Japan-US bilateral commodity-level trade and trade policy-related uncertainty under the COVID-19 pandemic: the nonlinear ARDL model

Serdar Ongan¹ · Ismet Gocer²

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Abstract

This study examines whether *trade policy-related uncertainties*, scaled by *TPU* index, and the COVID-19 pandemic affect Japan's bilateral commodity trade balance with the U.S concerning 60 industries. To this end, the nonlinear ARDL (autoregressive distributed lag) model is applied. Empirical findings of the disaggregated data model indicate that while changes in Japan's TPU index have significant, either improving or worsening, impacts on this balance concerning 23 industries, changes in US TPU index have impact on only 32 industries. Additionally, based on the behaviors of Japanese and US consumers through their import demands, it can be interpreted that neither of them is *uncertainty-sensitive* to each other's products and they continue to buy these products even if both countries' TPU indexes keep rising. Another expected empirical finding is that the COVID-19 pandemic worsens the trade balances of Japan for different industries shown in the tables.

Keywords TPU index · Nonlinear ARDL approach · Japan · The USA · Trade balances

JEL Classifications F10 · F14 · Q27

1 Introduction

Recent retaliatory tariff hikes-wars between the US and Chinese governments have not only affected the bilateral trade flows of these two countries, but also the world's multi-bilateral trade flows. Another impact of these wars and protectionist trade

✉ Serdar Ongan
serdarongan@usf.edu

¹ Department of Economics, University of South Florida, Tampa, USA

² Department of Econometrics, Adnan Menderes University, Aydın, Turkey

policies is that trade policy-related uncertainties (henceforth, TPU), scaled by the TPU index, have drastically increased. For instance, these indexes in the U.S and Japan, as our sample countries of this study, have increased by 1153% and 290%, respectively, between August 2016–2019 (Census 2020). In this context, firstly, we seek the answer to a crucial question as to whether the changes in the TPU indexes impact Japan's bilateral trade balance with its top partner, namely the U.S. which totaled at \$219 billion in two ways in 2019 (Census 2020). If so, secondly, as to whether this impact on this balance is symmetric (linear) or asymmetric (nonlinear). The answer to this question technically will require a decomposition process of the TPU index as TPU^+ and TPU^- , which corresponds to increases (+) and decreases (-) in this index. Detailed technical instruction about symmetry, asymmetry, and the decomposition process will be explained in the empirical methodology section. It should be noted that this study does not specifically test the impacts of increasing TPU indexes related to US-China trade policy tension in 2018 and U.S withdrawal from the Trans-Pacific Partnership in 2017, but, rather, it tests this in a longer period 1996M1–2021M5, which, of course, includes these two significant years.

To construct¹ the TPU index, leading national newspapers' coverages are used. Some predetermined words which may correspond to the uncertainties in trade policies are scanned-counted and scaled using a weighting process. These words include the following: *trade treaty*, *trade agreement*, *tariffs*, *trade policy*, *uncertainty*, *policy*, *economy*, *central banks*, *monetary policies*, etc. US and Japan's TPU indexes were created by Caldara et al. (2020) and Arbatli et al. (2019), respectively. Some such main newspapers scanned are *Yomiuri*, *Asahi*, *Mainichi* and *Nikkei* for Japan and *USA Today*, *Washington Post*, *Los Angeles Times*, *New York Times* for the U.S. The construction methodology for the TPU index consists of the following steps: (1): Scanning the (aforementioned) words in the newspapers; (2): Getting raw word counts; (3): Scaling the raw word count by the counts of all words; (4): Standardizing each newspaper's series of scaled TPU word counts; (5): Taking a monthly newspaper average to get the TPU index; (6): Multiplicatively normalizing the TPU index to 100.

It should be noted that the TPU index, as a categorical version of the EPU² (economic policy uncertainty) index by Baker et al. (2016), also gives references to trade policy uncertainties with additional scanned words in trade policy literature. Therefore, we can speculate that changes-shocks in trade flows related to trade policy uncertainties can be better/more thoroughly explained by the TPU index rather than by the EPU index. Hence, the TPU index seems to be a unique independent variable in trade models as compared to the EPU index.

The rest of this study is structured as follows: Sects. 2 provides a literature review, and Sect. 3 explains and provides the empirical methodology and data set. Section 4 provides empirical findings, and Sect. 5 presents the conclusion.

¹ For the detailed technical methodology, refer Davis et al. (2019), Baker et al. (2016), Caldara et al. (2020), Arbatli et al. (2019), Čižmešija et al. (2017).

² For the detailed technical methodology, refer Baker et al. (2016).

2 Literature review

The EPU index was widely used in many empirical studies to investigate the impacts of economic policy-related uncertainties on different micro-macroeconomic levels of variables, such as foreign direct investments (Hsieh et al. 2019; Canh et al. 2020), exchange rates (Beckmann and Czudaj 2017; Liming et al. 2020), Bitcoin prices (Demir et al. 2018; Wang et al. 2020), interest rates (Ashraf and Shen 2019), GDP (Ghirelli et al. 2019; Huang and Luk 2020), stock returns (Li et al. 2015; Yin et al. 2017; Chen and Chiang 2020) and demand for money (Ivanovski and Churchill 2019; Bahmani-Oskooosee and Nayeri 2020). However, the impacts of the EPU index on global-national level trade flows were not examined as much as the macroeconomic variables presented above. A few scholars have tested these impacts on trade flows. For instance, Han et al. (2016) applied the global vector autoregressive (GVAR) model for China and found that US and Japan's TPU indexes have negative impacts on China's export. Tam Sun (2018) applied the same methodology for China and the U.S and found that the EPU indexes of these countries have significant effects on global trade flows. Constantinescu et al. (2015) used a panel model for 18 countries and found that an increase in the EPU index significantly reduces the growth of trade flows. Beckmann and Czudaj (2017) applied the vector autoregression (VAR) model for some countries and found that the EPU indexes play determining roles in trade flows transmitted by exchange rates. Shin et al. (2018) applied the VAR model for South Korea and found strong correlations between the EPU index and the current account balance of this country. Wei (2019) used the VAR model for China and found that the global EPU index has negative impacts on Chinese real export. Adedoyin et al. (2020) used the export-led growth hypothesis (ELGH) for Malaysia and found that the EPU index has moderately negative impacts on export flows for this country. Jia et al. (2020) applied a gravity model approach for 20 countries. They found that exports of countries are negatively associated with the EPU indexes. However, unlike the EPU index, very little is known about whether changes in the TPU index affect trade flows in trade models. Therefore, we believe that this study, which uses the TPU index, will bridge this gap in relevant literature.

3 Empirical methodology and data set

The empirical methodology of this study consists of two steps. In the first step, we decompose the TPU indexes of both countries into their increases (+) and decreases (-) in the following partial sum process:

$$TPU_t^+ = \sum_{k=1}^T \Delta TPU_k^+ = \sum_{k=1}^T \max(\Delta(TPU_k, 0)) \quad (1)$$

$$TPU_t^- = \sum_{k=1}^T \Delta TPU_k^- = \sum_{k=1}^T \min(\Delta(TPU_k, 0)) \quad (2)$$

where TPU^+ and TPU^- are partial sums of increases (+) and decreases (-) of the TPU indexes. Hence, we obtain the TPU_t^{US+} , TPU_t^{US-} for the U.S and TPU_t^{JPN+} , TPU_t^{JPN-} for Japan. In the second step, we apply the nonlinear ARDL (autoregressive distributed lag) model of Shin et al. (2014). This model enables us to test the impacts of changing TPU_t^{US+} , TPU_t^{US-} , TPU_t^{JPN+} , and TPU_t^{JPN-} indexes on Japan's bilateral trade balance with the U.S (henceforth, BTB_{it}^{JPN-US}), *separately*. Because we assume that each index (series) may affect this balance in different magnitudes and different directions asymmetrically (nonlinearly). For instance, rises in the US TPU index (TPU_t^{US+}) may lead to declines in BTB_{it}^{JPN-US} or declines in the US TPU index (TPU_t^{US-}) may lead to rises in BTB_{it}^{JPN-US} nonlinearly asymmetrically. Furthermore, the impacts of TPU_t^{US+} on BTB_{it}^{JPN-US} can be higher or lower than the impacts of TPU_t^{US-} on it. Symmetry is defined as same magnitude and same direction impacts of TPU indexes on BTB_{it}^{JPN-US} . Before forming the nonlinear ARDL model of the study, we, first, present the following regressed basic model with decomposed TPU indexes (variables).

$$\begin{aligned} \text{Log}BTB_{it}^{JPN-US} = & \beta_0 + \beta_1 \text{REXR}_t^{JPY-USD} + \beta_2 \text{Log}Y_t^{JPN} + \beta_3 \text{Log}Y_t^{US} + \beta_4 \text{Log}TPU_t^{JPN+} \\ & + \beta_5 \text{Log}TPU_t^{JPN-} + \beta_6 \text{Log}TPU_t^{US+} + \beta_7 \text{Log}TPU_t^{US-} + \beta_8 D_{\text{Covid}_t} + \varepsilon_t \end{aligned} \quad (3)$$

The variables in the model above are defined as follows:

BTB_{it}^{JPN-US} : Japan's bilateral trade balance with the U.S, defined as the ratio of Japan's imports (m) from the U.S and Japan's exports (x) to the U.S as a ratio of m/x . This means that $BTB_{it}^{JPN-US} = m/x$. This ratio was proposed by Haynes and Stone (1982) and utilized by Bahmani-Oskooosee and Brooks (1999). Dependent variable of this study is based on the form of bilateral balance which shows the relative strength of a country's trade performance as a whole. Consequently, this form variable can make more sense than taking the variables export and import individually on a country's trade performance.

$\text{REXR}_t^{JPY-USD}$: the CPI adjusted real exchange rate between the Japanese YEN (JPY) and the USD. It is defined as $\text{REXR}_t^{JPY-USD} = (\text{NEX}_t * \text{CPI}_t^{JPN}) / \text{CPI}_t^{US}$. NEX is the nominal exchange rate, defined as units of USD per JPY.

Y_t^{JPN} and Y_t^{US} : Japan's and U.S income levels scaled by industrial production indexes, respectively

TPU_t^{JPN+} , TPU_t^{JPN-} , TPU_t^{US+} and TPU_t^{US-} : increases and decreases in Japan's and US trade policy uncertainty indexes (TPUs), respectively.

D_{Covid} is the COVID-19 pandemic and defined as a Dummy variable that takes value 1 after February 2020 as the first month for the worldwide pandemic cases recorded.

The expected sign of β_1 is to be positive since depreciations in JPY will improve BTB_{it}^{JPN-US} . The positive sign here denotes the same direction impact of β_1 on BTB_{it}^{JPN-US} . The expected signs of β_2 and β_3 are to be positive and negative, respectively. This means that while increases in Japan's income will worsen BTB_{it}^{JPN-US} due to increases in Japan's import from the U.S (it denotes same direction impact), increases in US income will improve BTB_{it}^{JPN-US} due to increases in US import from Japan (it denotes different direction impact). Finally, the expected signs of $\beta_4, \beta_5, \beta_6$

and β_7 are to be either positive or negative. This means that there is not any specific expectation for them about how they interact with $BTB_{it}^{JPN_US}$. The expected sign of β_8 is to be positive. This means that increases in COVID-19 cases will worsen.

$BTB_{it}^{JPN_US}$ due to decreases in Japan's export to the U.S. The model of this study was run for both aggregated and disaggregated data, separately. The disaggregated data model includes 60 (3-digits) industrial commodities traded between Japan and the U.S. The rationale of using disaggregated data is to avoid aggregation biases, which can cause misleading results. This means that disaggregated data can discover potentially concealed yet existing relationships between dependent and independent variables, which the aggregated data model cannot detect. Monthly commodity flows were obtained from the US Census Bureau. The nominal exchange rates, CPIs and GDPs series were obtained from the Federal Reserve Bank of St. Louis. The TPU index series of the US and Japan were obtained from <https://www.policyuncertainty.com>. The sample period is 1996M1–2021M5.

Following the basic model in Eq. 3, we apply the nonlinear ARDL model for both aggregated and disaggregated data in Eq. 4. The advantage of using this nonlinear model is that it is applicable regardless of whether the underlying regressors are $I(0)$, purely $I(1)$ or mutually cointegrated (Pesaran and Pesaran, 1997).

$$\begin{aligned} \Delta \text{Log} BTB_{it}^{JPN_US} = & \beta_0 + \beta_1 \text{Log} BTB_{it-1}^{JPN_US} + \beta_2 \text{REXR}_{t-1}^{JPY_USD} + \beta_3 \text{Log} Y_{t-1}^{JPN} + \beta_4 \text{Log} Y_{t-1}^{US} + \beta_5 \text{Log} TPU_{t-1}^{JPN+} \\ & + \beta_6 \text{Log} TPU_{t-1}^{JPN-} + \beta_7 \text{Log} TPU_{t-1}^{US+} + \beta_8 \text{Log} TPU_{t-1}^{US-} + \beta_9 D_{\text{Covid}_{t-1}} + \sum_{j=1}^{p_1} \beta_{10j} \Delta \text{Log} BTB_{it-j}^{JPN_US} \\ & + \sum_{j=0}^{p_2} \beta_{11j} \Delta \text{REXR}_{t-j}^{JPY_USD} + \sum_{j=0}^{p_3} \beta_{12j} \Delta \text{Log} Y_{t-j}^{JPN} + \sum_{j=0}^{p_4} \beta_{13j} \Delta \text{Log} Y_{t-j}^{US} + \sum_{j=0}^{p_5} (\beta_{14j} \Delta \text{Log} TPU_{t-j}^{JPN+} \\ & + \beta_{15j} \Delta \text{Log} TPU_{t-j}^{JPN-}) + \sum_{j=0}^{p_6} (\beta_{16j} \Delta \text{Log} TPU_{t-j}^{US+} + \beta_{17j} \Delta \text{Log} TPU_{t-j}^{US-}) + \varepsilon_t \end{aligned} \quad (4)$$

In Eq. 4, we determine the long-run impacts of changes in TPU_t^{JPN+} , TPU_t^{JPN-} and TPU_t^{US+} , TPU_t^{US-} indexes on $BTB_{it}^{JPN_US}$ with the signs and significances of $-\beta_5/\beta_1$, $-\beta_6/\beta_1$ and $-\beta_7/\beta_1$, $-\beta_8/\beta_1$, respectively.

4 Empirical findings

Descriptive statistics of the variables are provided in Table 1.

The low standard deviation indicates that the data of the variables are clustered closely around the mean. Table 2 reports the estimates of normalized long-run coefficients and diagnostics of the nonlinear ARDL model for both aggregated and disaggregated data.

Test results in Table 2 will be evaluated for aggregated and disaggregated (industries) data models, separately. The letters “W” and “I” in this table and text imply that the relevant independent variable in the relevant industry worsens and improves $BTB_{it}^{JPN_US}$, respectively. Furthermore, the letters “S” and “A” (at last two columns) correspond to symmetry and asymmetry determined by the Wald

Table 1 Descriptive statistics

	Total X	Total M	BTB	TPU ^{JPN}	TPU ^{USA}	IPJ ^{JPN}	IPJ ^{USA}	REX ^{JPY_USD}
Mean	5.70E+09	1.20E+10	48.13	132.58	116.40	102.72	93.50	0.01
Median	5.34E+09	1.13E+10	47.58	83.35	57.62	102.02	94.76	0.01
Maximum	1.20E+10	2.55E+10	71.59	722.30	1946.68	119.47	106.19	0.01
Minimum	4758.542	6646.898	36.15	11.12	10.56	78.29	71.73	0.01
Std. Dev	2.35E+09	5.04E+09	6.20	127.31	199.51	6.68	7.45	0.00
Skewness	0.45	0.52	0.72	2.28	4.78	-0.17	-0.66	0.20
Kurtosis	4.56	4.58	3.82	8.33	33.29	4.64	3.13	1.93
Jarque–Bera	41.16	45.24	34.83	626.21	12,821.20	35.81	22.35	16.54
Observations	305	305	305	305	305	305	305	305

test. W_{LRTPU_JPN} and W_{LRTPU_US} are long-run Wald tests of TPU indexes for Japan and the U.S, respectively.

The results of the *aggregated* data model in Table 2 (in the first row of the table) indicate that depreciations or appreciations ($REXR_t^{JPY_USD}$) in the JPY against the USD do not impact Japan's bilateral trade balance with the U.S. ($BTB_{it}^{JPN_US}$) since the coefficient of $REXR_t^{JPY_USD}$ is not statistically significant. This can be interpreted as meaning that neither country's consumers, through their import demands, are *exchange rate-sensitive* to each other's products. While rises in Japan's income (Y_t^{JPN}) do not impact $BTB_{it}^{JPN_US}$, rises in US income (Y_t^{US}) improve it. This can be interpreted as meaning that US consumers, through their import demands, are *income-sensitive* to Japanese products and they buy these products while their income levels rise. However, Japanese consumers are not *income-sensitive* to US products. Test results in Table 2 for the aggregated data model indicate that changes in both countries' TPU indexes have important impacts on $BTB_{it}^{JPN_US}$. While rises in Japan's TPU index (TPU_t^{JPN+}) worsen $BTB_{it}^{JPN_US}$, falls (TPU_t^{JPN-}) improve it. Based on the behaviors of Japanese consumers, through import demands, this can be interpreted as meaning that Japanese consumers are not *uncertainty-sensitive* to US products and they continue to buy such products, while Japan's TPU index rises (TPU_t^{JPN+}). Similarly, they are *uncertainty-sensitive* to US products and they reduce their purchases of these products while TPU index falls (TPU_t^{JPN-}). In regards to changes in the US TPU index, while rises in the US TPU index (TPU_t^{US+}) improve $BTB_{it}^{JPN_US}$, falls (TPU_t^{US-}) worsen it. Based on the behaviors of US consumers, through their import demands, this can be interpreted as meaning that US consumers are not *uncertainty-sensitive* to Japanese products and they continue to buy such products while the US TPU index rises (TPU_t^{US+}). Similarly, US consumers are *uncertainty-sensitive* to Japanese products and they reduce their purchases of these products while the US TPU index falls (TPU_t^{US-}). Aggregated data model finds no impacts of the COVID-19 on $BTB_{it}^{JPN_US}$ since the coefficient of $L_{D_{Covid}}$ is insignificant.

Empirical results of the *disaggregated* data model (industries) are totally different than empirical results of the aggregated data model. While aggregated data model finds no impacts of exchange rate on $BTB_{it}^{JPN_US}$, the disaggregated data

Table 2 The nonlinear ARDL model estimation results (normalized long-run coefficient)

	$L_{REXP^{PY_USD}}$	$L_{Y^{JPN}}$	$L_{Y^{US}}$	$L_{TPU^{JPN+}}$	$L_{TPU^{JPN-}}$	$L_{TPU^{US+}}$	$L_{TPU^{US-}}$	$L_{D_{Gold}}$	R^2
Aggregated	0.08 (0.31)	0.69 ^a W (0.00)	1.80 ^a W (0.00)	-0.04 ^c I (0.08)	-0.07 ^a W (0.00)	0.02 (0.10)	0.04 ^a I (0.00)	-0.08 (0.11)	0.50
081-Feeding Stuff for Animals	-0.92 ^b W (0.02)	2.07 ^b W (0.03)	-4.00 ^a I (0.00)	-0.16 ^c I (0.07)	-0.24 ^b W (0.01)	0.09 (0.13)	0.13 ^b I (0.02)	-0.26 ^b I (0.02)	0.52
111-Nonalco- holic Bever- ages	-0.41 (0.45)	-0.32 (0.81)	-1.14 (0.49)	0.07 (0.58)	0.27 ^c I (0.07)	-0.15 ^c I (0.07)	-0.28 ^a W (0.00)	-0.50 (0.16)	0.33
112-Alcoholic Beverages	0.37 (0.22)	0.07 (0.91)	-0.93 (0.28)	0.01 (0.79)	0.05 (0.43)	-0.05 (0.23)	-0.06 ^c W (0.08)	-0.23 (0.23)	0.41
222-Oil Seeds and Oleagi- nous Fruit	0.85 ^c I (0.05)	0.07 (0.94)	0.33 (0.79)	-0.01 (0.91)	0.04 (0.70)	0.02 (0.66)	-0.02 (0.64)	0.64 ^b (0.03)	0.55
232-Synthetic Rubber and Reclaim Rub- ber	-0.40 ^c W (0.07)	1.94 ^a W (0.00)	-2.55 ^a I (0.00)	-0.06 (0.15)	0.05 (0.28)	0.07 ^b W (0.02)	-0.02 (0.51)	-0.15 (0.28)	0.41
334-Oil (Not Crude)	1.24 (0.26)	-5.38 ^b I (0.04)	-3.84 (0.22)	0.41 (0.14)	0.46 (0.12)	0.11 (0.47)	0.10 (0.49)	1.93 ^a W (0.00)	0.45
411-Animal Oils and Fats	0.78 (0.30)	-0.18 (0.91)	-1.71 (0.43)	-0.46 ^a I (0.00)	-0.20 (0.27)	0.17 (0.13)	-0.005 (0.95)	-1.11 ^b I (0.03)	0.46
421-Fixed Vegetable Fats & Oils	-0.33 (0.53)	3.33 ^a W (0.00)	-6.33 ^a I (0.00)	0.04 (0.68)	0.12 (0.30)	-0.17 ^b I (0.02)	-0.21 ^a W (0.00)	-0.61 ^c I (0.07)	0.67
422-Fixed Veg- etable Fats & Oils; Crude	2.00 (0.79)	-5.72 ^a I (0.00)	-0.23 (0.91)	-0.21 (0.22)	0.26 (0.14)	-0.02 (0.81)	-0.41 ^a W (0.00)	-1.16 ^b I (0.02)	0.57

Table 2 (continued)

	L_{REXPV_USD}	L_{YIPN}	L_{YUS}	$L_{TPU^{IPN+}}$	$L_{TPU^{IPN-}}$	$L_{TPU^{US+}}$	$L_{TPU^{US-}}$	$L_{D_{Cold}}$	R^2
431-Animal/ Vegetable Fats/Oils Preparations	$-1.12^c \mathbf{W}$ (0.09)	$-5.71^a \mathbf{I}$ (0.00)	1.72 (0.38)	-0.12 (0.39)	-0.14 (0.36)	$0.34^a \mathbf{W}$ (0.00)	$0.39^a \mathbf{I}$ (0.00)	$0.88^b \mathbf{W}$ (0.04)	0.51
515-Organic Inorganic & Heterocyclic Compounds	$-1.03^c \mathbf{W}$ (0.06)	$5.67^a \mathbf{W}$ (0.00)	-2.39 (0.14)	0.21 (0.10)	0.05 (0.70)	0.09 (0.25)	$0.20^a \mathbf{I}$ (0.00)	$0.85^b \mathbf{W}$ (0.02)	0.44
516-Organic Chemicals	0.70 (0.24)	1.34 (0.40)	$-5.93^a \mathbf{I}$ (0.00)	$0.23^c \mathbf{W}$ (0.08)	0.09 (0.53)	-0.04 (0.64)	0.02 (0.81)	$-1.00^b \mathbf{I}$ (0.02)	0.51
541-Medicinal Products, Except Medicaments	0.28 (0.27)	-0.42 (0.49)	1.19 (0.11)	0.05 (0.35)	-0.02 (0.73)	$-0.12^a \mathbf{I}$ (0.00)	$-0.06^c \mathbf{W}$ (0.08)	$-0.89^a \mathbf{I}$ (0.00)	0.57
542-Medicaments (Includ- ing Veterinary Medicaments)	$5.56^a \mathbf{I}$ (0.00)	1.83 (0.60)	0.13 (0.97)	-0.54 (0.19)	-0.53 (0.19)	-0.07 (0.74)	-0.14 (0.48)	-1.55 (0.10)	0.47
598-Miscellane- ous Chemical Products	$-0.38^a \mathbf{W}$ (0.00)	-0.26 (0.35)	$-1.10^a \mathbf{I}$ (0.00)	$0.04^c \mathbf{W}$ (0.08)	0.02 (0.31)	-0.01 (0.33)	-0.001 (0.91)	$-0.34^a \mathbf{I}$ (0.00)	0.44
625-Rubber Tires and Accessories	$-1.30^a \mathbf{W}$ (0.00)	$3.65^a \mathbf{W}$ (0.00)	$-3.61^a \mathbf{I}$ (0.00)	$0.42^a \mathbf{W}$ (0.00)	$0.35^b \mathbf{I}$ (0.01)	-0.04 (0.54)	0.04 (0.53)	$0.65^b \mathbf{W}$ (0.03)	0.39
629-Articles of Rubber	$-0.77^b \mathbf{W}$ (0.04)	1.03 (0.28)	-1.41 (0.22)	-0.01 (0.84)	-0.15 (0.10)	0.07 (0.16)	$0.18^a \mathbf{I}$ (0.00)	$0.45^c \mathbf{W}$ (0.09)	0.35

Table 2 (continued)

	L_{REXPV_USD}	$L_{JP/N}$	L_{YUS}	$L_{TPU^{PN+}}$	$L_{TPU^{PN-}}$	$L_{TPU^{US+}}$	$L_{TPU^{US-}}$	$L_{D_{Cond}}$	R^2
679-Iron & Steel Tubes, Pipes & Fittings	- 0.63 (0.63)	- 3.58 (0.31)	3.75 (0.32)	0.07 (0.77)	0.15 (0.58)	0.18 (0.30)	0.13 (0.40)	0.55 (0.49)	0.38
695-Tools for Use in the Hand or in Machines	0.11 (0.65)	0.96 (0.13)	- 1.30 ^a I (0.08)	0.04 (0.45)	0.04 (0.48)	- 0.10 ^a I (0.00)	- 0.10 ^a W (0.00)	- 0.18 (0.29)	0.33
699-Manufactures of Base Metal	- 1.00 ^a W (0.00)	1.90 ^b W (0.01)	- 2.26 ^a I (0.00)	- 0.12 ^c I (0.09)	1.90 ^b I (0.01)	- 0.06 (0.13)	- 0.05 (0.20)	- 0.87 ^a I (0.00)	0.34
712-Steam Turbines & Other Vapor Turbines	- 1.39 (0.28)	5.01 (0.12)	- 4.31 (0.25)	0.28 (0.32)	- 0.10 (0.72)	- 0.14 (0.45)	0.17 (0.29)	1.51 ^c W (0.07)	0.44
713-Internal Combustion Piston Engines	- 0.37 (0.51)	1.26 (0.34)	- 1.86 (0.26)	0.05 (0.68)	- 0.09 (0.45)	- 0.02 (0.76)	0.08 (0.26)	- 0.22 (0.54)	0.212
714-Nonelectric Engines and Motors	- 1.40 ^a W (0.00)	- 0.82 (0.44)	- 0.14 (0.91)	0.30 ^a W (0.00)	0.07 (0.49)	0.03 (0.65)	0.25 ^a I (0.00)	1.17 ^a W (0.00)	0.45
716-Rotating Electric Plant and Parts	- 0.86 (0.27)	0.24 (0.89)	- 2.79 (0.21)	- 0.08 (0.70)	- 0.14 (0.52)	0.19 (0.10)	0.23 ^b I (0.03)	- 0.40 (0.44)	0.37
723-Civil Engineering & Contractors' Plant & Equipment	- 0.26 (0.63)	- 2.25 ^c I (0.09)	- 1.45 (0.37)	- 0.03 (0.77)	- 0.10 (0.43)	- 0.05 (0.48)	0.01 (0.87)	- 0.60 (0.10)	0.28

Table 2 (continued)

	L_{REXPV_USD}	$L_{JP/N}$	L_{JUS}	$L_{TPU^{PN+}}$	$L_{TPU^{PN-}}$	$L_{TPU^{US+}}$	$L_{TPU^{US-}}$	$L_{D_{Cold}}$	R^2
726-Printing & Bookbinding Machinery	0.72 (0.11)	-1.16 (0.29)	-1.17 (0.37)	-0.02 (0.80)	-0.02 (0.83)	0.003 (0.95)	-0.003 (0.95)	-0.35 (0.24)	0.50
728-Machinery Specialized for Particular Industries	-1.68 ^a W (0.00)	1.04 (0.38)	-0.53 (0.70)	-0.17 (0.18)	-0.24 ^c W (0.08)	0.08 (0.28)	0.14 ^c I (0.06)	0.19 (0.56)	0.56
731-Machine Tools Working by Removing Metal or Other	-1.83 (0.15)	-5.48 ^c I (0.08)	2.41 (0.51)	0.03 (0.89)	0.35 (0.24)	0.06 (0.74)	-0.13 (0.42)	-0.15 (0.84)	0.29
741-Heating & Cooling Equipment	-0.33 (0.19)	-1.50 ^b I (0.01)	2.21 ^a W (0.00)	-0.13 ^b I (0.01)	-0.02 (0.71)	0.07 ^c W (0.05)	0.01 (0.75)	0.17 (0.29)	0.44
742-Pumps for Liquids and Liquid Elevators	-0.50 ^c W (0.08)	1.24 ^c W (0.07)	-2.23 ^a I (0.00)	-0.02 (0.71)	-0.04 (0.47)	0.03 (0.43)	0.05 (0.17)	-0.25 (0.19)	0.37
743-Pumps, Air or Other Gas Compressors and Fans	-0.87 ^a W (0.00)	3.33 ^a W (0.00)	-2.76 ^a I (0.00)	0.07 (0.20)	-0.02 (0.67)	-0.02 (0.50)	0.04 (0.16)	0.01 (0.94)	0.37
744-Mechanical Handling Equipment	-0.75 ^a W (0.00)	1.34 ^b W (0.03)	-2.65 ^a I (0.00)	-0.10 ^c I (0.08)	-0.02 (0.66)	0.04 (0.29)	-0.01 (0.60)	-0.04 (0.78)	0.38

Table 2 (continued)

	L_{REXPV_USD}	$L_{JP/N}$	L_{YUS}	$L_{JP/N}^{+}$	$L_{JP/N}^{-}$	$L_{JP/N}^{+}$	$L_{JP/N}^{+}$	$L_{D_{Cold}}$	R^2
747-Taps, Cocks, Valves & Similar Appliances	- 0.18 (0.25)	0.39 (0.32)	- 0.85 ^c I (0.06)	0.07 ^c W (0.04)	0.06 ^c I (0.08)	0.01 (0.51)	0.01 (0.39)	0.11 (0.26)	0.49
748-Transmission Shafts and Cranks	0.41 (0.41)	- 0.56 (0.61)	- 2.87 ^b I (0.04)	- 0.005 (0.96)	0.03 (0.74)	- 0.13 ^b I (0.04)	- 0.20 ^a W (0.00)	- 0.74 ^b I (0.02)	0.29
749-Nonelectric Parts & Accessories of Machinery	- 0.24 (0.40)	- 1.73 ^b I (0.01)	1.56 ^c W (0.06)	- 0.03 (0.58)	0.05 (0.45)	0.06 (0.13)	- 0.001 (0.97)	0.26 (0.17)	0.38
751-Office Machines	0.44 (0.64)	- 2.91 (0.16)	6.76 ^a W (0.01)	0.22 (0.27)	- 0.02 (0.89)	- 0.06 (0.62)	0.15 (0.18)	0.89 (0.13)	0.31
752-Automatic Data Process Machines	0.04 (0.85)	1.28 ^b W (0.02)	- 1.56 ^b I (0.01)	0.05 (0.30)	0.05 (0.32)	- 0.04 (0.21)	- 0.07 ^b W (0.01)	- 0.17 (0.24)	0.43
762-Radio-broadcast Receivers	- 0.89 (0.39)	4.07 (0.10)	- 8.30 ^a I (0.00)	- 0.52 ^c I (0.05)	- 0.38 (0.18)	0.23 (0.12)	0.08 (0.55)	- 1.05 (0.13)	0.33
764-Telecommunications Equipment	- 0.99 (0.14)	- 0.70 (0.65)	- 0.67 (0.71)	0.44 ^b W (0.01)	0.37 ^b I (0.04)	0.03 (0.69)	0.10 (0.24)	0.10 (0.81)	0.41
771-Electric Power Machinery, and Parts	- 0.91 ^a W (0.00)	- 0.61 (0.21)	- 1.13 ^c I (0.06)	0.003 (0.93)	- 0.01 (0.72)	0.04 (0.20)	0.06 ^b I (0.01)	- 0.29 ^b I (0.03)	0.48

Table 2 (continued)

	L_{REXPV_USD}	L_{YIPN}	L_{YUS}	$L_{TPU^{IPN+}}$	$L_{TPU^{IPN-}}$	$L_{TPU^{US+}}$	$L_{TPU^{US-}}$	$L_{D_{Cold}}$	R^2
772-Electrical Apparatus for Switching or Protecting	$-0.92^b \mathbf{W}$ (0.03)	0.43 (0.67)	-1.35 (0.26)	-0.13 (0.22)	$-0.28^b \mathbf{W}$ (0.02)	$-0.15^b \mathbf{I}$ (0.01)	-0.05 (0.34)	$-0.59^b \mathbf{I}$ (0.04)	0.29
773-Equipment for Distributing Electricity	$-1.18^a \mathbf{W}$ (0.00)	$1.85^b \mathbf{W}$ (0.02)	$-4.24^a \mathbf{I}$ (0.00)	$0.16^b \mathbf{W}$ (0.04)	0.04 (0.58)	0.06 (0.22)	$0.15^a \mathbf{I}$ (0.00)	-0.03 (0.86)	0.42
774-Electro-Diagnostic Apparatus	$0.40^a \mathbf{I}$ (0.00)	0.17 (0.59)	-0.08 (0.82)	-0.01 (0.64)	-0.01 (0.59)	$-0.03^b \mathbf{I}$ (0.04)	$-0.03^c \mathbf{W}$ (0.05)	-0.12 (0.15)	0.51
775-Household Type Electric & Nonelectric Equipment	-0.07 (0.76)	-0.50 (0.35)	-0.56 (0.38)	0.04 (0.36)	-0.01 (0.80)	-0.04 (0.20)	0.01 (0.73)	0.08 (0.58)	0.38
776-Thermionic, Cold Cathode and Photocathode Valves	-0.23 (0.48)	$-2.42^a \mathbf{I}$ (0.00)	$2.11^b \mathbf{W}$ (0.02)	-0.02 (0.77)	0.09 (0.23)	0.02 (0.62)	-0.04 (0.29)	0.09 (0.66)	0.35
778-Electrical Machinery and Apparatus	-0.49 (0.15)	-0.88 (0.28)	-0.10 (0.92)	$-0.19^b \mathbf{I}$ (0.03)	-0.04 (0.63)	0.08 (0.11)	-0.02 (0.65)	$-0.55^b \mathbf{I}$ (0.02)	0.37
781-All Motor Vehicles	0.74 (0.30)	$3.08^c \mathbf{W}$ (0.08)	$-4.24^b \mathbf{I}$ (0.03)	-0.08 (0.61)	-0.20 (0.24)	0.11 (0.30)	$0.19^c \mathbf{I}$ (0.09)	0.34 (0.45)	0.45
782-Special Purpose Motor Vehicles	0.79 (0.44)	$5.97^b \mathbf{W}$ (0.02)	-1.99 (0.52)	0.20 (0.39)	-0.02 (0.90)	-0.09 (0.54)	0.09 (0.52)	$2.37^a \mathbf{W}$ (0.00)	0.37

Table 2 (continued)

	L_{REXPV_USD}	L_{JPY}	L_{USD}	L_{JPY}^{DN+}	L_{JPY}^{DN-}	L_{JPY}^{US+}	L_{JPY}^{US-}	$L_{D_{Contd}}$	R^2
784-Parts and Accessories of Motor Vehicles	$-1.01^a \mathbf{W}$ (0.00)	$1.84^b \mathbf{W}$ (0.01)	$-1.82^b \mathbf{I}$ (0.03)	0.01 (0.79)	-0.05 (0.46)	$0.09^b \mathbf{W}$ (0.04)	$0.16^a \mathbf{I}$ (0.00)	0.28 (0.14)	0.78
785-Motor-cycles and Cycles, Motorized & Not Motorized	$-0.64^c \mathbf{W}$ (0.09)	$1.78^b \mathbf{W}$ (0.04)	$-6.84^a \mathbf{I}$ (0.00)	$0.24^a \mathbf{W}$ (0.00)	0.13 (0.14)	$-0.15^b \mathbf{I}$ (0.01)	$-0.09^c \mathbf{W}$ (0.07)	-0.37 (0.14)	0.29
786-Trailers & Semi-Trailers	$-2.86^a \mathbf{W}$ (0.00)	1.25 (0.58)	$-6.77^b \mathbf{I}$ (0.02)	-0.04 (0.83)	0.05 (0.80)	$0.64^a \mathbf{W}$ (0.00)	$0.57^a \mathbf{I}$ (0.00)	-0.45 (0.49)	0.39
792-Aircraft & Associated Equipment	0.37 (0.21)	-0.29 (0.67)	0.17 (0.83)	$-0.26^c \mathbf{I}$ (0.00)	-0.01 (0.88)	$0.17^a \mathbf{W}$ (0.00)	-0.01 (0.79)	-0.08 (0.69)	0.40
793-Ships, Boats and Floating Structures	$1.48^c \mathbf{I}$ (0.06)	$7.03^a \mathbf{W}$ (0.00)	$-7.18^a \mathbf{I}$ (0.00)	-0.19 (0.29)	-0.26 (0.16)	0.20 (0.10)	$0.20^c \mathbf{I}$ (0.07)	-0.80 (0.12)	0.44
872-Medical Instruments & Appliances	$0.53^b \mathbf{I}$ (0.02)	0.80 (0.15)	-1.04 (0.11)	-0.07 (0.17)	-0.08 (0.16)	0.04 (0.90)	0.004 (0.90)	-0.17 (0.24)	0.50
873-Meters and Counters	$-3.08^a \mathbf{W}$ (0.00)	1.32 (0.55)	$-5.16^c \mathbf{I}$ (0.05)	-0.05 (0.79)	-0.11 (0.58)	0.03 (0.76)	0.08 (0.49)	-0.15 (0.79)	0.27
874-Measuring/Checking/Analyzing Instruments	$-0.54^a \mathbf{W}$ (0.00)	0.16 (0.59)	$-0.63^c \mathbf{I}$ (0.07)	0.01 (0.56)	0.02 (0.31)	0.02 (0.16)	0.02 (0.11)	$0.20^a \mathbf{W}$ (0.01)	0.43

Table 2 (continued)

	L_{REXPV_USD}	L_{JPJN}	L_{JUS}	$L_{TPU^{JPN+}}$	$L_{TPU^{JPN-}}$	$L_{TPU^{JUS+}}$	$L_{TPU^{JUS-}}$	$L_{D_{Gold}}$	R^2
898-Musical Instruments and Accessories	$0.68^b \mathbf{I}$ (0.01)	$1.31^b \mathbf{W}$ (0.16)	$-2.60^a \mathbf{I}$ (0.00)	$0.19^a \mathbf{W}$ (0.00)	0.03 (0.60)	$-0.16^b \mathbf{I}$ (0.00)	-0.04 (0.26)	-0.25 (0.16)	0.33
899-Miscellaneous Manufactured Articles	0.28 (0.56)	1.76 (0.16)	-1.02 (0.48)	-0.05 (0.60)	-0.13 (0.26)	$-0.15^b \mathbf{I}$ (0.04)	$-0.12^c \mathbf{W}$ (0.06)	-0.16 (0.62)	0.34
931-Special Transactions not Classified by Kind	$-0.78^b \mathbf{W}$ (0.04)	$-1.62^c \mathbf{I}$ (0.06)	-1.04 (0.33)	$-0.33^a \mathbf{I}$ (0.00)	$-0.15^c \mathbf{W}$ (0.09)	$0.15^b \mathbf{W}$ (0.01)	0.01 (0.79)	$-1.03^a \mathbf{I}$ (0.00)	0.40
971-Gold, Non-monetary	$0.63^c \mathbf{I}$ (0.09)	$-1.94^b \mathbf{I}$ (0.04)	0.93 (0.40)	$-0.15^c \mathbf{I}$ (0.07)	-0.06 (0.48)	$0.13^b \mathbf{W}$ (0.01)	0.05 (0.27)	$3.18^a \mathbf{W}$ (0.00)	0.63
$\bar{R}^2$	DW	χ^2_{SC}	χ^2_{HET}	χ^2_{NOR}	χ^2_{FF}	t_{BDM}	F_{PSS}	W_{LRPU_JPN}	W_{LRPU_US}
0.47	2.00	0.36 (0.84)	28.66 (0.09)	1.92 (0.38)	0.20 (0.64)	-4.07 (0.04)	5.76 (0.00)	-0.008 A (0.00)	0.004 A (0.01)
0.50	1.99	0.30 (0.85)	20.68 (0.19)	4.95 (0.08)	1.04 (0.30)	-7.10 (0.00)	17.21 (0.00)	0.07 S (0.12)	-0.03 S (0.38)
0.28	1.99	0.01 (0.91)	21.27 (0.21)	4.96 (0.08)	3.40 (0.06)	-3.94 (0.03)	5.20 (0.00)	-0.20 A (0.00)	0.13 A (0.01)
0.39	1.93	2.75 (0.09)	31.08 (0.17)	0.04 (0.97)	4.28 (0.39)	-5.91 (0.00)	35.41 (0.00)	-0.03 S (0.32)	0.01 S (0.56)
0.53	2.00	0.06 (0.79)	7.50 (0.67)	1.59 (0.45)	2.25 (0.13)	-18.04 (0.00)	108.88 (0.00)	-0.05 S (0.29)	0.05 S (0.19)
0.38	1.95	1.13 (0.58)	46.22 (0.30)	3.81 (0.10)	0.79 (0.37)	-5.92 (0.00)	11.74 (0.00)	-0.12 A (0.00)	0.09 A (0.00)

Table 2 (continued)

$\bar{R}^2$	DW	χ^2_{SC}	χ^2_{HET}	χ^2_{NOR}	χ^2_{FF}	t_{BDM}	F_{PSS}	$W_{LRPU_{JPN}}$	$W_{LRPU_{US}}$
0.41	2.07	2.56 (0.12)	20.14 (0.32)	3.33 (0.18)	2.11 (0.14)	- 7.14 (0.00)	17.48 (0.00)	- 0.05 S (0.69)	0.01 S (0.88)
0.44	2.03	1.46 (0.47)	15.89 (0.14)	2.94 (0.33)	1.00 (0.31)	- 9.11 (0.00)	27.94 (0.00)	- 0.26 A (0.00)	0.18 A (0.01)
0.65	1.96	0.63 (0.42)	7.42 (0.82)	4.39 (0.11)	2.97 (0.08)	- 9.55 (0.00)	30.48 (0.00)	- 0.08 S (0.22)	0.04 S (0.38)
0.54	2.05	3.00 (0.08)	22.67 (0.12)	3.30 (0.22)	0.12 (0.72)	- 4.12 (0.01)	5.87 (0.00)	- 0.48 A (0.00)	0.38 A (0.00)
0.49	2.08	5.11 (0.07)	16.32 (0.29)	3.16 (0.13)	0.69 (0.40)	- 4.90 (0.02)	8.11 (0.00)	0.01 S (0.85)	- 0.04 S (0.46)
0.41	1.98	0.07 (0.96)	16.94 (0.38)	3.98 (0.13)	0.68 (0.40)	- 5.05 (0.02)	8.89 (0.00)	0.16 A (0.02)	- 0.11 A (0.04)
0.48	2.06	4.32 (0.11)	23.38 (0.32)	0.52 (0.76)	1.57 (0.21)	- 2.92 (0.09)	2.86 (0.03)	0.14 A (0.06)	- 0.06 S (0.29)
0.55	2.00	1.01 (0.60)	16.46 (0.38)	1.66 (0.39)	3.97 (0.11)	- 5.23 (0.00)	9.45 (0.00)	0.07 A (0.02)	- 0.05 A (0.02)
0.44	2.04	3.54 (0.16)	27.61 (0.09)	1.09 (0.57)	2.21 (0.13)	- 2.32 (0.09)	2.70 (0.04)	- 0.004 S (0.98)	0.06 S (0.65)
0.42	2.00	0.24 (0.88)	10.43 (0.40)	4.15 (0.12)	8.30 (0.42)	- 6.27 (0.00)	13.39 (0.00)	0.01 S (0.24)	- 0.01 S (0.19)
0.35	1.99	3.24 (0.19)	38.44 (0.17)	0.90 (0.63)	0.38 (0.53)	- 3.62 (0.05)	4.41 (0.00)	0.07 S (0.22)	- 0.08 ^c A (0.07)
0.32	2.01	1.79 (0.40)	28.41 (0.48)	3.65 (0.14)	2.45 (0.11)	- 4.05 (0.02)	5.54 (0.00)	0.13 A (0.00)	- 0.11 A (0.00)
0.34	2.01	1.22 (0.54)	14.59 (0.74)	2.66 (0.77)	0.11 (0.73)	- 3.26 (0.08)	3.79 (0.02)	- 0.07 S (0.61)	0.04 S (0.68)

Table 2 (continued)

$\bar{R}^2$	DW	χ^2_{SC}	χ^2_{HET}	χ^2_{NOR}	χ^2_{FF}	t_{BDM}	F_{PSS}	$W_{LRPU_{JPN}}$	$W_{LRPU_{US}}$
0.30	1.98	0.05 (0.97)	19.57 (0.07)	2.38 (0.08)	0.003 (0.95)	− 10.79 (0.00)	38.92 (0.00)	0.0006 S (0.98)	0.001 S (0.96)
0.31	2.01	0.36 (0.83)	16.55 (0.41)	1.78 (0.27)	1.75 (0.18)	− 2.55 (0.09)	2.37 (0.07)	0.05 S (0.14)	− 0.01 S (0.60)
0.42	2.03	2.02 (0.36)	18.16 (0.15)	6.98 (0.30)	0.87 (0.35)	− 6.02 (0.01)	12.14 (0.00)	0.39 A (0.01)	− 0.31 A (0.01)
0.18	2.01	2.00 (0.36)	19.89 (0.09)	2.38 (0.20)	6.61 (0.10)	− 4.86 (0.00)	8.00 (0.00)	0.14 A (0.03)	− 0.10 A (0.04)
0.43	2.01	0.39 (0.82)	15.21 (0.44)	0.45 (0.79)	2.72 (0.09)	− 4.26 (0.00)	6.22 (0.00)	0.22 A (0.00)	− 0.22 A (0.00)
0.34	2.02	1.51 (0.46)	38.78 (0.19)	5.90 (0.10)	0.007 (0.93)	− 5.59 (0.00)	10.63 (0.00)	0.06 S (0.51)	− 0.04 S (0.55)
0.25	2.03	2.14 (0.34)	10.25 (0.50)	3.47 (0.24)	6.34 (0.12)	− 5.84 (0.00)	11.45 (0.00)	0.06 S (0.35)	− 0.06 S (0.20)
0.47	2.05	3.54 (0.17)	26.18 (0.24)	8.37 (0.15)	3.32 (0.06)	− 4.55 (0.01)	6.93 (0.00)	− 0.002 S (0.96)	0.006 S (0.88)
0.46	2.13	3.03 (0.21)	14.57 (0.55)	1.30 (0.52)	0.07 (0.78)	− 5.03 (0.00)	8.50 (0.00)	0.06 S (0.27)	− 0.59 A (0.09)
0.26	2.04	4.46 (0.10)	25.41 (0.13)	1.05 (0.59)	0.01 (0.89)	− 3.98 (0.04)	5.66 (0.00)	− 0.31 A (0.04)	0.43 S (0.80)
0.41	2.01	0.61 (0.73)	23.83 (0.13)	2.78 (0.24)	1.19 (0.27)	− 5.92 (0.00)	11.76 (0.00)	− 0.11 A (0.00)	0.06 A (0.01)
0.35	1.97	0.16 (0.91)	7.02 (0.07)	2.30 (0.48)	7.18 (0.78)	− 5.33 (0.00)	9.57 (0.00)	0.02 A (0.03)	− 0.01 S (0.48)
0.34	2.01	1.46 (0.48)	3.76 (0.79)	4.92 (0.08)	0.17 (0.67)	− 4.14 (0.05)	5.86 (0.00)	0.09 A (0.00)	− 0.07 A (0.00)
0.35	1.96	0.59 (0.74)	10.70 (0.46)	3.96 (0.25)	1.51 (0.21)	− 6.89 (0.00)	16.28 (0.00)	− 0.07 A (0.02)	0.06 A (0.02)
0.46	1.97	0.40 (0.81)	18.71 (0.28)	2.06 (0.35)	11.79 (0.70)	− 6.97 (0.00)	16.83 (0.00)	0.009 S (0.66)	− 0.002 S (0.85)

Table 2 (continued)

$\bar{R}^2$	DW	χ^2_{SC}	χ^2_{HET}	χ^2_{NOR}	χ^2_{FF}	t_{BDM}	F_{PSS}	$W_{LRPU_{JPN}}$	$W_{LRPU_{US}}$
0.25	1.99	0.38 (0.82)	10.83 (0.62)	8.73 (0.11)	0.17 (0.67)	− 3.80 (0.08)	5.11 (0.00)	− 0.04 S (0.49)	0.06 S (0.19)
0.35	2.00	0.13 (0.93)	10.74 (0.63)	5.96 (0.10)	3.38 (0.06)	− 10.91 (0.00)	39.72 (0.00)	− 0.08 A (0.01)	0.06 A (0.02)
0.28	2.00	0.33 (0.84)	3.58 (0.11)	5.10 (0.07)	1.44 (0.23)	− 3.75 (0.05)	4.85 (0.00)	0.04 S (0.59)	− 0.09 S (0.40)
0.40	1.94	3.41 (0.18)	18.42 (0.10)	0.09 (0.95)	0.86 (0.35)	− 5.73 (0.00)	11.01 (0.00)	− 0.0004 S (0.98)	0.03 S (0.16)
0.30	2.00	0.95 (0.62)	3.54 (0.65)	3.39 (0.21)	0.82 (0.36)	− 4.62 (0.05)	7.16 (0.00)	− 0.14 S (0.28)	0.15 S (0.13)
0.37	2.06	6.42 (0.07)	23.66 (0.16)	4.78 (0.09)	1.80 (0.18)	− 3.30 (0.09)	6.39 (0.00)	0.07 S (0.38)	− 0.06 S (0.30)
0.46	2.01	2.89 (0.23)	3.82 (0.26)	2.43 (0.29)	0.08 (0.76)	− 6.07 (0.00)	12.43 (0.00)	0.02 S (0.41)	− 0.02 S (0.16)
0.25	1.99	1.66 (0.43)	3.75 (0.26)	8.01 (0.18)	0.35 (0.55)	− 3.46 (0.09)	5.37 (0.00)	0.14 A (0.00)	− 0.10 A (0.01)
0.39	1.98	0.64 (0.73)	3.24 (0.35)	1.29 (0.24)	10.03 (0.17)	− 3.74 (0.09)	4.71 (0.00)	0.12 A (0.00)	− 0.09 A (0.00)
0.48	2.12	8.58 (0.13)	12.46 (0.71)	0.21 (0.89)	7.70 (0.59)	− 14.40 (0.00)	69.31 (0.00)	0.003 S (0.84)	− 0.003 S (0.76)
0.36	2.01	1.04 (0.60)	13.22 (0.27)	1.51 (0.46)	0.60 (0.43)	− 7.12 (0.00)	16.98 (0.00)	0.06 A (0.03)	− 0.05 A (0.01)
0.32	2.02	1.09 (0.57)	13.48 (0.48)	6.31 (0.42)	0.005 (0.94)	− 3.72 (0.06)	4.67 (0.00)	− 0.11 A (0.00)	0.06 A (0.02)
0.34	2.00	0.09 (0.95)	22.82 (0.11)	1.50 (0.47)	5.89 (0.18)	− 3.84 (0.08)	5.00 (0.00)	− 0.14 A (0.00)	0.10 A (0.00)
0.41	2.07	5.62 (0.06)	25.59 (0.16)	1.39 (0.49)	0.02 (0.88)	− 3.84 (0.08)	2.14 (0.01)	0.11 S (0.18)	− 0.07 S (0.26)
0.33	2.05	2.42 (0.40)	21.39 (0.20)	1.19 (0.54)	0.27 (0.59)	− 4.31 (0.00)	6.29 (0.00)	0.23 A (0.08)	− 0.18 A (0.06)
0.68	1.78	1.05 (0.58)	32.22 (0.73)	3.33 (0.18)	1.81 (0.18)	− 4.00 (0.03)	5.45 (0.00)	0.07 A (0.05)	− 0.07 A (0.01)
0.26	1.95	0.45 (0.79)	10.17 (0.51)	0.36 (0.83)	0.05 (0.82)	− 8.03 (0.00)	22.47 (0.00)	0.11 A (0.02)	− 0.05 S (0.12)

Table 2 (continued)

$\bar{R}^2$	DW	χ^2_{SC}	χ^2_{HET}	χ^2_{NOR}	χ^2_{FF}	t_{BDM}	F_{PSS}	$W_{LRPU,JPW}$	$W_{LRPU,US}$
0.36	2.04	2.63 (0.26)	23.10 (0.08)	2.36 (0.35)	0.004 (0.94)	− 3.08 (0.09)	3.45 (0.01)	− 0.10 S (0.39)	0.07 S (0.43)
0.37	2.03	0.95 (0.62)	19.26 (0.15)	6.67 (0.29)	0.38 (0.53)	− 6.18 (0.00)	12.80 (0.00)	− 0.25 A (0.00)	0.18 A (0.00)
0.41	2.02	0.84 (0.65)	7.96 (0.78)	3.97 (0.57)	1.54 (0.21)	− 7.04 (0.00)	16.77 (0.00)	0.07 S (0.46)	− 0.002 S (0.97)
0.48	1.99	0.21 (0.89)	23.76 (0.12)	5.21 (0.07)	0.79 (0.37)	− 4.06 (0.02)	6.35 (0.00)	0.008 S (0.77)	0.0004 S (0.98)
0.25	2.00	1.61 (0.44)	12.27 (0.35)	1.56 (0.39)	0.12 (0.72)	− 5.39 (0.00)	10.12 (0.00)	0.06 S (0.58)	− 0.04 S (0.62)
0.41	2.03	1.42 (0.49)	13.93 (0.20)	0.64 (0.72)	0.04 (0.82)	− 6.44 (0.00)	14.11 (0.00)	− 0.01 S (0.40)	− 0.0006 S (0.95)
0.30	1.97	0.32 (0.85)	6.05 (0.86)	5.35 (0.12)	0.07 (0.78)	− 4.54 (0.03)	6.97 (0.00)	0.15 A (0.00)	− 0.12 A (0.00)
0.31	1.99	0.25 (0.87)	9.88 (0.77)	7.22 (0.12)	0.50 (0.47)	− 3.42 (0.07)	4.88 (0.00)	0.07 S (0.22)	− 0.03 S (0.48)
0.37	2.06	3.91 (0.47)	12.65 (0.55)	1.10 (0.45)	0.005 (0.94)	− 3.48 (0.06)	4.23 (0.00)	− 0.18 A (0.00)	0.13 A (0.00)
0.60	1.86	4.84 (0.08)	14.57 (0.77)	2.37 (0.48)	9.74 (0.20)	− 6.53 (0.00)	12.00 (0.03)	− 0.08 A (0.06)	0.07 A (0.03)

a, b and c denote statistical significances at 1%, 5% and 10% levels, respectively. Prob values are in parentheses. t_{BDM} , Banerjee, Dolado and Mestre (1998), F_{PSS} : Pesaran et al. (2001) cointegration test results. W_{LR} is long-run Wald tests. Normalized long-run coefficients are obtained with $L_{REXP,JPW,USD} = -\frac{\beta_2}{\beta_1}$, $L_{Y,JPW} = -\frac{\beta_3}{\beta_1}$, $L_{Y,US} = -\frac{\beta_4}{\beta_1}$, $L_{TPU,JPW+} = -\frac{\beta_5}{\beta_1}$, $L_{TPU,US+} = -\frac{\beta_6}{\beta_1}$, $L_{TPU,US-} = -\frac{\beta_7}{\beta_1}$. χ^2_{SC} is Breusch–Godfrey LM test for autocorrelation. χ^2_{NOR} is the Jarque–Bera test for normality. χ^2_{FF} is Ramsey test for functional form misspecification. χ^2_{HET} for Breusch–Pagan–Godfrey heteroscedasticity test. All model specification test results are reliable. W: Related independent variable worsens $BTB_{t,JPW,US}$ in related industry. I: Related independent variable improves $BTB_{t,JPW,US}$ in related industry. $L_{REXP,JPW,USD}$ is defined as depreciation of YEN against the USD. $L_{Y,JPW}$ and $L_{Y,US}$ are defined as rises in Japan's and U. S.'s income levels, respectively. $L_{TPU,US+}$, $L_{TPU,US-}$ and $L_{TPU,JPW+}$ are increases and decreases of the U. S.'s and Japan's TPU Indexes, respectively. L denotes the long-run normalized coefficients. A and S denote asymmetry and symmetry, respectively. The null hypothesis of the Wald test is symmetry. $L_{D_{Covid}}$ is based on the increases in the COVID-19 cases.

model finds that changes in exchange rates worsen and improve this balance for 22 and 7 industries, respectively. Similarly, while the aggregated data model finds no impact of rises in Japan's income (Y_t^{JPN}) on BTB_{it}^{JPN-US} , the disaggregated data model finds that rises in Y_t^{JPN} worsen and improve this balance for 18 and 10 industries, respectively. While the aggregated data model finds that rises in US income (Y_t^{US}) improve this balance, the disaggregated data model finds that rises in Y_t^{US} worsen this balance for 5 industries. Moreover, while the aggregated data model finds that rises in Japan's TPU index (TPU_t^{JPN+}) worsen BTB_{it}^{JPN-US} , the disaggregated data model finds that rises in this index improve this balance for 11 industries. Similarly, while the aggregated data model finds that falls in Japan's TPU index (TPU_t^{JPN-}) improve BTB_{it}^{JPN-US} , the disaggregated data model finds that these falls worsen this balance for 5 industries. This is the same for US TPU indexes. While the aggregated data model finds that rises in the US TPU index (TPU_t^{US+}) improve BTB_{it}^{JPN-US} , the disaggregated data model finds that such rises worsen this balance for 8 industries. Similarly, while the aggregated data model finds that falls in TPU_t^{US-} worsen BTB_{it}^{JPN-US} , the disaggregated data model finds that such falls improve this balance for 14 industries. Similarly, while aggregated data model finds no impacts of the COVID-19 on BTB_{it}^{JPN-US} , the disaggregated data finds that this pandemic worsens this balance for 10 industries coded 334, 431, 515, 625, 629, 712, 714, 782, 874, and 971.

Based on the behaviors of Japanese consumers, through their import demands, it can be interpreted that they are not *uncertainty-sensitive* to US products coded 516, 598, 625, 714, 747, 764, 773, 785, and 898, while Japan's TPU index rises. However, they are *uncertainty-sensitive* to US products coded 081, 411, 699, 741, 744, 762, 778, 792, 931, and 971, while Japan's TPU index rises. This can be interpreted that Japan continues to import mainly inelastic US products such as organic chemicals (516), miscellaneous chemical products (598), and telecommunication equipment that are used as intermediate goods in this country. Similarly, Japan does not import mainly elastic US products such as feeding stuff for animals (081), animal oils and fats (411), and gold, nonmonetary (971). In the same vein, US consumers are *uncertainty-sensitive* to Japanese products coded 232, 431, 741, 784, 786, 792, 931, and 971, while the US TPU index rises. However, they are not *uncertainty-sensitive* to Japanese products coded 111, 421, 541, 695, 748, 772, 774, 785, 898, and 899, while the US TPU index rises.

In the evaluation of overall test results in Table 2, we could not find any impact of either the US TPU index or Japan's TPU index on Japan's bilateral trade balance with the U.S. (BTB_{it}^{JPN-US}) for 18 out of 60 industries. Furthermore, both rises and falls in Japan's TPU index (TPU_t^{JPN+} , TPU_t^{JPN-}) have significant improving or worsening impacts on this balance for a total of 30 industries. Similarly, both rises and falls in the US TPU index (TPU_t^{US+} , TPU_t^{US-}) have significant improving or worsening impacts on this balance for a total of 24 industries. In the comparison of US and Japan's TPU indexes, this can be interpreted as meaning that the impacts of Japan's TPU index on this balance are higher than those of the US TPU index.

For the sake of economy, the determination of symmetry and asymmetry by the Wald test will be explained for only one industry, namely the one coded 781. While rises (TPU_t^{JPN+}) and falls (TPU_t^{JPN-}) in Japan's TPU index have different magnitude

and different direction impacts (which denotes *asymmetry*) on BTB_{it}^{JPN-US} , rises (TPU_t^{US+}) and falls (TPU_t^{US-}) in the US TPU index have the same magnitude and same direction impacts (which denotes *Symmetry*) on it. The equations of $-\beta_5/\beta_1 = -\beta_6/\beta_1$ and $-\beta_7/\beta_1 \neq -\beta_8/\beta_1$ correspond to symmetry and asymmetry, respectively.

5 Conclusion

This study examines potential impacts of Japan's and US trade policy-related uncertainties, scaled by TPU indexes, on Japan's bilateral trade balance with the U.S concerning 60 industries. Furthermore, this study also considers-examines the impacts of the COVID-19 pandemic on this country's trade balance. The rationale of this consideration is based on that international trade volumes can be highly and directly affected by such a big pandemic. In this examination, we assume that aggregated trade data may conceal the true existing relations between this balance (dependent variable) and TPU indexes (independent variables) in our model. In order to discover such potentially existing relations and avoid this aggregation bias, we use disaggregated data. We also assume that increases and decreases in both countries' TPU indexes, considered separately, may have different (nonlinear) impacts on Japan's bilateral trade balance with the U.S. In order to examine these separate impacts, we apply the nonlinear ARDL model, which technically enables such a separation. Empirical findings of this study strongly verify that our assumptions are true. The disaggregated data model clearly finds which independent variable in which industry improves or worsens this balance aggregated data cannot find. Furthermore, the nonlinear model clearly reveals different impacts of increases or decreases of TPU indexes on this balance.

The main empirical finding of this study is that trade policy-related uncertainties of both countries (TPU indexes) have significant impacts on Japan's bilateral trade balance for 42 out of 60 industries, improving or worsening this balance (shown in Table 2). Additionally, based on the behaviors of Japanese and US consumers, through their import demands, it can be interpreted that Japanese consumers are not *uncertainty-sensitive* to US products and they continue to buy these products even Japan's TPU index keeps rising. Similarly, US consumers are also not *uncertainty-sensitive* to Japanese products and they continue to buy these products even the US TPU index keeps rising (findings from the aggregated data model). Another expected finding is that the COVID-19 pandemic worsens the trade balance of Japan for different industries such as oil (not crude), rubber tires and accessories, nonelectric engines and motors, special purpose motor vehicles, and organo-inorganic-heterocyclic compounds. This can be interpreted that Japan is not the *COVID-19-sensitive* to mainly inelastic US products.

We believe that the overall findings of this study will provide both countries' policymakers with crucial information about how each industry responds to changing trade policy uncertainties and pandemics. Hence, they will be able to create individual industry-level *uncertainty-sensitivity* and the COVID-19 affected maps-tables,

which will help them manage their bilateral trade balances proactively. In this context, the findings of this study indicate the need for future empirical studies concerning other countries for having such maps-tables globally and bilaterally.

Declarations

Conflict of interest The authors declare that there is no conflict of interest regarding the publication of this article.

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