Revisiting the Twin Deficits Hypothesis: A Quantile Cointegration Analysis over the Period of 1791-2013

Nikolaos Antonakakis
University of Portsmouth and Webster Vienna Private University

Juncal Cunado
University of Navarra

Rangan Gupta
University of Pretoria

Mawuli K. Segnon
University of Münster

Working Paper: 2016-07
February 2016
REVISITING THE TWIN DEFICITS HYPOTHESIS: A QUANTILE COINTEGRATION ANALYSIS OVER THE PERIOD 1791-2013

Nikolaos Antonakakis*, Juncal Cunado*, Rangan Gupta* and Mawuli K. Segnon*

Abstract

This paper revisits the twin deficits hypothesis by examining the long-run cointegrating relationship between the US budget and trade deficits across various quantiles using a unique dataset for the period 1791-2013. The main results point out to the existence of nonlinearities and structural breaks in the relationship between the US trade and budget deficits, suggesting that the long-run relationship between the two variables has not been constant overtime. Furthermore, we find evidence in favour of the twin deficits hypothesis. Finally, and more importantly, the results suggest that the cointegrating coefficient in the long-run relationship between the two variables is not constant across the different quantiles. In fact, we find that an increase in the budget deficit will have a greater effect on the trade deficit at quantiles below the median than at higher quantiles, suggesting thus, that private agents react in a “Keynesian manner” when budget deficits are below the median, while they react in a “Ricardian manner” when deficits are above the median.

JEL classification: C22, E62, F32.

Keywords: twin deficits hypothesis, structural breaks, non-linearities, quantile ARDL model.

* Corresponding author. University of Portsmouth, Economics and Finance Group, PO1 3DE, Portsmouth, United Kingdom. Email: nikolaos.antonakakis@port.ac.uk. Webster Vienna Private University, Department of Business and Management, 1020, Vienna, Austria. Email: nikolaos.antonakakis@webster.ac.at.

* University of Navarra, School of Economics, Edificio Amigos, E-31080 Pamplona, Spain. Email: jcunado@unav.es.

* Department of Economics, University of Pretoria, Pretoria, 0002, South Africa. Email: rangan.gupta@up.ac.za.

* University of Münster, Center of Quantitative Economics, Am Stadtgraben 9, 48143 Münster, Germany. Email: segnon@uni-muenster.de.
I. Introduction

According to the twin deficits hypothesis, there is a strong link between a country’s trade and fiscal balances, implying that a fiscal contraction will be followed by a fall in the current account deficit. From a theoretical point of view, this hypothesis could be both justified or rejected depending on the assumptions made in the model. First, according to a Keynesian view and based on the Mundell-Fleming framework, a fiscal contraction will lead to a decrease in the current account deficit through a decrease in interest rates and a depreciation of the real exchange rate (Obstfeld and Rogoff, 1996). On the contrary, under the Ricardian equivalence framework (Barro, 1989), the fiscal contraction will not lead to a decrease in the current account deficit since private agents will react by decreasing private consumption as these agents would like to save for expected future tax increases. That is, the relationship between fiscal policy and current account deficits will depend on whether the consumers react in a “Keynesian” or “Ricardian” manner, and thus, the twin deficits hypothesis will only hold in the first case.

From an empirical point of view, although this hypothesis has been extensively tested, the results on its validity are not yet conclusive. On the one hand, many papers support the conventional “twin-deficit” hypothesis (Summers, 1986; Abell, 1990; Zietz and Pemberton, 1990; Bahmani-Oskooee, 1992, 1995; Kasa, 1994; Piersanti, 2000; Leachman and Francis, 2002; Cavallo, 2005; Erceg et al., 2005 and Salvatore, 2006), by obtaining a positive relationship between the budget and trade deficits. On the other hand, evidence against this hypothesis has also been extensively documented (Miller and Russew, 1989; Dewald and Ulan, 1990; Enders and Lee, 1990; Boucher, 1991; Normandin, 1994; Kim, 1995; Papaioannou and Yi, 2001, and Kim and Roubini, 2008). For example, Kim and Roubini (2008), based on VAR models, find that the US government deficit shocks improve current account, rejecting thus the “twin deficits” hypothesis in favour of the “twin divergence” hypothesis.

In fact, we postulate that the different empirical results obtained in the literature respond to the fact that the relationship between these variables has changed over time (e.g., while the two variables moved together during the 80s, the two balances drifted apart at the mid-90s or the beginning of the 21st century). The evidence of structural breaks in the relationship between these two variables has also been documented in the literature. For example, Leachman and Francis (2002), use cointegration techniques for testing the existence of a long-run relationship between US government and external deficits in two subperiods (1948-1973 and 1974-1992), finding weak and time-specific evidence in favour of the twin deficits hypothesis. Grier and Ye (2009), using quarterly data for the period 1948Q1-2005Q1, argue that US budget and trade deficits present structural breaks which should be taken into account when testing the twin deficits hypothesis. Bagnai (2006) also finds evidence of structural breaks when testing the twin deficits hypothesis in 22 OECD countries. According to the theoretical discussion presented above, the change in the relationship between fiscal and external deficits over time suggests private agents have reacted differently (in a “Keynesian” or “Ricardian” manner) over the years.

Based on the idea that the cointegrating coefficients may vary over time, in this paper we analyse the long-run relationship between the US budget and external deficits across various quantiles using data from 1791 to 2013. The main contributions of the paper are the following. First, we test the twin deficits hypothesis using a long span of data covering the period 1791-2013, while most of the studies limit their analysis to the second half of the twentieth century. Second, given the evidence of nonlinearity and structural breaks, we pursue the non-linear/time-varying quantile autoregressive distributed lag (QARDL) approach to obtain the long-run relationship.
between the two variables across various quantiles. To our knowledge, this is the first paper that applies the QARDL methodology to test the twin deficits hypothesis using over two centuries (223 years) of data.

The remainder of the paper is structured as follows: Section 2 revises the methodology and justifies its application in this context. Section 3 presents the data and the main empirical results, while Section 4 contains some concluding comments.

II. Methodology

The standard autoregressive distributed lag (ARDL) model as discussed in Pesaran et al. (2001) is given as follows:

\[ Y_t = \alpha + \sum_{j=1}^{p} \phi_j Y_{t-j} + \sum_{j=0}^{q} \theta_j X_{t-j} + U_t, \quad (1) \]

The corresponding quantile ARDL (QARDL) model recently developed by Cho et al. (2015) can be formalized as follows:

\[ Y_t = \alpha(\tau) + \sum_{j=1}^{p} \phi_j(\tau) Y_{t-j} + \sum_{j=0}^{q} \theta_j(\tau) X_{t-j} + U_t(\tau), \quad (2) \]

where \( X_t \in \mathbb{R}^k \) is an integrated process of a stationary and ergodic process with mean zero, \( U_t(\tau) \) represents the error term that is defined as \( Y_t - Q_{Y_t}(\tau|F_{t-1}) \) with \( Q_{Y_t}(\tau|F_{t-1}) \) being the \( \tau - th \) quantile of \( Y_t \) conditional on \( F_{t-1} = \{ X'_t, Y_t, X'_{t-1}, \ldots \} \), and \( p \) and \( q \) are lag orders in the model.

For our analysis we use the following reformulation of the equation (2):

\[ Y_t = \alpha(\tau) + \sum_{j=0}^{q-1} W'_{t-j} \delta_j(\tau) + X'_t \gamma(\tau) + \sum_{j=1}^{p} \phi_j(\tau) Y_{t-j} + U_t(\tau), \quad (3) \]

Where \( \gamma(\tau) := \sum_{j=0}^{q-1} \theta_j(\tau), W_t := \Delta X_t, \) and \( \delta_j(\tau) := -\sum_{i=j+1}^{q} \theta_j(\tau). \) This reformulation allows to analyze the short-run dynamics between \( Y_t \) and \( X_t \). However, we are more interested in the long-run relationship between \( Y_t \) and \( X_t \) that can be captured through the following long-run quantile process:

\[ 1 \text{ Note that, one could use the time-varying cointegration approach of Bierens and Martins (2010), which in turn is the generalization of the constant parameter cointegrating model of Johansen (1991). However, as is well-known with standard cointegration approaches, this would require pre-testing for unit roots, which the ARDL model allows us to avoid. In addition, testing for significance of time-varying cointegrating parameters requires obtaining confidence sets of the estimates, which in turn, is not that straightforward. However, when we did apply the time-varying cointegration method of Bierens and Martins (2010), in general, we observed a positive relationship between the two deficits over time, thus validating the (twin deficit) hypothesis. Complete details of these results are available upon request from the authors.} \]
\[ Y_t = \mu_*(\tau) + X_t^i \beta_*(\tau) + R_t(\tau), \quad (4) \]

Where

\[ R_t(\tau) := \sum_{j=0}^{\infty} W_{t-j} \xi_{0,j,*}(\tau) + \sum_{j=0}^{\infty} \rho_{j,*}(\tau) U_{t-j}(\tau), \quad \mu_*(\tau) := \alpha_*(\tau)(1 - \sum_{j=1}^{p} \phi_{j,*}(\tau))^{-1}, \quad \beta_*(\tau) := \gamma_*(\tau)(1 - \sum_{j=1}^{p} \phi_{j,*}(\tau))^{-1}, \quad \xi_{0,j,*}(\tau) := -\sum_{i=j+1}^{\infty} \pi_{i,*}(\tau), \]

\{\rho_{0,*}(\tau), \rho_{1,*}(\tau), \ldots\} \text{ and } \{\pi_{0,*}(\tau), \pi_{1,*}(\tau), \ldots\} \text{ are such that}

\[ \sum_{j=0}^{\infty} \rho_{j,*}(\tau) L^j \equiv (1 - \sum_{j=1}^{p} \phi_{j,*}(\tau)L^j)^{-1} \text{ and} \]

\[ (1 - L)^{-1} \left( \frac{\sum_{j=0}^{q} \theta_{j,*}(\tau)L^j}{1 - \sum_{j=1}^{p} \phi_{j,*}(\tau)L^j} - \frac{\sum_{j=0}^{q} \theta_{j,*}(\tau)}{1 - \sum_{j=1}^{p} \phi_{j,*}(\tau)} \right) \equiv \sum_{j=0}^{\infty} \pi_{j,*}(\tau)L^j, \]

respectively. \( \beta_*(\tau) \) represents the long-run parameter in equation (4) and characterizes the long-run dynamics between \( Y_t \) and \( X_t \). We refer the reader to Cho et al. 2015 for more information concerning the estimation procedures.

III. Empirical Results

For our empirical analysis we use a unique annual data set consisting of U.S. trade and budget deficits covering the time period from 1791 until 2013, with the start and end date being purely driven by data availability. The ratio of trade and budget deficit with respect to GDP is obtained from Global Financial Database, as is the nominal GDP figures, which in turn, is used to recover the nominal trade and budget deficits. The corresponding real values are obtained by dividing the nominal values with the CPI, obtained from the website of Professor Robert Sahr: http://liberalarts.oregonstate.edu/spp/polisci/research/inflation-conversion-factors-convert-dollars-1774-estimated-2024-dollars-recent-year. The data have been plotted in Figure 1. For the sake of clarity, we use subplots of the data.
Based on the Bayesian Information Criterion (BIC), we first determine the order of lag in the model. We start-off with the standard ARDL models, once with budget deficit as the dependent variable and then trade-deficit taking its place. For the first case, $p=q=7$, while for the latter, $p=7$ and $q=6$. The $F$-statistics for the test of cointegration for the two cases were: 37.811 and 5.238 respectively. Based on the critical values in Table CI (iii) on p.300 of Pesaran et al. (2001), the null of no-cointegration is rejected in both cases at one $[6.84, 7.84]$ and ten $[4.04, 4.78]$ percent levels of significance respectively. Note that, when trade-deficit is the dependent variable, with the test value falling in-between the I(0) and I(1) limits $[4.94, 5.73]$, results regarding cointegration is inconclusive. The result tends to suggest that, perhaps, budget deficit is the endogenous variable in the system. The normalized statistically significant long-run coefficients were 0.951 and 0.724 respectively, implying a positive long-run relationship between the two deficits.

Now, given that our sample period covers over two centuries of data, the ARDL model is likely to suffer from nonlinearities and structural breaks. In this regard, we tested for nonlinearity by applying the Brock et al. (1996, BDS) test on the residuals of the two ARDL models. As seen from Table A1 in the Appendix, the null off $iid$ residuals were overwhelmingly rejected at one percent level of significance across all dimensions, suggesting the evidence of nonlinearity in the relationship between the two variables. In addition, when we applied the Bai and Perron (2003) test of multiple structural breaks, we detected four breaks each at 1866, 1918, 1950, and 1982; and 1883, 1915, 1948, and 1982, with budget and trade deficit respectively, as dependent variables. Note that, the last three breaks in the two equations are quite close to each other. Given the evidence of nonlinearity and structural breaks, we decided to pursue the non-
linear/time-varying QARDL approach to obtain the long-run relationship between these two variables across various quantiles, i.e., contingent on the conditional distribution of the variables, and hence account for these two possible misspecification problems in the linear ARDL model. Note that since the estimation is conditioned on the distribution of the dependent variable, we are able to capture the various states through which the dependent variable has evolved over time (Xiao, 2009). The estimations results are reported in Tables 1 and 2.

**Table 1.** Estimation of ARDL model via quantile regression using budget deficit as the dependent variable.

| $\tau$ | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| $\beta_*(\tau)$ | 0.362 | 0.051 | 0.134 | 1.690 | 0.147 | 0.430 | 0.507 | 0.500 | 0.626 |
| $S.E.$ | 0.000 | 0.001 | 0.002 | 0.008 | 0.004 | 0.002 | 0.001 | 0.001 | 0.000 |
| Wald-t | 1.120E+10 (p-value=0.000) |

Note: S.E.: denotes the standard deviation errors associated with the model estimation.

**Table 2.** Estimation of ARDL model via quantile regression using trade deficit as the dependent variable.

| $\tau$ | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| $\beta_*(\tau)$ | 1.969 | 2.468 | 4.065 | 7.744 | 0.816 | 1.363 | 3.084 | 2.902 | 1.600 |
| $S.E.$ | 0.001 | 0.004 | 0.032 | 0.152 | 0.012 | 0.009 | 0.012 | 0.006 | 0.001 |
| Wald-t | 1.0158E+9 (p-value=0.000) |

Note: S.E.: See Note to Table 1.

In Tables 1 and 2, all the estimates of $\beta_*(\tau)$ are positive and significant at any confidence level. In Table 1, with budget deficit as the dependent variable, the estimate reaches a peak at $\tau = 0.4$, but varies in general around this quantile, with values at higher quantile beyond the median being greater than those at quantile levels below 0.4. In Table 2, when trade deficit is the dependent variable, until quantile $\tau \leq 0.4$, the estimates of $\beta_*(\tau)$ increase monotonically, reaching a peak of 7.744 again at $\tau = 0.4$, and then decreases dramatically at the median of the conditional distribution of trade deficit. Beyond the median, the estimate varies between 1.363 and 1.600. In both tables, to see whether parameters are constant across quantiles we applied the Wald test. The null hypotheses of parameter constancy across quantiles are rejected at any confidence level, which is understandable given the variability across the quantiles. This result also highlights the need to use QARDL approach to account for nonlinearity and structural breaks. In general, we find a positive long-run relationship between budget deficit and trade deficit, implying that budget and trade deficits co-move, which in turn, is in conformity with the twin deficits hypothesis. However, the size of the effect of the two deficits on each other is variable and depends on which point of their respective conditional distribution trade and budget deficits are. Also note that, the effect of budget deficit on the trade deficit in the long-run across various quantiles of the QARDL model is much higher than that compared to the mean-based long-run coefficient in the ARDL model. For the case when trade deficit is the dependent variable, this happens to be the case only at $\tau=0.4$. 
IV. Concluding Comments

In this paper, we test for the twin deficits hypothesis by analysing the long-run relationship between the US trade and budget deficits across various quantiles using a long span of data covering the time period 1791-2013.

The main results of the paper are the following. First, the results point out to the existence of nonlinearities and structural breaks in the relationship between US trade and budget deficits, suggesting that the long-run relationship between the two variables has not been constant over the period. Second, we find evidence in favour of the twin deficits hypothesis, since a long-run positive cointegration relationship is found between the two variables. Finally, and more importantly, the results suggest that the cointegrating coefficient in the long-run relationship between the two variables is not constant across the different quantiles. For example, we find that an increase in the budget deficit will have a greater effect on the trade deficit at quantiles below the median than at higher quantiles.

Based on the theoretical discussion presented above, this last result suggests that private agents react in a “Keynesian manner” when budget deficits are below the median, while they react in a “Ricardian manner” when deficits are above the median. That is, the higher the budget deficit (at quantiles above the median), the more likely the consumers react in a “Ricardian manner”, tending to save more to be able to pay future tax increases. In this case, any increase (decrease) in the budget deficit will not be followed by an increase (decrease) in the trade deficit. However, for low deficit levels, consumers will not react so much to the budget deficit increase, and thus, this increase will be followed by a trade deficit increase. This idea is in line with Perotti (1999), who shows that government policies have a different effect in times of “fiscal stress” than in “normal times”.

We believe the results obtained in this paper provide a bird's-eye-view on explaining how the relationship between fiscal and trade deficits in the United States has changed over a period of more than two hundred years (1791-2913). Furthermore, the quantile analysis suggests a plausible explanation of why the evidence of the twin deficits hypothesis changes over time.

References:

Abell, J. D., 1990. Twin Deficits During the 1980s: An Empirical Investigation. Journal of Macroeconomics, 12, 81-96.

Bagnai, A., 2006. Structural breaks and the twin deficits hypothesis. International Economics and Economic Policy 3, 137–155.

Bahmani-Oskooee, M., 1992. What are the long-run determinants of the US trade balance? Journal of Post Keynesian Economics 14, 85–97.

Bahmani-Oskooee, M., 1995. The long-run determinants of the US trade balance revisited. Journal of Post Keynesian Economics 17, 457–465.

Bai, J. and Perron, P. 2003. Computation and analysis of multiple structural change models. Journal of Applied Econometrics 18, 1-22.

Barro, R.J., 1989. The Ricardian approach to budget deficits. Journal of Economic Perspectives 40, 37-54.
Bierens, H. J., and Martins L. F., 2010. Time-varying cointegration. Econometric Theory 26, 1453-1490.

Boucher, J.L., 1991. The U.S. Current Account: A Long and Short Run Empirical Perspective, Southern Economic Journal 58, 93-111.

Brock, W., Dechert, D., Scheinkman, J., LeBaron, B., 1996. A test for independence based on the correlation dimension. Econometric Reviews 15 197–235.

Cavallo, M., 2005. Government Consumption Expenditures and the Current Account, FRBSF Working Paper 2005-03.

Cho, J.S., Kim, T-H., and Shin, Y. (2015). Quantile Cointegration in the Autoregressive Distributed-Lag Modelling Framework. Journal of Econometrics, 188, 281-300.

Dewald, W. G. and Ulan, M., 1990. The twin deficit illusion. Cato Journal 10, 689–707.

Enders, W. and Lee, B., 1990. Current Account and Budget Deficits: Twins or Distant Cousins? Review of Economics and Statistics, 72, 373-381.

Erceg, C. J., Guerrieri, L. and Gust, C., 2005. Expansionary Fiscal Shocks and the Trade Deficit. International Finance Discussion Paper No. 825, Federal Reserve Board.

Grier, K., Ye, H., 2009. Twin sons of different mothers: the long and the short of the twin deficits debate. Economic Inquiry 47, 625–628.

Johansen, S., 1991. Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. Econometrica 59, 1551–1580.

Kasa, K., 1994. Finite Horizons and the Twin Deficits. Economic Review, Federal Reserve Bank of Boston 3, 19-28.

Kim, K. H., 1995. On the long-run determinants of the US trade balance: A comment. Journal of Post Keynesian Economics 17, 447–455.

Kim, S. and Roubini, N., 2008. Twin Deficits or Twin Divergence? Fiscal Policy, Current Account, and Real Exchange Rate in the US. Journal of International Economics 74, 362-383.

Leachman, L. L. and Francis, B., 2002. Twin Deficits: Apparition or Reality? Applied Economics 34, 1121-32.

Miller, S. M. and Russek, F. S., 1989. Are the twin deficits really related? Contemporary Economic Policy 7, 91–115.

Normandin, M., 1999. Budget Deficit Persistence and the Twin Deficits Hypothesis, Journal of International Economics 49, 171-194.

Obstfeld, M. and Rogoff, K., 1996. Foundations of International Macroeconomics. Cambridge, Massachusetts, MIT Press.

Papaioannou, S. and Yi, K. 2001. The Effects of a Booming Economy on the U.S. Trade Deficit. Current Issues in Economics and Finance, Federal Reserve Bank of New York, 7(2).

Perotti, R. 1999. Fiscal Policy in Good Times and Bad, Quarterly Journal of Economics, 114, 1399-1436.
Pesaran, M. H., Shin, Y. and Smith, R. J., 2001. Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16, 289–326.

Piersanti, G., 2000. Current Account Dynamics and Expected Future Budget Deficits: Some International Evidence, Journal of International Money and Finance 19, 255-171.

Salvatore, D. 2006. Twin deficits in the G-7 countries and global structural imbalances. Journal of Policy Modeling 28, 701–712.

Summers, L.H., 1986. Debt Problems and Macroeconomics Policies. NBER working paper 2061.

Xiao, Z. (2009). Quantile cointegrating regression. Journal of Econometrics 150, 248–260.

Zietz, J. and Pemberton, D.K., 1990. The US Budget and Trade Deficits: A Simultaneous Equation Model, Southern Economic Journal 57, 23-34.
## APPENDIX

### Table A1. BDS Test

| $m$ | $z$-statistic of Residual ARDL Model with Budget Deficit as Dependent variable | $p$-value | $z$-statistic of Residual ARDL Model with Trade Deficit as Dependent variable | $p$-value |
|-----|-----------------------------------------------------------------------------|-----------|-----------------------------------------------------------------------------|-----------|
| 2   | 9.731                                                                      | 0.000     | 11.340                                                                      | 0.000     |
| 3   | 12.054                                                                     | 0.000     | 12.585                                                                      | 0.000     |
| 4   | 13.817                                                                     | 0.000     | 14.738                                                                      | 0.000     |
| 5   | 14.960                                                                     | 0.000     | 16.363                                                                      | 0.000     |
| 6   | 16.356                                                                     | 0.000     | 18.353                                                                      | 0.000     |

**Note:** $m$ stands for the number of (embedded) dimension which embed the time series into $m$-dimensional vectors, by taking each $m$ successive points in the series; $p$-value corresponds to the test of i.i.d. residuals based on the $z$-statistic of the BDS test under the two ARDL models based on budget deficit and trade deficit as dependent variables.