CAUSAL RELATIONSHIP BETWEEN CURRENT ACCOUNT DEFICIT RATE AND INDUSTRIAL PRODUCTION GROWTH IN TURKEY: MIXED-FREQUENCY VAR APPROACH

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Abstract
In this study, the causal relationship between current account deficit rate and industrial production growth in Turkey is investigated by applying the mixed-frequency VAR approach developed by Ghysels et al. (2016). The data span from January 2005 to September 2018 for monthly industrial production index and from the first quarter of 2005 to the third quarter of 2018 for the quarterly current account deficit rate. Granger causality tests suggest that there is only one-way causal relationship between in the variables. It is running from industrial production to current account. Impulse response functions confirm the same causal relationship. Based on causality tests and impulse response functions, it can be concluded that the main reason for the recent improvement in the current account deficit is the contraction in industrial production in Turkey.

Keywords: *Current Account Deficit; Industrial Production; M-F VAR; Granger Causality; Turkish Economy*

1. Introduction

Over the last two decades, one of the two most discussed macroeconomic indicators on the Turkish economy is the current account deficit rate and the other is the industrial production growth. The current account deficit to GDP ratio in Turkey had an average of 5.5% between the years 2005-2018. It was in a continuous recovery period by fluctuating after reaching its highest level in the first quarter of 2011. Even in the third quarter of 2018, the current account yielded a surplus of 1%. Despite the positive developments in the current account deficit, industrial production experienced serious contradiction in the same period. Thus, in the period of 2005-2018, industrial production grew only by 1% on a monthly average and decreased by 9.8% in December 2018 having the sharpest decline in the last 10 years. The recent developments in both the current account deficit and the industrial production in Turkey have led to a re-evaluation of the relations between these two important indicators. Although the recent improvement in the current account deficit was seen as an economic success, the real sector of the economy argues that this is not a success but rather a result of the contraction in industrial production. Over twenty years, industrial production in Turkey is dependent on imports of intermediate and capital goods. Since the economic policy has been based on the model called as first import then export, it has been argued that the main reason for the improvement in the current account deficit is the contraction in industrial production. Another view argues that the decline in industrial production is not due to the foreign trade model, on the contrary, due to the contraction in domestic demand as well as stock surplus.

The related empirical literature is rich in terms of the study investigating the causal relationships between the current account deficit and economic growth. There are some studies that determine the bi-directional causal relationship as well as studies that determine one-way causal relationship between the two variables. Sadaf & Amin (2018), Akbaş *et al.* (2014), Erdoğan & Acet (2016), Arslan *et al.* (2017) can be given as an example of studies which find a bi-directional causal relationship. Malik *et al.* (2010), Erataş (2014) and Özer *et al.* (2018) are some of the studies that determine one-way causal relationship from current account deficit rate to economic growth. Uçak (2017), Yurdakul & Ucar (2015), Duman (2017), Yılmaz & Akıncı (2011) are among the studies detecting one-way causality from economic growth to current account deficit.

Although the applied method and the analyzed country in the studies differed, they all have a common feature. It is that they used either quarterly or annual data in their econometric analyses. In the current literature, the main reason for not using the high frequency series as monthly is the lack of high frequency of the GDP series, which is required in producing the current account balance rate series. Although the current account balance is available on a monthly basis, since the GDP is not present, quarterly data have been used as the highest frequency. As known, in the traditional multi time series analysis it is a necessity for the variables to be on the same frequency. In a two-variable time series analysis, it is not possible to use one of the variables at low frequency and the other at high frequency. However, until the 2000s, the most effective method used to eliminate the frequency difference in the series was to convert the high frequency series to the frequency of the lowest frequency variable in the analysis. The conversion was carried out by naturally aggregating the high frequency series for the desired frequency. However, such an approach may cause the findings to be statistically inefficient and biased (Andreou *et al.,* 2010). In addition, high frequency series contains more information than low frequency. As a result of temporal aggregation, the potential information in the high frequency series either disappears or has a different distribution (Marcellino, 1999; Götz *et al.,* 2015). Therefore, reducing the frequency of any time series with this approach means allowing the loss of potential information in the series. Granger (1988), Pesaran *et al.* (1989), Granger & Siklos (1995) demonstrated that the results of the analysis performed with temporally aggregated variables may be different from the findings obtained by disaggregated variables. For this reason, there are some doubts about the statistical reliability and accuracy of the analysis results with temporal aggregated variables.

The related frequency literature has drawn attention to the negative effects of the temporal aggregation approach since the beginning of the 2000s and hence focused on solution-oriented studies. One of the pioneering works in this area is Ghysels *et al.* (2004). In their study, Ghysels *et al.* (2004) developed a method called Mixed-Data Sampling (MIDAS), which allows a combination of different frequency series. This approach is a single-equation model approach in which low-frequency dependent variable and high-frequency independent variables or variables are used together. Later on, Ghysels (2016) and Ghysels *et al.* (2016) developed the Mixed-Frequency VAR (MF-VAR) method for VAR analysis, where all variables areassumed to endogenous. Therefore, the MF-VAR approach allows for Granger causality testing between different frequency series.

The purpose of the present study is to detect the possible causal relationship between current account deficit rate and industrial production growth in the light of the above discussions for the case of Turkey. In this study, the causal relationships between the quarterly current account deficit rate and the monthly industrial production growth were analyzed by using the MF-VAR approach for the period 2015-2017.

2. Data Set and Method

The data span from January 2005 to September 2018 for monthly industrial production index (IP) and from the first quarter of 2005 to the third quarter of 2018 for the quarterly current account deficit rate (CADR). All data were obtained from Central Bank of the Republic of Turkey. In this study, industrial production growth rates (DLIP) were calculated from logarithmic industrial production data (LIP). As mentioned earlier, the possible causality between CADR and DLIP is revealed by Granger causality under MF-VAR method which allows analysis on the original frequencies of the variables adapted for causality. The MF-VAR model is as shown in equation (2.1).

$$X(\tau_L) = (DLIP(\tau_L, 1)' \dots\dots.. DLIP(\tau_L, m)', CADR(\tau_l)')' \qquad (2.1)$$

In equation (2.1) above, $X(\tau_L)$ represents both high frequency DLIP variable and low frequency CADR variable. τ_L is low frequency time period while m is the number of time periods with high frequency corresponding to a time unit of the low frequency variable. In the MF-VAR model with $p \geq 1$, it is assumed that $X(\tau_L)$ follows the MF-VAR (p) process.

$$X(\tau_L) = \sum_{k=1}^{p} \beta_k X(\tau_L - k) + \varepsilon(\tau_L) \qquad (2.2)$$

In the above MF-VAR (p) model; $k = 1, \dots\dots. p$ is the coefficient matrix and $\varepsilon(\tau_L)$ is the error vector. Here, there is an assumption that error vector with $k \times 1$ follows a stationary process with $\varepsilon(\tau_L)$ =$[\varepsilon_1(\tau_L), \dots\dots.., \varepsilon_k(\tau_L)]'$

The least squares method is used to estimate the MF-VAR model. However, in calculating the variance-covariance matrix for the parameters, Newey & West (1987)'s HAC variance estimator and Newey & West (1994)'s automatic lag selection are used. Then, it is decided whether there is a causal relationship between variables by calculating the Wald statistics.

3. Findings

In this study, firstly the stationarity of CADR and LIP was examined by using the Augmented Dickey-Fuller (ADF) unit root test approach. In Table 1, it can be seen that CADR is stationary on its level while LIP is stationary on its first differences. These results mean that both current account deficit rate and industrial production growth are stationary on their levels.

Table 1. ADF Unit-Root Test Results

Variable	Constant	Constant and Trend
CADR	-2.946**	-2.899
LIP	-0.551	-2.073
DLIP	-6.587***	-6.522***

Note: ***, ** and * indicate 1%, 5% and 10% significance, respectively. CADR; The current account deficit rate which is calculated by dividing the GDP by the current account deficit, LIP; Logarithmic Industrial Production Index, D shows that the first difference of the series.

In the empirical analyze, MATLAB codes written by Motegi (2014) were used to perform Granger causality test based on the MF-VAR model between CADR and DLIP. In the MF-VAR model, monthly data of the high-frequency industrial production growth rate is divided into three sections, which correspond to the frequency of the quarterly current account deficit rate series. In the separation process, industrial production growth rates corresponding to the first months of the quarterly periods, the second months in the second part and the last months in the third part are included. Therefore, in the MF-VAR model, Granger causality test is applied on four different variables instead of two variables. Since there is no fixed term in the MF-VAR model developed by Ghysels *et al.* (2016), deviations of the variables from their averages are used in the analyzes.

Granger causality test was applied first between the monthly DLIP and quarterly CADR. Then the same test was also implemented between quarterly aggregated DLIP and quarterly CADR. The optimal lag length for both causality tests was determined to be one by using Final Prediction Error criteria. Table 2 reports the probabilities for rejecting the null hypotheses that there are no causal relationships between the two variables. The null hypothesis that implies no causal relationship from CADR to DLIP cannot be rejected in both mixed frequency and low frequency analyses. The probabilities for rejecting the null hypothesis are 0.173 and 0.589, respectively. On the other hand, according to probabilities given in the same table, the null hypothesis that indicates no causal relationship from DLIP to CADR is rejected in both mixed frequency and low frequency analyses. The probability for rejecting the null hypothesis is 0.004 in mixed frequency analysis while it is 0.019 in low frequency approach. According to both analyses, there is a causal relationship between both variables for the case of Turkey. It is running from industrial production growth rate to current account deficit rate. However, this conclusion is stronger in mixed-frequency (MF-VAR) model than in low frequency model.

Table 2. Probability Values of Granger Causality Test

H_0 Hypothesis	Mixed Frequency	Low Frequency
CADR "$\nRightarrow$" DLIP	0.173 (1)	0.589 (1)
DLIP "$\nRightarrow$" CADR	0.004 (1)	0.019 (1)

Note: The values in parentheses are the optimal lag length for MF-VAR and traditional VAR Models.

The diagnostic test statistics of MF-VAR and traditional VAR (aggregated industrial production growth rate) are given in Table 3. From the table, it can be observed that that there is no autocorrelation problem in both models. In addition, White heteroskedasticity test indicates that there is no heteroskedasticity problem in the MF-VAR model. But, the null hypothesis that implies the non-existence of the heteroskedasticity problem can be rejected at the significance level of 0.05 for the traditional VAR model. In other words, there exists a strong heteroskedasticity problem in the traditional VAR model where the monthly industrial production growth rate is converted into three months. AR roots of MF-VAR and traditional VAR models are presented in Graph 1. As can be seen from the graph, there is no unit root in both models.

Table 3. Diagnostic Test Results

	Mixed Frequency	**Low Frequency**
LM Autocorrelation Test	14.573 (0.556)	5.993 (0.2)
White Heteroskedasticity Test	139.318 (0.5)	29.558 (0.014)

The values in brackets are probability values of the calculated statistics.

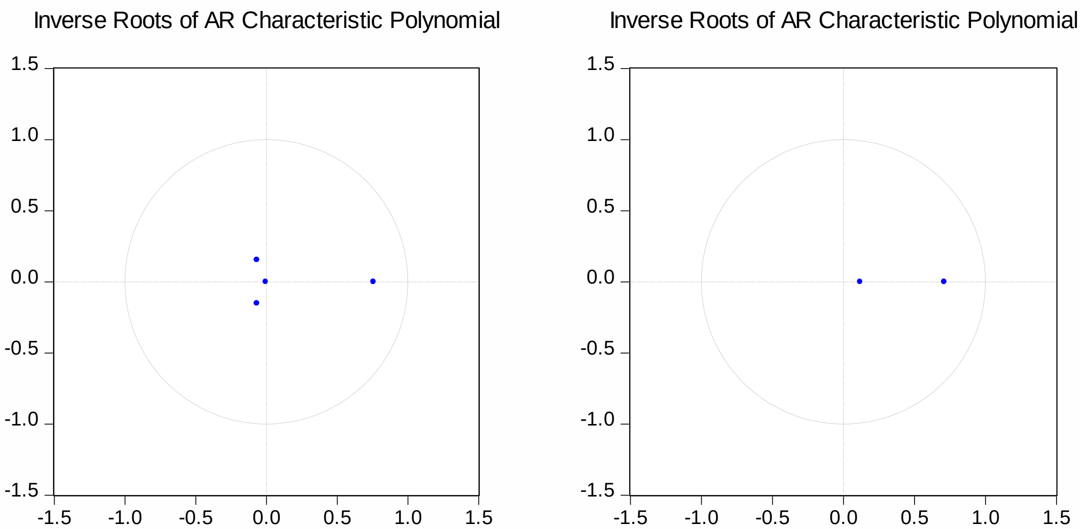

Figure 1. AR Roots for MF-VAR and Traditional VAR Models

Figure 2 shows the impulse-response functions of the MF-VAR model. In the figure, DLIP1, DLIP2 and DLIP3 are quarterly industrial production growth equivalent to the 1st, 2nd and 3rd months respectively. The first three graphs at the last column of Figure 2 show the response of DLIP to a one standard deviations shock to CADR for the 1st, 2nd, and 3rd months, respectively. In the first quarter, the response of DLIP to a shock in CADR is statistically significant and slightly negative for 1st and 3rd months, and slightly positive for 2nd month. After the first quarter, the response is no longer significant and after that, the impulse response function stabilizes around zero. The degree of the response of the industrial production growth rate to the current account deficit seems to be consistent with the above Granger causality test results. As can be recalled, the current deficit rate does not Granger-cause industrial production growth rate. Here too, industrial production growth rate does not give a significant response to any shock in current account deficit rate.

On the other hand, the first three graphs at the last row of Figure 2 demonstrate the response of current account deficit rate to a one standard deviations shock to industrial production growth for the 1st, 2nd, and 3rd months, respectively. The response of the current account deficit to the shock of industrial production growth shows a similar pattern for three months in the quarter. As can be seen from the figure, the response of the current deficit rate is similar to the V shape. As a result of the shock of industrial production growth, the current account deficit rate is first increasing, then decreasing and approaching the zero balance current account. The response of current account deficit rate to a standard deviation shock in the industrial production growth reaches its maximum value in the first quarter. The response of current account deficit rate disappears by approaching the zero value towards the fifth quarter. The V shape on the response of current account deficit rate to industrial production shock means that industrial production growth rate Granger-causes current account deficit rate. This conclusion is also consistent with the probability value of Granger causality test.

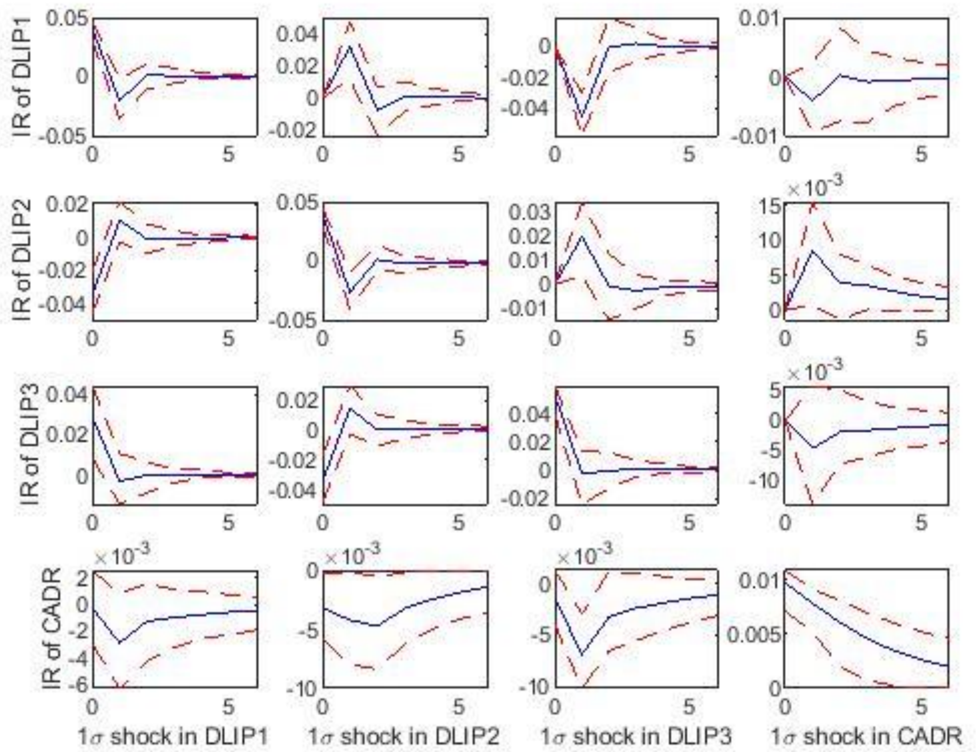

Figure 2. MF-VAR Impulse Response Function

As previously mentioned, in this present study, causality relationship between the two variables was investigated by using traditional VAR as well as MF-VAR. In Figure 3, impulse-response functions of traditional VAR model are presented. The graph at the top right of the relevant figure shows the response of aggregated industrial production growth to a one standard deviations shock to current account deficit rate. The response of industrial production growth to a shock in current account deficit rate is statistically insignificant and the impulse-response function stabilizes around zero by indicating that current account deficit rate dos not Granger-cause industrial production growth rate. The graph in the lower left part of

Figure 3 demonstrates the response of current account deficit rate to a one standard deviations shock to aggregated industrial production growth. The initial response of current account deficit rate to a shock in industrial production growth is statistically significant and negative. This negative shock reaches the maximum value in the first quarter. After that, it is approaching zero by slowly decreasing.

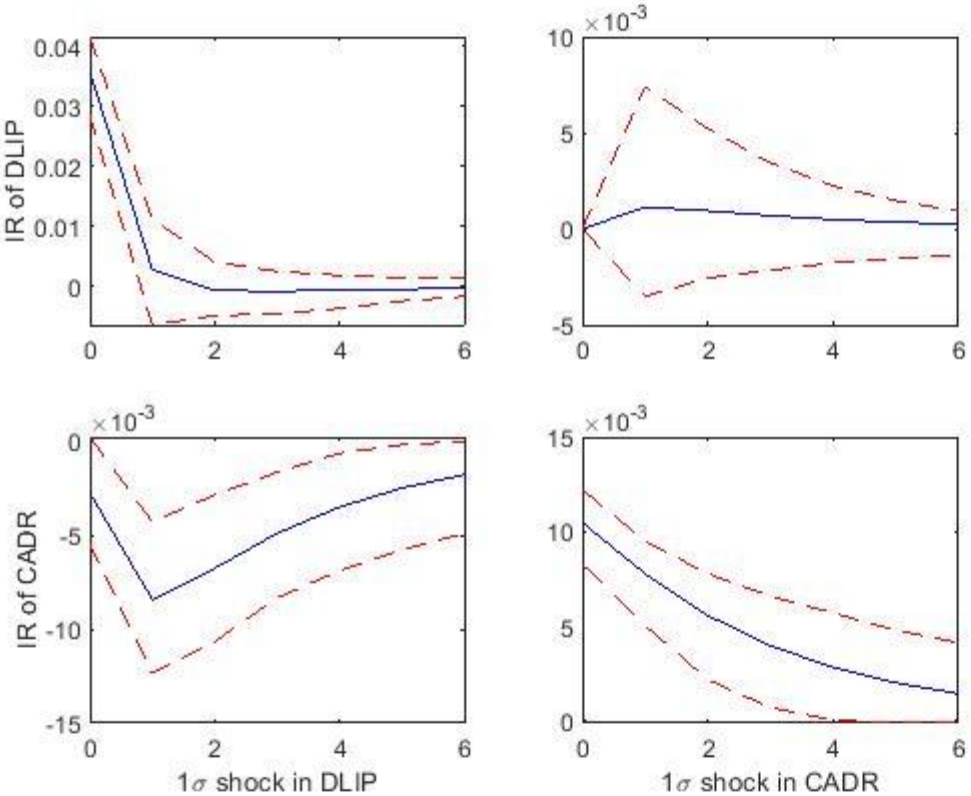

Figure 3. Traditional VAR Impulse Response Function

4. Conclusion

In this study, the possible causal relationship between current account deficit rate and industrial production growth rate were investigated by using Mixed-frequency VAR approach developed by Ghysels *et al.* (2016). The biggest advantage of the MF-VAR model is that it allows Granger causality test between the series with different frequency. The aim of the study is to determine whether there is any causal relationship between monthly DLIP and quarterly CADR for the case of Turkey.

Initially, both conventional and MF-VAR models were estimated separately. Then, Granger causality tests were performed based on both models. The findings of traditional VAR indicate that there is only one-way causality from quarterly industrial production growth rate to quarterly current account rate. The same result was also obtained from the MF-VAR model. According to MF-VAR, monthly industrial production growth rate Granger-causes quarterly current account deficit rate. There is no difference between the two models in terms of determining the direction of the causal relationship. However, the one-way causal relationship to the current account deficit from industrial production growth rate was found to be statistically stronger in the MF-VAR model, where high-frequency series was employed, than in traditional VAR model. Impulse response functions of MF-VAR validated one-way causality from DLIP to CADR. The response of CADR to DLIP seems to be V shape. In addition, the hypothesis that there is no causal relationship between the current deficit ratio and the industrial production growth rate in both models could not be rejected. However, in the MF-VAR model where the high frequency series is used, the probability of rejecting no Granger causality from current account deficit rate to industrial production growth rate is higher than in the conventional model.

From the empirical analysis of the study, it can be seen that the recent improvements in the Turkish current account deficit are not the result of a policy performance. On the contrary, these improvements seem to be a result of the contraction in industrial production. Whenever industrial production growth rate starts to increase, the current account deficit rate is likely to increase.

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