

ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH IN  
TURKEY: AN MF-VAR APPROACH

A Master's Thesis

by

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August 2019



To Adalet, Oğuz & my cat Hercules



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The Graduate School of Economics and Social Sciences  
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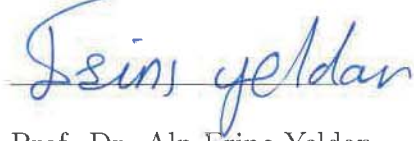
I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Economics.



Prof. Dr. Hakan Berument

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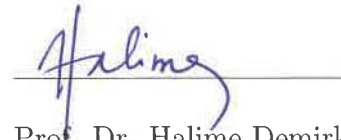
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# ABSTRACT

## ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH IN TURKEY: AN MF-VAR APPROACH

Berksun, Dilara

M.A., Department of Economics

Supervisor: Prof. Dr. Hakan Berument

August 2019

This thesis investigates the relationship between monthly electricity consumption, quarterly GDP and quarterly components of GDP using a Mixed Frequency VAR model for Turkey. The empirical evidence reveals that an increase in electricity consumption increases GDP. However, an increase in electricity consumption increases Private Consumption, Investment, Imports expenditures, Construction, Industrial, Manufacturing and Service Sector outputs more than it increases GDP. In addition to this, the empirical evidence reveals that an increase in electricity consumption increases Agricultural sector output less than it increases GDP.

Keywords: Economic Development, Electricity Consumption and Mixed Frequency Vector Autoregression Model.

## ÖZET

### TÜRKİYE'DE ELEKTRİK TÜKETİMİ VE İKTİSADİ BÜYÜME

Berksun, Dilara

Yüksek Lisans, İktisat Bölümü

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Bu çalışmada Türkiye'deki aylık elektrik tüketimi ile çeyreklik Gayri Safi Yurtiçi Hasıla (GSYİH) ve GSYİH'nın alt bileşenleri arasındaki ilişki Karma Frekanslı Vektör Otoregresyon model kullanılarak incelenmiştir. Ampirik sonuçlar elektrik tüketiminin GSYİH'yı artırdığını gösterirken elektrik tüketimindeki artış özel tüketimi, yatırımı, ithalatı ve aynı zamanda inşaat, endüstri, imalat, servis sektörlerinin üretimini GSYİH'dan daha fazla artırdığını göstermektedir. Buna ek olarak sonuçlar bize elektrik tüketimindeki artışın tarım sanayisindeki üretimi GSYİH'yı düşürdüğünden daha fazla düşürdüğünü göstermektedir.

Anahtar Kelimeler: Elektrik Tüketimi, İktisadi Büyüme ve Karma Frekans Vektör Otoregresyon Model.

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I would like to give special thanks to my parents, Adalet and Oğuz, for always being by my side and always believing in me. They are the best parents that anyone could ever ask for. I am grateful for the love they have given me all my life. This accomplishment would not have been possible without them. I would also like to thank them for giving me the best gift of my life, Hercules, my cat. He was the most adorable boy.

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## CHAPTER 1

### INTRODUCTION & LITERATURE REVIEW

There has been a vast amount of literature on the relationship between electricity consumption and GDP. However, in terms of the direction of this causal relationship, the studies vary. While some authors find a unidirectional causality running from one of the variables to the other, others detect a bidirectional causality or no causality at all. The literature has uncovered four possible relationships between electricity consumption and economic growth, which has been synthesized into four testable hypotheses each requiring a different policy implication for energy investment and macroeconomic policy design (Apergis & Payne, 2009; Payne, 2010a). First, the growth hypothesis corresponds to the positive unidirectional causality running from electricity consumption to economic growth. This hypothesis is based on the idea that energy is a factor of production (Csereklyei & Humer, 2012). Hence, it implies that an increase in electricity consumption will cause an increase GDP. Therefore, under the growth hypothesis, implementing policies that reduce electricity consumption will hinder economic growth and putting into effect policies that result in an increase in electricity consumption would boost it. Hence, for a resource stagnated country, an increase in electricity consumption will have a significant positive effect on output. Authors like, Narayan and Singh (2007), Shiu and Lam (2004), and Altinay and Karagol (2005) find results supporting the growth hypothesis for the Fiji Islands, China and Turkey, respectively.

Second, the conservation hypothesis represents the positive unidirectional causality running from output to electricity consumption. To be more precise, this hypothesis implies that an increase in GDP causes an increase in electricity consumption. When this is the case, implementing electricity conservation policies will not have a negative effect on the growth of GDP (Narayan & Singh, 2007). Some of the empirical evidences for the conservation hypothesis include Ghosh (2002), Narayan and Smyth (2005), and Yoo and Kim (2006) for India, Australia and Indonesia, respectively.

Third, the feedback hypothesis captures the bidirectional relationship between electricity consumption and output. It is based on the idea that electricity consumption and GDP are two interdependent variables. For this reason, an increase (decrease) in electricity consumption causes an increase (decrease) in GDP and an increase (decrease) in GDP causes an increase (decrease) in electricity consumption (Payne, 2010a). That is to say, implementing policies that promote one of them may trigger an increase in both GDP and electricity consumption and putting into effect policies that hinder one may cause a decline in both. Based on this, putting into effect policies directed toward improvements in energy may not have an adverse effect on GDP, it may even have a positive effect on it (Payne, 2010b). Empirical evidence that support the feedback hypothesis include Yoo (2006), Jumbe (2004) and Odhiambo (2009) on Korea, Malawi and South Africa, respectively.

Fourth, the neutrality hypothesis depicts the absence of any causal relationship between electricity consumption and income. It is based on the idea that electricity consumption represents a very small and insignificant part of GDP (Apergis & Payne, 2009). Hence, implementing policies that promote or hinder one of the variables would not have a significant effect on the other. Based on this, a cut in electricity production, for example, would not have an adverse impact on real GDP that would count as noteworthy (Payne, 2010a).

The studies that support the neutrality hypothesis include Wolde and Rufael (2006) on Algeria, Congo Republic, Kenya, South Africa and Sudan. Using Toda-Yamamoto causality, they could not find any statistically significant causal relationship between electricity consumption and GDP based on 1971-2001 annual data.

Researchers investigate the relationship between electricity consumption and the subcomponents of GDP as well. This is an interesting question because results may vary between aggregate and individual levels because of the aggregation bias problem for GDP (Tang & Shahbaz, 2013). While finding a certain type of causality at the aggregate level, it is possible to find a different type of causality at the individual level. For example, while finding a bidirectional causality between per capita electricity consumption and GDP at the aggregate level, Kouakou (2011) finds a unidirectional causality at the sectoral level. In addition to this, electricity demand of each subcomponent of GDP is different from the other due to their difference in capital intensiveness. For this reason, the direction of causality across the subcomponents of GDP may also vary for a specific country.

The causal relationship may run from electricity consumption to certain components of GDP. For example, Mawejje and Mawejje (2016), Kouakou (2011) and Shahbaz et al. (2014) find a unidirectional causality running from electricity consumption to industrial production for Uganda, Ivory Coast and Bangladesh, respectively. Similarly, Abokyi, Appiah-Konadu, Sikayena and Oteng-Abayie (2018) find a unidirectional causality running from electricity consumption to manufacturing sector output in Ghana. This is also important for countries' growth strategies. For example, export led growth strategy may require a different electricity generation policy than domestic lead (say health-care) growth.

However, Lean and Smyth (2010) find that causality runs from the export sector to electricity consumption for Malaysia. Likewise, Jamil and Ahmad (2010) find that growth in output in commercial, manufacturing and agricultural sectors and growth in private expenditure increase electricity consumption in Pakistan. Similarly, Mawejje and Mawejje (2016) find a unidirectional causality running from service sector output to electricity consumption for Uganda and Kwakwa (2012) find a unidirectional causality running from agricultural production output to electricity consumption for Ghana.

Third, causality between electricity consumption and the subcomponents of GDP may be bidirectional. Authors like Kwakwa (2012), and Danmaraya and Hassan (2016) find results that support this feedback hypothesis for the manufacturing sector and electricity consumption in Ghana and Nigeria, respectively. On the other hand, causality between the two variables may not exist at all. For example, Kermani, Ghasemi and Abbasi (2015) could not find a causal relationship between the industry value added and electricity consumption in Iran. Similarly, Mawejje et al. (2016) could not find any causality between electricity consumption and real output in the agricultural sector for Uganda. For a more detailed summary of literature on electricity consumption and economic growth one may look at the survey of the electricity consumption-growth literature reviewed by Payne (2010).

Vector autoregressive models have been one of the most widely used models to capture the relationship between electricity consumption and output (see, for example, Borozan, 2013, and references cited in). However, the common pitfall of the VAR models is that they require the researcher to use same frequency data. Hence, researchers working with annual GDP were compelled to use annual electricity consumption even if they had access to quarterly or monthly electricity consumption data. Similarly, researchers using quarterly GDP were compelled to use quarterly electricity consumption in their models even if they

had access to monthly electricity consumption data.

It is certainly possible to align variables either downward or upward in order to transform them to the same frequency. However, aligning variables either downward or upward in order to transform them into the same frequency has consequences in terms of potentially misspecifying the comovements (Ghysels, 2016). More specifically, downward alignment discards valuable information in the high frequency data while upward alignment by interpolating the high frequency data with heuristic rules such as polynomial fillings introduces noises to the data (Qian, 2013). This in turn affects the results of the analysis. For this reason, I have refrained from interpolating quarterly GDP to monthly GDP or aggregating monthly electricity consumption to quarterly electricity consumption. I was able to do this by employing Mixed Frequency VAR model (MF-VAR), which allowed us to examine mixed frequency data. I was also able to include the subcomponents of GDP into our model without being forced to upward/downward align GDP. This is the first contribution of this thesis to the existing literature. MF-VAR also contributes to decreasing type 2 error in the estimation.

The second contribution of this thesis is that I add different components of GDP relative to GDP into our model. Hence, from the impulse response functions I analyze how a shock in monthly electricity consumptions affects the subcomponents of GDP relative to GDP itself and how a shock in the subcomponents of GDP relative to GDP effect monthly electricity consumptions. In addition to this, instead of using causality in our model I have resorted to examining the causal relationship with impulse response function (IRF). The reason behind this is that using impulse response functions enables us to not only analyze the direction of causality but also observe the dynamic interaction of electricity and GDP and electricity and the subcomponents of GDP relative to GDP.

The purpose of this thesis is to determine the causal relationship between electricity consumption and economic growth in the case of Turkey. Like many other developing countries Turkey's natural resources that can be used to generate electricity are limited. For this reason, Turkey relies heavily on imported primary energy resources to generate electricity. Thus, Turkey is a good representative case for a set of resource poor emerging markets that generate most of its resources that are used to generate electricity from imports. Second, while the electricity generation of Turkey was about 125 billion kWh in 2000, it reached to more than 295 billion kWh in 2010 with an average of 7.5% increase per year based on 2018 BP Statistics. Based on these statistics, Turkey became the first in Europe and third in the world in the increase in electricity generation. Thus, studying Turkey itself is important for its generated capacity in the world.

Parallel to the increase in electrical energy consumption, GDP has also been increasing. Based on the statistics of World Bank, Turkey has experienced an annual GDP per capita growth rate of 3.119% on average between the years 1987 and 2017. However, the growth rate per capita income has always been highly volatile. This is also true for our sample period where the standard deviation is equal to 4.5. Additionally, the maximum value of the electricity consumption growth between 1987 and 2017 is 9.475% in 2011 and the minimum is -7.356 in 2001. Thus, with the high volatility of GDP growth rate per capita, I have a lower chance of making a *type II error*; failing to reject a false null hypothesis. This is the third reason of using the Turkish data.

Based on our empirical results, when I used conventional quarterly VAR model I could not find any causal relationship between electricity consumption and GDP growth. However, when I used Mixed Frequency VAR specification I found that electricity consumption does increases GDP growth. Repeating the same exercise by adding other low frequency variables I have also found that

a shock given to monthly electricity consumptions increases Private Consumption, Investment, Imports, Construction sector output, Manufacturing sector output, Industrial sector output, Service sector output and decreases Agricultural sector output relative to GDP lending support to the growth hypothesis.

The rest of the thesis is organized as follows. Mixed Frequency VAR, data source and notations will be explained in Chapter 2. In Chapter 3, I will discuss the empirical results of the impulse response functions and lastly the concluding remarks will be given in Chapter 4.



## CHAPTER 2

### DATA AND METHODOLOGY

To examine the dynamic relationship between monthly electricity consumption, quarterly GDP and quarterly subcomponents of GDP, I employ Mixed Frequency Vector Autoregression (MF-VAR) approach by using 1987:2Q-2017:3Q data. I obtained the quarterly data on GDP and its subcomponents from Turkish Statistical Institute, and monthly data on electricity consumption from the Republic of Turkey Ministry of Energy and Natural Resources. Based on the trajectory of the impulse responses I will first be using two variable Mixed Frequency VAR specification with monthly electricity consumption as the high frequency variable and GDP as the low frequency one. Then by adding a quarterly measured subcomponent of GDP into our model I will look at the three variable case.

Starting out with the two variable MF-VAR model, let  $x_{t-i/m}^m$  and  $y_t$  denote the high and low frequency variables respectively for  $t = 1, \dots, T$ . As there are 122 quarters in our sample,  $T$  is equal to 122. For the high frequency variable,  $i$  denotes the specific month under consideration and  $m$  denotes the high-frequency observations per low frequency observation which is equal to 3 in our study. Based on the work of Chauvet, Gotz and Hecq (2013) I use  $L^{1/m}$  for the high frequency lag operator and  $L$  for the low frequency counterpart. These amount to  $Ly_t = y_{t-1}$  or  $Lx_t^m = x_{t-i/m}^m$  and  $L^{1/m}x_{t-i/m}^m = x_{t-i/m-1/m}^m =$

$x_{t-(i+1)/m}^m$ . Apart from this, we also have  $L^{1/m}x_{t-(m-1)/m}^m = x_{t-1}^m$ .

Following Gotz, Hecq and Smeekes (2016), I take the high frequency variables as  $X^t = (x_t^m, x_{t-1/m}^m, \dots, x_{t-(m-1)/m}^m)$  and after ensuring their stationarity, I specify the VAR(p) for  $Z_t = (X_t', y_t)'$  as follows

$$Z_t = \mu + \Gamma_1 Z_{t-1} + \dots + \Gamma_p Z_{t-p} + \varepsilon_t \quad (1)$$

Using Schwarz Criteria, I took the optimal lag length to be one. Apart from adding seasonal dummies in order to account for the seasonality I also included crises dummies into our model for 1994:Q2, 2000:Q4, 2001:Q1 and 2008:Q3 time periods. The VAR model for quarterly GDP growth rate and for the monthly electricity consumption growth rate can be written in the explicit form as follows

$$\begin{bmatrix} EC_{t-2/3}^3 \\ EC_{t-1/3}^3 \\ EC_{t-0/3}^3 \\ GDP_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \end{bmatrix} + \begin{bmatrix} \lambda_{1,1} & \lambda_{1,2} & \lambda_{1,3} & \lambda_{1,4} \\ \lambda_{2,1} & \lambda_{2,2} & \lambda_{2,3} & \lambda_{2,4} \\ \lambda_{3,1} & \lambda_{3,2} & \lambda_{3,3} & \lambda_{3,4} \\ \lambda_{4,1} & \lambda_{4,2} & \lambda_{4,3} & \lambda_{4,4} \end{bmatrix} \times \begin{bmatrix} EC_{t-1-2/3}^3 \\ EC_{t-1-1/3}^3 \\ EC_{t-1-0/3}^3 \\ GDP_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \end{bmatrix} \quad (2)$$

where  $\varepsilon_t \sim MVN(0_{4 \times 1}, \Sigma)$ . In this equation  $EC_{t-2/3}^3$ ,  $EC_{t-1/3}^3$  and  $EC_{t-0/3}^3$  represent the electricity consumptions of the first, second and third month of each quarter respectively and  $GDP_t$  represents the quarterly GDP at time t.

In order to capture the relative contribution of the subcomponents of GDP, following Strongin (1995), I added another low frequency variable just after GDP growth. This low frequency variable, which I will denote by  $S_t$ , will be Private Consumption, Government Spending, Investment, Export, Import, Construc-

tion Sector, Private Industry, Manufacturing Industry, Service and Agricultural Sector output growths by turns. Thus, the impulse responses to a given shock of  $S_t$ , captures how  $S_t$  affects other variables once the effect of GDP growth is accounted for. In other words, how  $S_t$  affects and affected by other variables relative to GDP growth. Based on this, the equation will become as follows

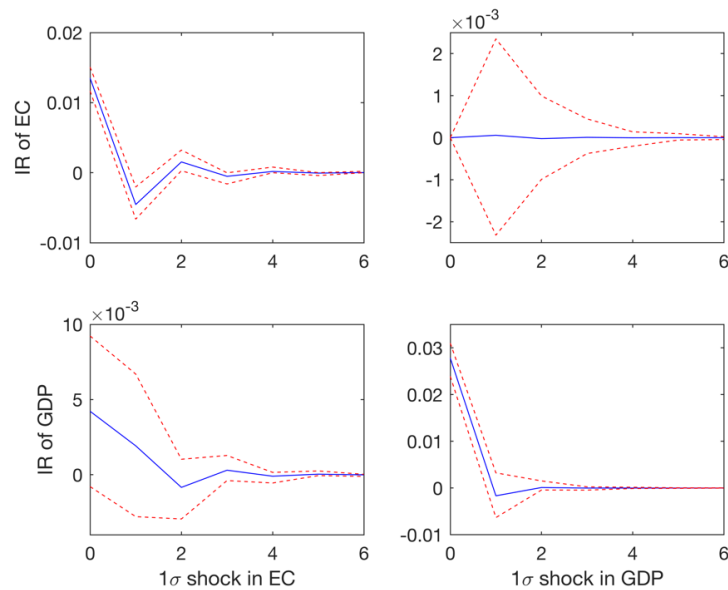
$$\begin{bmatrix} EC_{t-2/3}^3 \\ EC_{t-1/3}^3 \\ EC_{t-0/3}^3 \\ GDP_t \\ S_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \end{bmatrix} + \begin{bmatrix} \lambda_{1,1} & \lambda_{1,2} & \lambda_{1,3} & \lambda_{1,4} & \lambda_{1,5} \\ \lambda_{2,1} & \lambda_{2,2} & \lambda_{2,3} & \lambda_{2,4} & \lambda_{2,5} \\ \lambda_{3,1} & \lambda_{3,2} & \lambda_{3,3} & \lambda_{3,4} & \lambda_{3,5} \\ \lambda_{4,1} & \lambda_{4,2} & \lambda_{4,3} & \lambda_{4,4} & \lambda_{4,5} \\ \lambda_{5,1} & \lambda_{5,2} & \lambda_{5,3} & \lambda_{5,4} & \lambda_{5,5} \end{bmatrix} \times \begin{bmatrix} EC_{t-1-2/3}^3 \\ EC_{t-1-1/3}^3 \\ EC_{t-1-0/3}^3 \\ GDP_{t-1} \\ S_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \\ \varepsilon_{5,t} \end{bmatrix} \quad (3)$$

Next, I employ conventional impulse response analysis using Cholesky decomposition for inferences with order  $EC_{t-2/3}^3, EC_{t-1/3}^3, EC_{t-0/3}^3, GDP_t$  and  $S_t$ . The decomposition imposes a recursive causal ordering that restricts the contemporaneous impact of each variable on the following variables (Pereira & Matheson, 2016). That is each variable affects the subsequent variable and no variable affects the previous one contemporaneously; however, each variable affects each other with a lag.

## CHAPTER 3

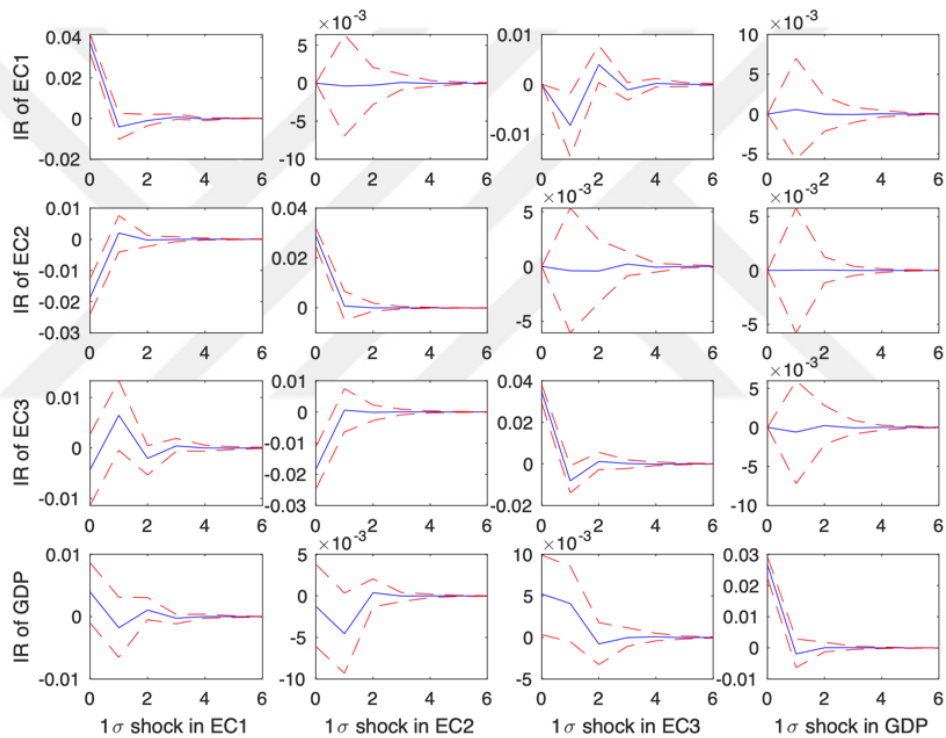
### EMPIRICAL RESULTS

I examine the dynamic interactions among a set of macro variables and electricity consumption using VAR and MF-VAR models by employing impulse response functions (IRF). The IRF report the estimated effects of a one-standard deviation shock given to a variable on current and future values of all variables in the VAR system (Borozan, 2013). The dotted lines in the figures show 95% confidence intervals and the middle line between these two dotted lines give the impulse responses. If the confidence bands include zero line, then we fail to reject the null hypothesis stating that impulse responses are equal to zero.



**Figure 1: Impulse Response Functions based on the VAR(1) model of quarterly Electricity Consumption (*EC*) and quarterly GDP**

Figure 1 reports the analysis on the impulse responses of quarterly electricity consumption (EC) and GDP using a conventional VAR model. As VAR model requires all the variables in the model to be in the same frequency, I aligned monthly electricity consumption downward to treat it as a quarterly variable. As it can be seen from this figure, neither a one-standard deviation shock in quarterly electricity consumption nor a one-standard deviation shock in GDP generate statistically significant results in terms of the impulse responses of GDP and quarterly electricity consumption, respectively.



**Figure 2: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions ( $EC1$ ,  $EC2$ ,  $EC3$ ) and quarterly GDP**

In Figure 2, however, I used the MF-VAR model to test the same relationship but with monthly electricity consumption and quarterly GDP data without doing any alignment. For notational convenience I use  $EC1$  instead of  $EC_{t-2/3}^3$  which is the electricity consumption of the first month of each quarter. Similarly, I indicate the electricity consumption of the second month of each quar-

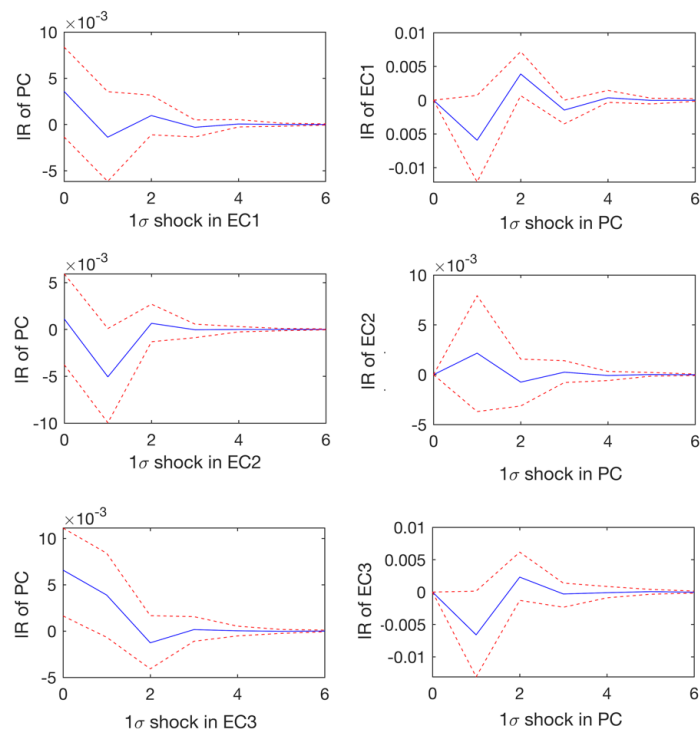
ter  $EC_{t-1/3}^3$ , and the electricity consumption of the third month of each quarter  $EC_{t-0/3}^3$  with  $EC2$  and  $EC3$ , respectively. The last column of Figure 2 suggests that a shock in GDP does not affect any of the monthly electricity consumptions in a statistically significant fashion. However, the last row of the figure reports that a shock in  $EC3$  increases GDP growth in a statistically significant fashion. Hence, an increase in electricity consumption causes an increase in GDP lending support for the growth hypothesis. This result is parallel to the one found by Altinay and Karagol (2005); using 1950-2000 data, they too find a unidirectional causality running from electricity consumption to income for Turkey.

Here, the reason behind the difference between the two impulse responses may arise from the possibility that Figure 1 may suffer from the consequences of ignoring the availability of high frequency data. For this reason, the impulse responses of the MF-VAR model has a greater explanatory power than the impulse responses of the quarterly VAR (lower type-II error).

Next, I re-perform the analysis by adding an additional quarterly variable to the MF-VAR specification. There are two reasons to adding this second low frequency variable. Firstly, I want to see if monthly electricity consumptions affect these added variables differently than how they affect GDP. Secondly, I want to analyze if a shock in the added variable effects electricity consumption differently compared to a shock in GDP.

Figure 3 to Figure 12 reports the impulse responses of our MF-VAR model with added variables. From Figure 3, I report the impulse response estimates that concern the added variables and monthly electricity consumptions only because the rest is almost identical to Figure 2. Based on this, the first columns of Figure 3 to 12 report how a one-standard deviation shock in  $EC1, EC2, EC3$  affects the added variable. The second column of these fig-

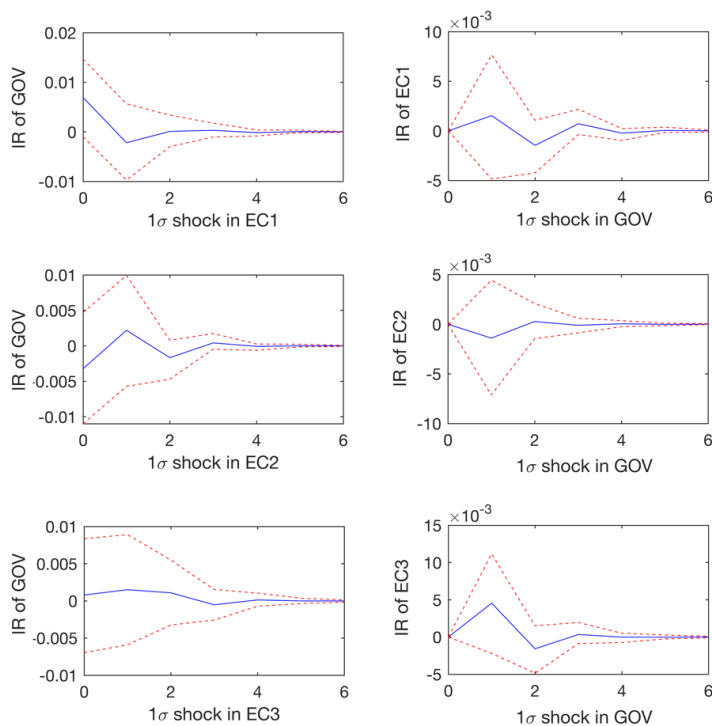
ures, on the other hand, report how a one-standard deviation shock in the added variables affects the monthly electricity consumptions. The added variables from Figure 3 to 7 are based on the expenditure approach of GDP calculation that includes Private Consumption Expenditure; Government Spending; Investment; Exports; and Imports. The added variables From Figure 8 to 12, on the other hand, are based on the production approach of GDP calculation and include Construction Sector; Industrial Sector; Manufacturing Industry; Service; and Agricultural Sector outputs.



**Figure 3: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions ( $EC1$ ,  $EC2$ ,  $EC3$ ) and quarterly Private Consumption ( $PC$ )**

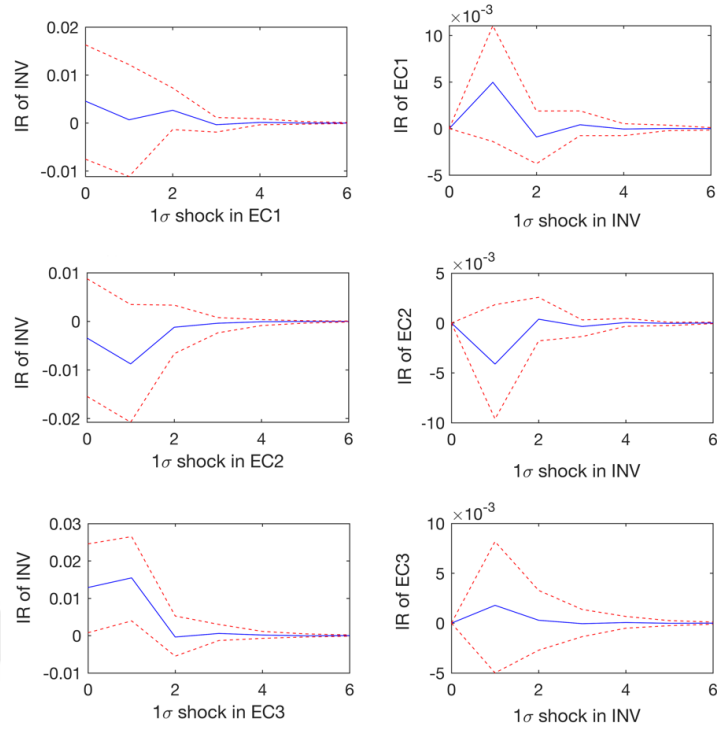
Figure 3 reports the impulse responses of Private Consumption Expenditure relative to GDP and monthly electricity consumptions. The first column of Figure 3 reports that a one-standard deviation shock in  $EC1$  and  $EC2$  do not generate statistically significant results. However, a shock in  $EC3$  increases Private Consumption Expenditure more than it increases GDP in a statisti-

cally significant fashion. The second column on the other hand, reports that a one-standard deviation shock in Private Consumption relative to GDP increases only *EC1* in the second period in a statistically significant fashion.



**Figure 4: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions (*EC1*, *EC2*, *EC3*) and quarterly Government Spending (*GOV*)**

Repeating the same exercise with Government Spending as the second low frequency variable that is placed after GDP, Figure 4 reports that impulse responses of Government Spending to a one-standard deviations shock in monthly electricity consumption and the impulse responses of monthly electricity consumption to a one-standard deviation shock in Government Spending relative to GDP are not statistically significant.



**Figure 5: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions ( $EC1, EC2, EC3$ ) and quarterly Investment ( $INV$ )**

The first column of Figure 5 reports that a one-standard deviation shock in only  $EC3$  among the three monthly electricity consumptions affect Investment relative to GDP in a statistically significant fashion. It increases Investment more than it increases GDP as it can be seen for the first period. This implies that generating more electricity to Investment will have a positive affect in GDP. The second column on the other hand, reports that a one-standard deviation shock in Investment relative to GDP does not generate statistically significant impulse responses of monthly electricity consumptions.

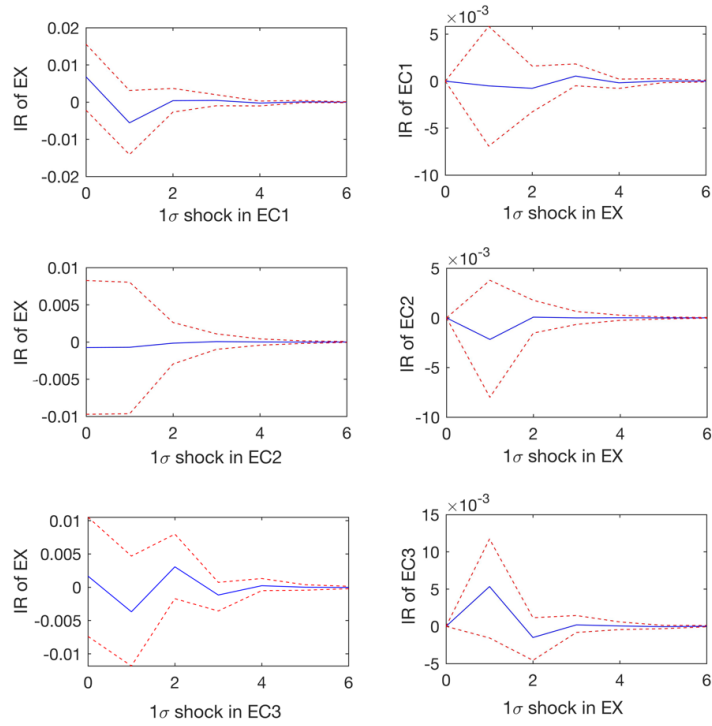


Figure 6: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions ( $EC1, EC2, EC3$ ) and quarterly Exports ( $EX$ )

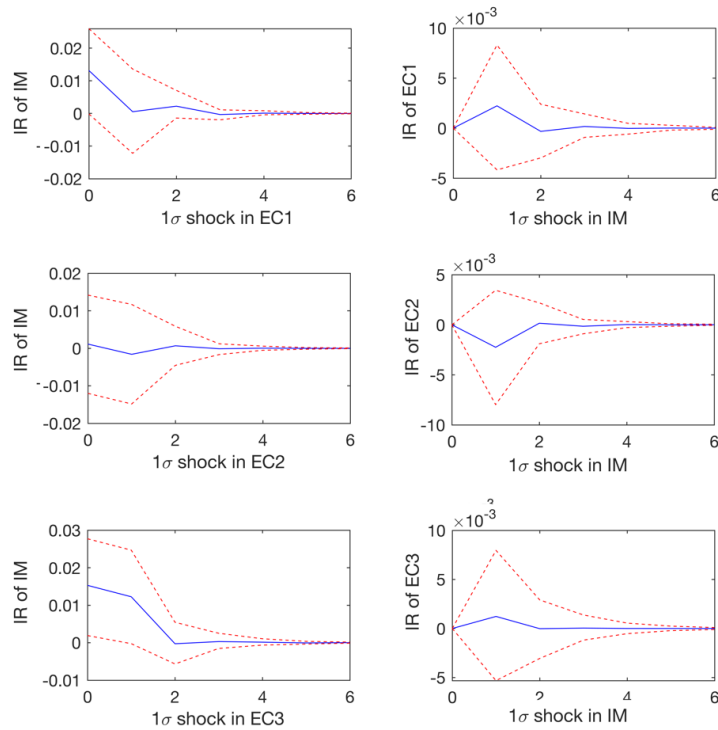
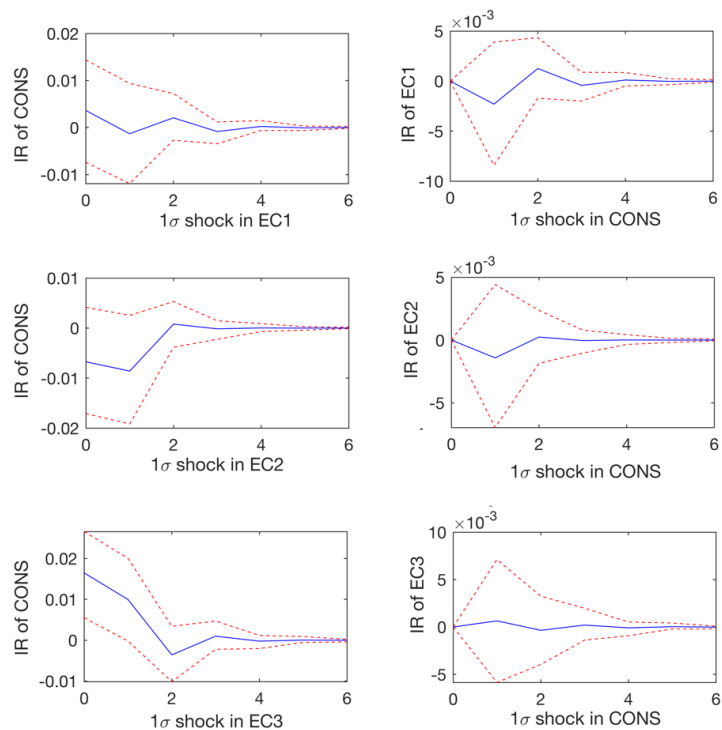


Figure 7: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions ( $EC1, EC2, EC3$ ) and quarterly Imports ( $IM$ )

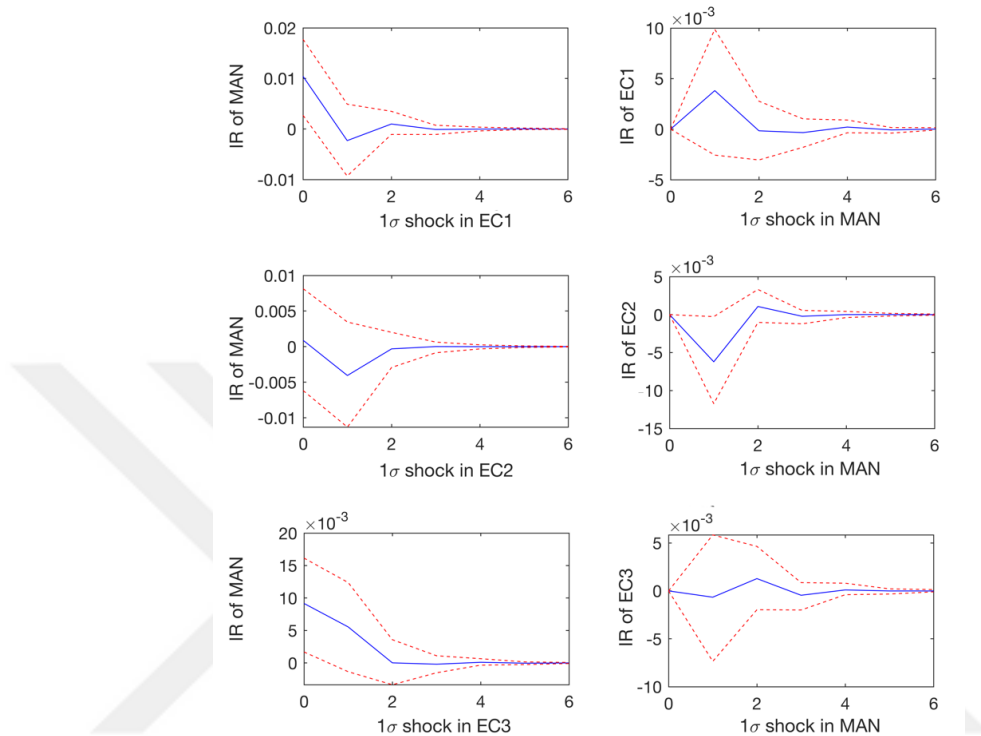
Replacing the second low frequency variable with Exports, Figure 6 reports that neither of the responses are statistically significant. However, when I take Imports relative to GDP as the second low frequency variable it is evident that a one-standard deviation shock in  $EC3$ , which is the only shock that generates statistically significant results in Figure 7, increases Imports more than it increases GDP. The second column of both figures show that neither a shock in Exports nor Imports relative to GDP have a statistically significant affect on monthly electricity consumptions.



**Figure 8: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions ( $EC1$ ,  $EC2$ ,  $EC3$ ) and quarterly Construction Sector output ( $CONS$ )**

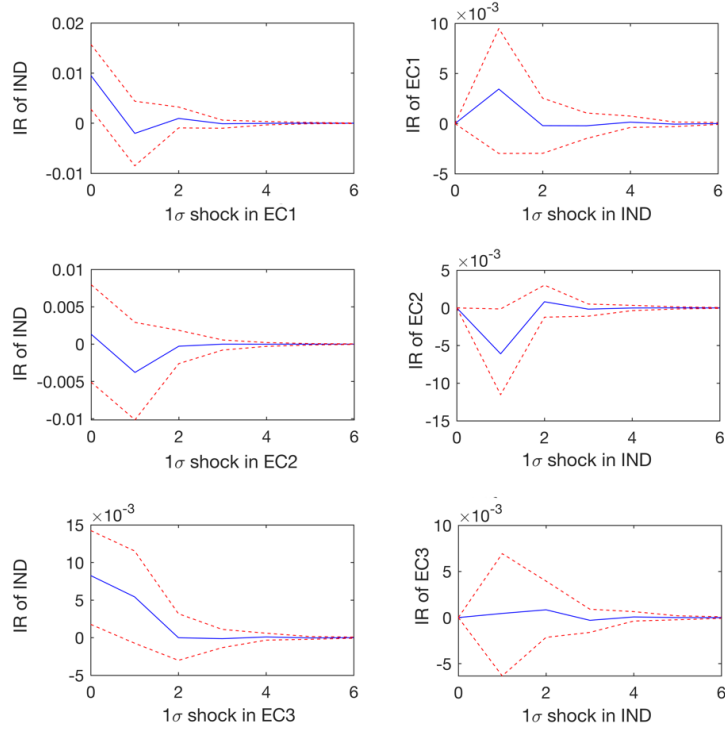
Figure 8 on the other hand reports the impulse responses of the monthly electricity consumptions and Construction Sector output relative to GDP. The first column reports a shock in  $EC1$  and  $EC2$  does not affect Construction Sector output relative to GDP in a statistically significant fashion. However, a shock in  $EC3$  increases Construction Sector output more than it increases GDP in

a statistically significant way. For the impulse responses of the electricity consumption to a one-standard deviation of the added variables, I was not able to find any statistically significant results for Figures 8 to 12.



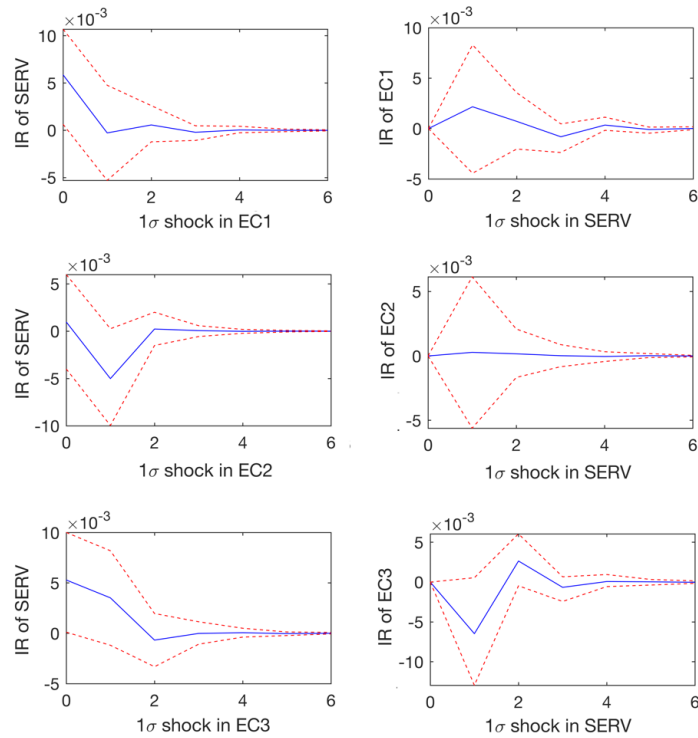
**Figure 9: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions ( $EC1$ ,  $EC2$ ,  $EC3$ ) and quarterly Manufacturing Sector output ( $MAN$ )**

Figure 9 shows the impulse response functions with the Manufacturing Industry output, ( $MAN$ ) as the second low frequency variable. The first column of the figure reports that the response of  $MAN$  relative to  $GDP$  to a shock in  $EC2$  is not statistically significant. However, a shock in  $EC1$  and  $EC3$  increases Manufacturing Sector output relative to  $GDP$  in a statistically significant fashion. Hence, an increase in electricity consumption increases manufacturing sector output more than it increases  $GDP$ .



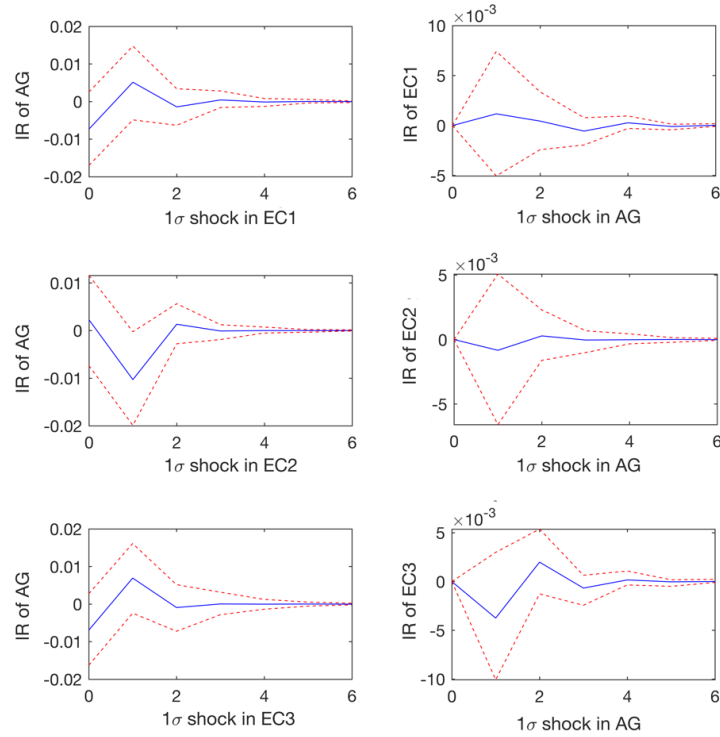
**Figure 10: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions ( $EC1, EC2, EC3$ ) and quarterly Industrial Sector output ( $IND$ )**

Replacing the last variable in the model with Industrial Sector output, ( $IND$ ) the first column of Figure 10 reports the impulse responses of industrial sector output relative to GDP to a shock in monthly electricity consumptions. Based on the Distribution of net electricity consumption by sectors statistics of TUIK, the sector that consumes electricity the most is the Industrial sector. For this reason, I expect its relation with electricity consumption to be strong. Based on the first column of Figure 10 it is evident that a shock in  $EC2$  does not generate statistically significant results. However, a shock in  $EC1$  and  $EC3$  increases Industrial Sector output relative to GDP in a statistically significant fashion. This in turn means that an increase in electricity consumption increases Industrial Sector output more than it increases GDP.



**Figure 11: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions ( $EC1, EC2, EC3$ ) and quarterly Service Sector output ( $SERV$ )**

In Figure 11, I take Service Sector output as the second low frequency variable. Looking at the first column of this figure, we see that shocks to  $EC1$  and  $EC3$  increases Service Sector output more than they increase GDP. A shock in  $EC2$  does not generate any statistically significant impulse responses in the added variable.



**Figure 12: Impulse Response Functions based on the MF-VAR(1) model of monthly Electricity Consumptions ( $EC1, EC2, EC3$ ) and quarterly Agricultural Sector output ( $AG$ )**

Figure 12 reports the impulse responses of monthly electricity consumption and Agricultural Sector output relative to GDP. Different from the previous results, this figure reports that in the first period an increase in  $EC2$  increases Agricultural sector output less than it increases GDP which is the only statistically significant result in this table.

## CHAPTER 4

### CONCLUSION

In this study, I investigated the relationship between electricity consumption and GDP growth as well as the relationship between electricity consumption and relative growth of GDP's components to GDP for the Turkish economy. When I used a conventional quarterly VAR model, I could not find a statistically significant relationship between quarterly electricity consumption and quarterly GDP growth with the impulse response analysis. However, when I adopted the Mixed Frequency VAR specification with monthly electricity consumption and quarterly GDP I found that an increase in electricity consumption increases GDP growth.

Continuing to use MF-VAR model but with an added low frequency variable, I found that an increase in electricity consumption increases Private Consumption, Investment, Imports more than a positive shock in electricity consumption increases GDP. Similarly, an increase in electricity consumption increases Construction sector output, Manufacturing sector output, Industrial sector output and Service sector output more than a positive shock in electricity consumption increases GDP. Different from these results, I found that an increase in electricity consumption increases Agricultural sector output less than it increases GDP. One of the reasons behind this difference may be due to the fact that Construction, Manufacturing, Industrial and Service sectors are more cap-

ital intensive when compared to the Agricultural sector. Hence, their electricity consumptions are higher. Second reason may be the farmers in Turkey stick to more traditional tools instead of using electricity dependent agricultural machines to improve crops, livestock, fishery and forestry or they use diesel fuel dependent machines rather than electricity dependent ones in the Agricultural sector especially when the Turkish government gives subsidies to this sector for diesel fuel from time to time.

Looking at the effect of a shock in the added variable on electricity consumption, on the other hand, I could not find a statistically significant result except for the effect of a shock in Private Consumption on electricity consumption. The estimation suggests that a positive shock in Private Consumption increases electricity consumption.

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