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A NEW LOOK AT THE RELATIONSHIP BETWEEN AVIATION DEMAND AND ECONOMIC GROWTH: STRUCTURAL MODEL ESTIMATION FOR THE CASE OF TURKEY

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Abstract

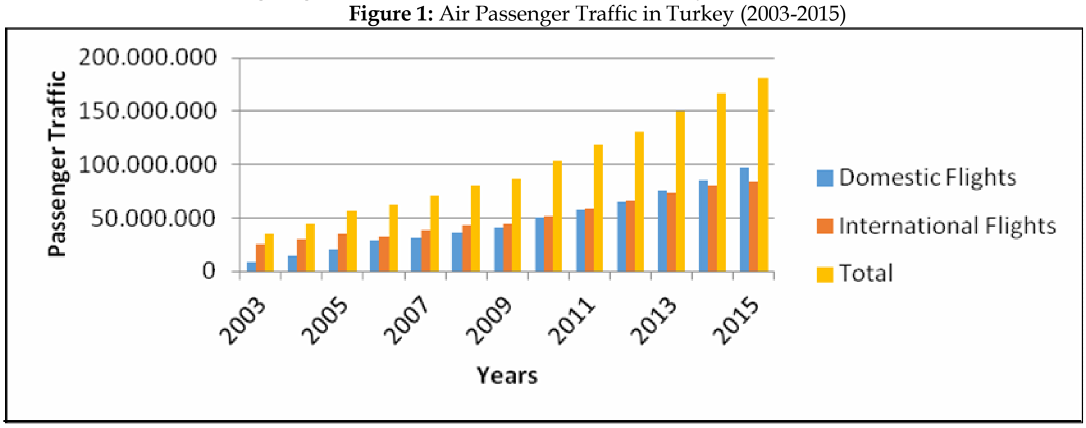
This study aims to consider the relationship between aviation demand and economic growth in an empirical way. For this purpose, the Turkish data are used in light of the advances in time series estimation techniques. The results reveal that cointegration between the variables cannot be rejected. Aviation demand is found like a luxury good and economic growth tend to act as a constraint on demand conditions. Further, a positive real income shock in a structural vector error correction framework leads nearly one-to-one significant response in aviation demand. The forecast error variance decomposition findings give support to these results.

Keywords: Economic Growth, Aviation Demand, SVEC, Impulse-Response Function, Granger Causality, Variance Decomposition, VAR.

1. INTRODUCTION

An important aspect of economic growth is the increasing demand for services. The transportation sector, in this sense, fulfills one of the needs mostly required by economic agents. Such a tendency also validates for Turkey as a developing country. The main trends in the aviation sector indicate a huge volume of transactions mainly due to the high quality, security and fastness of these services. Especially, for the post-2000 period, this is an explicit stylized fact witnessed by the Turkish economy. For instance, the number of aircrafts increased by %233, seat capacity rose by % 264, cargo capacity pushed up by %502, and the number of flying destinations reached to 341 (Directotate General of Civil Aviation, 2016: 25). Figure 1 give some other data realizations that highlight this issue of interest in recent years.

Figure 1: Air Passenger Traffic in Turkey (2003-2015)



The figure above gives further evidence with respect to the fast development in this sector. It is easy to notice that there has been an ever-increasing trend in total air passenger traffic. As the sub-determinants, both the domestic and the international flights have a similar pattern acting together. Thus, this preliminary search provides us an insight dealing with the course of aviation demand in Turkey.

In the related literature, we see that there exist a limited number of studies that examine the linkages between aviation and economic growth. Marazzo (2010) tests the relationship between aviation demand and gross domestic product (GDP) for Brazil. Using the data from 1966 to 2006 in a vector autoregressive (VAR) framework, a long-run equilibrium is found between the two variables and a uni-directional causality running from GDP to aviation demand is observed in a positive manner. Thus, economic growth seems to retain valuable information to forecast air transport demand. Impulse-response functions support these findings in the sense that aviation demand reacts positively to the change in GDP. Zhang and Zhu (2011) examine the relation between air transportation and GDP for the case of Chine between 1990-2009. The

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results obtained from the time series techniques and causality analyses indicate that economic growth substantially promote the civil aviation growth in the long-run. However, the development of civil aviation has a catalytic role on economic growth. Likewise, Sun and Li (2011) carry out an empirical analysis between air transport industry and economic growth in China for the 1978-2009 period. There seems to be a strong correlation between these indicators, and economic growth has a significant role in improving the development of air transport industry. Air passenger contributes more to economic growth than air cargo, but a structural change happens after civil aviation reform in 2002 that leads air cargo to have a more prominent role on economic growth. Chi and Baek (2013) examine the short- and long-run effects of economic growth and some market shocks on air passenger and freight services for the case of US economy. The so-called market shocks are represented by 9/11 terrorist attacks, Iraq war, SARS epidemic and 2008 financial crisis. For the 1996-2011 period in an autoregressive distributed lag (ARDL) framework of cointegration, the study finds that air passenger and freight services tend to increase with economic growth in the long-run. But, in a short-run perspective, only air passenger service is responsive to economic growth. Mehmood et al. (2013) search for interactions between aviation demand and economic growth for India by means of causality analyses, graphic methods and variance decomposition estimates. Results from the 1970-2012 period reveal a cointegration relationship between aviation demand and economic growth, and it is found that economic growth reacts strongly to the shocks in aviation demand. Hu et al. (2015) investigate the domestic air passenger traffic and real economic growth in China by using heterogeneous panel models. For the 2006-2012 period, they find a unidirectional short-run causality from air passenger traffic to real economic growth, but a reverse causality cannot be observed. Cointegration between these indicators cannot be rejected. There are also regional studies on this subject such as Baker et al. (2015). They examine the relation between regional air transportation and economic growth by using 88 airports data in Australia and find a strong mutual relation between these indicators.

Our paper aims to implement this task in light of contemporaneous time series estimation techniques. The outline of the paper can be summarized as follows. The next section deals with some methodological issues used for estimation purposes. Section 3 introduces the data and questions the validity of stationary relationships between the variables. Based on these findings, some causality analyses are carried out in section 4. Section 5 is devoted to the dynamic nature of the model and reports briefly the structural vector error correction (SVEC) innovation accounting estimates. Section 6 summarizes the results and concludes the paper.

2. METHODOLOGICAL BASE

The study tries to utilize the system approach of Johansen (1995) with the maximum likelihood estimation to see the rank condition of the model. In this procedure, it is searched for a long-run coefficient matrix of a reduced rank $r > k$, and $k \times r$ matrices α and β with rank r are examined such that $\Pi = \alpha\beta'$. Here, $\beta' y_t$ is a $I(0)$ process where y_t is endogenous variable vector in a VAR model, β cointegrating vector(s), and α adjustment parameter(s) with respect to a disturbance in the stationary equilibrium relationship. The cointegrating vectors are estimated by using two likelihood test statistics known as maximum eigenvalue for the null hypothesis of r versus the alternative of $r+1$ and trace for the null hypothesis of r against the alternative of n cointegrating relations, for $r = 0, 1, \cdots, n-1$ where n is the number of endogenous variables. This approach enables the researcher to examine whether there exist a single or more cointegrated vector in the long-run variable space and yields information about the model based exogeneity properties of the variables with increased asymptotic properties.

Having considered the cointegration relationship, a SVEC model is employed to reveal the dynamic structure of the data. To fulfill such a purpose, the interactions between the variables are designed in line with the SVEC impulse response functions. This task requires identification of the economic relationships as shocks traced in structural impulse responses and is carried out by restricting the estimated covariance matrix in the VAR process. Some restrictions need to be imposed on the $C(1)$ matrix of long-run effects of shocks and the non-singular B matrix of contemporaneous effects of shocks. The reduced form disturbances ε_t and structural innovations u_t are associated with each other such that $u_t = B\varepsilon_t$ with the matrix of long-run effects of the u_t residuals.

$$C(1) = \beta_\perp \left(\alpha_\perp' \Psi \beta_\perp\right)^{-1} \alpha_\perp' = \beta_\perp \left(\alpha_\perp' \left(I_m - \sum_{i=1}^{p-1} \Gamma_i\right) \beta_\perp\right)^{-1} \alpha_\perp' \qquad (1)$$

Where $\alpha_\perp$ and $\beta_\perp$ are orthogonal complements of α and β, respectively: $\alpha_\perp'\alpha = \beta_\perp'\beta = 0$ and Ψ is the mean lag matrix of the VAR representation. If cointegration rank $r = 0$, this model specification is reduced to $C(1) = \Psi^{-1}$, whereas if Π matrix is of full rank when $r = n$, where n is the number of endogenous variables, all elements in y_t endogenous variable vector would be stationary in their levels and thus $C(1)$ is a null matrix. What is important here is the identification of the structural model to discern the effects of shocks from each other that requires to estimate structural innovations. The relationship between the variances of reduced form residuals and the structural innovations yields that $BB' = \Omega$, which imposes $n(n+1)/2$ independent restrictions on B. The orthogonality assumption for the structural shocks requires $n(n-1)/2$ additional zero restrictions to the off-diagonal elements for exact identification.

3. TESTING FOR COINTEGRATION

The sample period for model construction is chosen as 1980 – 2013 with annual frequency of the data. The aviation demand is represented by the variable PAX which includes the knowledge of passengers carried in air transport. The other variable GDP is used for economic growth, and for this purpose, the GDP data with constant 2005 US$s are considered. Both data are in their natural logarithms and taken from the electronic data delivery system of the World Development Indicators published by World Bank (http://data.worldbank.org/). Due to the crisis-prone nature of the Turkish economy within the sample, some dummies are created for the slump periods of the economy. These dummies enter the model in an unrestricted way not to have a long-run effect that is endogenous to the system.

$$d94_t = \begin{cases} 1, t \in [1994] \\ 0, otherwise \end{cases}, \quad d99_t = \begin{cases} 1, t \in [1999] \\ 0, otherwise \end{cases}, \quad d01_t = \begin{cases} 1, t \in [2001] \\ 0, otherwise \end{cases}, \quad d09_t = \begin{cases} 1, t \in [2009] \\ 0, otherwise \end{cases}$$

Then, some unit root tests are employed. The results from preliminary Augmented Dickey-Fuller / ADF (1981) unit root test and Perron (1997) unit root test with single endogenously determined break date in Table 1 give no evidence of stationarity in the level form. Both tests assume the null hypothesis of a unit root for the estimation process. Following the recommendation of Ng and Perron (2001), the choice of optimum lag in unit root analyses was decided on the basis of minimizing a modified version of the Schwarz information criterion.

Table 1: Unit Root Tests

ADF (1981) test	PAX		GDP	
	Intercept	intercept&trend	intercept	intercept&trend
level	1.77	-3.24	-0.20	-3.08
differenced	-7.78	-8.60	-6.26	-6.15
5% CV	-2.95	-3.55	-2.95	-3.55

Perron (1997) test	Model A (break in intercept)	Model B (break in trend)	Model C (break in intercept & trend)
PAX	-3.75	-3.65	-3.79
GDP	-4.02	-3.53	-3.96
5% CV	-5.23	-4.83	-5.59

For the lag length of unrestricted VAR model, various model selection information criterions are examined. With the maximum lag selection 4, the sequential modified LR statistics and minimized Schwarz (SC) and Hannan-Quinn (HQ) information statistics suggest to use lag order 1, while Akaike information criterion (AIC) and final prediction error (FPE) statistics minimize with lag order 2. In this paper, we choose to follow SC criterion to construct the dynamics of the model. Given these bases for the VAR model, the cointegration relationship is estimated. For this purpose, at first, the data trend and test type specifications are examined. We obtain no cointegrated relationship when a linear or quadratic data trend is assumed. Thus, the model is estimated with intercept and no trend restricted as the test type in the long-run variable space. The rank test results with 5% CVs and the cointegration statistics are given in Table 2. CVs are taken from Osterwald-Lenum (1992) and use *p*-values from MacKinnon et al. (1999). From the table, the existence of at most one cointegrating relationship cannot be rejected by both rank statistics. The adjusment coefficients indicate real income has a weakly exogenous characteristic as a forcing variable, so the normalization is carried out upon the variable PAX to give the estimated equation economic meaning. The long-run relationship between the variables is reported in Eq. 1 with asymptotic $t-$statistics beneath the coefficients.

Table 2: Cointegration Results (p-values in parentheses)

Data trend and test type: No deterministic trend & restricted constant					
H_0	Eigenvalue	Trace test 0.05 CV	Max-eigen test	0.05 CV	
$r = 0$	0.70	49.13	20.26 (0.00)	40.40 (0.00)	15.89 (0.00)
$r \leq 1$	0.23	8.73	9.16 (0.07)8.73 (0.07)9.16 (0.07)		
Unrestricted cointegrating coefficients					
PAX		GDP		C	
0.59		-1.60		50.02	
2.92		-9.31		307.53	
Unrestricted adjustment coefficients					
D(PAX)		-0.11		-0.08	
D(GDP)		-0.04		-0.01	
Cointegrating equation (standard error in parentheses)					
PAX		GDP		C	
1.0000		-2.72 (0.58)		85.17 (22.10)	
Adjustment coeficients (standard error in parentheses)					
D(PAX)		-0.06 (0.02)			
D(GDP)		-0.02 (0.02)			

$$\beta' y_t = PAX - 2.72 * GDP + 85.17 \qquad (2)$$
$$(-4.67) \qquad (3.85)$$

There exists a positive relationship between aviation demand and real income, and a 1% increase in real income leads nearly to a 2.7% increase in air passenger carried in transportation sector. This means that aviation demand is considered by economic agents like a luxury good. Additionally, 6% of the adjustment in aviation demand disequilibrium conditions to long-run equilibrium is realized within one period.

4. THE SHORT- AND LONG-RUN CAUSALITY

In this section, the possible long-run causality relationships are tested between aviation demand and real income. It is obvious that cointegration necessarily implies causality in at least one direction. For this purpose, briefly to state, long-run causality captured by the significance of error correcting term in the Johansen procedure has been examined such that:

$$\Delta PAX = \phi_i + \sum_{i=1}^{n} \gamma_{1i} \Delta GDP_{t-i} + \sum_{i=1}^{n} \eta_{1i} \Delta PAX_{t-i} + \sum_{i=1}^{n} \lambda_{1i} ECT_{t-1} + \varepsilon_{1t}$$
$$(3)$$
$$\Delta GDP = \phi_i + \sum_{i=1}^{n} \gamma_{2i} \Delta PAX_{t-i} + \sum_{i=1}^{n} \eta_{2i} \Delta GDP_{t-i} + \sum_{i=1}^{n} \lambda_{2i} ECT_{t-1} + \varepsilon_{2t}$$

For the dynamic structure of causality test, it is assumed that $\eta = 1$ for the order of autoregressive model similar to the cointegration analysis. $ECTs$ stand for the error correction term taken from the long-run cointegrating space. Error correction mechanism included in the autoregressive models gives some additional knowledge of causal relations between the variables which allow to distinguish short- and long-run causality from each other. The $Wald-$ or $F-$ tests applied to the joint significance of the sum of the lags of each explanatory variable and the $t-$ tests of the lagged error correction terms highlight us for the knowledge of Granger exogeneity or endogeneity of each dependent variable in a statistical sense. If the dependent variables can be driven by the error term yielded in the stationary cointegrating vector, this implies the existence of a long-run causal relationship. Such a finding would mean that the variable considered has not been found weakly exogenous with respect to the stationary cointegrating variable space. This can be done by testing $H_0 : \lambda_{ti} = 0$ through the $t-$ tests of the lagged error correcting terms. If the non-significance of the error correction is accepted, this means that the dependent variable responds only to short-term shocks to the stochastic environment. In this sense, the rejection of the non-significance of the differenced explanatory variables will be referred to as short-term causality. This can be done by testing the null hypothesis of the non-significance of γ_i or η_i in a statistical sense. Finally, we test jointly the non-significance of all the explanatory variables including both the differenced variables and the lagged error correcting term for the absence of Granger causality, called as "strong exogeneity of the dependent variable". The results are given in Table 3.

Table 3: Granger Causality Analysis F – type Wald Tests in a VEC Form
(Probs. in parentheses**)**

Dep. Var.	Short run dynamics		
H$_0$: there is no causal relation (source of causation is independent variables)			
	ΔPAX	ΔGDP	ECT
ΔPAX	------	3.24 (0.05)	3.86 (0.02)
ΔGDP	0.76 (0.59)	------	1.35 (0.33)
Joint tests of both short run dynamics and ECT			
Dep. Var.	H$_0$: there is no causal relation (source of causation is independent variables)		
ΔPAX	ΔGDP and ECT	3.00 (0.04)	
ΔGDP	ΔPAX and ECT	1.12 (0.42)	

Our findings imply that there exists a unidirectional causality between changes in aviation demand and real income growth, and real income growth is a Granger-cause of the changes in aviation demand. However, we cannot reject the the null hypothesis of no Granger causality from real income growth to aviation demand. The inclusion of cointegrating knowledge derived from error correcting term makes no difference in our results. Thus, it is possible to infer that changes in economic growth tend to act as a constraint on aviation demand.

5. SVEC ANALYSIS

Given the long-run nature of the model, in this sub-section, only the short-run structure of a dynamic form is tested to identify the system with contemporaneous restrictions. For this purpose, it is benefited from the exogeneity properties of the cointegration model. Due to the weakly exogenous characteristic of the real income variable, no contemporaneous impact of the variable PAX is allowed on the variable GDP. This restriction leads to exact identification of the structural VAR in a cointegrating framework. Bootstrap standard errors are given in parentheses.

Table 4: SVEC Model Short Run Identification

Estimated B matrix / Structural VAR is just identified (SEs in parentheses)
Maximum likelihood method using Amisano and Giannini (1997) scoring algorithm.
Contemporaneous zero restrictions to the off-diagonal elements $[n(n-1)/2 = 1]$

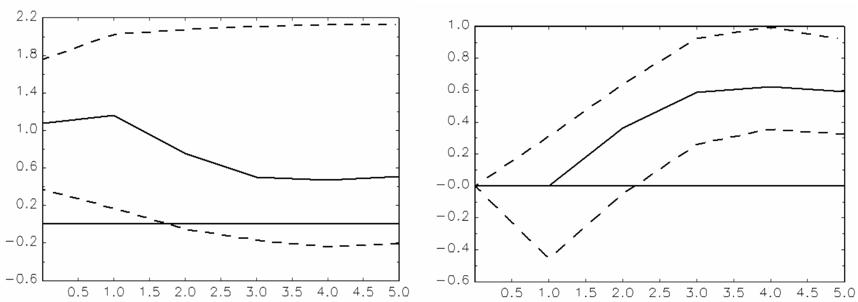
	ε_t^{PAX}	ε_t^{GDP}
PAX	1.9852 (0.5656)	1.0760 (0.4297)
GDP	0.000	1.7743 (0.6304)

It is seen that an immediate (ε_t^{PAX}) shock is resulted significantly in a positive response upon itself (of a value 1.9852). Likewise, the variable GDP reacts positively to own ε_t^{GDP} shock in a significant way (of a value 1.7743). What is more important at this point is the dynamic interaction between both variables. A positive 1% real income shock leads nearly one-to-one significant response (of a value 1.0760) in variable PAX. Let us now relate these statistics to the graphs obtained from the impulse response of the structural shocks using 95% Hall percentile confidence intervals and 2000 bootsrap replications within a horizon of 5 year. The vertical axis in Figure 2 below gives the magnitude of the impulse response shocks, while the horizontal axis is the time period forecasted in annual basis.

For the diagram (a), the confidence intervals have the same sign that recalls statistical significance nearly 2 years following the shock, while in diagram (b) this emerges nearly 2½ years later than the occurance of the related shock. These results clearly are in tandem with the cointegration findings obtained in the earlier sections. Finally, the SVEC forecast error variance decompositions are presented in Table 5.

Figure 2: SVEC Impulse → Response Functions

(a) Response of PAX to GDP (b) Response of GDP to PAX



The results indicate that the larger the sample period in the estimation process the higher the proportion of forecast error of aviation demand explained by real income. Indeed, for a forecast horizon of 20 years, the forecast error of the variable PAX accounted by real income is explained more by the variable GDP (of a value 0.54). However, proportions of forecast error in the variable GDP is explained to a much larger extent by itself. The SVEC forecast error variance decomposition findings support the exogeneity characteristic of the real income variable and the endogeneity characteristic of the aviation demand with respect to the real income for the empirical model considered in this paper.

Table 5: SVEC Forecast Error Variance Decompositions

Proportions of forecast error in 'PAX' accounted for by		
Forecast horizon	PAX	GDP
1	0.99	0.01
3	0.97	0.03
6	0.79	0.21
9	0.68	0.32
12	0.60	0.40
20	0.46	0.54
Proportions of forecast error in 'GDP' accounted for by		
Forecast horizon	PAX	GDP
1	0.23	0.77
3	0.21	0.79
6	0.13	0.87
12	0.09	0.91
20	0.08	0.92

CONCLUDING REMARKS

Since the 1980s, airline industry has grown dramatically in worldwide. With its various extensions, such as airlines, airports, ground handling services, aircraft manufacturers, the air transport sector has an important place in national economies. Aviation demand form the basis for investment decisions and allow the rotation of the wheel of the aviation industry. There are limited numbers of studies searching for the relationship between passenger demand and real income especially for emerging market economies. This paper aims to contribute to this strand of literature by conducting an empirical model for the case of the Turkish economy. Our results reveal that cointegration between aviation demand and real income cannot be rejected and that real income is found weakly exogenous within the estimation process. For the sample period, aviation demand seems to be considered like a luxury good by economic agents. Then, some causality analyses are performed by also using the stationary knowledge taken from the cointegrating vector. A unidirectional causality is found in the sense that real income growth is a Granger-cause of the changes in aviation demand. This means that economic growth is able to act as a constraint on aviation demand. Finally, the innovation accounting methods used for the dynamic nature of the model estimate that a positive real income shock leads nearly to one-to-one significant response in aviation demand. The forecast error variance decomposition findings give support to all these estimation results.

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