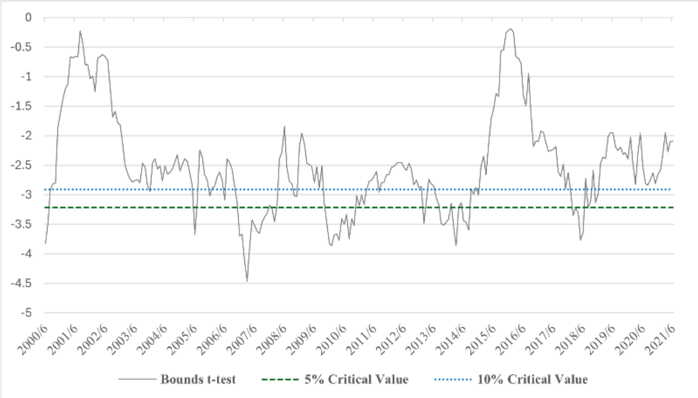
A19i. Batteries and Accumulators



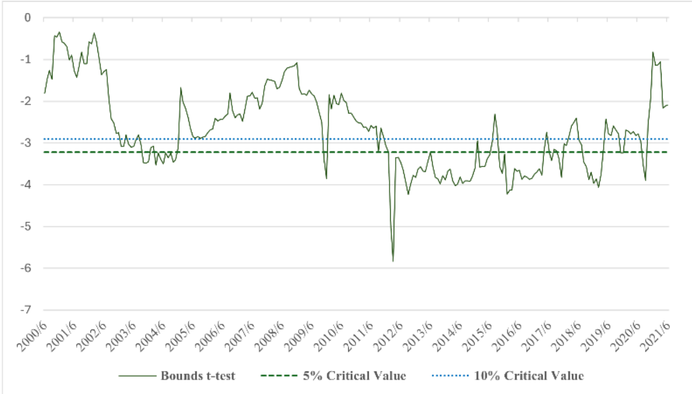

A19j. Thermionic Valves, Tubes, Transistors, etc.



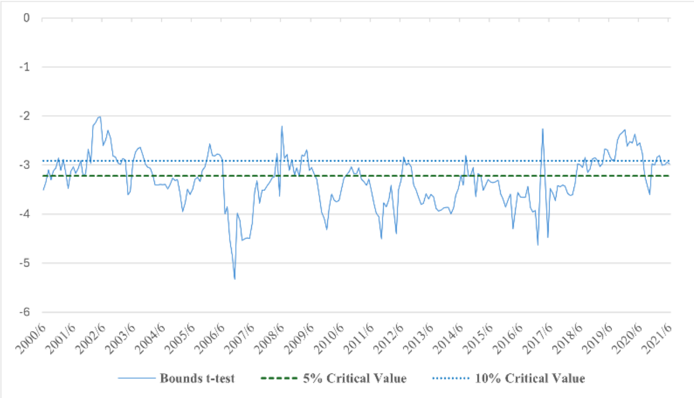

A19k. Transistors and Diodes



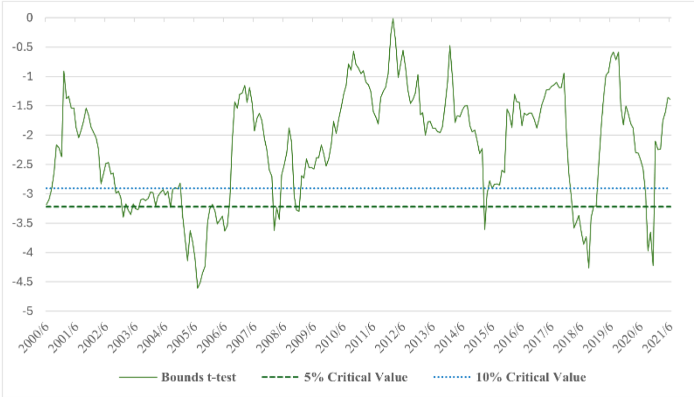

A19l. Electronic Integrated Circuits



A19m. Elect. Measuring & Controlling Instrument




A19n. Condenser



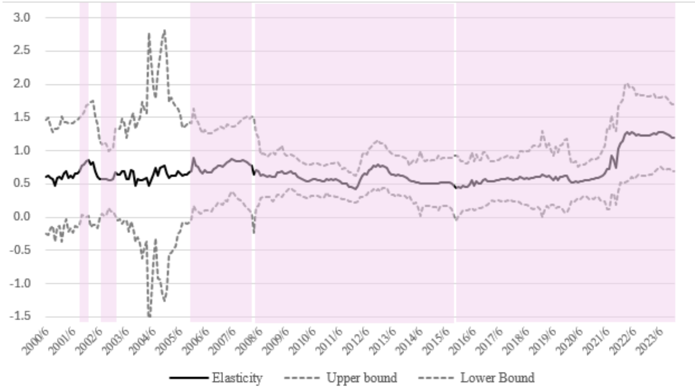

*Note*: The estimated bounds *t*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

*Source*: Authors' estimation.

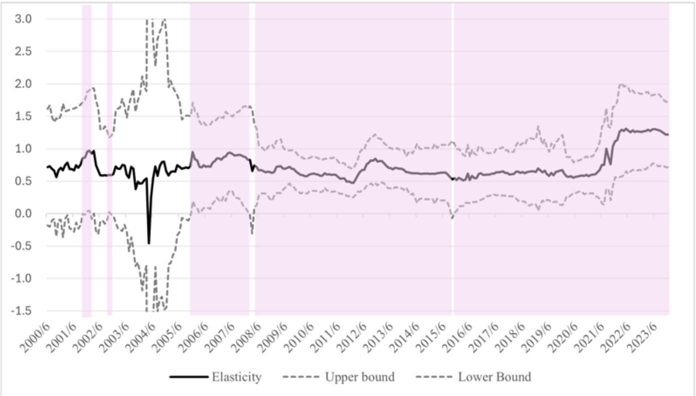
**Appendix Figure A20.** Export Price Elasticity to Exchange Rates for Transport Equipment

A20a. Transport Equipment

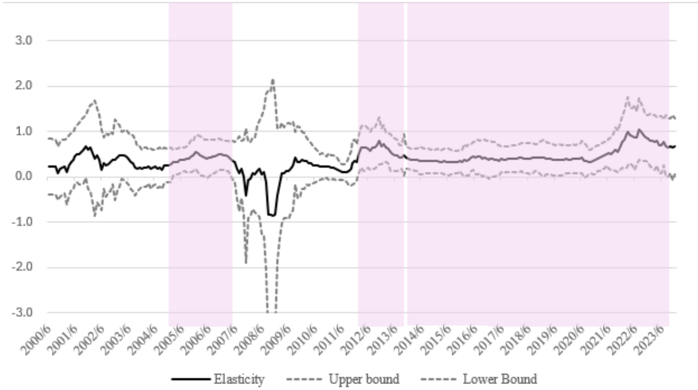

A20b. Motor Vehicles




A20c. Passenger Motor Car




A20d. Parts of Motor Vehicles

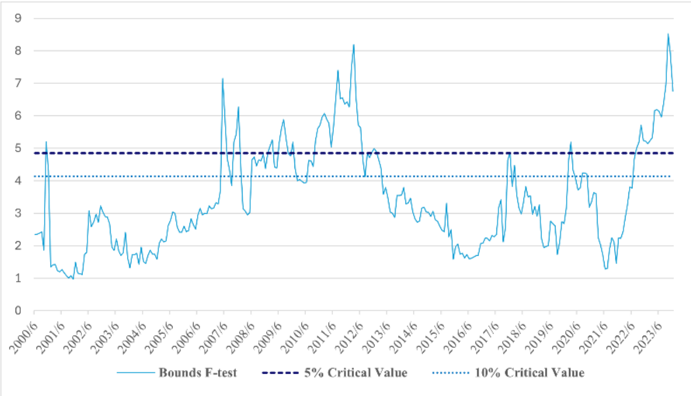



*Note*: The upper and lower bounds denote plus and minus two standard errors. Shaded areas in pink show the statistical significance at least at the 5% level.

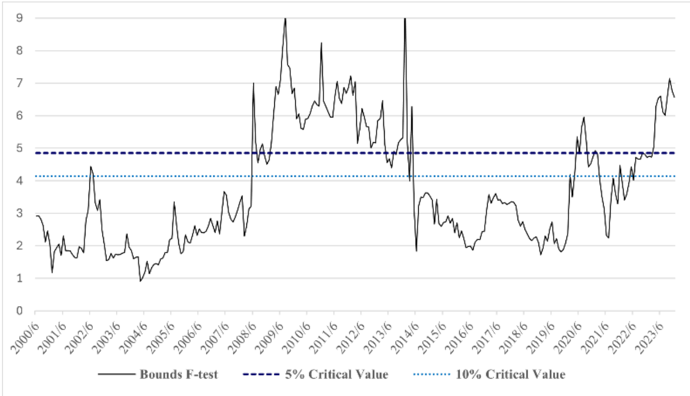
*Source*: Authors' estimation.

**Appendix Figure A21.** Bounds *F*-Test for Rolling ARDL Estimation of Japanese Export Price for Transport Equipment

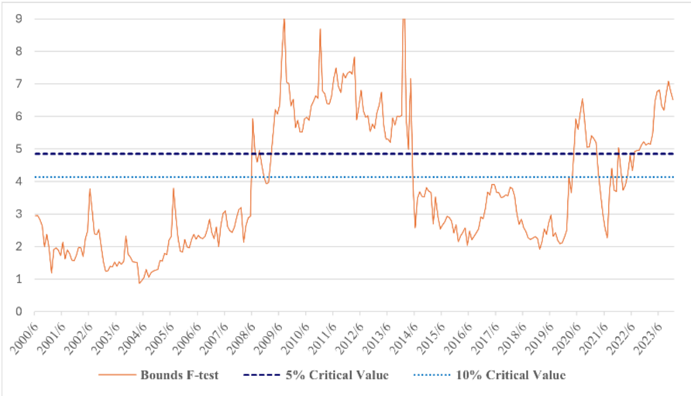
A21a. Transport Equipment



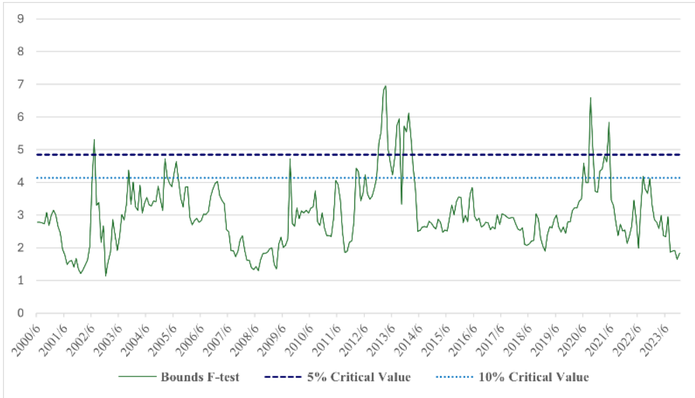

A21b. Motor Vehicles




A21c. Passenger Motor Car




A21d. Parts of Motor Vehicles

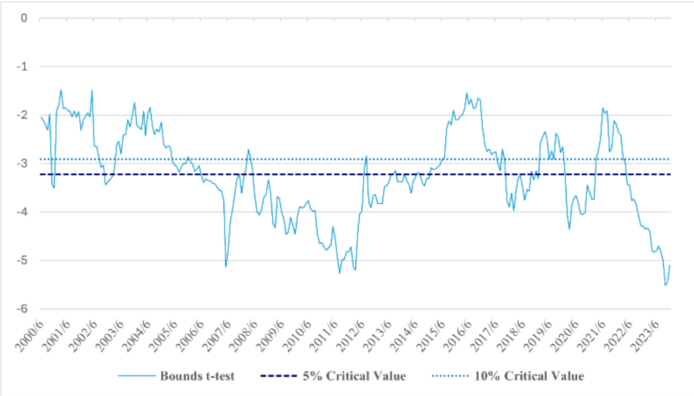



*Note*: The estimated bounds *F*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

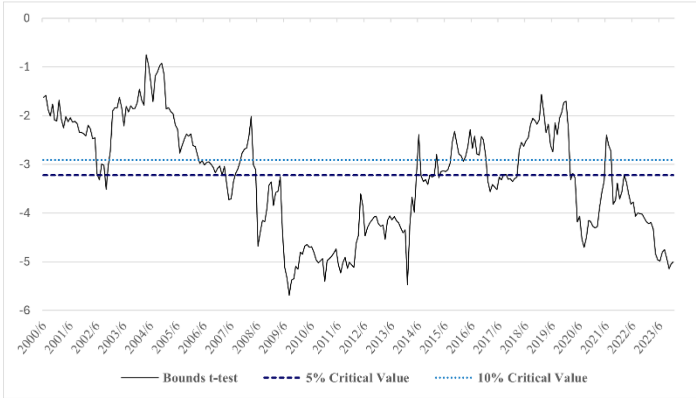
*Source*: Authors' estimation.

**Appendix Figure A22.** Bounds *t*-Test for Rolling ARDL Estimation of Japanese Export Price for Transport Equipment

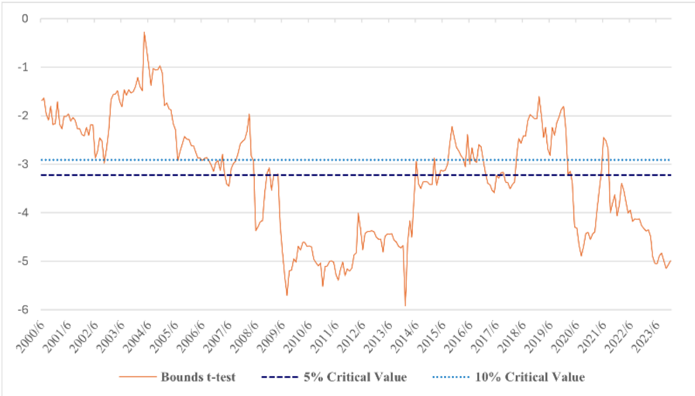
A22a. Transport Equipment



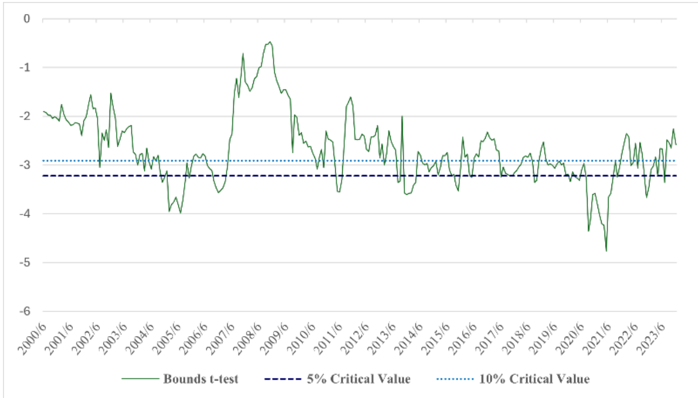

A22b. Motor Vehicles




A22c. Passenger Motor Car




A22d. Parts of Motor Vehicles

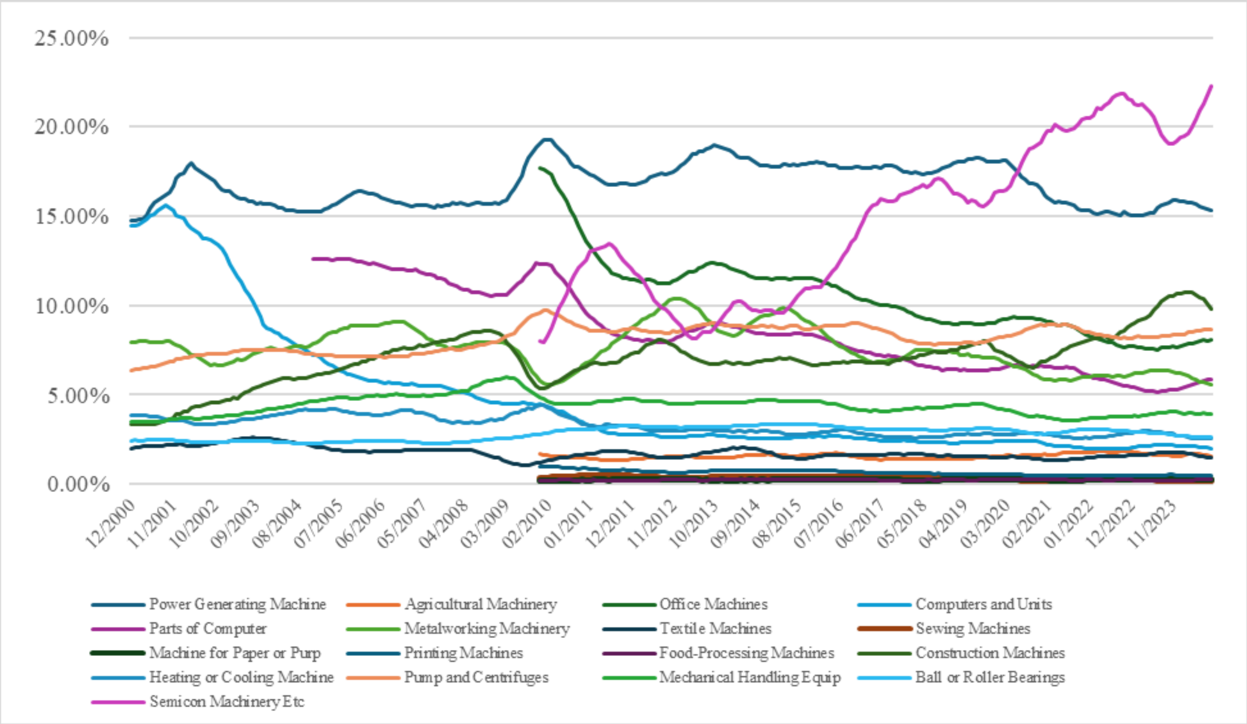



*Note*: The estimated bounds *t*-statistics are reported based on the rolling ARDL estimation. 5 percent and 10 percent critical values are reported by dotted lines.

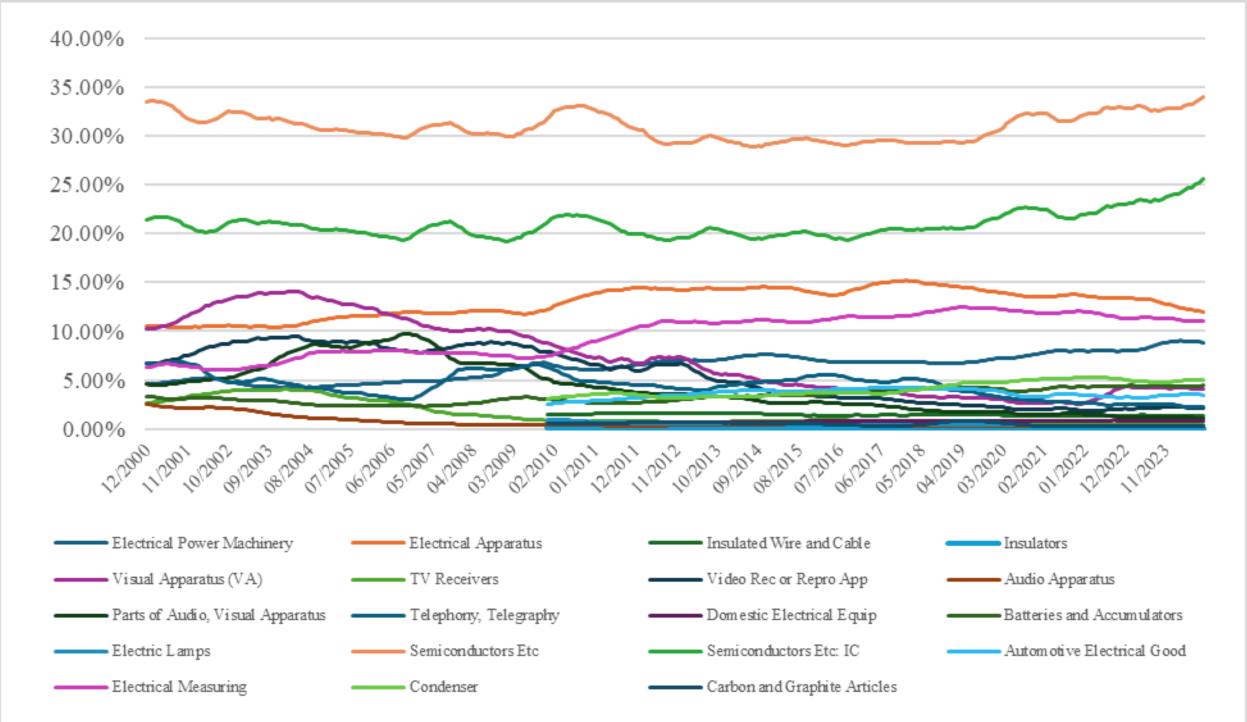
*Source*: Authors' estimation.

**Appendix Figure A23.** Industry Classification of Japan Export Value

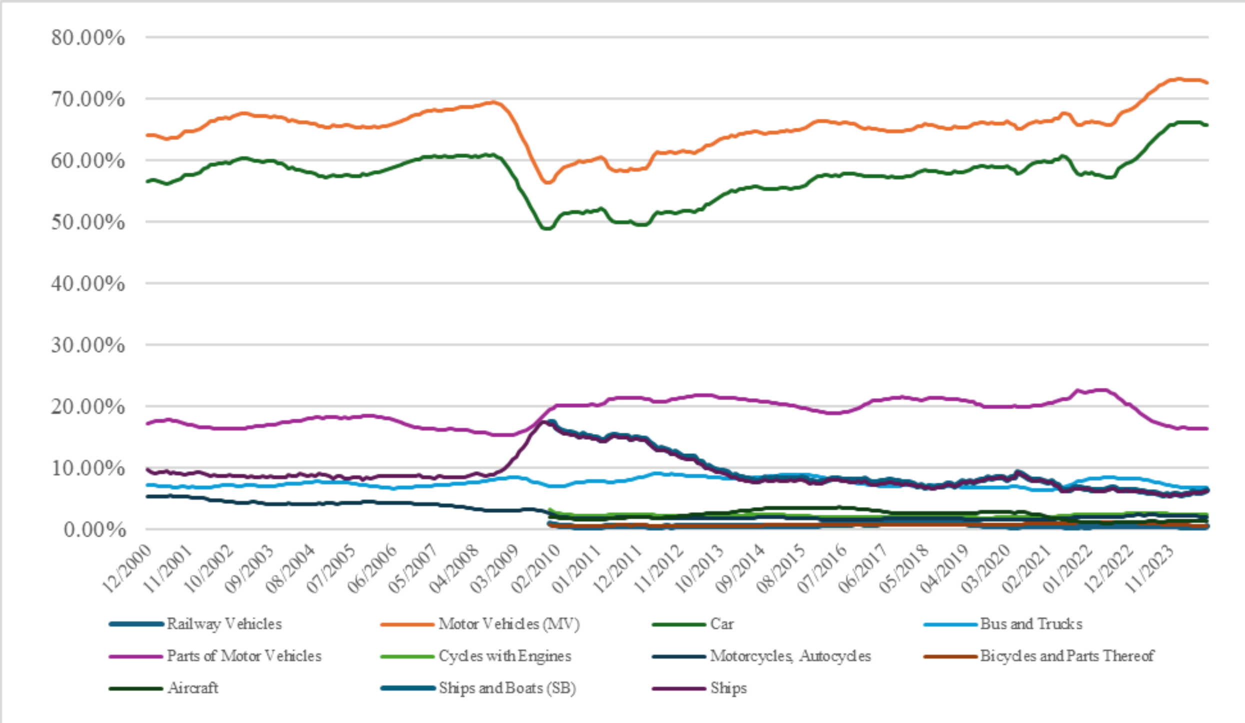
A23a. General Machinery




A23b. Electrical Equipment



A23c. Transport Equipment




*Source*: Ministry of Finance.