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Revisiting the twin deficits hypothesis: a quantile cointegration analysis over the period 1791-2013

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ABSTRACT

We revisit 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 suggest the existence of nonlinearities and structural breaks in the relationship between the trade and budget deficits, indicating 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, the results suggest that the cointegrating coefficient in the long-run relationship between the two variables is not constant across 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 that the effectiveness of restrictive fiscal policies directed to reduce trade deficits will depend on the actual size of the budget deficit.

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Twin deficits hypothesis; structural breaks; nonlinearities; quantile ARDL model

1. Introduction

According to the twin deficits hypothesis, there is a strong link between a country's trade and fiscal balances. From a theoretical point of view, this hypothesis could be either justified or rejected depending on the assumptions made in the model. In particular, 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 & 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 increasing private consumption, as these agents would like to save less given the expected future tax cuts. That is, the relationship between

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fiscal policy and current account deficits will depend on whether the consumers react in a "Keynesian" or "Ricardian" manner. Essentially, the twin deficits hypothesis will only hold in the first case, while in the second case, the private savings will decrease to compensate for the government savings increase, and the current account will not be affected by the decrease in the budget deficit.

The objective of this article is to revisit 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 contributions of the article 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. During this period of time, several episodes have caused various disruptions in the temporal evolution of these two deficits in the US, such as the two World Wars, the two oil crisis in 1973 and 1979, the US recession in 1981–1982, the Gulf War in 1990 and the collapse of the Soviet Union in 1991 (see Hatemi & Shukur, 2002), which could explain how the relationship between the two deficits might have changed over time in the US. Second, and more importantly, given the evidence of nonlinearity and structural breaks, we employ a non-linear /time-varying quantile autoregressive distributed lag (QARDL) approach to obtain the long-run relationship between the two variables across various quantiles.[1] To our knowledge, this is the first article that applies the QARDL methodology to test the twin deficits hypothesis using over two centuries (223 years) of data obtained from an unique database (as discussed in the Data segment of the article), which in turn, is not publicly available, but is only obtained through subscription. The main contribution of using this methodology in the context of the twin deficit hypothesis is that we can test whether or not the twin deficits hypothesis holds for each of the conditional quantiles. While a positive and constant (across quantiles) long-run relationship between the two deficits will mean that the twin deficits hypothesis holds, differences in the long-run coefficient will mean that the twin deficits hypothesis might hold for only some of the conditional quantiles. For example, we could find that an increase in the budget deficit will have a greater effect on the trade deficit at quantiles below the conditional median than at higher conditional quantiles, suggesting thus, that private agents are more likely to react in a "Keynesian manner" (i.e. they will decrease their investment or saving levels after the increase in the interest rates due to the increase in the public deficit) when trade deficits are below the conditional median, i.e., below their normal state for given values of the budget deficit.

The focus of this article on the US economy is mainly justified by the availability of a unique dataset consisting of U.S. trade and budget deficits covering the time period from 1791 until 2013. Furthermore, the large body of the literature that has studied the US case (recall that the term "twin deficits" became widely used because the US federal budget

[1]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.

deficit increased from 2.7% of the GDP to 5% of GDP and the US current account deficit increased from 0 to 3.5% of GDP from 1980 to 1986, so that the first papers were applied to the US case, Summers, 1986), and the consequences that the US current account behaviour have on other economies also justify the focus on the US case.

Although the twin deficits hypothesis has already 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; Bachman, 1992; Zietiz & Pemberton, 1990; Bahmani-Oskooee, 1992, 1995; Kasa, 1994; Piersanti, 2000; Leachman & Francis, 2002; Cavallo, 2005; Erceg, Guerrieri, & Gust, 2005; Salvatore, 2006), by obtaining a positive relationship between the budget and trade deficits. For example, Abell (1990) uses a seven variable VAR model to analyse the relationship between the US budget and trade deficits during the period 1979 to 1985 and finds that the two deficits are indirectly connected, through the transmission mechanisms of interest rates and exchange rates. Bahmani-Oskooee (1992, 1995)) uses cointegration techniques to determine what variables have long-run relationships with the US current account and trade balance. The author shows that there is a long-run relationship between the US current account and fiscal deficits during the period 1971Q1-1989Q2. Bachman (1992), by means of estimating different bivariate VAR models, also finds that budget deficits have a significant effect on US trade deficits using quarterly data for the period 1974–1988. In fact, he analyses the impact of four variables on the current account (budget deficit, investment, relative productivity and the risk premium) and finds that only the Federal budget deficit can explain the evolution of the current account deficit. Salvatore (2006), by means of using Granger causality tests, analyses the twin deficits hypothesis for the G7 countries during the 1973–2005 period, finding a direct relationship between the two variables, with budget deficits leading to current account deficits.

On the other hand, evidence against this hypothesis has also been extensively documented (Miller & Russek, 1989; Dewald & Ulan, 1990; Enders & Lee, 1990; Boucher, 1991; Normandin, 1999; Kim, 1995; Papaioannou & Yi, 2001,; Kim & Roubini, 2008). For example, Enders and Lee (1990) estimate a six variable VAR model using quarterly data for the period 1947–1989 for the US economy, and find no evidence that budget deficit raises current account deficits. Corsetti and Muller (2006) estimate different VAR models for Australia, Canada, the UK and the US using quarterly data for the period 1979–2005, and find evidence in favour of the twin deficits hypothesis for the cases of Canada and the UK (more open economies than Australia and the US) and evidence against the twin deficit hypothesis for Australia and the US. Kim and Roubini (2008) estimate different VAR models using quarterly data for the period 1973–2004 and find that the US government deficit shocks improve the current account balance, rejecting thus the "twin deficits" hypothesis in favour of the "twin divergence" hypothesis.

In this article, we postulate that the different empirical results obtained in the literature correspond to the fact that the relationship between these variables has changed over time. For instance, while the two variables moved together during the 1980s, the two balances drifted apart at the mid-1990s and at the beginning of the 21st century in the US. Evidence of structural breaks in the relationship between these two variables has also been documented in the literature. For example, Leachman and Francis (2002), that 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), find weak and time-specific evidence in favour of the twin deficits hypothesis. Hatemi and Shukur (2002) also identify a structural break in 1989 for the US case and find that, while the casual relationship runs from the fiscal deficit to the external deficit before 1989, the opposite holds true after 1989. Grier and Ye (2009), using quarterly data for the period 1948Q1-2005Q1, argue that US budget and trade deficits present structural breaks that should be taken into account when testing the twin deficits hypothesis. Bagnai (2006) and Daly and Siddiki (2009) also find evidence of structural breaks when testing the twin deficits hypothesis in 22 OECD countries.

According to the discussion presented above, the change in the relationship between fiscal and external deficits over time could be explained by the different reaction of private savings to increases in the budget deficits over the years. Thus, based on the idea that the cointegrating coefficients may vary over time, in this article we analyse the long-run relationship between the US budget and external deficits across various quantiles, which in turn captures various states of the dependent variable that prevails over the period of 1791 to 2013. The hypothesis or novelty this methodology brings out is that the relationship between the budget and external deficits might vary over time (conditional states) depending on the magnitude of the trade deficit.

According to this new hypothesis, we postulate that the higher the trade deficit (i.e., at quantiles way below the conditional median of the trade balance) given the values of the budget deficit, the less likely that private agents would start saving more to be able to pay future tax increases following an increase in the budget deficit. By contrast, they are more likely to react after a shock in the budget deficit when the magnitude of the trade deficit is low (i.e. at conditional quantiles below but closer to the median of trade balance). Based on this argument, we would expect to find more evidence in favour of the "twin deficits" hypothesis at the smallest quantiles below the conditional median than at conditional quantiles below but closer to the median of trade balance.

At the same time, sudden increases (decreases) in the trade deficit (trade balance) are likely to harm the economy more when the budget deficit is higher compared to the case where the budget deficit is smaller, leading, in turn, to a more sizable impact on the budget deficit at the lowest conditional quantiles of the trade balance.

The remainder of the article is structured as follows: In Section 2, we describe the methodology and provide a justification for its application in this context. In Section 3, we present the data and the main empirical results, while in Section 4 we conclude this study.

2. Methodology

The standard autoregressive distributed lag (ARDL) model as discussed in Pesaran, Shin, and Smith (2001) is given as follows:

$$Y_t = \alpha_* + \sum_{j=1}^{p} \boldsymbol{\phi}_{j*} Y_{t-j} + \sum_{j=0}^{q} \theta_{j*}{}' X_{t-j} + U_t \tag{1}$$

where Y_t is the dependent variable, X_t denotes the vector matrix of explanatory variables and U_t is the error term with a zero mean and constant variance.

As shown in Pesaran and Shin (1999) the ARDL model is more appropriate for the analysis of long-run relationships, and once the orders p and q are determined the relationship can be easily estimated via OLS. Compared to the traditional cointegration methods, the ARDL cointegration approach does not require all variables to be I(1) as in the Johansen framework and is still applicable to a dataset containing a mixture of I (1) and I(0) variables. This implies that there is no need for a specific identification of the order of integration of the data at hand. This is exceptionally advantageous, since it is impossible to know the true data generating process of a specific variable, irrespective of whether we impose no-breaks or breaks in the unit root testing. It is only when the test statistic of the ARDL model falls within the upper and lower bounds of critical values for all cases corresponding to various variables being used as a dependent variable, that we need to conduct formal unit root tests. Furthermore, the aforementioned approach provides unbiased estimates of the long-run relationship and is also suitable with small or finite sample sizes.

In order to properly model both the dynamics and the nonlinear long-run relationship between two or more variables Cho, Kim, and Shin (2015) recently developed a quantile ARDL (QARDL) model that can be formalized as follows:

$$Y_t = \alpha_*(\tau) + \sum_{j=1}^{p} \boldsymbol{\phi}_{j*}(\tau) Y_{t-j} + \sum_{j=0}^{q} \theta_{j*}(\tau)' X_{t-j} + U_t(\tau) \tag{2}$$

where $X_t \epsilon\, \mathbb{R}^k$ is an integrated process of a stationary and ergodic process with mean zero, $U_t(\tau)$ represents the error term that is defined as $Y_t - Q_{Y_t}(\tau|\mathcal{F}_{t-1})$ with $Q_{Y_t}(\tau|\mathcal{F}_{t-1})$ being the $\tau - th$ quantile of Y_t conditonal on $\mathcal{F}_{t-1} = \left\{X_t^{'},\ Y_{t-1}, X_{t.-1}^{'}, \dots\right\}$, and p and q are lag orders in the model. It is also assumed that the k variables in X_t are not cointegrated among themselves. Note that the QARDL approach is a further innovation on the ARDL approach by allowing us to study the long-run and short-run relationships between the variables over various parts of the conditional distribution of the dependent variable. This being a nonlinear approach, it prevents misspecification in the linear (conditional mean-based) ARDL model due to possible nonlinearity and/or structural breaks. This is because we have parameter estimates at each point of the conditional distribution of the variables, and hence, the model captures the evolution of the variables and, is, thus, implicitly a time-varying approach.

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

$$Y_t = \alpha_*(\tau) + \sum_{j=0}^{q-1} W_{t-j}^{'} \delta_{j*}(\tau) + X_t^{'} \gamma_*(\tau) + \sum_{j=1}^{p} \boldsymbol{\phi}_{j*}(\tau) Y_{t-j} + U_t(\tau) \tag{3}$$

where we let $\gamma_*(\tau) := \sum_{j=0}^{q} \theta_{j*}(\tau)$, $W_t := \Delta X_t$, and $\delta_{j*}(\tau) := -\sum_{i=j+1}^{q} \theta_{j*}(\tau)$. This reformulation allows to analyse the short-run dynamics between Y_t and X_t. However, we are more interested in the long-run relationship between and X_t that can be captured

through the following long-run quantile process, and which is obtained by solving for Y_t from Equation (3):

$$Y_t = \mu_*(\tau) + +X_t^{'}\beta_*(\tau) + R_t(\tau) \tag{4}$$

where we let $R_t(\tau) := \sum_{j=0}^{\infty} W_{t-j}^{'}\xi_{0,j*}(\tau) + \sum_{j=0}^{\infty}\rho_{j*}(\tau)U_{t-j}(\tau)$, $\mu_*(\tau) := \alpha_*(\tau)\left(1-\sum_{j=1}^{p}\phi_{j*}(\tau)\right)^{-1}$, $\beta_*(\tau) := \gamma_*(\tau)\left(1-\sum_{j=1}^{p}\phi_{j*}(\tau)\right)^{-1}$, $\xi_{0,j*}(\tau) := -\sum_{l=j+1}^{\infty}\pi_{l*}(\tau)$, and $\{\rho_{0*}(\tau),\ \rho_{1*}(\tau),\ldots\}$ and $\{\pi_{0*}(\tau),\ \pi_{1*}(\tau),\ldots\}$ are such that $\sum_{j=0}^{\infty}\rho_{j*}(\tau)L^j \equiv \left(1-\sum_{j=1}^{p}\phi_{j*}(\tau)L^j\right)^{-1}$ 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. $R_t(\tau)$ is the residual term in the long-run process that expresses the collection of serially correlated stationary variables irrelevant to the long-run relationship. $\beta_*(\tau)$ 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. In our case, Equation (3) is estimated first with the budget balance as the dependent variable, and then trade balance taking its place. We run the model in both directions, due to the possibility of endogeneity in the relationship between budget and trade balances.

3. Empirical results

For our empirical analysis we use a unique annual data set consisting of US trade and budget balances covering the time period from 1791 until 2013, with the start and end date being purely driven by data availability.[2] The ratio of trade and budget balances with respect to GDP is obtained from the Global Financial Database (available only with a subscription), as is the nominal GDP figures, which in turn, is used to recover the nominal trade and budget balances in levels. The corresponding real values are obtained by dividing the nominal values with the CPI, obtained from the website of Professor Robert Sahr.[3] The data are plotted in Figure 1. For the sake of clarity, we use subplots of the data. According to Figure 1, we observe a lot of heterogeneity in the evolution of the budget balance and trade balance series. In particular, the trade balance has been negative (i.e., trade deficit) between 1790 and 1840, 1850 and 1870, and 1970 and 2013, and positive (i.e., trade surplus) elsewhere. By contrast, the budget balance

[2]Given that this is the first paper to use this dataset, it is not possible for us to compare our results with existing studies, which tends to rely on short-samples involving post World War II data.

[3]http://liberalarts.oregonstate.edu/spp/polisci/research/inflation-conversion-factors-convert-dollars-1774-estimated-2024-dollars-recent-year.

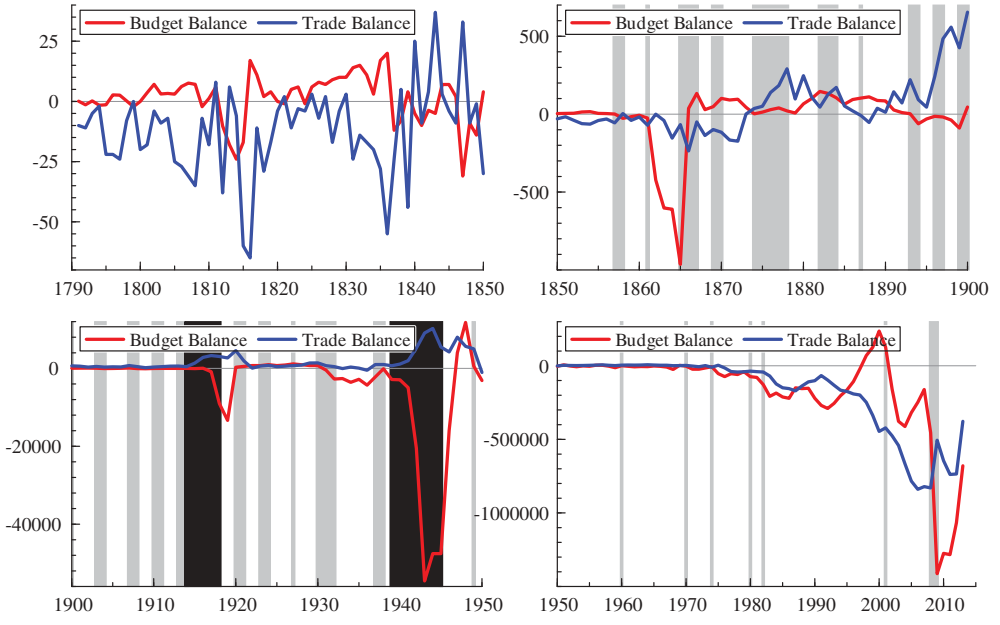

Figure 1. Budget Balance and Trade Balance: 1791–2013.

Note: Shaded grey areas denote US recessions as defined by the National Bureau of Economic Research (NBER) and shaded black areas denote world wars.

oscillated around zero, apart from the 1810s, 1860s, during World War I and II, and the last 3 decades of our sample, wherein the US economy experienced substantial budget deficits. Yet, both series have reached unprecedented negative levels during the global financial crisis (GFC) of 2008–2009. Put differently, the twin deficits the US economy experienced during the GFC were of exceptional heights.

Based on the Bayesian Information Criterion (BIC), we first determine the order of lags in the model. We start-off with the standard ARDL models, once with budget balance as the dependent variable and then trade balance taking its place. For the first case, $p = q = 7$, while for the latter, $p = 7$ and $q = 6$. The F-statistics of the cointegration test 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 1% [6.84, 7.84] and 10% [4.04, 4.78] levels of significance, respectively. The normalized statistically significant long-run coefficients were 0.951 and 0.724, respectively, implying a positive long-run relationship between the trade balance and the budget balance.

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 1% level of significance across all dimensions, providing evidence of nonlinearities in the relationship between the two variables. The fact that the two variables are nonlinearly related statistically could be explained by the fact that the trade balance and budget balance are driven by a common variable, namely the nonlinear business cycles as discussed in Kim and Roubini (2008) and Çatık, Gök, and

Akseki (2015). Besides, Perotti (1999) lays out a model where fiscal shocks have asymmetric effects on economic decisions across periods of fiscal stress and tranquillity. Furthermore, as is well-known, nonlinearity could arise due to agents perceiving a deterioration of the trade/budget balance (bad news) differently from an improvement (good news). This holds true even when the magnitudes of these changes are proportionate, as bad news is always believed to have a stronger impact than good news (Kahneman & Tversky, 1979). Empirical evidence along these lines dealing with the twin deficits hypothesis can be found in Bayat, Tasar, Kayhan, and Acci (2017).

We applied the Bai and Perron (2003) test of multiple structural breaks and detected four structural breaks each at 1866, 1918, 1950, and 1982; and 1883, 1915, 1948, and 1982, for the budget balance and trade balance, respectively, as dependent variables.[4] Note that, the last three breaks in the two equations are quite close to each other, and are related to the World War I (1914–1918), World War II (1939–1945), while the first and last breaks correspond to US recessionary periods.[5] As shown in Figure 1, all these episodes coincide with large budget deficits that are followed by trade deficits. Also, the fact that break dates are associated with US recessions, highlights the role of productivity (output) shocks as indicated by Kim and Roubini (2008), which in turn, should be modelled explicitly in future analysis associated with twin deficits. 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 balance as the dependent variable.

τ	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 balance as the dependent variable.

τ	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.

[4]Hansen's (1992) test of parameter stability in a cointegrating equation also confirmed instability in the relationship between trade and budget balances. This test also implies that linear models of cointegration are misspecified. In light of this, we applied the Gregory and Hansen (1996) test of cointegration with one structural break to reject the null of no-cointegration, suggesting that these two variables are indeed nonlinearly related in the long-run. The QARDL approach allows us to tackle this issue and is more informative being based on quantiles, i.e., it allows us to study the entire conditional distribution of the dependent variable.

[5]See: http://www.nber.org/cycles.html.

In Tables 1 and 2, all the estimates of $\beta_*(\tau)$ are positive and significant at any confidence level. In Table 1, with budget balance as the dependent variable, the estimate reaches a peak at $\tau = 0.4$, but varies in general around this quantile, with values at quantiles above the median being greater than those at quantiles below 0.4. In Table 2, when trade balance 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 decrease dramatically at the median of the conditional distribution of trade deficit. Beyond the median, the estimates vary between 1.363 and 3.084 In order to determine whether the estimated parameters are constant across quantiles we applied the Wald test. The results of this test are presented at the lower part of Tables 1 and 2. According to these results, the null hypotheses of parameter constancy across quantiles are rejected at any confidence level, which is understandable given the variability across the quantiles. These results also highlight the appropriateness of employing the QARDL approach in order to account for nonlinearity and structural breaks. Based on this approach, we generally find a positive long-run relationship between the budget balance and the trade balance, implying that budget balance and trade balance co-move, which in turn, is in line with the twin deficits hypothesis. However, the size of the effect of the trade (budget) balance on the budget (trade) is variable and depends on part of their respective conditional distributions. Also note that the long-run effect of the budget balance on the trade balance across the various quantiles based on the QARDL model is much higher than that associated with the mean-based long-run coefficient obtained from the ARDL model. On the other hand, when the trade balance is the dependent variable, this happens to be the case only at τ= 0.4.[6]

At this stage, it is important to analyse intuitively as to what our results mean drawing on the discussion in the introduction on the relationship between these two variables to be possibly different conditional on the quantile of their respective distributions. As we see from Tables 1 and 2, the peak-effect is reached at a quantile-level (0.4) below the median, i.e., towards the lower end of the conditional distributions of both budget and trade balances, suggesting that the effect of budget deficit (trade deficit) on trade deficit (budget deficit) is strongest when the values of these two variables are moderately high (which in turn corresponds to low conditional quantiles of trade and budget balances), given the values of the independent variable in concern. This suggests that the Keynesian channel, through which the budget deficit can affect the trade deficit, is operating, and the contractionary effect of trade deficit on the budget deficit is more pronounced when the values of the trade and budget balances are below their conditional medians given the values of the respective independent variable under consideration in the model.

So to elaborate further, when the trade deficit is above its normal value, given the budget deficit, economic growth is likely to be lower, i.e., below its potential, hence an expansionary fiscal policy is likely to increase the trade deficit through the increase in output, as suggested by Çatık et al. (2015). Moreover, when the trade deficit is low given

[6]We have first tested for unit root using the powerful Ng and Perron (2001) test to find that both budget and trade balances are I(1) processes, and then we applied various other cointegration tests. Specifically, we applied the Engle and Granger (1987), Phillips and Ouliaris (1990) and Johansen (1991) test to find that these two variables are indeed cointegrated, as the null of no-cointegration was overwhelmingly rejected. Details of these results have been suppressed from the text given the obvious advantages of the QARDL model (and the evidence of nonlinear cointegration discussed in footnote 3), especially in terms of pre-testing for unit root tests and capturing nonlinearity and structural breaks, but are available upon request from the authors.

the budget deficit, it is likely to be driven by other factors such as asset price movements (see, for instance, Fratzscher, Juvenal, & Sarno, 2010, Fratzscher & Straub, 2009, 2010) rather than the budget deficit itself.

While it is true that the quantiles-based approach allows us to capture the various conditional states of the two balances in turn, and hence show how the relationship has evolved over time, the method is silent about the relationship between the two variables over time conditional on a particular state of the dependent variable. For this reason, we perform a rolling-window based analysis of both the ARDL and the QARDL models with budget and trade balances as dependent variables.[7] The results are reported in Figure 2 through 5. Note that, since the earliest break amongst the two equations was observed in 1866, our window size is of 76 observations (i.e., 1866 minus 1791) in each of the rolling estimations. As can be seen from Figures 2 and 3, which report the ARDL rolling estimates of β, the relationship between the two balances have in general been positive. As far as significance is concerned, based on 95% confidence intervals, the effect of the trade balance on the budget balance is not statistically significant, while the effect of the budget balance on the trade balance is only significant over the years of 1873 to 1897. Next when

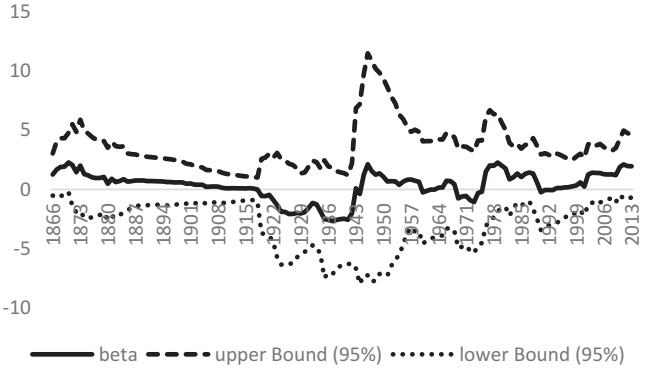

Figure 2. Rolling estimates of the response of budget balance to trade balance from ARDL model.

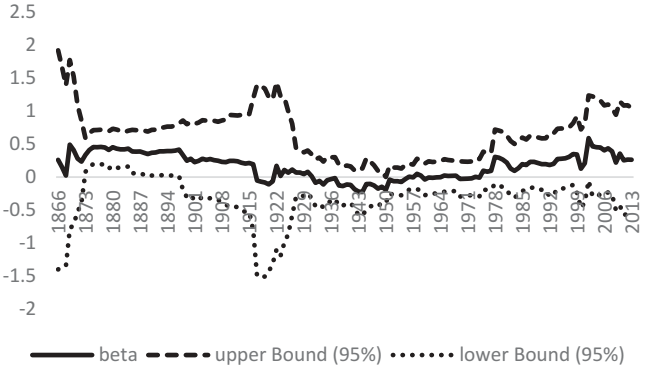

Figure 3. Rolling estimates of the response of trade balance to budget balance from ARDL model.

[7]We would like to thank an anonymous referee for pointing this out to us.

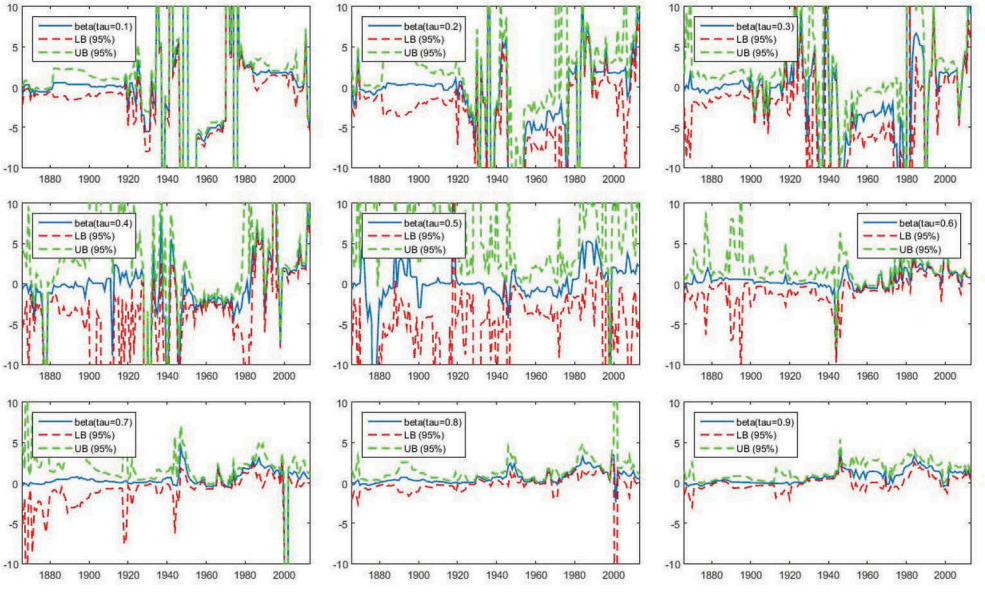

Figure 4. Rolling estimates of the response of budget balance to trade balance from QARDL model for quantiles (tau(τ)) 0.10 to 0.90.

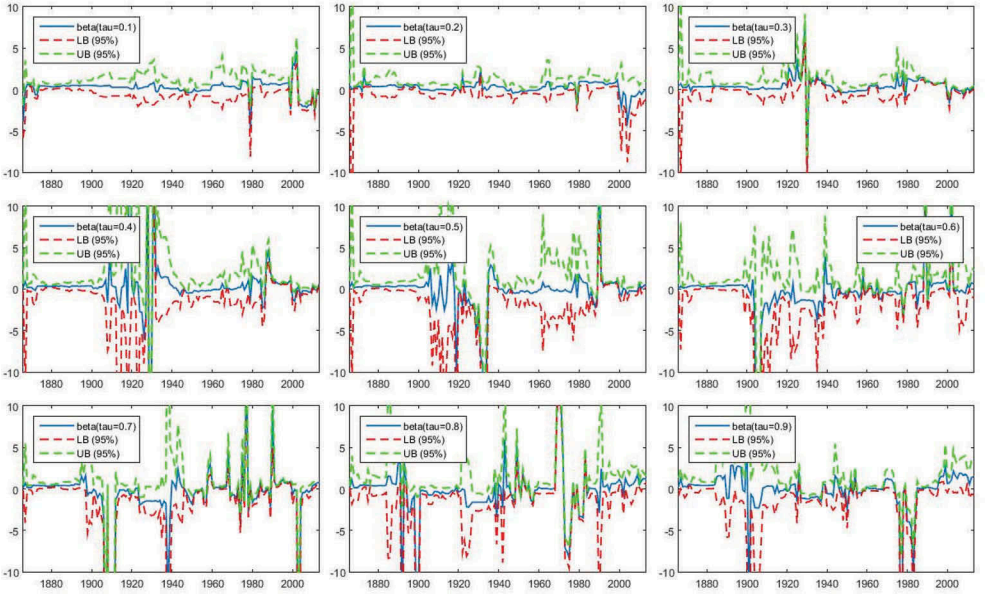

Figure 5. Rolling estimates of the response of trade balance to budget balance from QARDL model for quantiles (tau(τ)) 0.10 to 0.90.

we turn to the corresponding cases in Figures 4 and 5 under the QARDL model for τ = 0.10 to 0.90, we also observe a similar pattern across the quantiles, with the relationship being positive in a stable fashion (barring some large spikes) over the bulk of the time period, with some exceptions associated with huge negative spikes

in between (especially for upper quantiles towards the early part of the sample), with the effects being statistically significant consistently at the 5% level. In sum, based on the correctly specified QARDL model, we tend to find evidence in favour of the twin deficits hypothesis, based on the long-run analysis.

4. Concluding comments

In this article, we test the twin deficits hypothesis by analysing the long-run relationship between the trade and budget balances across various quantiles using a long span of data covering the time period 1791–2013 in the US. Based on the assumption that the twin deficits hypothesis might hold only for some subperiods, this article contributes to previous studies by means of testing whether or not the long-run relationship between the two deficits changes across quantiles. That is, by testing whether or not the twin deficits hypothesis holds across the different parts of the conditional distribution of the series. According to our best knowledge, this is the first study that postulates the "twin deficit" hypothesis could be only valid across some of the quantiles. As discussed above, the theoretical explanation of this assumption relies on the different reaction of private agents following a fiscal policy change, which in turn depends on the conditional size of the trade deficit.

The main results of the article can be summarized as follows. First, the results point out to the existence of nonlinearities and structural breaks in the relationship between US trade and budget balances, suggesting that the long-run relationship between the two variables has not been constant over the period of examination. In fact, the results provide suggestive evidence of structural breaks coinciding with the World War I, World War II and US recessions. Second, we find supportive evidence of the twin deficits hypothesis, since a long-run positive cointegration relationship is found between the two variables, thereby rejecting the "twin divergence" hypothesis suggested by Kim and Roubini (2008).[8] Finally, and more importantly, the results indicate that the cointegrating coefficient in the long-run relationship between the two variables is not constant across the different quantiles. In particular, we find that a deterioration of the budget balance will have a greater effect on the trade balance at quantiles below the conditional median of trade balance compared to that at higher conditional quantiles. This result suggests that the effectiveness of restrictive fiscal policies directed to reduce trade deficits will depend on the actual size of the trade deficit. In particular, fiscal policies will be more effective in reducing trade deficits when trade balances are below the conditional median, i.e. in the case of large trade deficits.

[8]It must however, be pointed out that, unlike the long-run analysis of ours, the paper of Kim and Roubini (2008) was primarily a short-run analysis based on a linear model (which is likely to be misspecified in the presence of nonlinearity and breaks). In fact, when we conducted a VAR analysis based on Choleski decomposition, with budget deficit ordered first, we also observed, as in Kim and Roubini (2008), that in the short-run, an increase in budget deficit reduces the trade deficit. The effect is, however, mostly statistically insignificant. Using the sum of short-run coefficients from the QARDL model with the trade balance as the dependent variable, we found that this negative relationship between trade and budget deficits, holds from the median to the upper quantiles of the conditional distribution of trade balance, but not below the median. This result again highlights the importance of using a quantiles-based nonlinear approach to analyse the short-run relationships between the variables, instead of just relying on conditional-mean based models. Complete details of these results are available upon request from the authors.

Based on the theoretical discussion presented above, this last result suggests that private agents are more likely to react in a "Keynesian manner" when the trade balances are below the median. That is, for high trade deficit levels, consumers' reaction of increasing private saving will be less pronounced compared to the budget deficit increase, and as such, this budget deficit increase will be followed by a trade deficit increase.

The results obtained in this article provide a bird's-eye-view on explaining the evolution of the relationship between the fiscal balance and the trade balance in the US over a period of more than 200 years (1791–2013). Furthermore, the quantile analysis suggests a plausible explanation as to why the evidence of the twin deficits hypothesis changes over time. Following the extant literature, we also employ a cointegration analysis so as to provide any evidence in favour or against the twin deficits hypothesis. However, it is challenging to relate the cointegrating relationship to economic theories, as it is more statistical in nature than being structural. Hence, as part of future analysis, it would be interesting to use our data set to analyse the twin deficits hypothesis using a time-varying VAR controlling for productivity (output-related) shocks, which will allow us to analyse the evolution of the relationship between the two variables in a structural fashion over time and across horizons based on time-varying impulse responses.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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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.