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Role of Exchange Rate on the UK-Germany Trade Balance: An Analysis at Industry Level*

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Abstract

The existing literature regarding the effect of exchange rate on trade balance shows the inconclusive empirical results. The current arguments for the mixed findings rest on the aggregation bias from aggregating of trading products and the exclusion of asymmetric effect in the analysis. This article examines the effect of exchange rate on the UK-Germany bilateral trade balance. The study is conducted at 2-digit level of 38 SITC industries, using monthly data during January 1999 to May 2017. The asymmetric effect is included by employing the nonlinear autoregressive distributed lag model (NARDL) in the estimations. The empirical findings confirm the existence of asymmetric effect. In the short run, a real depreciation of the British Pound (GBP) against Euro (EUR) improves the British trade balance in 17 industries, while a real appreciation of GBP deteriorates the trade balance in 10 industries. In the long run, the UK trade balance is improved from a real depreciation of GBP in 15 industries which constitute 38.12 per cent of the UK's total trade share with Germany. On the other hand, it is aggravated by a real appreciation of GBP in 11 industries which hold 25.63 per cent of total trade. The J-curve effect is found in only 3 industries. The research findings indicate that exchange rate policy is still a valid tool to manage the Britain's chronic trade deficit vis-à-vis Germany. The existence of asymmetric effect implies that the UK trade balance is affected by a depreciation rather than an appreciation of GBP.

Key words: Trade balance, Real exchange rate, Asymmetric effect, J-curve effect, NARDL model

Ⅰ. Introduction

The role of exchange rate on trade balance of the United Kingdom (the UK) has been examined extensively. Some previous works[1] which included the UK as one of their studied countries were conducted based on the Marshall-Lerner condition which argued that a depreciation of domestic currency would improve a trade balance, if the absolute sum of export and import demand elasticity is larger than one. Nonetheless, the Marshall-Lerner condition is an indirect way to assess the impact of exchange rate on trade balance. Moreover, its analysis is based on the long run perspective. The current works tend to adopt a direct approach and incorporate the short run dimension into their studies. The cointegration technique is employed to capture the long run aspect whereby an error correction model is used to include the short run dimension in the study. As a consequence, the J-curve effect, by which a depreciation worsens the trade balance in the short run before it will improve in the long run, could be examined.

The existing literature, in section III, has shown mixed empirical results regarding the effect of change in exchange rate on trade balance. The current important arguments for the inconclusive findings rest on the issue of aggregation bias problem and the exclusion of asymmetric effect. The aggregation bias problem stems from an aggregation of commodities and trading partners in the study. Because the effect of exchange rate on trade balance might be different across certain trading products and certain trading partners, clustering the

1) Mohsen Bahmani-Oskooee and Farhang Niroomandb, "Long-run price elasticities and the Marshall–Lerner condition revisited", *Economics Letters*, Vol. 61, Issue 1 (October 1998), pp. 103-104.; Jaime Marquez, "Long-Period Trade Elasticities for Canada, Japan, and the United States", *Review of International Economics*, Vol. 7, Issue 1 (February 1999), pp. 110–113.; Mohsen Bahmani-Oskooee and Orhan Kara, "Income and price elasticities of trade: Some new estimates", *The International Trade Journal*, Vol. 19, Issue 2 (2005), pp. 170–173.

products and the countries may create the biased empirical results.

In addition, the current studies have revealed that the response of trade balance to a depreciation is not identical to its response to an appreciation of the domestic currency, so-called asymmetric effect. Ignoring the asymmetric effect in the study may lead to the wrong interpretation of the empirical result.

According to the existing literature in section III, many existing literature examined the effect of exchange rate on trade balance between the UK and her major trading partners. In the case between the UK and Germany, which is the biggest trading partner of the UK, the analysis at disaggregated level of trading product has not been conducted yet. Accordingly, this study aims at scrutinizing the effect of bilateral real exchange rate on real trade balance of the UK vis-à-vis Germany, both in the short run and in the long run at 2-digit level of 38 SITC(Standard International Trade Classification, Rev.1) industries, using monthly data during January 1999 to May 2017. This resolves the aggregation bias problem in our research. In addition, the asymmetric effect of change in exchange rate is taken into account in our study by employing the nonlinear autoregressive distributed lag model(NARDL) in the estimations. To the best of our knowledge, our work is the first study which is conducted at the disaggregated level of product and takes the asymmetric effect into account in the case between the UK and Germany.

The paper is organized as follows. Section II elaborates the trade relationship between the UK and Germany, while section III reviews the existing literature pertaining the effect of exchange rate on trade balance of the UK. Section IV describes our research methodology, while section V presents the empirical results. Section VI is conclusion of our study.

Ⅱ. The UK-Germany trade relations

Germany is the largest trading partner of the UK. The statistics during 1999 to 2016 in <Table 1> show that Germany accounts for 12.03 per cent of the UK's total trade with the world. However, while Germany is also the biggest import partner of the UK(12.97 per cent of the UK's total import), the United States of America(USA) is the largest export partner of the UK(13.91 per cent of the UK's total export). Germany accounts for 10.74 per cent of the UK's total export. Furthermore, the evidence indicates that Germany contributes 18.12 per cent of the UK's total trade deficit.

<Table 1> The UK's major trade partners(1999-2016)

Country	Total trade		Export		Import		Deficit	
	$10^{10}usd$	%	$10^{10}usd$	%	$10^{10}usd$	%	$10^{10}usd$	%
Germany	209.14	12.03	78.37	10.74	130.77	12.97	-52.41	-18.82
USA	195.91	11.27	101.47	13.91	94.43	9.37	7.04	TS
France	125.89	7.24	59.26	8.12	66.63	6.61	-7.37	-2.65
Netherlands	120.52	6.93	51.08	7.00	69.43	6.89	-18.35	-6.59
China	96.46	5.55	18.35	2.51	78.11	7.75	-59.76	-21.46
Belgium	80.61	4.64	34.69	4.75	45.93	4.56	-11.24	-4.04
Ireland	80.56	4.64	47.15	6.46	33.41	3.31	13.74	TS
Italy	65.50	3.77	25.91	3.55	39.59	3.93	-13.67	-4.91
Spain	57.61	3.31	27.50	3.77	30.10	2.99	-2.60	-0.93
Switzerland	52.65	3.03	32.59	4.47	20.06	1.99	12.53	TS
TOP-10	1084.83	62.42	476.37	65.28	608.46	60.35	-132.09	-59.39
ROW	653.11	37.58	253.36	34.72	399.76	39.65	-146.40	-40.61
World	1737	100	729	100	1008	100	-278	-100

Source: Author's calculations based on the data from WITS database.
Note: TS = Trade surplus, TOP-10 = Top ten trade partners, ROW = Rest of the world.

According to <Table 2>, the statistics exhibit that the two countries traded mostly in machinery and transport equipment: SITC7(48.03 per cent) during 1999 to 2016, followed by chemicals and related products: SITC5(15.43 per cent), manufactured goods classified chiefly: SITC6(11.75 per cent) and miscellaneous manufactured articles: SITC8(10.19 per cent), respectively. As a result, only these 4 product groups formed 85.40 per cent of total bilateral trade between the two nations. Moreover, the numbers in <Table 2> reveal that the UK encountered a trade deficit in 8(out of 10) industries. The machinery and transport equipment(SITC7) alone contributed 66.72 per cent of total trade deficit of the UK vis-à-vis Germany.

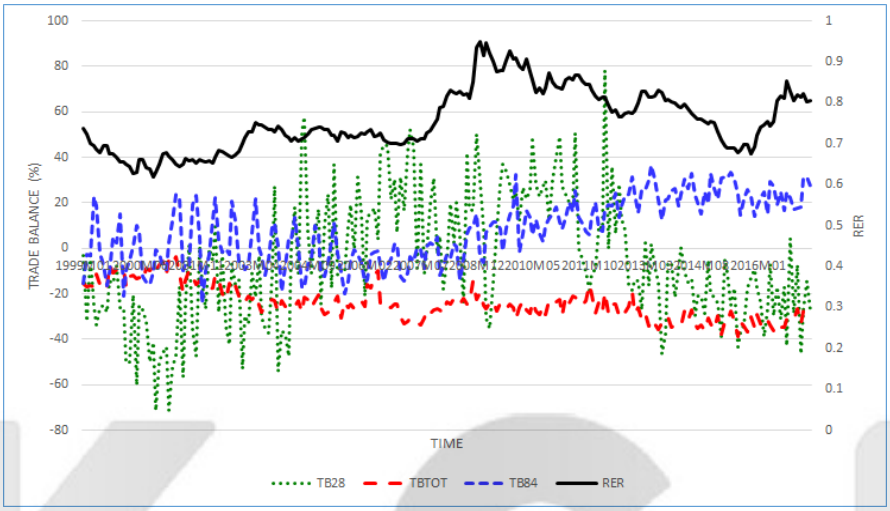
<Table 2> The UK-Germany trade pattern, 1999-2016(Per cent)

SITC	Industry	Total trade	Export	Import	Deficit
0	Food and live animals	3.73	2.32	4.58	-6.72
1	Beverages and tobacco	0.84	0.84	0.83	-0.68
2	Crude materials	1.23	1.43	1.11	-0.52
3	Mineral fuels & lubricants	4.98	11.46	1.08	TS
4	Animal & vegetable oils	0.18	0.23	0.16	-0.05
5	Chemicals	15.43	18.32	13.69	-5.62
6	Manufactured goods	11.75	11.36	11.98	-10.87
7	Machinery & transport equipment	48.03	37.66	54.26	-66.72
8	Miscellaneous manufactured articles	10.19	10.09	10.25	-8.82
9	Commod. & transactions not classif.	3.65	6.29	2.06	TS
TO	Total trade	100	100	100	-100

Source: Author's calculations based on the data from WITS database.
Note: TS = Trade surplus.

The relationship between real exchange rate(RER) and trade balance of the UK against Germany is shown in <Figure 1>.

<Figure 1> Real exchange rate and the UK-Germany trade balance(1999-2016)



Source: Author's calculations based on the data from WITS database.

Note: 1. TBTOT = Total trade balance, TB28 = Trade balance of metalliferous ores(SITC28), TB84 = Trade balance of apparel and clothing accessories(SITC84), RER = Real exchange rate between the UK and Germany

2. Trade balance is presented as % of industry's total trade, $tb_{it} = (x_{it} - m_{it})/(x_{it} + m_{it}) * 100$ where x_{it}, m_{it}, tb_{it} indicate export, import, trade balance of product i at time t, respectively.

The figure indicates that while the total trade balance(TBTOT) has deteriorated over time since 1999, the trade balance of apparel and clothing accessories(SITC84) or TB84 has improved gradually. Nonetheless, the pattern of trade balance of metalliferous ores(SITC28) or TB28 increased initially and dropped down afterward. The figure in general implies that there is no common pattern of response of trade balance to the movement of RER over time among SITC28, SITC84 and total trade.

The evidence in <Figure 1> illustrates the aggregation bias problem from clustering trading commodities in the study. The studied result at the aggregate level cannot represent the result of a certain industry. Accordingly, the study on

the effect of exchange rate on trade balance at a disaggregated level of industry is necessary since it can give more specific and accurate empirical result.

Ⅲ. Literature review

The existing empirical studies regarding the effect of exchange rate on trade balance have shown mixed results. Two significant arguments for the inconclusive results are the aggregation bias problem due to the aggregation of either trading commodities or trading partners and the exclusion of asymmetric effect in the analysis. Accordingly, this section reviews the literature pertaining to the effect of exchange rate on the UK's trade balance, which investigates both short run and long run impact, in three categories based on the aggregation bias and the asymmetric effect perspective.

Firstly, the studies which used total trade balance vis-à-vis the rest of the world: the study employed the error correction model and the cointegration approach to capture the short run and the long run effect of the exchange rate on trade balance, respectively. The UK was included as one of their studied countries. The empirical results showed mixed and very weak effect of the exchange rate on trade balance of the UK in general.[2)3)4)]

Secondly, the studies which adopted bilateral trade balance but excluded

2) Kanta Marwah and Lawrence R. Klein, "Estimation of J-Curves: United States and Canada", *The Canadian Journal of Economics*, Vol. 29, No. 3 (August 1996), pp. 528-530.

3) Luis A. Gil-Alana, Natalia Luqui and Juncal Cunad, "Trade Balance and Exchange Rate: Unit Roots, Co-integration and Long Memory in the US and the UK", *Economic Notes*, Vol. 37, Issue. 1 (February 2008), pp. 65–69.

4) Charalambos Pattichis, "Exchange rate effects on trade in services", *Journal of Economic Studies*, Vol. 39, Issue. 6 (2012), pp. 700-701.

asymmetric effect: the studies solved the aggregation bias by using the bilateral trade balance, instead of total trade balance vis-à-vis the rest of the world, in their estimations. Nevertheless, they still used bilateral total trade flows in their works. The cases of the UK and her 20 major trading partners including Germany were examined. The studies gave better results in comparison to the first category. Although the short run impact was not found, the improvement of the British trade balance was discovered in the long run in general with some trading partners such as Austria, Spain, Greece, including some non-EU countries which are Australia and Singapore. When the case of the UK-Germany was observed, the studies affirmed that there was no role of exchange rate on trade balance both in the short run and in the long run perspective.[5] Nonetheless, the most recent work which examined the case between the UK and the Eurozone countries argued that there was no short run effect of the exchange rate on trade balance of the UK vis-à-vis Germany, while the long run impact was found.[6]

Thirdly, the studies which employed bilateral total trade balance and included asymmetric effect: since most of recent literature affirmed the significance of asymmetric effect of exchange rate change on price and also on trade balance.[7][8] Consequently, the effect of exchange rate on bilateral trade balance between the

5) Mohsen Bahmani-Oskooee, Charikleia Economidou and Gour G. Goswami, "Bilateral J-curve between the UK vis-à-vis her major trading partners", *Applied Economics*, Vol. 38, Issue 8 (2006), pp. 880-884.; Mohsen Bahmani-Oskooee and Scott W. Hegerty, "The J- and S-curves: a survey of the recent literature", *Journal of Economic Studies*, Vol. 37, Issue 6 (2010), pp. 585-590.

6) Nektarios A. Michail, "Estimating a Bilateral J-curve between the UK and the Euro Area", *The Manchester School*, Vol 00, No. 00 (2017), pp. 5-9.

7) Anne-Laure Delatte and Antonia López-Villavicencio, "Asymmetric exchange rate pass-through: Evidence from major countries", *Journal of Macroeconomics*, Vol. 34, Issue 3 (September 2012), pp. 835-840.

8) Matthieu Bussiere, "Exchange Rate Pass-through to Trade Prices: The Role of Nonlinearities and Asymmetries", *Oxford Bulletin of Economics and Statistics*, Vol. 75, Issue 5 (October 2013), pp. 740–746.

UK and each of her 19 major trading partners was re-examined by taking the asymmetric effect into account.[9] The study found that, in many other trading partners, the short run effect of exchange rate on trade balance was detected significantly. However, the bilateral trade balance of the UK against Germany still was not affected by the change in exchange rate both in the short run and in the long run.

In sum, two points are worth mentioning according to the review of existing literature. Firstly, the arguments of aggregation bias and the exclusion of asymmetric effect seem to be valid. The effect of exchange rate on trade balance is more statistically significant when the bilateral trade balance and the asymmetric effect are incorporated into the study. Secondly, most of the existing literature examined the case between the UK and her major trading partners. Although Germany is the biggest trading partner of the UK, the analysis at disaggregated level of trading product has not been conducted yet. Consequently, our study contributes to the existing works in that we analyze the effect of change in the real exchange rate on bilateral trade balance of the UK vis-à-vis Germany at SITC 2-digit level of industry. In addition, the asymmetric effect of change in exchange rate is taken into account in the study framework.

9) Mohsen Bahmani-Oskooee, Seyed Hesam Ghodsi and Ferda Halicioglu, "UK trade balance with its trading partners: An asymmetry analysis", *Economic Analysis and Policy,* Vol. 56 (December 2017), pp. 192-193.

Ⅳ. Methodology

1. Model specification

A standard two-country imperfect substitution model[10)11)] is adopted as our research framework. The model asserts that real trade balance of the UK(B^{uk}) vis-à-vis Germany is determined by British real income(Y^{uk}), real income of Germany(Y^{de}) and bilateral real exchange rate(Q), as follows.

$$B^{uk} = f(Y^{uk}, Y^{de}, Q) \tag{1}$$

The theory argues that increase in real income of the UK stimulates higher import from Germany whereas the rise in German real income triggers larger export of the UK. In addition, a real depreciation of British Pound against EURO is anticipated to improve the British trade balance, if the Marshall-Lerner condition holds. To perform an empirical analysis at industry level, the log linear form of equation (1) is specified as equation (2).

$$\ln B_{it}^{uk} = a + b\ln Y_t^{uk} + c\ln Y_t^{de} + d\ln Q_t + \varepsilon_t \tag{2}$$

Since the log of zero and negative number is not defined, the trade balance of commodity i of the UK with Germany is described by the ratio of export to

10) Morris Goldstein and Mohsin Khan, "Income and Price Effect in Foreign Trade," Ronald W. Jones and Peter B. Kenen (eds.), *Handbook of International Economics* (Amsterdam: North Holland, 1985), p. 1045.

11) Andrew K. Rose, "The role of exchange rates in a popular model of international trade: Does the 'Marshall–Lerner' condition hold?", *Journal of International Economics*, Vol. 30, Issues 3-4 (May 1991), pp. 309-312.

import of product i in our work. Therefore, it is a unit-free variable which indicates trade balance in both nominal and real term at the same time.[12] For simplicity purpose, equation (2) is converted to equation (3), by replacing the natural logarithm of the uppercase with the lowercase($buk_{it} = \ln B_{it}^{uk}$).

$$buk_{it} = a + byuk_t + cyde_t + dq_t + \varepsilon_t \tag{3}$$

As a result, the expected value of b is negative whereas the positive value of c is anticipated. The real bilateral exchange rate is defined in a way that an increase reflects a real depreciation of the GBP. Hence, an estimate of d should be positive.

Equation (3) implies the long run relationships of the studied variables. To take the short run dynamics into account, it is converted into an autoregressive distributed lag(ARDL) cointegration model which is based on a bounds testing cointegration approach.[13] The conditional ARDL error correction model is obtained as follows;

$$\begin{aligned}\Delta buk_{it} = \pi + \sum_{j=1}^{n1}\gamma_j \Delta buk_{it-j} + \sum_{j=0}^{n2}\delta_j \Delta yuk_{t-j} + \sum_{j=0}^{n3}\rho_j \Delta yde_{t-j} + \sum_{j=0}^{n4}\lambda_j \Delta q_{t-j} \\ + \alpha_1 buk_{it-1} + \alpha_2 yuk_{t-1} + \alpha_3 yde_{t-1} + \alpha_4 q_{t-1} + \mu_t\end{aligned} \tag{4}$$

The coefficient $\alpha_1, \alpha_2, \alpha_3,$ and α_4, the $\triangle$ and $n_1, n_2, n_3,$ and n_4 stand for the long run multipliers, the first difference operator and the optimal lag lengths, which are selected on the basis of the Akaike Information Criterion, respectively. Equation (4) is also employed by Bahmani-Oskooee *et. al.*[14] and Michail[15] in their

12) Mohsen Bahmani-Oskooee, "Is There a Long-Run Relation Between the Trade Balance and the Real Effective Exchange Rate of LDCs?", *Economic Letters*, Vol. 36, No. 4 (August 1991), pp. 404-405.

13) Mohammad Hashem Pesaran, Yongcheol Shin and Richard Smith, "Bounds Testing Approaches to the Analysis of Level Relationships", *Journal of Applied Econometrics*, Vol. 16, No. 3 (2001), pp. 293-301.

studies.

Equation (4) is estimated in order to test for cointegration among studied variables by using F-test under the bounds testing approach. A null hypothesis of no cointegration, $Ho: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$, is tested against an alternative hypothesis, $H1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0$. Once the cointegration is established, the long run coefficients can be estimated by substituting the short run terms with zero($\triangle buk = \triangle yuk = \triangle yde = \triangle q = 0$), as presented in equation (5).

$$buk_{it} = \Omega_0 + \Omega_1 yuk_t + \Omega_2 yde_t + \Omega_3 q_t + \upsilon_t \quad (5)$$

where, $\Omega_0 = -\pi/\alpha_1, \Omega_1 = -\alpha_2/\alpha_1, \Omega_2 = -\alpha_3/\alpha_1, \Omega_3 = -\alpha_4/\alpha_1$ and υ_t is an error term.

In order to get the short run coefficients, an error correction form of equation (5) is employed, as follows.

$$\Delta buk_{it} = \pi + \sum_{j=1}^{n1} \gamma_j \Delta buk_{it-j} + \sum_{j=0}^{n2} \delta_j \Delta yuk_{t-j} + \sum_{j=0}^{n3} \rho_j \Delta yde_{t-j} + \sum_{j=0}^{n4} \lambda_j \Delta q_{t-j} + \psi ECT_{t-1} + \mu_t \quad (6)$$

The ECT_{t-1} is one-period lagged error correction term, whereby $\gamma_j, \delta_j, \rho_j, \text{and} \lambda_j$ are the short run coefficients, and ψ is the speed of adjustment.

The ARDL model generally holds two advantages. The model is valid as long as the studied variables are integrated of order zero, I(0), or one, I(1), and even a combination of them, whereas all of the series have to be I(1) variables in the other methods.[16] Moreover, the empirical results are still valid in the case of small

14) Mohsen Bahmani-Oskooee, Seyed Hesam Ghodsi and Ferda Halicioglu, *op. cit.*, p. 190.

15) Nektarios A. Michail, *op. cit.*, pp. 4-5.

16) Robert F. Engle and Clive W. J. Granger, "Co-Integration and Error Correction:

samples.[17] As a consequence, the ARDL model is a suitable approach in our study as the studied variables are mixed between I(0) and I(1) variables (based on the results of unit root tests in section V) with small samples (from January 1999 to May 2017).

The above model assumes linearity, or a symmetric effect, between the real exchange rate and the trade balance. This implies that while the currency depreciation improves trade balance, the currency appreciation worsens it equally. Nevertheless, it does not need to be the case[18] with various reasons, such as the nature of changes in prices and the behaviour of traders create the different response of trade balance to a depreciation and an appreciation of the currency. The existing evidences exhibit that the responses of price to the depreciation and the appreciation of real exchange rate show asymmetric effect, in both domestic price[19] and import and export price.[20] As a result, these lead to the asymmetric effect of exchange rate change on trade balance.[21]

To incorporate the asymmetric effect into our ARDL model, we follow the

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Representation, Estimation, and Testing", *Econometrica*, Vol. 55, No. 2 (March 1987), pp. 257-263.; Søren Johansen, "Statistical analysis of cointegration vectors", *Journal of Economic Dynamics and Control*, Vol. 12, Issues 2–3 (June–September 1988), pp. 235-245.; Søren Johansen, *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models* (Oxford: Oxford University Press, 1995), pp. 85-112.

17) Ekaterini Panopoulou and Nikitas Pitt, "A comparison of autoregressive distributed lag and dynamic OLS cointegration estimators in the case of a serially correlated cointegration error", *The Econometrics Journal*, Vol. 7, Issue 2 (December 2004), pp. 590–595.

18) Mohsen Bahmani-Oskooee and Muhammad Aftab, "Asymmetric effects of exchange rate changes on the Malaysia-EU trade: evidence from industry data", *Empirica*, Vol. 44, Issue 2 (May 2017), pp. 342-350.

19) Anne-Laure Delatte and Antonia López-Villavicencio, *op. cit.*, p. 839.

20) Matthieu Bussiere, *op. cit.*, p. 748.

21) Mohsen Bahmani-Oskooee and Hadise Fariditavana, "Nonlinear ARDL Approach and the J-Curve Phenomenon", *Open Economies Review*, Vol. 27, Issue 1 (February 2016), pp 57-61.

existing literature[22] in that the change in the real exchange rate(q_t) is decomposed into positive change (depreciation of GBP) and negative change (appreciation of GBP). Accordingly, the real exchange rate is stated as $q_t = q_0 + q_t^+ + q_t^-$, where $q_t^+ \text{and} q_t^-$ are the partial sum process of positive and negative change of q_t, respectively. The value of $q_t^+ \text{and} q_t^-$ can be generated as follows.

$$pos_t = q_t^+ = \sum_{j=1}^{t} \triangle q_t^+ = \sum_{j=1}^{t} \max(\triangle q_j, 0) \tag{7}$$

$$neg_t = q_t^- = \sum_{j=1}^{t} \triangle q_t^- = \sum_{j=1}^{t} \min(\triangle q_j, 0) \tag{8}$$

The asymmetric ARDL model, or the nonlinear autoregressive distributed lag model(NARDL), can be derived by substituting q_t in equation (4) with $pos_t \text{ and } neg_t$, as stated in equation (9).[23]

22) Florian Verheyen, "Interest rate pass-through in the EMU-new evidence using the nonlinear ARDL framework", *Economics Bulletin*, Vol. 33, Issue 1 (2013), pp. 731-733.; Mohsen Bahmani-Oskooee and Hadise Fariditavana, "Do Exchange Rate Changes have Symmetric Effect on the S-Curve?", *Economics Bulletin*, Vol. 34, Issue 1 (2014), pp. 166-168.; Mohsen Bahmani-Oskooee and Sahar Bahmani, "Nonlinear ARDL Approach and the Demand for Money in Iran", *Economics Bulletin*, Vol. 35, Issue 1 (2015), pp. 387-388.

23) Yongcheol Shin, Byungchul Yu and Matthew Greenwood-Nimmo, "Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework", William C. Horrace and Robin C. Sickles (eds.), *Festschrift in Honor of Peter Schmidt: Econometric Methods and Applications* (New York: Springer Science & Business Media, 2014), pp. 281-314.

$$\begin{aligned}\Delta buk_{it} = \pi + \sum_{j=1}^{n1}\gamma_j \Delta buk_{it-j} + \sum_{j=0}^{n2}\delta_j \Delta yuk_{t-j} + \sum_{j=0}^{n3}\rho_j \triangle yde_{t-j} \\ + \sum_{j=0}^{n4}\lambda_j \Delta pos_{t-j} + \sum_{j=0}^{n5}\varsigma_j \triangle neg_{t-j} + \alpha_1 buk_{it-1} \\ + \alpha_2 yuk_{t-1} + \alpha_3 yde_{t-1} + \alpha_4 pos_{t-1} + \alpha_5 neg_{t-1} + \mu_t\end{aligned} \quad (9)$$

Hence, the hypothesis testing for cointegration is changed to $Ho: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ against $H1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0$, based on equation (9). If the cointegration is found, the long run symmetric effect of real exchange rate on trade balance represents by the same in sign and size of normalized coefficients of pos_{t-1} and neg_{t-1}, which are $-\alpha_4/\alpha_1$ and $-\alpha_5/\alpha_1$. Otherwise, the effect of the real exchange rate is symmetric. With the same concept, the asymmetric effect in the short run can be investigated through the values of λ_j and ς_j.

2. Data

The variables in our study are monthly data from January 1999 to May 2017. The empirical analysis is performed at 2-digit level of SITC(Standard International Trade Classification, Rev.1) product for 38 industries, which constitute 96.26 per cent of total trade of the UK with Germany. To construct the trade balance(buk) variable, the data of both export and import(in 1,000 U.S. dollars) are obtained from the World Integrated Trade Solution(WITS) database. Industrial production index (2010=100), from the International Financial Statistics(IFS) database of International Monetary Fund, is used to measure the income level of the UK and Germany(yuk, yde). The real exchange rate(q) is defined as $Q = E.P^{DE}/P^{UK}$ where E denotes nominal bilateral exchange rate(GBP/EUR), P^{DE} and P^{UK} indicate consumer price index(CPI) of Germany and the UK, respectively. Both of the nominal exchange rate(period-average) and the

CPI series (2010=100) come from the EUROSTAT database. Consequently, a real depreciation of GBP is indicated by an increase in value of q, which should improve the bilateral trade balance of the UK vis-à-vis Germany, theoretically.

V. Estimation results

1. Test for unit root and cointegration

Because the NARDL method is valid if the variables are either I(0) or I(1) and even a combination of them, we employ the Augmented Dickey-Fuller(ADF) test to all the studied variables to ensure the nonexistence of I(2) variable. The results in <Table 3> confirm that there is no I(2) variable in our study.

<Table 3> Test for unit root and cointegration

The UK trade balance(buk)		ADF test		I(n)	Bounds test	
SITC	Industry	Level	1st-diff		F-stat	Coint
TO	Total trade	-2.84	-15.39 a	I(1)	3.76	n
01	Meat & meat preparations	-3.66 b		I(0)	3.05	n
02	Dairy products & birds' eggs	-3.91 a		I(0)	8.07	y
04	Cereals & cereal preparations	-3.10	-16.60 a	I(1)	4.01	y
05	Vegetables & fruit	-2.83	-14.33 a	I(1)	4.85	y
07	Coffee, tea, cocoa, spices	-3.25 c		I(0)	4.19	y
09	Miscellaneous edible product	-5.11 a		I(0)	4.24	y
11	Beverages	-4.91 a		I(0)	4.59	y
28	Metalliferous ores	-4.62 a		I(0)	7.62	y
33	Petroleum & related products	-3.73 b		I(0)	4.56	y
51	Organic chemicals	-1.96	-14.66 a	I(1)	4.38	y
52	Inorganic chemicals	-10.25 a		I(0)	10.78	y

53	Dyeing, tanning materials	-1.98	-13.96 a	I(1)	4.45	y
54	Medicinal & pharma products	-2.09	-14.52 a	I(1)	3.95	y
55	Essential oils & perfume mat.	-2.63	-15.74 a	I(1)	6.17	y
57	Plastics in primary forms	-3.45 b		I(0)	4.55	y
58	Plastics in non-primary forms	-5.69 a		I(0)	8.73	y
59	Chemical materials & products	-3.51 b		I(0)	2.15	n
62	Rubber manufactures	-6.51 a		I(0)	7.13	y
64	Paper, paperboard & articles	-0.91	-13.17 a	I(1)	1.61	n
65	Textile yarn, fabrics	-3.50 b		I(0)	4.13	y
66	Non-metallic mineral manufac.	-2.74	-15.19 a	I(1)	4.22	y
67	Iron & steel	-3.42 b		I(0)	4.46	y
68	Non-ferrous metals	-3.69 b		I(0)	3.85	y
69	Manufactures of metals	-4.46 a		I(0)	5.06	y
71	Power-generating machinery	-5.40 a		I(0)	3.98	y
72	Machine specialized for indust.	-3.41 b		I(0)	4.65	y
73	Metalworking machinery	-4.43 a		I(0)	5.45	y
74	General industrial machinery	-2.84	-16.37 a	I(1)	6.31	y
75	Office machines	-3.32 c		I(0)	4.07	y
76	Telecommunications equipme.	-3.52 b		I(0)	2.61	n
77	Electrical machine & appliance	-3.49 b		I(0)	6.54	y
78	Road vehicles	-2.62	-5.76 a	I(1)	1.46	n
79	Other transport equipment	-2.81	-19.68 a	I(1)	4.90	y
82	Furniture & parts thereof	-3.09	-12.30 a	I(1)	1.08	n
84	Apparel & clothing accessories	-3.18 c		I(0)	7.18	y
87	Professional/scientific equipm.	-3.94 a		I(0)	2.41	n
88	Photographic apparatus	-3.34 c		I(0)	4.12	y
89	Miscell. manufactured articles	-1.87	-14.79 a	I(1)	4.29	y
	Other variables					
q	Real exchange rate	-2.16	-12.32 a	I(1)		
pos	Real exchange rate depreciation	-2.09	-11.54 a	I(1)		
neg	Real exchange rate appreciation	-0.83	-14.29 a	I(1)		
yde	Germany's income	-6.02 a		I(0)		
yuk	The UK's income	-3.00	-3.22 c	I(1)		

Note: 1. Statistical significance is denoted as a, b, and c for 1%, 5%, and 10% respectively.
2. ADF test = Augmented Dickey-Fuller test, Level = Level form, 1st-diff = The first difference form, Coint = Cointegration existence, y =Yes, n= No, I(n) = Integrated of order nth variable.
3. ADF test includes intercept and trend.

The bounds test is perform to check for the existence of cointeration. The test results indicate that the calculated F-statistics of 31 industries in <Table 3> are higher than the upper bound critical value(F-critical = 3.77 at 10 % level of significance). This implies that the cointegration is found in 31(out of 38) industries at 2-digit level. As a result, 7 industries, which do not pass the cointegration test, will be dropped out from our study. In addition, the total trade balance will also be excluded from our work since it fails the test for cointegration. Nonetheless, the total trade variables will be estimated and the obtained coefficients will be reported in the related tables, just for the reference in our study.

2. Estimation results from the NARDL model

The estimation procedures start by choosing the optimal lengths n($n_1 - n_5$) of equation (9). To do so, a maximum of four lags on each first-differenced variable are imposed and followed by the estimation of all possible lag-lengths combinations among them. The optimum lag lengths are determined by using the Akaike Information Criterion. Consequently, the short run and the long run coefficients can be determined afterward.[24] Since the estimations produce the large volume of the empirical outcomes, only the estimates of real exchange rate are reported for the short run coefficients whereas the coefficients of all studied variables are provided in the long run results. The short run and the long run

24) Mohsen Bahmani-Oskooee and Muhammad Aftab, *op. cit.*, p. 352.

coefficients are presented in <Table 4> and <Table 5>, respectively.

<Table 4> Short run coefficient estimates

SITC	Industry	$\triangle pos_t$	$\triangle pos_{t-1}$	$\triangle pos_{t-2}$	$\triangle pos_{t-3}$	$\triangle neg_t$	$\triangle neg_{t-1}$	$\triangle neg_{t-2}$	$\triangle neg_{t-3}$
TO	Total trade	0.64 a	−0.50 c	0.70 b	−0.51 a	−0.45c			
		(0.00)	(0.09)	(0.02)	(0.01)	(0.10)			
02	Dairy products	0.94	−1.38 b			−0.23			
		(0.17)	(0.05)			(0.18)			
04	Cereals	0.53 a				−2.55a	1.63	−2.18 a	
		(0.01)				(0.00)	(0.18)	(0.01)	
05	Vegetables & fruit	0.19				−0.18			
		(0.14)				(0.17)			
07	Coffee, tea, cocoa, spices	−0.65 c				−0.26a			
		(0.09)				(0.01)			
09	Mis. edible product	0.08				−0.03			
		(0.47)				(0.83)			
11	Beverages	0.45 c				0.54 b			
		(0.06)				(0.02)			
28	Metalliferous ores	−1.48	3.16	2.05	−5.34 b	2.66 a			
		(0.55)	(0.43)	(0.60)	(0.03)	(0.00)			
33	Petroleum & products	0.06				−0.28			
		(0.83)				(0.21)			
51	Organic chemicals	0.96 b				−0.36	0.70	1.36 c	−1.04 b
		(0.02)				(0.53)	(0.34)	(0.07)	(0.05)
52	Inorganic chemicals	1.04	3.62 b			0.34			
		(0.56)	(0.05)			(0.39)			
53	Dyeing, materials	0.01	0.11	0.39 b		−0.10c			
		(0.94)	(0.74)	(0.05)		(0.06)			
54	Medicinal & pharma prod	0.24 a				0.20 b			
		(0.00)				(0.02)			
55	Essential oils & perfume	−0.30				0.79 b	−0.68 c	0.81 a	
		(0.21)				(0.01)	(0.10)	(0.01)	

57	Plastics in primary form	0.41 c				−0.03			
		(0.07)				(0.49)			
58	Plastics in non-primary	−0.15 c				0.11			
		(0.09)				(0.23)			
62	Rubber manufactures	−1.36 b	2.92 a	−1.15 c		−0.37b			
		(0.04)	(0.01)	(0.10)		(0.02)			
65	Textile, yarn, fabrics	−0.08				0.07 c			
		(0.13)				(0.07)			
66	Non-metallic mineral man	−0.19	−0.87 b	0.59 a		−0.24a			
		(0.41)	(0.02)	(0.01)		(0.00)			
67	Iron & steel	−0.38				0.11			
		(0.34)				(0.18)			
68	Non-ferrous metals	0.16 c				0.22 b			
		(0.08)				(0.03)			
69	Manufactures of metals	0.55	2.24 b	−1.30 b		0.00			
		(0.34)	(0.02)	(0.03)		(0.98)			
71	Power-generating machin	−0.25				−0.04			
		(0.11)				(0.82)			
72	Machine specialized	2.01 b	1.50 c			−2.84b			
		(0.04)	(0.10)			(0.04)			
73	Metalworking machine	0.14 c				0.19 b			
		(0.06)				(0.02)			
74	Gen. indust machinery	0.18 a				−0.41b			
		(0.00)				(0.05)			
75	Office machines	0.14				−0.17			
		(0.52)				(0.39)			
77	Electrical machine	0.66 b	0.25	0.58	−0.85 a	0.01	−0.86 b		
		(0.02)	(0.54)	(0.14)	(0.00)	(0.98)	(0.02)		
79	Oth transpor equipment	3.74 a				−0.62	−1.54	3.92	−9.19 b
		(0.00)				(0.89)	(0.83)	(0.57)	(0.04)
84	Apparel & clothing	0.05				0.74 c			
		(0.52)				(0.07)			
88	Photographic apparatus	0.16				0.23	1.00 c		
		(0.17)				(0.68)	(0.08)		

89	Miscell. manuf article	0.75 a (0.00)	0.89 b (0.02)	−0.38 (0.14)		−0.13 (0.19)

Notes: Statistical significance is denoted as a, b, and c for 1%, 5%, and 10% respectively(P−values are in parenthesis).

Based on <Table 4>, the left side of the table exhibits the response of bilateral trade balance to the positive change (depreciation of GBP against EUR) of the real exchange rate variable. The result reveals that a one per cent in depreciation of GBP vis-à-vis EUR improves trade balance by 0.41 per cent for plastics in primary forms(SITC57). The general outcomes show that there are 17 industries(out of 31 industries), which display at least one positive coefficient, as indicated by the theory, at 10 per cent level of significance for the positive change of the real exchange rate variable. These 17 industries account for 39.89 per cent of total trade of the UK with Germany. On the other hand, the right side of the table presents the reaction of trade balance to the negative change (appreciation of GBP against EUR) of the real exchange rate variable. Accordingly, a one per cent in appreciation of GBP vis-à-vis EUR worsens trade balance by 0.22 per cent for non-ferrous metals(SITC68). Generally, there are 10 industries, which display at least one positive coefficient of the negative change of the real exchange rate variable, at 10 per cent level of significance. The 10 industries constitute 17.30 per cent of total trade of the UK with Germany.

The pattern of asymmetric effect of real exchange rate change on trade balance is found in all industries which the obtained coefficients are statistically significant since all coefficients of pos and neg variable are different in size and sign. For instance, for metalworking machinery(SITC73), a one per cent in depreciation of GBP improves trade balance by 0.14 per cent, whereas a one per cent in appreciation of GBP deteriorates trade balance by 0.19 per cent.

The evidence of traditional J-curve effect[25], by which the depreciation of GBP deteriorates trade balance of the UK before it will improve in the later period, is

found only in one industry: non-metallic mineral manufactures(SITC66). The empirical evidence indicates that a one per cent in depreciation of GBP aggravates the British trade balance of non-metallic mineral manufactures(SITC66) by 0.87 per cent before the improvement of trade balance by 0.59 per cent will be detected in the following period. The non-metallic mineral manufactures(SITC66) represents only 0.90 per cent of total trade of the UK with Germany.

<Table 5> Long run coefficient estimates

SITC	Industry	%	pos_{t-1}	neg_{t-1}	yde_{t-1}	yuk_{t-1}
TO	Total trade	100	1.51 a	−0.19	0.90 c	0.82
			(0.00)	(0.65)	(0.09)	(0.50)
02	Dairy products & birds' eggs	0.46	1.77 b	−1.00	1.82 c	−6.95 a
			(0.03)	(0.16)	(0.10)	(0.00)
04	Cereals & cereal preparations	0.58	3.54 a	−0.77	3.16 b	−11.96 a
			(0.00)	(0.43)	(0.04)	(0.00)
05	Vegetables & fruit	0.51	1.06	−1.05	2.82 a	−8.18 a
			(0.14)	(0.13)	(0.01)	(0.00)
07	Coffee, tea, cocoa, spices	0.54	−0.64	−1.95 a	2.40 b	−4.50 b
			(0.41)	(0.01)	(0.02)	(0.03)
09	Miscellaneous edible product	0.46	0.33	−0.11	−1.00	0.76
			(0.48)	(0.83)	(0.16)	(0.26)
11	Beverages	0.63	1.49 c	1.80 b	1.26	−5.60 b
			(0.07)	(0.04)	(0.32)	(0.04)
28	Metalliferous ores	0.66	2.44 c	6.04 a	0.72	1.43
			(0.07)	(0.00)	(0.58)	(0.49)
33	Petroleum & related products	4.69	0.40	−1.84	4.99 b	−9.36 a
			(0.83)	(0.17)	(0.02)	(0.01)
51	Organic chemicals	2.70	0.17	1.20 c	4.50 a	13.31 a

25) Stephen P. Magee, "Currency Contracts, Pass-Through, and Devaluation", *Brookings Papers on Economic Activity*, Vol. 4, Issue 1 (1973), pp. 310-315.; Mohsen Bahmani-Oskooee, "Devaluation and the J-Curve: Some Evidence from LDCs", *The Review of Economics and Statistics*, Vol. 67, Issue 3 (1985), pp. 501-502.

			(0.84)	(0.09)	(0.00)	(0.00)
52	Inorganic chemicals	0.59	0.23	0.59	−0.13	2.40
			(0.77)	(0.38)	(0.89)	(0.04)
53	Dyeing, tanning materials	0.86	0.48	−0.87	2.62 a	−7.46 a
			(0.36)	(0.42)	(0.00)	(0.00)
54	Medicinal & pharma products	5.39	3.33 a	2.85 a	−1.15	9.00 b
			(0.00)	(0.00)	(0.47)	(0.03)
55	Essential oils & perfume mat.	1.48	0.43	−2.01 a	−0.02	−0.62
			(0.44)	(0.00)	(0.98)	(0.64)
57	Plastics in primary forms	1.75	−0.63	−0.21	−0.30	1.33
			(0.14)	(0.50)	(0.52)	(0.12)
58	Plastics in non-primary forms	1.19	−0.42	0.32	0.79 c	−3.07 a
			(0.12)	(0.22)	(0.06)	(0.00)
62	Rubber manufactures	1.00	−0.06	−0.72 a	0.90 b	−2.16 a
			(0.87)	(0.01)	(0.03)	(0.00)
65	Textile yarn, fabrics	0.94	−0.41 c	0.38 b	0.40	−2.07 a
			(0.10)	(0.04)	(0.22)	(0.00)
66	Non-metallic mineral manufac.	0.90	0.74 c	−1.59	1.95 a	−1.95 b
			(0.09)	(0.22)	(0.00)	(0.02)
67	Iron & steel	1.89	1.79 b	0.78	2.43 a	−1.59
			(0.03)	(0.18)	(0.01)	(0.40)
68	Non-ferrous metals	2.83	1.01 c	1.38 b	0.39	2.35
			(0.07)	(0.02)	(0.60)	(0.19)
69	Manufactures of metals	2.51	1.35 a	−0.01	0.94 c	−0.40
			(0.00)	(0.98)	(0.06)	(0.56)
71	Power-generating machinery	4.59	−0.80 c	−0.12	0.56	−1.07
			(0.10)	(0.82)	(0.42)	(0.34)
72	Machine specialized for indust.	2.47	0.62	−0.90 c	1.01	−3.03 b
			(0.38)	(0.09)	(0.18)	(0.02)
73	Metalworking machinery	0.52	0.70 b	0.96 b	−0.87	0.69
			(0.05)	(0.02)	(0.17)	(0.25)
74	General industrial machinery	4.62	1.04 a	−0.44	0.85 a	1.16 c
			(0.00)	(0.13)	(0.01)	(0.06)
75	Office machines	3.98	0.46	−0.56	−1.74 c	3.26 b

			(0.53)	(0.36)	(0.06)	(0.02)
77	Electrical machine & appliance	5.73	1.36 a	0.93 a	−0.54	−2.18 b
			(0.00)	(0.00)	(0.25)	(0.02)
79	Other transport equipment	2.77	12.56 a	7.90 b	−3.04	−5.61
			(0.00)	(0.05)	(0.38)	(0.43)
84	Apparel & clothing accessories	1.51	0.20	−1.26	0.85 b	−4.64 a
			(0.53)	(0.28)	(0.04)	(0.00)
88	Photographic apparatus	0.65	1.08	−1.35 b	1.90 b	−3.84 b
			(0.16)	(0.02)	(0.05)	(0.04)
89	Miscell. manufactured articles	4.06	2.43 c	−2.10	0.81	−6.92 b
			(0.07)	(0.31)	(0.58)	(0.02)

Notes: 1. Statistical significance is denoted as a, b, and c for 1%, 5%, and 10% respectively (P-values are in parenthesis).
2. % = Share of each industry in total trade (in per cent) between the UK and Germany.

In the long run, based on <Table 5>, the empirical evidence demonstrates that a one per cent in depreciation of GBP boosts the trade balance of metalworking machinery(SITC73) by 0.70 per cent. The improvements of trade balance in response to the depreciation of GBP are detected in 15 industries which compose 38.12 per cent of total trade of the UK with Germany. In the other way, a one per cent in appreciation of GBP worsens the trade balance by 0.96 per cent for the same industry. The deterioration in trade balance due to the appreciation of GBP vis-à-vis EUR is found in 11 industries which hold 25.63 per cent of total trade of the UK with Germany.

The patterns of asymmetric effect of real exchange rate change on trade balance in the long run are also discovered in all industries which the estimated coefficient s are statistically significant. The response of trade balance of metalworking mach inery(SITC73) is an example of the effect. The existence of asymmetric effect may r eflect the higher competitive structures of the industries and the large-scale trade surplus of Germany vis-à-vis the UK.

Besides the traditional definition of the J-curve effect, an alternative definition

was defined as a short run aggravation of trade balance followed by its long run improvement.[26] Accordingly, the J-curve effect presents in another two industries. A one per cent in depreciation of GBP worsens the trade balance of dairy products and birds' eggs(SITC02) by 1.38 per cent in the short run, but the trade balance shows improvement by 1.77 per cent in the long run. The same pattern is discovered in metalliferous ores and metal scrap(SITC28), which the short run aggravation of trade balance(-5.34 per cent) followed by its long run improvement(2.44 per cent). The two industries constitute only 1.12 per cent of total trade between two countries.

With regard to the role of national income on trade balance, the empirical results exhibit that the income coefficient of the UK is negative and significant in 16 industries, which account for 26.70 per cent of total trade. In case of Germany, the positively significant estimates present in 15 industries. The share of the 15 industries in total trade is 24.60 per cent.

It is worth comparing our empirical findings with the most two recent works w hich examined the effect of exchange rate on bilateral trade balance of the UK agai nst Germany. Both studies conducted an analysis by using the bilateral total trade balance variable. While Michail[27] excluded asymmetric effect and used quarterly data(2008Q1-2016Q1) in his work, Bahmani-Oskooee *et. al*.[28] incorporated the asy mmetric effect into their model and used monthly data during January 2000 to No vember 2016 in the estimations. The outcome of the comparison is shown as follo ws.

For the short run perspective, while our empirical results indicate that the British trade balance is affected by the change in real exchange rate(17 and 10

26) Andrew K. Rose, *op. cit.*, p. 309.; Mohsen Bahmani-Oskooee and Hadise Fariditavana, *op. cit.*, pp 59–61.

27) Nektarios A. Michail, *op. cit.*, pp. 3-4.

28) Mohsen Bahmani-Oskooee, Seyed Hesam Ghodsi and Ferda Halicioglu, *op. cit.*, pp. 192-194.

industries respond to the depreciation and appreciation of GBP against EUR, respectively), the change in exchange rate has no impact on trade balance in both studies.

In the long run, our empirical results also reveal that the change in real exchange rate can influence trade balance of the UK(15 and 11 industries respond to the depreciation and appreciation of the GBP, respectively). While the long run impact of exchange rate on trade balance was not found in the work of Bahmani-Oskooee *et. al.*[29], our findings are consistent with Michail[30] who claimed that a one per cent in depreciation of GBP improves the Britain's trade balance by 0.51 per cent. Nonetheless, while Michail[31] assumed that the effect of change in exchange rate on trade balance is symmetric, our findings suggest that the impact of exchange rate on trade balance is actually asymmetric between depreciation and appreciation of GBP against EUR.

Moreover, while none of them found the J-curve effect in their studies, our empirical results reveal the existence of J-curve effect in three industries.

As a consequence, our study which is conducted at the disaggregated level of industry and takes asymmetric effect into account shows that the Britain's trade balance vis-à-vis Germany is affected by change in the exchange rate between GBP and EUR both in the short run and in the long run. Furthermore, the impact of exchange rate on trade balance reveals the pattern of asymmetric effect in response to the depreciation and the appreciation of GBP. These results have never been presented by the previous works which studied the case of the UK vis-à-vis Germany.

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29) MohsenBahmani-Oskooee, Seyed Hesam Ghodsi and Ferda Halicioglu, *op. cit.*, pp. 195-196.

30) Nektarios A. Michail, *op. cit.*, p. 5.

31) Nektarios A. Michail, *op. cit.*, p. 10.

3. Diagnostic tests of the NARDL model

To evaluate the reliability of the obtained coefficients and the validity of the methodology, we perform various diagnostic tests on our model, as displayed in <Table 6>.

<Table 6> Diagnostic statistics of the NARDL model

SITC	Industry	ECM_{t-1}		R^2	LM	RESET	CS	CSS
TO	Total trade	−0.11	(0.00)	0.15	0.11	5.78 *	S	S
02	Dairy products & birds' eggs	−0.23	(0.00)	0.20	7.56 *	1.72	S	S
04	Cereals & cereal preparations	−0.15	(0.00)	0.14	0.73	0.02	S	S
05	Vegetables & fruit	−0.18	(0.00)	0.19	0.08	0.00	S	S
07	Coffee, tea, cocoa, spices	−0.13	(0.00)	0.13	0.02	0.07	S	US
09	Miscellaneous edible product	−0.25	(0.00)	0.38	0.05	1.18	S	US
11	Beverages	−0.30	(0.00)	0.44	5.20 *	2.72	S	US
28	Metalliferous ores	−0.44	(0.00)	0.35	4.32 *	0.11	S	S
33	Petroleum & related products	−0.15	(0.00)	0.15	0.75	2.64	S	S
51	Organic chemicals	−0.12	(0.00)	0.19	0.81	0.32	S	US
52	Inorganic chemicals	−0.59	(0.00)	0.41	1.60	1.17	S	S
53	Dyeing, tanning materials	−0.11	(0.00)	0.15	0.35	0.11	S	S
54	Medicinal & pharma products	−0.07	(0.00)	0.11	0.13	0.02	S	US
55	Essential oils & perfume mat.	−0.11	(0.00)	0.16	1.34	0.04	S	S
57	Plastics in primary forms	−0.15	(0.00)	0.13	0.86	14.42*	S	S
58	Plastics in non-primary forms	−0.36	(0.00)	0.48	0.20	6.88 *	S	US
62	Rubber manufactures	−0.51	(0.00)	0.54	0.02	0.16	US	S
65	Textile yarn, fabrics	−0.19	(0.00)	0.14	0.82	9.35 *	S	S
66	Non-metallic mineral manufac.	−0.15	(0.00)	0.13	0.20	3.98 *	S	US
67	Iron & steel	−0.14	(0.00)	0.14	0.00	0.62	S	S
68	Non-ferrous metals	−0.16	(0.00)	0.08	0.35	0.45	S	US
69	Manufactures of metals	−0.33	(0.00)	0.36	0.30	0.05	S	S
71	Power-generating machinery	−0.31	(0.00)	0.38	0.38	1.91	S	S
72	Machine specialized for indust.	−0.37	(0.00)	0.44	2.13	0.27	US	S

73	Metalworking machinery	−0.20	(0.00)	0.15	0.28	0.62	S	S
74	General industrial machinery	−0.18	(0.00)	0.14	0.89	1.10	S	S
75	Office machines	−0.30	(0.00)	0.50	7.03 *	5.44 *	S	S
77	Electrical machine & appliance	−0.17	(0.00)	0.18	0.03	4.61 *	S	S
79	Other transport equipment	−0.30	(0.00)	0.49	0.96	0.55	S	S
84	Apparel & clothing accessories	−0.27	(0.00)	0.20	0.52	0.01	S	S
88	Photographic apparatus	−0.15	(0.00)	0.10	0.01	1.50	S	S
89	Miscell. manufactured articles	−0.06	(0.01)	0.21	0.80	0.64	S	S

Note: 1. LM = LM statistic, RESET = Chi-square statistic, * = Fail the test, CS = CUSUM, CSS = CUSUM of Squares, S(US) = Stable(Unstable) at 5% level of significance, R^2 = Goodness of fit

2. ECM_{t-1} = Coefficient or speed of adjustment, with p-values in parentheses.

According to <Table 6>, the values of all coefficients of ECM_{t-1} are lower than one in absolute term with negative signs. Therefore, the convergence from a short run toward a long run equilibrium exists in all studied industries, at 1 per cent of significance level. The R^2 measures the goodness of fit of the model. The Breusch-Godfrey serial correlation LM test with one degree of freedom of χ^2 distribution shows that only 4(out of 31) industries fail the test, implying autocorrelation-free residuals in our models, at 10 per cent level of significance. Likewise, only 6 industries fail the Ramsey's RESET test, at 10 per cent level of significance, indicating that our models are correctly specified in general. The stability of the coefficient estimates over time is examined by using the cumulative sum of recursive residuals(CUSUM) test and the cumulative sum of squares of recursive residual(CUSUM of Squares). The stability and unstability are denoted by "S" and "US", respectively. The results suggest that most of the estimated coefficients are stable.

Ⅵ. Conclusion

The existing literature regarding the effect of exchange rate on trade balance shows the inconclusive empirical results. The current arguments for the mixed findings rest on the aggregation bias from aggregating of trading products and the exclusion of asymmetric effect in the analysis.

For the UK, the existing literature generally examined the case between the UK and her major trading partners including Germany using aggregate data. Although Germany is the biggest trading partner of the UK, the analysis on the effect of exchange rate on trade balance of the UK vis-à-vis Germany at disaggregated level of trading product has not been conducted yet. Consequently, our study contributes to the existing works in that we analyze the case of the UK-Germany at 2-digit level of 38 SITC industries, using monthly data during January 1999 to May 2017. This resolves the aggregation bias problem in our research. In addition, the asymmetric effect of change in exchange rate is taken into account in the study by employing the nonlinear autoregressive distributed lag model(NARDL) in the estimations. The findings of our study can be summarized in five main points.

Firstly, in the short run, a real depreciation of GBP against EUR improves the UK's trade balance with Germany in 17 industries (which account for 39.89 per cent of total trade), while a real appreciation of GBP worsens the trade balance in 10 industries (which constitute 17.30 per cent of total trade share).

Secondly, in the long run, the UK trade balance is improved from a real depreciation of GBP in 15 industries which form 38.12 per cent of the UK's total trade share with Germany. On the other hand, the trade balance is aggravated by a real appreciation of GBP in 11 industries which hold 25.63 per cent of total trade.

Thirdly, the J-curve effect is found in only 3 industries which make up only 2.02 per cent of total trade share.

Fourthly, the asymmetric effect of depreciation and appreciation of GBP against EUR is detected obviously from the difference in size and sign of the coefficients of the pos and the neg variable. Moreover, the existence of asymmetric effect implies that the UK trade balance is affected by a depreciation (17 industries with 39.89 per cent in the short run and 15 industries with 38.12 percent in the long run) rather than an appreciation of GBP(10 industries with 17.30 per cent in the short run and 11 industries with 25.63 percent in the long run).

Finally, the UK's trade balance is improved due to the increase in Germany's income in 15 industries (24.60 per cent of total trade share), whereas it is deteriorated because of the increase in the British income in 16 industries (26.70 per cent of total trade share).

In sum, our work indicates that the Britain's real trade balance vis-à-vis Germany is still influenced by change in the real exchange rate between GBP and EUR, both in the short run and in the long run. As a consequence, the empirical results of our study are crucial for policy implication of the UK. Given that the UK has encountered with chronic trade deficit against Germany, our findings indicate that exchange rate policy is still a significant tool to manage the Britain's trade deficit vis-à-vis Germany. The previous works lack this detailed policy recommendation as we suggested, when the aggregate trade balance was used and the asymmetric effect was excluded in their analysis.

Our findings can be used as ideas for further research in two potential ways. Firstly, the cause of ineffectiveness of change in exchange rate on certain industries (62.88 per cent and 74.37 per cent of total trade volume by depreciation and appreciation of GBP against EUR, respectively) might be investigated. Secondly, it is worth comparing the empirical results from the time series model of a 2-digit SITC industry with the analysis which is based on the panel data of sub-industry of a 2-digit product.

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▌Abstract▐

영-독 무역수지에 대한 환율의 역할: 산업 수준 분석*

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무역수지에 대한 환율의 역할을 다룬 기존 연구들은 실증적인 결론에 이르지 못했음을 보여준다. 다양한 연구 조사결과들에 대한 현재 논쟁은 무역 상품 집계와 분석 시 비대칭적인 영향의 누락으로 인해 집적된 편향에서 비롯된다. 본 글에서는 환율이 영-독 쌍방 무역수지에 미치는 영향에 대해서 검토한다. 본 연구에서는 1999년 1월부터 2017년 5월까지의 월간 자료를 활용하여 38개 표준 국제 무역 분류 (SITC) 산업 중 2자리 단계(2-digit level)를 가지고 분석을 행하였다. 이를 바탕으로하는 실증적 연구결과는 비대칭적인 효과의 존재를 확인시켜 주는데, 비대칭적인 효과는 비선형 자기 회귀 시차 분포(NARDL) 모형을 추정치에 적용하여 결과를 도출했다. 단기적으로 유로(EUR) 대비 영국파운드(GBP) 실질 가치 하락은 17개 산업군의 영국 무역수지를 향상시켰으나 영국파운드(GBP)의 실질 가치상승은 10개 산업군의 무역수지를 악화시켰다. 장기적으로, 독일과의 전체 무역의 38.12퍼센트를 차지하는 15개 산업군의 영국 무역수지는 영국파운드(GBP)의 평가 절하로 인해 향상되었다. 반면에, 전체 무역의 25.63퍼센트를 차지하는 11개 산업군의 영국파운드(GBP)의 실제 평가 절상은 무역 수지를 악화시켰다. 제이커브

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효과는 단 3개의 산업군에서만 나타났다. 본 연구결과는 환율정책이 여전히 영국의 만성적인 독일과의 무역수지적자를 관리하는데 유효한 도구임을 나타낸다. 비대칭적인 영향의 존재는 영국 무역수지가 영국 파운드(GBP)의 평가절상보다는 평가절하에 영향을 받음을 암시한다.

주 제 어 : 무역수지, 실질 환율, 비대칭적인 영향, 제이커브 효과, 비선형 자기회귀 시차 분포(NARDL) 모형

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