

## Yusuf Ekrem Akbas

Department of Economics,  
Faculty of Economics and  
Administrative,  
Adiyaman University,  
Turkey

akbasyea@gmail.com

## Mehmet Senturk

Foreign Trade Department,  
Vocational High School,  
Kilis 7 Aralik University,  
Turkey

msenturk@kilis.edu.tr

## Canan Sancar

Accounting and Tax Applications  
Department,  
Kelkit Aydin Dogan Vocational High  
School,  
University of Gumushane,  
Turkey

canansancar@gumushane.edu.tr

**Acknowledgement:** We thank Lect.  
Alison Teresa Thomas and Lect. Lutfi  
Cem Yener for their valuable contribu-  
tion to our paper translation.

# Testing for Causality between the Foreign Direct Investment, Current Account Deficit, GDP and Total Credit: Evidence from G7

**Summary:** In this study, countries were analyzed between 1990 and 2011 in order to determine whether a causal relationship exists among current account deficit, GDP, foreign direct investment, and total credits of G7. Analysis took into account the cross-sectional dependence and was applied to test the causality among the variables from the panel. Firstly, panel unit root tests were used for determining stationarity of variables. As a result of the panel unit root tests, it was found that GDP and foreign direct investment have a stationary structure and that total credits and current account deficit contain unit root. In order to see whether there is a long-term relationship among the variables or not, the panel co-integration test was used. As a result of the test, it was concluded that there is a co-integration relationship among the series. The possibility of a causal relationship was analyzed among the variables using the causality test developed by Elena Ivona Dumitrescu and Christophe Hurlin (2012). Results of the analysis showed a unidirectional causal relationship from current account deficit and foreign direct investment to GDP. Bidirectional causality was found between current account deficit and total credits. Finally, a unidirectional relationship was found from foreign direct investment to current account deficit and total credits.

**Key words:** Current account deficit, Foreign direct investment, GDP, Credit, Panel co-integration and causality, G7.

**JEL:** F21, F30, F43, C33.

Since the liberalization process of the 1980s, the importance of foreign direct investment within the global financial conjecture has increased. For macroeconomic stability, transactions of current accounts and capital transactions are of great importance within the deficit of balance of payment. The fact that foreign direct investments result in more intensity within the capital balance (that is to say, the country's foreign investment is higher than out flowing capital) is vital in terms of financing the balance of payment deficit. Apart from contributing to the financing of balance of payment deficits, foreign direct investments also help correct the instabilities in current account deficits indirectly. This indirect effect of foreign direct investments in the financing of current account deficits appears with a positive effect the export performance of a country. As a matter of fact, the current account balance contains export and import of goods, services balance, and unilateral transfers. Foreign direct investments may contribute to the increase of the rivalry power of firms and this leads to a growing number of firms. Therefore, with foreign direct investments, an

increase in both employment and export performance of the country can be achieved. An increase in export performance not only helps to finance the current account deficit with foreign trade deficit but also has a positive effect on growth.

In addition to the increasing number of firms, quality of services and goods also increases. This increase is accompanied by a decline in prices as a result of the rivalry between firms, which increase the welfare of the people as well. Thus, total demand and consumption expenditures increase accordingly. In such an environment, credits can be used. An increase in the number of firms as a result of foreign direct investment increases not only the power of rivalry but also efficiency and profitability. As a result of increased profits, firms either move towards new investments or distribute the profits among their partners. In both situations, credits are needed. Firms do not want to utilize their own sources while making investments or the equity of the firms may not be sufficient for new investments. For these reasons, firms apply for credits to make new investments. Since the distribution of profits to the partners will create positive effects on partners' income levels as well as on total demand, they are injected into the market sooner or later. Therefore, a bounce in the market occurs, and the basis for capacity increases is prepared. The increase in investments may affect the total credits in connection with interest rates and long-term profitability ratios.

Foreign direct investments have been used by policy makers as an important economic tool. This situation has a positive effect on financing the current account deficit and on economic growth by increasing the rivalry power of firms.

In this paper, we investigate the causal relationship among the current account deficit, GDP, foreign direct investment and total credits for G7 countries between 1990 and 2011. This study is a causality analysis in which we apply the panel causality method. Three approaches have been employed to examine the direction of causality in the panel data. The first approach is based on estimating a panel vector error correction model by means of a generalized method of moments (GMM) estimator (Muhsin Kar, Saban Nazlioglu, and Huseyin Agir 2011). However, this approach does not take into account cross-sectional dependence (Hashem M. Pesaran, Youngcheol Shin, and Ron P. Smith 1999). Although a second approach proposed by Christophe Hurlin (2008) checks for the heterogeneity, it is not able to explain the cross-sectional dependence. In order to cover up this lack, the third approach was utilized. This third approach proposed by Elena Ivona Dumitrescu and Hurlin (2012) does account for the cross-sectional dependence.

In the literature, there has been no empirical study that examines capital flows, current account deficit, and economic growth together, which led us to study the case mentioned above. This study examined total credits, in addition to foreign direct investment, current account deficit, and economic growth. In this study, analyses were performed, enabling us to make deductions for each cross-sectional individual and for the general study. Panel data methods taking into account cross-sectional dependence were used. In this respect, the study differs from other empirical studies in terms of scope and method. We believe, therefore, that this study will contribute to the existing literature.

The study is organized as follows: the first part comprises the literature review and contained studies performed on the subject. The second part presents the variables used in the study and the data related to these variables. Moreover, this section explains the methods used in the study. The third part presents the empirical findings, including the results of the econometrical methods used in the study. Finally, the fourth part concluded the study.

## 1. Literature Review

The researchers found no studies focusing on current account deficits, direct capital flows, GDP, and total credits all-in-one. Thus, this section was divided into four subsections.

In several studies within the literature, researchers noted a causal relationship between economic growth and current account deficit (Hamid Faruqee and Guy Debelle 1996; Alberto Bagnai and Stefano Manzochi 1998; Caroline Freund 2000; Rudi Dornbusch 2001; Aleksander Aristovnik 2002; Magda Kandil and Joshua Greene 2002; Branko Urošević and Milan Nedeljković 2012). In these studies, Faruqee and Debelle (1996) used the cross-sectional model for twenty-one developed countries, while Bagnai and Manzochi (1998), Freund (2000), and Aristovnik (2002) used panel data models that did not take into account cross-sectional dependence for nine developed countries, twenty-five developing countries, and thirteen Central and Eastern European countries, respectively. As mentioned above, Kandil and Green (2002) found a causal relationship between economic growth and current account deficit using VECM models for the U.S. economy. Urošević and Nedeljković (2012) researched the determinants of current account deficit in 5 Transition countries (Serbia, Romania, Hungary, Poland and Czech Republic). As a result of OLS applied in analysis it was determined that real GDP affect negatively to current account deficit in Transition countries except Czech Republic. In the literature, few studies revealed causality between current account deficit and economic growth (Stanley Fischer 1993; Shah Nawaz Malik et al. 2010; Erdem C. Hepaktan and Serkan Çınar 2012). In these studies, Fischer (1993) and Hepaktan and Çınar (2012) used panel data models that did not take into account the cross-sectional dependence for twenty-three countries, including America, Eastern Asia, Africa and Organization for Economic Cooperation and Development (OECD), and twenty-seven countries from OECD, respectively. Malik et al. (2010) used standard Granger causality tests to examine Pakistan's economy. In addition to the above, some studies found a weak causality between economic growth and current account deficit (Gian Maria Milesi-Ferreti and Assaf Razin 1996; Cesar Calderon, Alberto Chong, and Loayza Norman 1999; Menzie D. Chin and Eswar S. Prasad 2000; Matthieu Bussiere, Fratzscher Marcet, and Gernot J. Muller 2004; Freund and Franck Warnock 2005). In these studies, Milesi-Ferreti and Razin (1996), Calderon, Chong, and Norman (1999), Chin and Prasad (2000), and Freund and Warnock (2005) used panel data models that did not take into account cross-sectional dependence for 105 countries of low- and mid-income groups, 44 developing countries, 70 developed and developing countries, and OECD countries with high income, respectively.

Although numerous empirical studies analyzed whether a causal relationship existed between current account deficits and economic growth, there were insufficient studies analyzing the causality between capital flows and economic growth directly. Maxwell J. Fry (1996) stated that foreign direct capital flows do not have any effect on economic growth for seven Asian Pacific countries and developing countries. Although an insufficient number of studies analyzed the causality between foreign direct capital flows and economic growth in the literature, financial and capital transactions were substituted for capital flows to detect whether a causal relationship existed between current account deficits in many studies. Yet no precise results were found in terms of direction of causal relationship between current account deficit and capital flows in these studies. Sebastian Edwards (2007), as a result of a panel data analysis that did not take into account cross-sectional dependence for 163 countries among industrialized countries from Eastern Europe, Middle East, Africa, Asia, and Latin America, found a causality relationship from current account deficit to capital flows. Felipe Morande (1988), Chong Huey Wong and Luis Carranza (1998) and Ho Don Yan (2007) — for Chile, Argentina, and Korea, respectively — using Granger causality test, found the opposite of what Yilmaz Kaya (1998) and Edwards (2007) detected. In some studies, a bidirectional causality relationship was found between current account deficit and capital flow (Akhter Foroque and William Veloce 1990; Chul Hwan Kim and Donggeun Kim 2010). These studies applied time series analyses for Canada and Korea, respectively. Nuri Yildirim and Huseyin Tastan (2012), examined interactions between capital flows and economic growth in Turkey for the 1992:01-2009:08 period with the frequency domain analysis. As a result of analysis over business cycle frequencies, two out of four subcategories of inflows, short-term external borrowings and portfolio investments on government bonds, drive growth whereas the other two components, long-term borrowings and portfolio investments on shares, are driven by growth. Moreover, for the post-2001 financial crisis period they found significant bidirectional causality between long-term external borrowings and growth whereas portfolio investments, bond flows and short-term external borrowings do not affect growth in the long run.

As in the studies analyzing the causality between current account deficit and capital flows, the studies that analyzed the causal relationship between foreign direct capital flows and economic growth could not come to a precise result in terms of causality. In some studies, unidirectional causality was found from foreign direct capital flows to economic growth (Laura Alfaro et al. 2004; Xiaoying Li and Xiaming Liu 2004; Ahmad Zubaidi Baharumshah and Marwan Abdul-Malik Thanoon 2006; Frank S. T. Hsiao and Mei-Chu W. Hsiao 2006; Shujie Yao and Kailei Wei 2007; Chien-Chiang Lee and Chun-Ping Chang 2009; Chyau Tuan, Linda F. Y. Ng, and Bo Zhao 2009; W. N. W. Azman-Saini, Siong Hook Law, and Abd Halim Ahmad 2010; Elsadig Musa Ahmed 2012). In these studies, Li and Liu (2004) for 84 countries, Alfaro et al. (2004) for 20 OECD countries as well as for 49 countries that were not members of OECD, Yao and Wei (2007) for 29 provinces in China, Azman-Saini, Law, and Ahmad (2010) for 91 countries, and Lee and Chang (2009) for 37 countries used panel data models that did not take into account the cross-sectional dependence. Baharumshah and Thanoon (2006) for 8 Asian countries,

Tuan, Ng, and Zhao (2009) for 23 provinces in China, and Ahmed (2012) for the Malaysian economy, used a linear time series method. The causal relationship between economic growth and foreign direct investment (FDI) could not be determined in some studies (Enisan A. Akinlo 2004; Dierk Herzer, Sephan Klasen, and Nowak Lehmann D. Felicitas 2008). In these studies, Akinlo (2004) for Nigeria and Herzer, Klasen, Felicitas (2008) for 28 developing countries used OLS, co-integration, and Granger causality tests, which are standard time series methods. In addition to the empirical studies, several theoretical studies investigated the relationship between economic growth and foreign direct investment. Nathalie Homlong and Elisabeth Springler (2010) expressed that foreign direct investment was critically effective for sustainable growth in India. Mihai Daniel Roman and Andrei Padureanu (2011) presented that Romanian economic growth was positively influenced by fiscal policy, FDI, and also by adherence to the EU.

Although the literature does not contain many studies related to credit amount, there are still some standing. Scott W. Hegerty (2009) used the VAR method to analyze the effect of direct capital flows on credit growth for four Eastern European countries, including Bulgaria, Estonia, Latvia, and Latvia. In the results of this study, he concluded that direct capital flows and non-FDI flows positively affect credit growth in Bulgaria but decrease credit growth in the other three countries.

## 2. Data and Methodology

In this study, the mutual relationship among foreign direct investment, current account deficit, GDP, and total credits in G7 countries between the years of 1990-2011 were analyzed using panel data methods. First, the order of stationary variables was proven. Then, a panel co-integration test developed by Durbin and Hausman, was used to determine whether a long-term relationship existed among the variables in the model, in which GDP was endogenous and CD, CR and FDI were exogenous variables. Finally, a panel causality test developed by Dumitrescu and Hurlin (2012) determined whether a causal relationship existed among the variables. Four variables were employed in this study. FDI represented the ratio of net direct investment to GDP, CD was the ratio of current account deficit to GDP, CR was the ratio of total credit to GDP, and GDP was percentage of growth rate in gross domestic product. Nominal value and annual data related to these four variables were used in the study. Moreover, data were evaluated as a percentage of GDP. The series related to these countries were obtained from the electronic database of the World Bank, and the data of these countries were preferred according to their availability in the database. The data used in the study were as follows:

**Table 1** Data Set

Variables	Explanations	Source
FDI	Direct capital flows (% GDP)	World Bank
CD	Current account deficit (% GDP)	World Bank
GDP	Growth rate of gross domestic product (%)	World Bank
CR	Total credits (%GDP)	World Bank

Source: World Bank (2013).

To analyze the relationship between foreign direct investment, current account deficit, GDP, and total credits, the question of whether a cross-sectional dependency existed was tested first. According to results shown in the appendix of the study (Table 6 and Table 7) methods taking cross-sectional dependency into consideration were used because cross-sectional dependency was found both in the variables and in the model. After the cross-sectional dependency tests, unit root tests were used. Then, panel co-integration test was carried out to see whether there was a long-term relationship among the variables. Finally, to test whether there was a causal relationship among the variables, a panel causality test was performed.

## 2.1 Cross Sectional Dependence and Panel Unit Root Tests

Cross-sectional dependency could be explained in terms of econometrics, as individuals forming panels are related to error terms in the panel data model, which is given in Equation (1). In terms of economics, it could be explained that in a situation in which individuals forming a panel are affected by a shock, then other individuals of the panel are affected as well.

$$y_{it} = \alpha_i + \beta_i x_{it} + \varepsilon_{it} \quad (1)$$

$$Cov(\varepsilon_{it}, \varepsilon_{ij}) \neq 0$$

There are various tests that analyze cross-sectional dependence in panel data. In this study, tests developed by, Pesaran (2004),  $CD_{LM2}$ , Pesaran (2004),  $CD_{LM}$ , and Pesaran, Aman Ullah, and Takashi Yamagata (2008) were used.

The  $CD_{LM2}$  test, which is another test to examine cross-sectional dependence, is calculated as below.

$$CD_{LM2} = \sqrt{\frac{1}{N(N-1)}} \left[ \sum_{i=1}^{N-1} \sum_{j=i+1}^N T \hat{\rho}_{ij} \right] \sim N(0,1) \quad (2)$$

In this equation,  $\hat{\rho}_{ij}^2$  shows the estimation of the sum of cross-sectional residuals. The test, which is used when  $N$  and  $T$  are great ( $T \rightarrow \infty$  and  $N \rightarrow \infty$ ), is asymptotically normal distribution.

The  $CD_{LM}$  test, which is also another test to examine cross-sectional dependence, is calculated with the formula mentioned below.

$$CD_{LM} = \sqrt{\frac{2T}{N(N-1)}} \left[ \sum_{i=1}^{N-1} \sum_{j=i+1}^N \hat{\rho}_{ij} \right] \sim N(0,1) \quad (3)$$

This test is based on the sum of correlation coefficient squares among cross-sectional residuals. This test, which is asymptotically standard normal distribution, is used when  $T > N$  and  $N > T$ . The null and alternative hypothesis of this test is similar to  $CD_{LM1}$  and  $CD_{LM2}$  tests.

Finally, the  $CD_{LM1adj}$  test is a modified version of the  $CD_{LM1}$  test, which was developed by Pesaran, Ullah, and Yamagata (2008). This test is formulated below.

$$CD_{LM1adj} = \frac{1}{CD_{LM1}} \left[ \frac{(T-k)\rho_{ij}^2 \mu T_{ij}}{\sqrt{v_{ij}^2}} \right] \sim N(0,1) \quad (4)$$

In this study, the CADF test developed by Pesaran (2006) and Kaddour Hadri and Eiji Kurozumi (2012) panel unit root tests were used as unit root tests.

### 2.1.1 CADF Unit Root Test

The CADF test is a test that considers cross-sectional dependence. This test could be used when  $N > T$  and also gives strong results when  $T > N$ . In a CADF test developed by Pesaran, the bootstrap method is not used to calculate critical values. Instead of the bootstrap, a Monte Carlo simulation is applied. Because of this, the critical values for the CADF test are obtained from table values of Pesaran. Another difference between this test and SURADF is that it is able to apply a unit root test for each individual forming panel and for the panel itself. The CADF test could be calculated as follows:

$$\Delta Y_{it} = \alpha_i + b_i Y_{i,t-1} + \sum_{j=1}^{\rho_i} c_{ij} \Delta Y_{i,t-j} + d_i t + h_i \bar{Y}_{t-1} + \sum_{j=0}^{\rho_i} \eta_j \Delta \bar{Y}_{t-1} + \varepsilon_{i,t} \quad i=1,2,\dots,t \quad (5)$$

In this equation,  $\alpha_i$  is constant,  $t$  is trend,  $\Delta \bar{Y}_{t-1}$  is delays of differences and  $\bar{Y}_{t-1}$  is the value of one term delay of  $\bar{Y}_t$ , respectively. Null and alternative hypotheses for CADF testing are as follows:

$$H_0 = \beta_1 = \beta_2 = \dots = \beta_n \text{ (series contain unit root),}$$

$$H_A = \text{At least one is different from zero (series are stationary).}$$

### 2.1.2 Hadri Kurozumi Unit Root Tests

Hadri-Kurozumi (2012) test was benefited from the CADF test. This test states that under a null hypothesis, series do not contain unit root, while an alternative hypothesis states that they contain unit root. Although the CADF test checks for stationarity for each individual forming the panel, it cannot test the stationarity of the whole panel. However, because the Hadri-Kurozumi test can check the stationarity for the whole panel, it makes up for this shortcoming in the CADF test.

The Hadri-Kurozumi test can be used in situations where both  $T > N$  and  $T < N$ . Additionally, this test has specific results. This test also takes into account the cross-sectional dependence and allows for serial correlation.

In the Hadri-Kurozumi test, the long-term variance is estimated in two ways:  $Z_A^{SPC}$  and  $Z_A^{LA}$ . In the  $Z_A^{SPC}$  method, seemingly unrelated regression (SUR) is used. Therefore, the bootstrap method is used. In the  $Z_A^{LA}$  method, t-stat and p-value are taken into account. If there is a cross-sectional dependence in the series, then the  $Z_A^{SPC}$  method is preferred; if there is no cross-sectional dependence, then the  $Z_A^{LA}$  method is preferred.

The Hadri-Kurozumi test can also be considered as the panel version of the Denis Kwiatkowski et al. (KPSS) (1992) test. This test is calculated as follows:

$$y_{it} = z'_t \delta_i + f'_t \gamma_i + \varepsilon_{it}, \quad \varepsilon_{it} = \phi_{i1} \varepsilon_{it-1} + \dots + \phi_{ip} \varepsilon_{it-p} + v_{it} \quad (6)$$

In Equation (6),  $z_t, z'_t \delta_i, f_t, \gamma_i, \varepsilon_{it}$  are deterministic, individual effect, observing common factor, loading factor, and individual specific error following the AP(p) process, respectively.

In Equation (6), to correct cross-sectional dependency for each  $i$ , because  $\varepsilon_{it}$ , has AR(p) process,  $y_{it}$  is regressed on  $w_i = [z'_t, \bar{y}_t, \bar{y}_{t-1}, \dots, \bar{y}_{t-p}]'$ . Thus, the test statistic for the Hadri-Kurozumi test is calculated as follows:

$$Z_A = \frac{\sqrt{N}(\overline{ST} - \xi)}{\zeta} \quad (7)$$

In Equation (7),  $\overline{ST}$  is calculated as:  $\overline{ST} = \frac{1}{N} \sum_{i=1}^N ST_i, ST_i = \frac{1}{\hat{\sigma}_i^2 T^2} \sum_{t=1}^T (S_{it}^w)^2,$

$S_{it}^w = \sum_{s=1}^t \hat{\varepsilon}_{is}$  and  $\hat{\sigma}_i^2$  is a long-term variance estimator.

$$\text{Here: } \left\{ \begin{array}{l} \text{For constant model: } z_t = z_T^\mu = 1 \\ \xi = \xi_\mu = \frac{1}{6} \quad \zeta^2 = \zeta_\mu^2 = \frac{1}{45}, \\ \\ \text{For trend model: } z_t^\tau = [1, t]' \\ \xi = \xi_\tau = \frac{1}{15} \quad \zeta^2 = \zeta_\tau^2 = \frac{11}{6300}, \end{array} \right.$$

In Equation (7), it can be seen that  $\overline{ST}$  is the average of the test statistics of KPSS.  $Z_A$  can be expressed as the panel augmented KPSS test statistic, and  $S_{it}^w$  is created using these regression remains. In this case, numerators of each  $ST_i$  can be seen.

$$\frac{1}{T^2} \sum_{t=1}^T (S_{it}^w)^2 \Rightarrow \sigma_i^2 \int_0^1 (V_i^\varepsilon(r) + \tilde{\gamma}_i R_N)^2 \quad (8)$$

To find the long-term variance of  $Z_A^{SPC}$  and  $Z_A^{LA}$  used in the Hadri-Kurozumi test, first of all the AR(p) model below must be estimated.

$$y_{it} = z'_t \hat{\delta}_i + \hat{\phi}_{i1} y_{it-1} + \dots + \hat{\phi}_{ip} y_{it-p} + \hat{\psi}_{i0} \bar{y}_t + \dots + \hat{\psi}_{ip} \bar{y}_{t-p} + \hat{V}_{it} \quad (9)$$

After these calculations are applied, the long-term variance of  $Z_A^{LA}$  and  $Z_A^{SPC}$

can be created as:  $\hat{\sigma}_{ISPC}^2 = \frac{\hat{\sigma}_{vi}^2}{(1 - \hat{\phi}_i)^2}, \hat{\phi}_i = \min \left\{ 1 - \frac{1}{\sqrt{T}}, \sum_{j=1}^p \hat{\phi}_{ij} \right\}$  and  $\hat{\sigma}_{vi}^2 = \frac{1}{T} \sum_{t=1}^T \hat{V}_{it}^2$



Next, Equation (2) can be created using the formula below:

$$ST_i^{SPC} = \frac{1}{\hat{\sigma}_{ISPC}^2 T^2} \sum_{t=1}^T (S_{it}^w)^2 \quad (10)$$

Equation (10) can be expressed as the test statistic of  $Z_A^{SPC}$ .

To determine the test statistic of  $Z_A^{LA}$ , the lag method by Hiro Y. Toda and Taku Yamamoto (1995) must be used. In this case, additional lag of  $y_t$  is added instead of the AR(p) model, and AR(p+1) model is estimated.

$$y_{it} = Z_t' \tilde{\delta}_i + \tilde{\phi}_{i1} y_{it-1} + \dots + \tilde{\phi}_{ip+1} y_{it-p-1} + \tilde{\psi}_{i0} \bar{y}_t + \dots + \tilde{\psi}_{ip} \bar{y}_{t-p} + \tilde{v}_{it} \quad (11)$$

After this calculation, the following test statistic is obtained.

$$ST_i^{LA} = \frac{1}{\hat{\sigma}_{LA}^2 T^2} \sum_{t=1}^T (S_{it}^w)^2, \hat{\sigma}_{LA}^2 = \frac{\hat{\sigma}_{vi}^2}{(1 - \tilde{\phi}_{i1} - \dots - \tilde{\phi}_{ip})^2}. \text{ The test above can be defined as the } Z_A^{LA} \text{ test.}$$

## 2.2 Panel Co-Integration Test

The Durbin-Hausman panel co-integration test developed by Joakim Westerlund (2008) was used in this study because orders of stationary of series were not at the same level.

Unlike other panel co-integrations tests, the Durbin-Hausman test allows the stability ranks of the independent variables to be different. It allows a series to be  $Y \rightarrow I(1)$ ,  $X \rightarrow I(1) - I(0)$ . Common factors are taken into account in this test. Additionally, the Durbin-Hausman test can be used only when the cross-sectional dependence is available; it cannot be used if it is not available. Two tests are calculated — one panel and one group — in this test. The panel statistics infer results for the panel in general, while the group statistics infer results for the individuals that make up the panel.

The hypothesis for the panel statistics is as below:

$$H_0 : \phi_i = 1 \quad \text{No co-integration for } \forall_i'$$

$$H_1 : \phi_i = \phi_i < 1 \quad \text{Co-integration for } \forall_i'$$

The hypothesis test for the group statistics is as below:

$$H_0 : \phi_i = 1 \quad \text{No co-integration for } \forall_i'$$

$$H_1 : \quad \text{Co-integration for some individuals, but for some it no co-integration.}$$

If the panel data model below is considered:

$$y_{it} = \alpha_i + \beta_i x_{it} + z_{it} \tag{12}$$

$$x_{it} = \delta x_{it-1} + w_{it} \tag{13}$$

The  $z_{it}$  distribution allows for common factors. In the Durbin-Hausman test, it is assumed that  $z_{it}$  distribution adapted according to the equations below to allow for cross-sectional dependence.

$$z_{it} = \lambda_i' F_t + e_{it} \tag{14}$$

$$F_{jt} = p_j F_{jt-1} + u_{jt} \tag{15}$$

$$e_{it} = \phi_i e_{it-1} + v_{it} \tag{16}$$

$p_j < 1$  for each  $j$  's.

Here,  $F_t$ , is the  $k$ -sized vector of the  $F_{jt}$  ( $j = 1 \dots k$ ) common factor.  $\lambda_i$  is the conformable vector of factor loadings.

To create the Durbin-Hausman test, first of all, the difference of Equation (14) is taken.

$$\Delta z_{it} = \lambda_i' \Delta F_t + \Delta e_{it} \tag{17}$$

If  $\Delta z_{it}$  were known, then  $\lambda_i$  and  $\Delta F_t$  could be estimated. However as  $\Delta z_{it}$  is unknown, a principal component estimator must be used. Equation (14) principal component can be written as below:

$$\Delta \hat{z}_{it} = \Delta y_{it} - \hat{\beta}_i \Delta x_{it} \tag{18}$$

The  $\Delta \hat{F}_t$ , which is the principal component estimator of  $\Delta F_t$ , can be obtained by calculating the eigenvector  $\sqrt{T-1}$  times among the greatest eigen value of the  $(T-1)(T-1)$  matrix.  $\hat{\lambda}$  can be calculated as  $\hat{\lambda} = \frac{\Delta \hat{F}' \Delta z}{T-1}$ .

When  $\Delta \hat{F}$  and  $\hat{\lambda}_i$  are calculated, the difference of the remainders and the defector can be calculated as below:

$$\begin{aligned} \Delta \hat{e}_{it} &= \Delta \hat{z}_{it} - \hat{\lambda}_i' \Delta \hat{F}_t \\ \hat{e}_{it} &= \sum_{j=2}^t \Delta \hat{e}_{ij} \end{aligned} \tag{19}$$

The null hypothesis, which expresses that there is no co-integration is the asymptotic equation that tests whether  $\phi_i = 1$  below:

$$\hat{e}_{it} = \phi_i \hat{e}_{it-1} + error \tag{20}$$

As In Choi (1994) states, the instrumental estimator (IV) is inconsistent under the alternative hypothesis. It is only consistent under the null hypothesis. On the other hand, the OLS estimator is consistent both in the null and alternative hypothesis. That is why, to use the Durbin-Hausman test OLS and IV, estimators are used (Peter C. B. Phillips and Bruce E. Hansen 1990).

Another estimator required to create Durbin-Hausman is the Kernel estimator. The Kernel estimator can be defined as below:

$$\hat{\omega}_i^2 = \frac{1}{T-1} \sum_{j=M_i}^{M_i} \left(1 - \frac{j}{M_i+1}\right) \sum_{t=j+1}^T \hat{u}_{it} \hat{u}_{it-j} \quad (21)$$

The  $\hat{u}_{it}$  in equation (21) is the remainder of the OLS from Equation (16).  $M_i$ , is the bandwidth parameter that expresses how many auto co-variances  $\hat{u}_{it}$  has in the kernel estimator.  $\hat{\omega}_i^2$  is the consistent estimator of  $u_{it}$ 's long-term variance,  $\omega_i^2$ . The corresponding contemporaneous variance estimate is expressed as  $\hat{\sigma}_i^2$ . Two variance ratios can be calculated after these estimates are made.

These variance ratios are as follows:

$$\hat{\omega}_i^2 = \frac{1}{n} \sum_{i=1}^n \hat{\omega}_i^2 \quad \text{and} \quad \hat{\sigma}_n^2 = \frac{1}{n} \sum_{i=1}^n \hat{\sigma}_i^2 \quad (22)$$

After these calculations are completed, the Durbin-Hausman test is calculated with the formula below.

$$DH_g = \sum_{i=1}^n \hat{S}_i (\tilde{\phi}_i - \hat{\phi}_i)^2 \sum_{t=2}^T \hat{e}_{it-1} \quad \text{and} \quad DH_p = \hat{S}_n = (\tilde{\phi} - \hat{\phi})^2 \sum_{i=1}^n \sum_{t=2}^T \hat{e}_{it-1} \quad (23)$$

$DH_p$  expresses the panel statistic, while  $DH_g$  expresses the group statistics.

### 2.3 Panel Causality Test

In this study, a panel causality test developed by Dumitrescu-Hurlin (2012) was used. This test can be used when N is growing and T is constant. Moreover, it can also be used when  $T > N$  and when  $N > T$ . The test, which is based on VAR, assumes that there is no cross-sectional dependency. Yet, the Monte Carlo simulations show that even under the conditions of cross-sectional dependency, this test can produce strong results. This test is used for balanced and heterogeneous panels.

There are two different distributions in this test: asymptotic and semi-asymptotic. Asymptotic distribution is used when  $T > N$ , while semi-asymptotic distribution is used when  $N > T$ . When there is cross-sectional dependency, simulated and approximated critical values, obtained from 50.000 replications, are used. If the panel data model is taken into consideration:

$$y_{it} = \sum_{k=1}^K \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^K \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t} \tag{24}$$

Here,  $K$  stands for the lag length. Moreover, the panel for the test is a balanced panel.  $\gamma_i^{(k)}$ , which is an autoregressive parameter, and  $\beta_i^{(k)}$ , which is the regression coefficient, can change among the groups. In addition to these, the tests do not have a random process. This test is a fixed one and has a fixed coefficient model.

Apart from these, individual remainders for each cross-sectional unit are independent. This test is based on normal distribution and allows for heterogeneity. Also, individual remainders are independently distributed among the groups.

In this test, homogenous non-stationary (HNC) hypothesis was used for the analysis of causality relationship and heterogeneous models. For  $T > N$  asymptotic and for  $N > T$  semi-asymptotic, a distribution was used in HNC hypothesis. When there is cross-sectional dependency, simulated and approximated critical values are used. According to this, the null and alternative hypotheses of HNC are as follows:

$$\begin{aligned} H_0 : \beta_i &= 0 & \forall_i = 1, \dots, N & \quad \text{with } \beta_i = (\beta_i^{(1)} \dots \beta_i^{(k)}) \\ H_1 : \beta_i &\neq 0 & \forall_i = 1, \dots, N & \\ \beta_i &\neq 0 & \forall_i = N+1, N_1+2, \dots, N & \end{aligned}$$

The alternative hypothesis of HNC allows for some of the individual vectors ( $\beta_i$ ) to be equal to zero. For the Dumitrescu-Hurlin test, the average statistic  $W_{N,T}^{HNC}$  hypothesis can be written as follows:

$$W_{N,T}^{HNC} = \frac{1}{N} \sum_{i=1}^N W_{i,T} \tag{25}$$

Here,  $W_{i,T}$  stands for the individual Wald statistical values for cross-section units.

The average statistic  $W_{N,T}^{HNC}$ , which has asymptotic distribution, associated with the null HNC hypothesis, is defined as:

$$Z_{N,T}^{HNC} = \sqrt{\frac{N}{2K}} (W_{N,T}^{HNC} - K) \quad T, N \rightarrow \infty \quad N(0, 1) \tag{26}$$

$$W_{i,T} = (T - 2K - 1) \begin{pmatrix} \tilde{\varepsilon}_i' \phi_i \tilde{\varepsilon}_i \\ \tilde{\varepsilon}_i' M_i \tilde{\varepsilon}_i \end{pmatrix}, \quad i = 1, \dots, N \tag{27}$$

The average statistic  $W_{N,T}^{HNC}$ , which has semi-asymptotic distribution, associated with the null HNC hypothesis, is defined as:

$$Z_N^{HNC} = \frac{\sqrt{N}[W_{N,T}^{HNC} - N^{-1} \sum_{i=1}^N E(W_{i,T})]}{\sqrt{N^{-1} \sum_{i=1}^N Var(W_{i,T})}} \quad N \rightarrow \infty, \quad N(0,1) \quad (28)$$

Here,  $E(W_{i,T})$  is also  $Var(W_{i,T})$  and is the variant statistic of Equation (27).

If there is cross-sectional dependency, 5% of the simulated critical values from 50000 replications of the benchmark model and 5% of the approximated values are used.

### 3. Empirical Findings

The unit root tests results related to GDP, current account deficit, total credits, and foreign direct investments are shown in Table 2:

**Table 2** CADF Test Results

CADF test statistics				
	GDP	CD	CR	FDI
USA	-0.2515	-1.925	-1.862	-1.361
UK	-3.254	-2.667	-0.6390	-1.993
Canada	-4.828**	-1.872	0.9109	-1.886
Japan	-3.922**	-2.076	-1.482	-1.629
France	-2.551	-0.6668	-1.709	-3.747*
Germany	-1.372	-0.5623	1.113	-1.522
Italy	-5.307***	-0.7214	-0.6674	-1.899

Note: \*\*\*, \*\* and \* stand for significance at 1%, 5%, and 10% confidence levels, respectively. The critical values are -4.90, -3.90 and -3.52 at 1%, 5%, and 10% confidence levels respectively. The critical values were obtained from Pesaran (2006) Case III intercept and trend.

Source: Authors' estimations.

According to the CADF test results, the GDP series are significant in Canada and Japan at 5% and in Italy at 1%. The null hypothesis of unit root is rejected. Because critical table values of other G7 countries apart from these three countries are higher than CADF test statistics, the null hypothesis is rejected. The FDI series is significant for France only at the 10% level. In other G7 countries, it is not statistically significant. CD and CR series are not statistically significant in other G7 countries. As a result, while the GDP series is stationary in the period studied in Canada, Japan and Italy, it is not stationary in other G7 countries. The FDI series is only stationary in France. In other G7 countries, it is not a stationary structure. CR and CD series do not contain a unit root in all other countries.

After the CADF panel unit root test and the stability structure of GDP, CD, CR, and FDI series are analyzed for each of the G7 countries, they are also analyzed using the Hadri-Kurozumi panel unit root test in general to see whether these series contain unit root. The results of the analysis are shown in Table 3.

**Table 3** Hadri-Kurozumi Unit Root Test Results

Variable	Test	t-stat	p-value
GDP	$Z_A^{SPC}$	0.2339	0.4075
	$Z_A^{LA}$	-0.7912	0.7856
CD	$Z_A^{SPC}$	3.1564	0.0008
	$Z_A^{LA}$	-2.2229	0.9869
CR	$Z_A^{SPC}$	6.9723	0.0000
	$Z_A^{LA}$	8.6839	0.0000
FDI	$Z_A^{SPC}$	-0.6226	0.7332
	$Z_A^{LA}$	3.1801	0.0007

Source: Authors' estimations.

For the GDP series, the null hypothesis express that the series are stationary according to the results of both the  $Z_A^{SPC}$  and  $Z_A^{LA}$  tests cannot be rejected. The null hypothesis is rejected for the CD series according to the result of the  $Z_A^{SPC}$  test. According to the  $Z_A^{LA}$  test, the null hypothesis of no unit root cannot be rejected. For the CR series, the null hypothesis is rejected for both the  $Z_A^{SPC}$  and  $Z_A^{LA}$  tests. For the FDI series, the null hypothesis cannot be rejected according to the  $Z_A^{SPC}$  test, while, according to the  $Z_A^{LA}$  test, the null hypothesis is rejected.  $Z_A^{SPC}$  is calculated using the bootstrap method, while  $Z_A^{LA}$  is calculated using the t-statistics method. In cases of cross-sectional dependency, the  $Z_A^{SPC}$  test, calculated using the bootstrap method, is taken into consideration. In cases in which there is no cross-sectional dependence, the  $Z_A^{LA}$  test calculated using t-statistics is considered. In our study on G7 countries, cross-sectional dependence is discovered both for variables and for the model. In fact, the results of  $Z_A^{SPC}$  are taken into consideration in the study. According to this, the GDP and FDI series have a stationary structure in G7 countries between 1990 and 2011. The CR and CD series do not contain a unit root.

After the order of stationary for series is analyzed, it is also analyzed to see whether a long-term relationship exists among the series. For the analysis, the Durbin-Hausman panel co-integration test that takes into account the cross-sectional dependency and that allows  $y \rightarrow I(1)$ ,  $x \rightarrow I(1)$  or  $I(0)$  was used. The results of the co-integration test are shown in Table 4.

**Table 4** Durbin-Hausman Panel Co-Integration Test Results

Dependent variable	Test	t-stat	p-value
GDP	$DH_g$	26.117	0.000***
	$DH_p$	10.029	0.000***
CD	$DH_g$	1.777	0.0380**
	$DH_p$	-0.303	0.6190
CR	$DH_g$	1.797	0.0360**
	$DH_p$	4.036	0.0000***
FDI	$DH_g$	21.415	0.0000***
	$DH_p$	57.356	0.0000***

**Note:** All tests are based on an intercept and the Whitney K. Newey and Kenneth D. West (1994) procedure for selecting the bandwidth order. The p-values are based on the asymptotic normal distribution.

**Source:** Authors' estimations.

According to the results of Durbin-Hausman, in the model showing GDP as a dependent variable, the panel statistics explaining that individuals forming the panel under the null hypothesis do not have overall co-integration relationship—is significant at the 1% level. Therefore, it can be said that there is an overall co-integration relationship among the individuals forming the panel by rejecting the null hypothesis. The null hypothesis is significant at the 1% level when compared to the same group statistics. Therefore, the null hypothesis of no co-integration relationship is rejected. According to this, an alternative hypothesis expressing that no co-integration exists in any of the individuals makes up the panel, while co-integration exists in some of them. The group statistics are significant at the 5% level for the model in which CD is a dependent variable. The panel statistics are not statistically significant. In the model in which CR is a dependent variable, model group statistics and panel statistics are significant at the 5% and 1% levels, respectively. In the last place, in the model where FDI is a dependent variable, both group and panel statistics are significant at the 1% level. Therefore, it can be said that there is a long-term relationship among GDP, CD, CR, and FDI in G7 countries between 1990 and 2011. After analyzing whether a long-term relationship exists among the variables, the potential for a causal relationship among the variables was also analyzed. The causality test developed by Dumitrescu and Hurlin (2012), which can return successful results, even under the conditions of cross-sectional dependence, was used for the analysis.

According to the results shown in Table 5, a unidirectional causal relationship was found from current account deficit to GDP between the years of 1990 and 2011 in G7 countries. No causal relationships were found between GDP and current account deficit or total credits and GDP for the same period. A relationship of unidirectional causality was found from foreign direct investment to GDP, and a relationship of bidirectional causality was found between total credits and current account deficit. Finally, unidirectional causal relationships were found from foreign direct investment to total credits and from total credits to current account deficit.

**Table 5** Dumitrescu-Hurlin Panel Granger Causality Test Results

Direction of causality	$W^{HNC}$	$Z_{NT}^{HNC}$	$Z_N^{HNC}$
CD→GDP	0.000959 (-5.923)	0.00272*** (-3.157)	0.103865 (-1.640)
GDP→CD	0.00822 (-4.120)	0.191882 (-1.209)	0.372922 (0.367)
CR→GDP	0.083725 (-1.767)	0.142467 (-1.435)	0.252341 (0.957)
GDP→CR	0.128982 (-1.502)	0.940581 (0.256)	0.553533 (0.342)
FDI→GDP	0.00081 (8.225)	0.000745*** (8.235)	0.0186** (-5.810)
GDP→FDI	0.196845 (-1.188)	0.224250 (-1.073)	0.218161 (-1.098)
CR→CD	0.000194 (-6.187)	0.001063*** (-3.443)	0.092457* (-1.710)
CD→CR	0.0000121 (-5.479)	0.011064** (-2.677)	0.201160 (-1.170)
CR→FDI	0.149060 (-1.403)	0.300166 (0.754)	0.366555 (0.411)
FDI→CR	0.0000471 (-4.253)	0.000361*** (-608)	0.00082*** (-4.656)
CD→FDI	0.079727 (-1.794)	0.384477 (-0.271)	0.351394 (-0.503)
FDI→CD	0.004582 (-2.988)	0.089548)* (-4.308)	0.091992 (-4.668)

**Note:** \*\*\*, \*\*, \* determine significance at 1%, 5%, and 10% level respectively. The values in parentheses show t-stat values. The approximated critical values for the average statistic  $W_{NT}^{HNC}$  are computed from Equation (30) at Dumitrescu and Hurlin (2012) for the case  $K=1$ . The simulated critical values are computed via stochastic simulations with 50,000 replications.

**Source:** Authors' estimations.

Current account deficit is an undesirable situation but is seen in many countries. Exportation is an engine of economic growth in developing countries. Because these countries do not have the required technology and resources for exportation, they import the technology and resources needed to manufacture the products to be exported. Therefore, their economic growth depends on their imports. Growth in importation has a negative effect on the current account deficit. While this is experienced in developing countries, it is not experienced in developed ones. Because G7 countries have the required technology and resources for production, economic growth is unlikely to be dependent on imports. Balance of payment problems in developed countries generally stem from short-term financing problems. Nevertheless, the economy is harmed unless the problem of current account deficit is solved. The continual increase in the current account deficit leads to the exit of foreign exchanges and the increase of foreign exchange rates. The absence of foreign direct investments to sustain the current account deficit continuously gives way to major fluctuations in the foreign exchange rates and to the increase in the price of imported products and inflation. Therefore, what matters regarding current account deficit is sustainability. As long as the foreign exchange input that can sustain the current account deficit is provided, the harm rendered by the current account deficit on the country's economy can be minimized.



Foreign direct investments lead to increased investments by the host country as well as to increases in rivalry and efficiency. This has a positive effect on the economy. Moreover, the foreign exchange input into the host country as a result of foreign direct investment gives way to an increase in foreign exchange demand. Increased demand in foreign exchange has a positive effect on total credits and current account deficit. The increased demand in foreign exchange gives way to the increase in bank deposits. The increase in bank deposits leads to growth of credit facilities and, therefore, to the enlargement of credit amounts. In addition, the increase in foreign exchange has a positive effect on foreign exchange rates. With foreign direct investments, researchers have seen an increase in foreign exchange demand. This foreign exchange inflow is crucial in financing the current account deficit. One of the methods of financing foreign currency deficit occurred because of current account deficits in direct capital flows. Hence, being crucial for economic growth and total credits as well as being used for financing current account deficit, foreign direct investments have important effects on current account deficit.

Total credits are also very important for current account deficits. The banks' decreasing of interest rates leads to growth in total demand and consumption. An increase in consumption also leads to increases in imports. Hence, current account deficits are negatively affected. For this reason, current account deficits can increase as a result of the increase in total credits. Changes in the current account deficit can affect the total credit amount. That the current account balance returns more shows that the foreign exchange supply also increases. An increase in foreign exchange supply leads to an increase in investments in the domestic market and, accordingly, in the creation of new funds. These funds and foreign exchange inputs increase the potential for bank deposits. Hence, in cases of directing these funds and foreign exchanges into banks, the banks are expected to increase the amount of total credits.

#### 4. Conclusion

This study evaluates whether there is a relationship among current account deficit, GDP, foreign direct investment, and total credits of G7 countries between 1990 and 2011. First, we analyzed whether variables contained a unit root using the CADF and Hadri-Kurozumi tests. As a result of the CADF test, we found that the GDP series was stationary for Canada, Japan, and Italy where direct capital flow series was stationary for France. Also, we found that the series of total credits and current account deficits in all G7 countries contained unit root. As a result of the Hadri-Kurozumi test, which drew conclusions for the whole of the individuals that form the panel, we found that GDP and foreign direct investment series had a stationary structure and that total credits and current account deficit series contained unit root. To determine whether a long-term relationship among the variables existed, the Durbin-Hausman panel co-integration test was used. As a result of the test, we concluded that there was a co-integration relationship among the series. Finally, the study analyzed whether there was a causality relationship among the variables using the causality test developed by Dumitrescu and Hurlin (2012). As a result of the analysis, a unidirectional causal relationship was found from current account deficit and foreign direct investment to GDP, and bidirectional causality were found between current ac-

count deficit and total credits. Finally, a unidirectional causal relationship was found from foreign direct investment to current account deficit and total credits.

The importance of foreign direct investment for current account deficit and total credits was presented as a result of the completed analysis. Additionally, the results indicate that current account deficits are a problem for some countries, but the problem can be eliminated as long as it is sustained. In the sustainability of a current account deficit, foreign direct investments have an important place. Therefore, policy makers play an important role for foreign direct investment in sustaining the current account deficit. Hence, policy makers should make the kinds of decisions that support foreign direct investment.

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## Appendix

**Table 6** Test Results of Cross-Sectional Dependence of the Variables

Variables	CD <sub>LM2</sub>		CD <sub>LM</sub>		Bias-adjusted CD test	
	t-stat	p-value	t-stat	p-value	t-stat	p-value
FDI	5.397	0.000	-2.512	0.006	1.798	0.036
CD	10.223	0.000	-2.814	0.002	1.760	0.039
GDP	3.810	0.000	-3.129	0.001	4.958	0.000
CR	10.853	0.000	-2.405	0.008	2.067	0.019

Source: Authors' estimations.

**Table 7** Test Results of Cross-Sectional Dependence of the Model

	t-stat	p-value
CD <sub>LM2</sub>	20.106	0.000
CD <sub>LM</sub>	14.029	0.000
Bias-adjusted CD test	5.200	0.000

Source: Authors' estimations.