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US Bilateral Trade with Euro Area Members: An Asymmetry Analysis of the J-Curve Effect

Mohsen Bahmani-Oskooee[1] and Hanafiah Harvey[2]

ABSTRACT

Recent application of nonlinear asymmetry error-correction modeling and cointegration has revealed more support for the J-curve phenomenon compared to symmetric and linear ARDL approach. We add to this literature by considering the bilateral trade balance of the US with each of the 12 original members of the euro area. While the linear approach supported the J-curve effect only for the US trade balance with three countries (Greece, Italy, and Luxembourg), the nonlinear approach supports it for the US trade balance with five partners (Finland, Greece, Italy, Luxembourg, and Portugal). Clearly, introducing nonlinear adjustment of the real exchange rate yields more support for the J-curve effect.

JEL Classification: F31
Keywords: Asymmetry J-Curve, Euro Area, Euro-Dollar Rate, the US, Trade Balance

1. INTRODUCTION

One of the main reasons for forming an optimum currency area is expectations of stable prices within the area, and the European Union (EU) is no exception. Although EU members face the same nominal exchange rate between the euro and a reserve currency such as the US dollar, they face different real exchange rates since prices in member countries change at different rates. Indeed, this has been recognised by the European Commission in its quarterly report that each member has different degrees of vulnerability to changes in the exchange rate, mostly due to differences in pass-through of the exchange rate into traded goods prices and due to different price elasticities of traded goods.[3] The question we seek to answer in this paper is: Which original euro area members benefit from trade with the US as a result of member-specific real euro depreciation? This question was recently asked by Bahmani-Oskooee and Mohammadian (2019) for each member's trade with the rest of the world. Since each member's trade balance was measured against the world, the exchange rate was the real effective value of the euro. They found that real euro depreciation will improve the trade balance of France, Germany, Ireland, Italy, the Netherland and Portugal with the world, but it will have no long-run effects on the trade balance of Austria, Belgium, Finland, Luxembourg, and Spain.

Rose and Yellen (1989) criticised such studies on the ground that they suffer from aggregation bias. To reduce the bias, they recommended using trade data at bilateral level, as they did between the US and each of the other G7 countries. Following the same tradition, we suspect that the findings of Bahmani-Oskooee and Mohammadian (2019) also suffer from aggregation bias so, to reduce the bias, we consider the trade balance of each of the 12 original euro area countries with the US rather than the world. However, unlike Rose and Yellen (1989), who engaged only in symmetric analysis of the link between the trade balance and the real bilateral exchange rate, we will take an additional step and undertake an asymmetry analysis, which is the new trend in this literature.

The new literature advanced by Bahmani-Oskooee and Fariditavana (2015, 2016) demonstrates and argues that since traders' reactions to currency appreciation could be different from their reaction to currency depreciation (as a result of changes in their expectations), exchange rate changes could have asymmetric effects on the trade balance. Other reasons could be asymmetric responses of import and export prices to exchange rate changes (Bussiere 2013) and hysteresis in trade, which implies firms may not exit the market during currency appreciation at the same rate as they enter during depreciation (Arize *et al* 2017).

In what follows we introduce the models and methods in Section 2 and then present our empirical results in Section 3. A summary is provided in Section 4, followed by definition of variables and sources of the data in an Appendix.[4]

2. The Models and Methods

Rose and Yellen (1989) introduced a trade balance model between two countries that identified both countries' domestic economic activities and the real bilateral exchange rate to be three main determinants of the bilateral trade balance. Others such as Halicioglu (2008), Durmaz (2015), and Arize *et al* (2017) have modified their reduced-form models so that they can specify their models in logarithmic form. Their model was also recently criticised by Bahmani-Oskooee and Fariditavana (2016) for assuming the response of the bilateral trade balance to changes in the real bilateral exchange rate to be symmetric. As discussed in the previous section, the response could be asymmetric. Thus, we closely follow Bahmani-Oskooee and Fariditavana (2016) and adopt the following specification:

$$LnTB_{i,t} = a + b\,LnIP_{US,t} + c\,LnIP_{i,t} + d\,Ln\,REX_{i,t} + \varepsilon_t \qquad (1)$$

where TB_i is a measure of the trade balance between the US and partner *i* from euro area. As the Appendix reveals, the bilateral trade balance is defined as the ratio of US imports from a euro area partner *i* over its exports to partner *i*. In (1), the level of economic activity in the US is proxied by the index of industrial production and is denoted by IP_{US} and that of partner *i* from euro area by IP_i.[5] Since economic growth is supposed to stimulate imports, we expect an *b* to be positive and *c* to be negative. The real bilateral exchange rate between the US and euro area member *i* is identified by REX_i and, as the Appendix shows, it is defined as euros per dollar in real terms. Thus, a decline reflects a real depreciation of the dollar. If dollar depreciation is to reduce US imports and stimulate exports, hence improve the US trade balance, *d* should be positive.[6]

Estimation of specification (1) by any method yields only the long-run coefficient estimates. However, the J-curve literature alerts us to a different response of the trade balance to exchange rate changes. Given the existence of different adjustment lags, in the short-run the trade balance either may not respond to exchange rate changes, or it can even deteriorate after a depreciation and improve only in the long run, hence the J-curve effect. Therefore, in order to distinguish short-run effects of exchange rate changes on the trade balance from long-run effects, we must incorporate the short-run dynamic adjustment process into (1). The new specification is outlined by (2):

$$\begin{aligned}\Delta LnTB_{i,t} &= \alpha + \sum_{j=1}^{n}\beta_{t-j}\Delta LnTB_{i,t-j} + \sum_{j=0}^{n}\delta_{t-j}\Delta LnIP_{US,t-j} + \sum_{j=0}^{n}\gamma_{t-j}\Delta LnIP_{i,t-j} + \sum_{j=0}^{n}\pi_{t-j}\Delta LnREX_{i,t-j} \\ &\quad + \lambda_1 LnTB_{i,t-1} + \lambda_2 LnIP_{US,t-1} + \lambda_3 LnIP_{i,t-1} + \lambda_4 LnREX_{i,t-1} + \mu_t \qquad (2)\end{aligned}$$

Equation (2) is an error-correction model close to Engle and Granger's (1987) representation theorem. The only difference is that rather than including the lagged error term from (1) in (2), Pesaran *et al* (2001) include a linear combination of lagged level variables.[7] Once (2) is estimated by OLS, short-run effects are reflected by the estimates of coefficients attached to first-differenced variables; and the long-run effects by the estimates of $\lambda_2 - \lambda_4$ normalised on λ_1.[8] However, in order for the normalised long-run estimates to be meaningful, Pesaran *et al* (2001) recommend applying the F test with new critical values that they tabulate. Since critical values account for the degree of integration of variables, variables could be a combination of I(0) and I(1). Since these are properties of almost all macro variables, there is no need for pre-unit root testing under this approach, making this one of its main advantages. Another advantage is that the short-run and long-run effects are estimated in one step, just by estimating equation (2).

Specification (1) or (2) assumes that the effects of exchange rate changes on the trade balance are symmetric. However, as discussed before the effects could be asymmetric. Therefore, our next step is to modify (2) so that it could be used to test asymmetric effects of exchange rate changes on the trade balance. The modification involves decomposing $LnREX_{i,t}$ into two new time-series variables, where one reflects only dollar appreciation and the other only dollar depreciation. This is done by using the concept of partial sum as in (3):

$$POS_{i,t} = \sum_{j=1}^{t}\max(\Delta LnREX_{i,j},0),\ \textit{and}\ NEG_{i,t} = \sum_{j=1}^{t}\min(\Delta LnREX_{i,j},0) \qquad (3)$$

where *POS*, the partial sum of positive changes, reflects only dollar appreciation; and *NEG*, the partial sum of negative changes, reflects only dollar depreciation. Shin *et al* (2014), who introduced this approach, recommend then going back to model (2) and replacing $LnREX_{i,t}$ by two new series *POS* and *NEG*, to arrive at:

$$\begin{aligned} \Delta LnTB_{i,t} = a' &+ \sum_{j=1}^{n1} b'_j \Delta LnTB_{i,t-j} + \sum_{j=0}^{n2} c'_j \Delta LnIP_{US,t-j} + \sum_{j=0}^{n3} d'_j \Delta LnIP_{i,t-j} \\ &+ \sum_{j=0}^{n4} e'_j \Delta POS_{i,t-j} + \sum_{j=0}^{n5} f'_j \Delta NEG_{i,t-j} + \theta_0 LnTB_{i,t-1} + \theta_1 LnIP_{US,t-1} \\ &+ \theta_2 LnIP_{i,t-1} + \theta_3 POS_{i,t-1} + \theta_4 NEG_{i,t-1} + \xi_t \end{aligned} \qquad (4)$$

Since constructing the partial sum variables introduce nonlinearity into the adjustment process, Shin *et al* (2014) label models like (4) as nonlinear ARDL models, whereas models like (2) are labeled as linear ARDL models.

Specification (4) is another error-correction model and once it is estimated by OLS, a few asymmetry assumptions can be tested. First, short-run effects of exchange rate changes will be asymmetric if, at a given lag j, the estimate of the e'_j differs from the estimate of the f'_j. Second, short-run cumulative or impact asymmetric effects will be established if we can reject the null hypothesis of $\sum \hat{e}'_j = \sum \hat{f}'_j$ by using the Wald test. Third, short-run adjustment asymmetry will be established if, by using a set lag selection criterion, ΔPOS_i takes a different lag order than ΔNEG_i, i.e. if $n4 \neq n5$. Finally, long-run effects of exchange rate changes on the trade balance will be asymmetric if we can reject the null of $-\hat{\theta}_3/\hat{\theta}_0 = -\hat{\theta}_4/\hat{\theta}_0$.[9]

3. EMPIRICAL RESULTS

Using monthly data over the period 1991M1–2017M12 we estimate both the linear model (2) and the nonlinear model (4) between the US and each of the 12 original members of the euro area: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. The main reason for including only the 12 original members is to avoid conversion factors since other members adopted the euro at various later dates. Following the literature we impose a maximum of 12 lags on each first-differenced variable and use Akaike's Information Criterion (AIC) to select an optimum model.[10] Furthermore, we have collected all critical values in the notes to tables and used them to identify the significance level of estimates (* for 10 per cent significance; ** for 5 per cent). A dummy is also included in all models to account for the Global Financial Crisis of 2008. The results are reported in Table 1.

From the short-run estimates (Panel A) of the linear ARDL model reported in the column headed by L-ARDL we gather that the real bilateral exchange rate carries at least one significant coefficient in the US trade balance with Austria, Finland, Greece, Italy, Luxembourg, the Netherlands, and Spain, supporting

Table 1: Full-Information Estimates of Both Linear ARDL (L-ARDL) and Nonlinear ARDL (NL-ARDL) Models

	i = Austria		*i = Belgium*		*i = Finland*	
	L – ARDL	*NL – ARDL*	*L – ARDL*	*NL - ARDL*	*L – ARDL*	*NL – ARDL*
Panel A: Short–Run Estimates						
$\Delta LnTB_{i,t-1}$	–0.15	–0.03	–0.35**	–0.28	–0.54**	–0.36**
$\Delta LnTB_{i,t-2}$	–0.19	–0.08	–0.22	–0.16	–0.49**	–0.26**
$\Delta LnTB_{i,t-3}$	–0.25	–0.15	–0.16	–0.09	–0.49**	–0.23**
$\Delta LnTB_{i,t-4}$	–0.24	–0.16	–0.14	–0.09	–0.35**	–0.11
$\Delta LnTB_{i,t-5}$	–0.34**	–0.27	–0.09	–0.04	–0.27**	
$\Delta LnTB_{i,t-6}$	–0.43**	–0.35**	–0.13	–0.07	–0.32**	
$\Delta LnTB_{i,t-7}$	–0.33**	–0.25*	–0.06	–0.03	–0.22**	
$\Delta LnTB_{i,t-8}$	–0.39**	–0.33**	–0.05	–0.03	–0.25**	
$\Delta LnTB_{i,t-9}$	–0.35**	–0.29**	–0.07	–0.05	–0.13	
$\Delta LnTB_{i,t-10}$	–0.45**	–0.43**	–0.12	–0.11	–0.18**	
$\Delta LnTB_{i,t-11}$	–0.33**	–0.31**	–0.32**	–0.32**	–0.19**	
$\Delta LnIP_{US,t}$	1.11	–2.11	–0.88	–0.75	0.56	–3.85
$\Delta LnIP_{US,t-1}$	1.78	–0.36	–0.54	–0.38		
$\Delta LnIP_{US,t-2}$	–8.45**	–10.41**	2.42	2.25		
$\Delta LnIP_{US,t-3}$	–4.06	–3.37	–0.46	–0.40		
$\Delta LnIP_{US,t-4}$	7.99*	8.01*	1.11	0.83		
$\Delta LnIP_{US,t-5}$			2.34	2.23		
$\Delta LnIP_{US,t-6}$			–1.39			
$\Delta LnIP_{US,t-7}$						
$\Delta LnIP_{i,t}$	–1.90	–2.33	–0.49**	–0.48*	–0.98	–0.03
$\Delta LnIP_{i,t-1}$					–2.21**	–1.68**
$\Delta LnIP_{i,t-2}$					–0.62	
$\Delta LnIP_{i,t-3}$					–1.78**	
$\Delta LnIP_{i,t-4}$						
$\Delta LnREX_{i,t}$	–1.15		–0.14		0.47	
$\Delta LnREX_{i,t-1}$	–4.07**				–0.91*	
$\Delta LnREX_{i,t-2}$					–0.56	
$\Delta LnREX_{i,t-3}$					0.16	
$\Delta LnREX_{i,t-4}$					–0.78	
$\Delta LnREX_{i,t-5}$					1.22**	
$\Delta LnREX_{i,t-6}$					–0.29	
$\Delta LnREX_{i,t-7}$					0.96*	
$\Delta LnREX_{i,t-8}$					0.85	
ΔPOS_{t}		–3.09		–0.32		1.09**
ΔPOS_{t-1}		–15.30**				
ΔPOS_{t-2}						
ΔPOS_{t-3}						
ΔPOS_{t-4}						
ΔPOS_{t-5}						
ΔNEG_{t}		–2.07**		–0.25		–0.24
ΔNEG_{t-1}						–3.55*
ΔNEG_{t-2}						–3.41*
ΔNEG_{t-3}						
Panel B: Long–Run Estimates						
$LnIP_{US}$	0.28(0.15)	–0.61(0.40)	–0.33(0.61)	–0.25(0.51)	4.82(1.01)	0.22(0.13)
$LnIP_{i}$	1.40(1.21)	0.82(0.71)	–0.83(2.28)**	–0.71(1.76)*	–1.73(0.62)	–0.54(0.54)
$LnREX_{i}$	–0.75(2.13)**		–0.23(1.60)		2.37(1.18)	
POS		–2.33(3.32)**		–0.47(1.49)		3.34(2.65)**
NEG		–2.83(3.04)**		–0.38(0.94)		2.48(1.98)**
Constant	–6.80(1.43)	0.08(0.02)	4.79(2.72)**	–0.01(0.19)	–13.15(0.72)	1.75(0.26)
Panel C: Diagnostic Statistics						
F	2.12	1.74	3.51	3.44	1.36	3.33
ECM_{t-1}	–0.61(2.69)	–0.73(3.00)	–0.59(3.26)	–0.67(3.52)	–0.12(1.05)	–0.33(3.62)*
LM	0.01	0.56	0.85	1.27	0.43	0.004
RESET	0.15	0.10	4.39**	4.74**	2.59	5.02*
Adjusted R^2	0.47	0.47	0.55	0.55	0.35	0.27
CS (CS^2)	S(US)	S(US)	S(S)	S(S)	S(US)	S(S)
WALD – S		5.71**		0.49		3.96**
WALD – L		0.05		1.83		4.36**

Notes: See notes on page 29.

Table 1 continued.

	i = France		*i = Germany*		*i = Greece*	
	L – ARDL	*NL – ARDL*	*L – ARDL*	*NL – ARDL#*	*L – ARDL*	*NL – ARDL*
Panel A: Short–Run Estimates						
$\Delta LnTB_{i,t-1}$	–0.28*	–0.36**	–0.75**	–0.84**	–0.13	–0.14
$\Delta LnTB_{i,t-2}$	–0.29*	–0.34**	–0.76**	–0.85**	–0.04	–0.05
$\Delta LnTB_{i,t-3}$	–0.22	–0.22	–0.51**	–0.59**	0.08	0.08
$\Delta LnTB_{i,t-4}$	–0.21	–0.23	–0.45**	–0.53**	0.04	0.05
$\Delta LnTB_{i,t-5}$	–0.21	–0.27*	–0.32**	–0.39**		
$\Delta LnTB_{i,t-6}$	–0.23*	–0.27*	–0.37**	–0.45**		
$\Delta LnTB_{i,t-7}$	–0.29**	–0.37**	–0.28**	–0.35**		
$\Delta LnTB_{i,t-8}$	–0.23**	–0.32**	–0.23**	–0.29**		
$\Delta LnTB_{i,t-9}$	–0.19*	–0.26**	–0.24**	–0.29**		
$\Delta LnTB_{i,t-10}$	–0.33**	–0.32**	–0.33**	–0.36**		
$\Delta LnTB_{i,t-11}$	–0.28**	–0.26**	–0.23**	–0.25**		
$\Delta LnIP_{US,t}$	0.27	0.89**	0.37	0.49	3.36**	1.89
$\Delta LnIP_{US,t-1}$			1.91**	2.16**		
$\Delta LnIP_{US,t-2}$			1.72**	1.77*		
$\Delta LnIP_{i,t}$	1.26**	1.09*	–0.002	0.20	–1.63**	–1.71**
$\Delta LnIP_{i,t-1}$						
$\Delta LnREX_{i,t}$	0.04		–0.12		–1.15	
$\Delta LnREX_{i,t-1}$					0.59	
$\Delta LnREX_{i,t-2}$					0.64	
$\Delta LnREX_{i,t-3}$					2.24**	
$\Delta LnREX_{i,t-4}$					–0.69	
$\Delta LnREX_{i,t-5}$					1.47	
$\Delta LnREX_{i,t-6}$					2.40**	
$\Delta LnREX_{i,t-7}$					0.99	
$\Delta LnREX_{i,t-8}$					0.34	
$\Delta LnREX_{i,t-9}$					–1.20	
$\Delta LnREX_{i,t-10}$					2.49**	
ΔPOS_{t}		1.01		–0.05		1.24*
ΔPOS_{t-1}		0.76				
ΔPOS_{t-2}		2.55**				
ΔPOS_{t-3}		1.65				
ΔPOS_{t-4}		–2.99**				
ΔPOS_{t-5}		–2.06*				
ΔPOS_{t-6}						
ΔNEG_{t}		–3.04**		–0.54		–5.25
ΔNEG_{t-1}		–0.18				2.15
ΔNEG_{t-2}		–1.66				6.45*
ΔNEG_{t-3}		–1.89				5.32
ΔNEG_{t-4}		1.00				–3.36
ΔNEG_{t-5}		0.23				10.16**
ΔNEG_{t-6}		–0.38				6.56*
ΔNEG_{t-7}		–2.95**				7.41**
ΔNEG_{t-8}		–2.17**				0.78
ΔNEG_{t-9}						2.19
ΔNEG_{t-10}						10.13**
Panel B: Long–Run Estimates						
$LnIP_{US}$	0.45(1.53)	1.61(1.68)*	11.17(0.65)	5.33(1.76)*	4.53(5.02)**	2.53(1.75)*
$LnIP_{i}$	0.37(0.86)	–0.56(0.64)	0.07(0.01)	–1.66(1.03)	–2.19(3.46)**	–2.28(2.93)**
$LnREX_{i}$	0.07(0.71)		–0.83(0.33)		0.87(2.64)**	
POS		0.49(1.56)		–0.21(0.19)		1.65(2.14)**
NEG		0.68(1.47)		–0.87(0.71)		1.44(1.56)
Constant	–3.41(1.65)*	–4.43(1.80)*	–51.13(0.60)	–16.42(1.48)	–10.82(1.78)*	–0.96(0.13)
Panel C: Diagnostic Statistics						
F	3.36	3.09	2.38	2.46	8.32**	7.77**
ECM_{t-1}	–0.60(3.38)	–0.56(3.02)	0.04(0.49)	0.12(1.20)	–0.74(5.85)**	–0.75(5.70)**
LM	0.27	0.21	1.79	1.69	2.33	1.99
RESET	1.08	1.32	1.18	1.45	0.04	0.66
Adjusted R^2	0.47	0.50	0.41	0.40	0.36	0.37
CS (CS^2)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)
WALD – S		2.21		0.02		1.60
WALD – L		1.79		0.01		0.32

Notes: See notes on page 29.

Table 1 continued.

	i = Ireland		*i = Italy*		*i = Luxembourg*	
	L – ARDL	*NL – ARDL*	*L – ARDL*	*NL – ARDL#*	*L – ARDL#*	*NL – ARDL*
Panel A: Short–Run Estimates						
$\Delta LnTB_{i,t-1}$	–0.64**	–0.59**	–0.49**	–0.49**	0.03	0.19
$\Delta LnTB_{i,t-2}$	–0.52**	–0.46**	–0.62**	–0.63**	0.02	0.14
$\Delta LnTB_{i,t-3}$	–0.53**	–0.47**	–0.51**	–0.52**	–0.03	0.07
$\Delta LnTB_{i,t-4}$	–0.49**	–0.44**	–0.57**	–0.58**	–0.08	–0.002
$\Delta LnTB_{i,t-5}$	–0.48**	–0.45**	–0.47**	–0.48**	–0.09	–0.02
$\Delta LnTB_{i,t-6}$	–0.44**	–0.39**	–0.54**	–0.55**	–0.08	–0.02
$\Delta LnTB_{i,t-7}$	–0.51**	–0.47**	–0.52**	–0.53**	–0.12	–0.07
$\Delta LnTB_{i,t-8}$	–0.52**	–0.49**	–0.58**	–0.59**	–0.10	–0.08
$\Delta LnTB_{i,t-9}$	–0.47**	–0.46**	–0.52**	–0.52**	–0.03	–0.02
$\Delta LnTB_{i,t-10}$	–0.39**	–0.39**	–0.66**	–0.67**	–0.04	–0.03
$\Delta LnTB_{i,t-11}$	–0.24**	–0.24**	–0.49**	–0.49**	–0.06	–0.06
$\Delta LnIP_{US,t}$	–0.52	–0.58	0.56**	0.61**	–4.99	0.32
$\Delta LnIP_{US,t-1}$					–3.65	–2.12
$\Delta LnIP_{US,t-2}$					4.28	4.93
$\Delta LnIP_{US,t-3}$						
$\Delta LnIP_{i,t}$	0.05	0.002	–0.31**	–0.35*	1.89*	1.67*
$\Delta LnIP_{i,t-1}$						
$\Delta LnREX_{i,t}$	0.83		0.11**		1.19**	
$\Delta LnREX_{i,t-1}$						
$\Delta LnREX_{i,t-2}$						
$\Delta LnREX_{i,t-3}$						
ΔPOS_{t}		3.76**		0.23*		3.14**
ΔPOS_{t-1}						
ΔPOS_{t-2}						
ΔPOS_{t-3}						
ΔPOS_{t-4}						
ΔPOS_{t-5}						
ΔPOS_{t-6}						
ΔPOS_{t-7}						
ΔNEG_{t}		0.11		0.26**		4.32**
ΔNEG_{t-1}						
ΔNEG_{t-2}						
ΔNEG_{t-3}						
ΔNEG_{t-4}						
ΔNEG_{t-5}						
ΔNEG_{t-6}						
ΔNEG_{t-7}						
Panel B: Long–Run Estimates						
$LnIP_{US}$	–2.64(1.11)	–2.18(1.29)	1.77(3.39)**	2.06(1.89)*	1.27(1.07)	3.90(2.66)**
$LnIP_{i}$	0.25(0.48)	0.01(0.01)	–0.97(1.97)*	–1.18(1.39)	1.96(1.88)*	1.45(1.70)*
$LnREX_{i}$	0.46(0.64)		0.34(1.88)**		1.23(2.55)**	
POS		0.89(0.68)		0.77(1.69)*		2.72(2.98)**
NEG		0.40(0.23)		0.86(1.63)		3.74(3.53)**
Constant	12.52(1.18)	11.19(1.44)	–0.27(2.65)**	–2.97(2.22)**	-15.07(2.96)**	–24.73(3.97)**
Panel C: Diagnostic Statistics						
F	2.99	2.39	5.11**	3.89*	3.98*	4.43**
ECM_{t-1}	–0.19(1.88)	–0.27(1.54)	–0.32(3.06)	–0.29(2.66)	–0.97(3.79)**	–1.15(4.37)**
LM	0.03	0.01	0.14	0.22	0.04	0.26
RESET	0.02	0.03	0.14	0.04	0.04	0.09
Adjusted R^2	0.39	0.39	0.57	0.57	0.40	0.40
CS (CS^2)	S(S)	S(S)	S(S)	S(S)	S(S)	S(S)
WALD – S		1.41		1.89		0.65
WALD – L		1.64		5.16**		15.71**

Notes: See notes on page 29.

Table 1 continued.

	i = the Netherlands		*i = Portugal*		*i = Spain*	
	L – ARDL#	*NL – ARDL#*	*L – ARDL*	*NL – ARDL#*	*L – ARDL#*	*NL – ARDL#*
Panel A: Short–Run Estimates						
$\Delta LnTB_{i,t-1}$	0.02	0.03	–0.58**	–0.22**	–0.40**	–0.31*
$\Delta LnTB_{i,t-2}$	0.18**	0.18*	–0.38**		–0.37**	–0.26*
$\Delta LnTB_{i,t-3}$	0.11	0.11	–0.37**		–0.38**	–0.33**
$\Delta LnTB_{i,t-4}$	0.14**	0.14**	–0.35**		–0.33**	–0.27*
$\Delta LnTB_{i,t-5}$			–0.37**		–0.27**	–0.21*
$\Delta LnTB_{i,t-6}$			–0.32**		–0.33**	–0.29**
$\Delta LnTB_{i,t-7}$			–0.36**		–0.35**	–0.33**
$\Delta LnTB_{i,t-8}$			–0.40**		–0.23**	–0.19*
$\Delta LnTB_{i,t-9}$			–0.31**		–0.35**	–0.33**
$\Delta LnTB_{i,t-10}$			–0.27**		–0.26**	–0.25**
$\Delta LnTB_{i,t-11}$			–0.16**		–0.12**	–0.11*
$\Delta LnIP_{US,t}$	–1.08**	–1.07**	1.75	–0.98	0.55**	0.14
$\Delta LnIP_{US,t-1}$			5.23			
$\Delta LnIP_{US,t-2}$						
$\Delta LnIP_{i,t}$	0.60	0.65	0.56	2.77**	0.99	0.84
$\Delta LnIP_{i,t-1}$	–1.39**	–1.26**	3.40**			–1.33
$\Delta LnIP_{i,t-2}$	–0.30	–0.30	0.93			
$\Delta LnIP_{i,t-3}$	–1.02**	–0.95**	0.26			
$\Delta LnIP_{i,t-4}$			0.21			
$\Delta LnIP_{i,t-5}$						
$\Delta LnREX_{i,t}$	0.62**		0.21		–0.003	
$\Delta LnREX_{i,t-1}$					–0.69*	
$\Delta LnREX_{i,t-2}$					0.49	
$\Delta LnREX_{i,t-3}$					0.14	
$\Delta LnREX_{i,t-4}$					–0.48	
$\Delta LnREX_{i,t-5}$					0.20	
$\Delta LnREX_{i,t-6}$					0.59	
$\Delta LnREX_{i,t-7}$					–0.97**	
$\Delta LnREX_{i,t-8}$					–0.78*	
ΔPOS_{t}		1.82		0.89**	0.27	0.10
ΔPOS_{t-1}						–2.49*
ΔPOS_{t-2}						2.24
ΔPOS_{t-3}						1.48
ΔPOS_{t-4}						–2.12
ΔPOS_{t-5}						0.31
ΔPOS_{t-6}						2.93*
ΔPOS_{t-7}						–3.42**
ΔPOS_{t-8}						–3.19**
ΔNEG_{t}		–0.47**		0.20		–0.03
ΔNEG_{t-1}						
ΔNEG_{t-2}						
Panel B: Long–Run Estimates						
$LnIP_{US}$	–1.53(5.04)**	–1.53(3.34)**	–9.56(1.04)	–2.28(1.45)	1.89(2.17)**	0.37(0.34)
$LnIP_{i}$	2.43(4.28)**	2.47(4.02)**	–6.69(1.42)	–1.47(1.09)	–2.23(2.12)**	–1.34(1.39)
$LnREX_{i}$	–0.30(2.37)**		1.45(1.19)		0.15(0.45)	
POS		–0.64(2.07)**		2.07(2.43)**		0.51(0.84)
NEG		–0.68(2.19)**		0.48(0.50)		–0.09(0.15)
Constant	–4.56(2.06)**	–4.69(1.95)*	77.25(1.27)	17.79(1.95)*	2.07(0.29)	4.71(0.74)
Panel C: Diagnostic Statistics						
F	12.75**	10.10**	4.53**	7.87**	3.29	2.65
ECM_{t-1}	–0.71(7.16)**	–0.69(6.93)**	–0.15(1.57)	–0.43(6.05)**	–0.29(2.39)	–0.37(2.27)
LM	1.72	0.06	0.59	2.47	1.17	2.46
RESET	2.11	1.94	2.35	0.88	0.50	0.25
Adjusted R^2	0.22	0.21	0.29	0.23	0.37	0.36
CS (CS^2)	S(S)	S(S)	S(S)	S(US)	S(S)	S(S)
WALD – S		0.41		0.01		0.01
WALD – L		27.57**		3.09*		0.11

Notes to Table 1:

a. * significant at the 10% level; ** significant at the 5% level.

b. Numbers in parentheses are absolute value of t-ratios.

c. The upper bound critical value of the F-test for cointegration when there are three exogenous variables is 3.77 (4.35) at the 10% (5%) level of significance. These come from Pesaran *et al* (2001, Table CI, Case III, p 300).

d. The critical value for significance of ECM_{t-1} is –3.46 (–3.78) at the 10% (5%) level when k = 3. The comparable figures when k = 4 are –3.66 and –3.99 respectively. These come from Pesaran *et al* (2001, Table CII, Case III, p 303).

e. LM is the Lagrange Multiplier test of residual serial correlation. It is distributed as χ^2 with one degree of freedom (first order). Its critical value at 5% (10%) significance level is 2.71(3.84).

f. RESET is Ramsey's test for misspecification. It is distributed as χ^2 with one degree of freedom. The critical value is 3.84 at the 5% level and 2.70 at the 10% level.

g. symbol, #, shows that dummy for Global Financial Crisis of 2008 is significant.

h. Wald test are distributed as χ^2 with 1 degree of freedom i.e. critical value is 2.71(3.84) at the 10% (5%) significance level.

short-run effects of exchange rate changes on the trade balance. However, when we move to estimates of the nonlinear model reported in the column headed by NL-ARDL, either ΔPOS or ΔNEG carry at least one significant coefficient in all nonlinear models except Belgium and Germany. This increase in the number of significant short-run cases must be attributed to nonlinear adjustment of the real bilateral exchange rate. Furthermore, the short-run estimates of the nonlinear models support adjustment asymmetry in the cases of Austria, Finland, France, Greece, and Spain since in these cases ΔPOS and ΔNEG accept different lag orders. Additionally, in most instances the short-run effects are asymmetric since at a given lag order, the size of the estimate attached to ΔPOS is different from the one attached to ΔNEG. However, the sum of the coefficients attached to ΔPOS is significantly different from the sum attached to ΔNEG only in the cases of Austria and Finland. Only in these two countries is the Wald test, reported as Wald-S in Panel C, significant, rejecting the null hypothesis of the equality of the two sums. In how many models, however, do the short-run effects last into the long run?

The normalised long-run coefficient estimates are reported in Panel B and reveal that the real exchange rate carries a significant coefficient in the linear models of Austria, Greece, Italy, Luxembourg, and the Netherlands. While the estimate is negative in the cases of Austria, and the Netherlands, it is positive in the cases of Greece, Italy, and Luxembourg. Thus, the linear models predict that while a real depreciation of the dollar will improve the US trade balance with Greece, Italy, and Luxembourg, it will hurt its trade balance with Austria and the Netherlands.[11] These long-run estimates are meaningful since cointegration is supported by the F test (Panel C) in all cases except Austria. In this case we tried an alternative test known as ECM_{t-1} or the t-test for cointegration. Under this alternative test we use long-run normalised coefficient estimates and long-run model 1, and generate the error term which is usually denoted by *ECM*.

We then go back to the linear model (2) and replace the lagged level variables by ECM_{t-1} and estimate this new specification at the same optimum lag orders. If ECM_{t-1} carries a significantly negative coefficient, convergence of variables toward their long-run equilibrium or cointegration is supported. Since the t-test is used to judge the significant of this estimate, the test is also known as the t-test. Like the F test, Pesaran *et al* (2001 p 303) provide new critical values that account for integrating properties of variables. The coefficient estimate attached to ECM_{t-1}, as well as the t-test, are reported in Panel C. They do not support cointegration in the case of Austria. In sum, only in four partners are the long-run effects meaningful (the Netherlands, Greece, Italy, and Luxembourg). Now, can we improve the outcome by shifting to estimates of nonlinear models?

From the long-run estimate of the nonlinear models we gather that either the *POS* or the *NEG* variable carries a meaningful and significant coefficient in the cases of Finland, Greece, Italy, Luxembourg, the Netherlands, and Portugal.[12] Clearly, the findings are partner-specific. For example, consider the bilateral models with Finland. In the linear model the real bilateral exchange rate does not carry any significant long-run coefficient, nor is there evidence of cointegration. However, the nonlinear model reveals that dollar depreciation against Finland's specific real euro will improve the US trade balance with Finland and dollar appreciation will reduce it. These estimates are meaningful since asymmetry cointegration is supported at least by ECM_{t-1}, which must be attributed to nonlinear adjustment of the exchange rate.

Such findings from the nonlinear models are masked by the linear models. Furthermore, these long-run effects are asymmetric since the Wald test reported as Wald-L in Panel C is significant, rejecting equality of the two coefficients. The Wald-L test supports significant long-run asymmetric effects in Finland, Italy, Luxembourg, the Netherlands, and Portugal. In sum, the *NEG* variable carries a meaningful and significantly positive coefficient only in the cases of Finland and Luxembourg. Thus, a real depreciation of the dollar will only improve the US trade balance with these two countries. However, a real depreciation of the dollar will hurt the US trade balance with the Netherlands. On the other hand, a real dollar appreciation will hurt the US trade balance with Finland, Greece, Italy, Luxembourg, and Portugal, since the *POS* variable carries a meaningful and significantly positive coefficient in these cases. The fact that a depreciation or an appreciation has different effects on the US trade balance with different euro area partners could be caused by different import demand and export demand elasiticies.[13, 14]

4. SUMMARY AND CONCLUSIONS

Since the introduction of cointegration and error-correction modeling, researchers have relied on a reduced form model of the trade balance in order to assess the short-run and long-run effects of exchange rate changes on the trade balance. If a significantly positive relation between the trade balance and the exchange rate is interpreted as a sign of improvement in the trade balance following a depreciation, it automatically implies that an appreciation will have adverse effects on the trade balance. However, recent advances in asymmetric cointegration and error-correction modeling show the above symmetric interpretation to be wrong. An appreciation may hurt the trade balance but due to downward price rigidity, a depreciation may not improve it. Since asymmetry analysis requires using nonlinear models, the literature so far reveals that nonlinear models yield more significant results than the linear models.

In this paper we consider the response of the US bilateral trade balances with each of the 12 original members of the euro area. When we employed the traditional approach and a linear model, we found that a real depreciation of dollar against the euro improves the US trade balance only with Greece, Italy, and Luxembourg, supporting the traditional definition of the J-curve effect, i.e. insignificant or negative short-run effects combined with favourable and positive long-run effects. However, when dollar appreciations were separated from dollar depreciations and a nonlinear model was employed, we found that a real dollar depreciation improves US bilateral trade balances with Finland, and Luxembourg and a dollar appreciation hurts the US trade balance with Finland, Greece, Italy, Luxembourg, and Portugal, supporting an asymmetric J-curve effect with five partners. Clearly, introducing nonlinear adjustment of partner specific real dollar-euro rates provides more support for the J-curve effect.

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APPENDIX

Data Definition and Sources

Monthly data over the period 1999MI-2017M12 are used to carry out the empirical analysis with each partner except that due to unavailability of some data, the study period was reduced to 2000M1-2017M12 for Austria and Luxembourg, and to 2001M1-2017M12 for Greece.

Data come from the following sources:
a. Direction of Trade Statistics (DOT) of the IMF.
b. International Financial statistics (IFS) of the IMF.

Variables:

TB_i = the US trade balance with partner i is defined as US imports from partner i over exports to partner i. The data come from source (a).

IP_{US} = Measure of US income. It is proxied by the industrial production index. The data come from (b).

IP_i = Trading partner i's income. This is also proxied by the industrial production index in country i and the data come from source (b).

REX_i = The real bilateral exchange rate of the currency of partner i per US dollar (USD). It is defined as $REX_i = (P_{US}.\ NEX_i / P_i)$ where NEX_i is the nominal exchange rate defined as number of euros per dollar, P_{US} is the price level in the US (measured by CPI) and P_i is the price level in country i (also measured by CPI). Thus, a decline in *REX* reflects a real depreciation of the US dollar. The nominal euro-dollar rate and CPI data come from source (b).

Endnotes

1. The Center for Research on International Economics and Department of Economics, the University of Wisconsin-Milwaukee, Milwaukee, WI 53201. We would like to thank valuable comments of two anonymous referees. Any remaining errors, however, are our own. Corresponding author's e-mail: bahmani@uwm.edu

2. Pennsylvania State University, Mont Alto. Department of Economics, Mont Alto, PA 17237 e-mail: hhh10@psu.edu

3. European Commission: Quarterly Report of the Euro Area (2014 p 27).

4. The literature prior to the asymmetry analysis (old literature) has been reviewed by Bahmani-Oskooee and Ratha (2004) and Bahmani-Oskooee and Hegerty (2010). Some example of studies that have used the aggregate trade balance of a country with the rest of the world include Moffet (1989), Noland (1989), Lal and Lowinger (2002), Moura and Da Silva (2005), among others.

5. Note that as the Appendix shows, because we use monthly data, IP is the only measure of economic activity that is available with monthly frequency.

6. As can be seen, the definition of the real bilateral exchange rate leads us to define the trade balance as imports/exports and not exports/imports.

7. Note that by deduction they are the same. We can easily see this if we solve equation (1) for ε_t and lag the solution by one period.

8. Note that once normalisation takes place, we can match normalised long-run estimates with those in equation (1). More precisely, we will have

$$\hat{b} = \hat{\lambda}_2 / -\hat{\lambda}_1 ,\ \hat{c} = \hat{\lambda}_3 / -\hat{\lambda}_1 ,\ \hat{d} = \hat{\lambda}_4 / -\hat{\lambda}_1$$

9. Note that applying the F test to establish asymmetry cointegration in (4) requires using the same critical values of the F test for both the linear and nonlinear models, even though the nonlinear model has one more variable than the linear model (Shin *et al* 2014 p 291).

10. Note that where there was evidence of serial correlation, following Bahmani-Oskooee and Fariditavana (2019) we added additional lags of the dependent variable to reduce serial correlation.

11. Note that the negative effect of dollar depreciation on the US trade balance with Austria and the Netherlands could be caused by import demand being inelastic (Bahmani-Oskooee and Aftab 2017 endnote 11).

12. By 'meaningful' we mean cointegration is supported either by the F or ECM_{t-1} test.

13. As for other diagnostics, the LM test supports autocorrelation-free residuals in all nonlinear models and the RESET test indicates misspecification only in two models (Belgium and Finland). Furthermore, estimates are stable in almost all models. For more on some other applications of these methods see Halicioglu (2007, 2008), Nusair (2012, 2017), Aliyu and Tijjani (2015), Baghestani and Kherfi (2015), Durmaz (2015), Gogas and Pragidis (2015), Al-Shayeb and Hatemi-Jarabad (2016), Lima *et al* (2016), Aftab *et al* (2017), Arize *et al* (2017), and Gregoriou (2017). Note that Belke and Gocke (2005), Belke *et al* (2013, 2015), and Belke and Kronen (2016) have used non-linear models in which they introduce path-dependent play-hysteresis into a regression framework so that they can assess the hysteretic impact of real exchange rates on trade flows of different countries in the euro area.

14. As an additional exercise and for sensitivity analysis we also tried the Schwarz Bayesian Criterion (SBC) to select optimum lags. While the optimum lags were somewhat shorter in most models, there was no significant change in the long-run estimates.

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