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ÖZGÜN ARAŞTIRMA

The Impact of Foreign Direct Investment on Innovation Performance: Evidence from a Nonlinear ARDL Approach*

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Abstract

Innovative firms have a distinct competitive advantage and foreign direct investment is an important channel for technological transfers. The aim of this study is to analyse that foreign direct investment coming into Turkey that affects innovation performance of local and foreign investors. Our analysis covers the period of 1984-2017 and the three types of patent applications (residents, non-residents and total) are used as an indication of innovation in our analysis. The nonlinear ARDL model is applied because the impact of positive and negative shocks that caused foreign direct investments on innovation performance decomposes in short and long term. Analysis results indicate that positive and negative shocks experienced FDI have a greater impact on the innovative performance of local investors than foreign investors.

Keywords: Foreign direct investments, Patent applications, Nonlinear ARDL
Jel Codes: F21, O34, C22

Doğrudan Yabancı Yatırımlarının Yenilik Performansı Üzerindeki Etkisi: Doğrusal Olmayan ARDL Yaklaşımı

Özet

Yenilikçi firmalar daha fazla rekabet avantajına sahiptir ve doğrudan yabancı yatırımlar da teknoloji transferinin önemli bir kanalıdır. Çalışmamızın amacı, Türkiye'ye gelen doğrudan yabancı yatırımlarının yerli ve yabancı yatırımcının yenilik performansı üzerindeki etkisini analiz etmektir. Analizimiz 1984-2017 dönemlerini kapsamaktadır ve analizimizde yeniliğin göstergesi olarak üç tür patent başvuru sayıları (yerleşikler, yerleşik-olmayanlar ve toplam) kullanılmıştır. Kısa ve uzun dönemde doğrudan yabancı yatırım girişlerinden kaynaklanan pozitif ve negatif şokların yenilik performansı üzerindeki etkisini ayrıştırarak analiz edebilmek için Doğrusal-olmayan ARDL Modeli kullanılmıştır. Analiz bulguları, doğrudan yabancı yatırımlardan kaynaklanan pozitif ve negatif şokların yerel yatırımcıların yenilik performansı üzerindeki etkisinin, yabancı yatırımcılara nazaran, daha fazla olduğunu göstermektedir.

Anahtar kelimeler: Doğrudan yabancı yatırımlar, Patent başvuruları, Doğrusal-olmayan ARDL
Jel Kodu: F21, O34, C22

1. INTRODUCTION

Technology and innovation capacity are one of the main factors of achieving international competitive advantage. Developed countries produce innovation and technology by allocating large funds to research and development activities. However, developing countries, whose main objectives are developmenthave to transfer existing technologies from developed countries due to insufficient physical and human capital. Thus, this transfer should be considered as a process involving the monitoring of the technological developments in the world, the selection of the technologies needed, the import of the selected technologies into the country, the process of adapting the imported technologies to the national conditions and technologies,

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and finally, the development and dissemination of these technologies (Karacasulu, 2001: 101).

Developing countries are able to transfer technology to their own countries through different channels (Damijan et al., 2003: 4). The first channel is international licensing agreements that provide a direct transfer of technology (Eaton and Kortum 1996: 26). Foreign direct investments (FDI) is the second way which allows a significant and cheap method for "direct technology transfer, indirect intra-industry and knowledge spillovers" to developing countries (Blomström and Kokko, 1997: 9). Most studies present empirical evidence on the positive effect of FDI on innovative performance of developing countries[3]. International trade, especially imports of intermediate products and capital equipment[4], is the third channel of technological transfer (besides learning by exporting to industrial countries) (Clerides et al.,1998: 35). Moreover, domestic firms can learn from the foreign goods they purchase by reverse-engineering the technological innovations embodied in these goods (Branstetter, 2006: 326). Finally, local firms can take the technological know-how of foreign firms via labor transfer from them. Labor mobility permits employees trained by the multinational enterprise to perform their knowledge in the local firm (Smeets, 2008: 114).

FDI toward host countries has a positive impact on local economy such as increasing employment, capital stock, production capacity and export as well as improving the innovation and management approach provided by technology transfer (Nur and Bilici, 2017: 19-20). Thus, countries experiencing the positive economic effects of foreign investments have started to compete for attracting FDI since 1980s. Developing countries with inadequate investment and capital-savings deficit have began to attract more FDI since 1980s, in particular. During this period, some factors increased FDI toward developing countries, such as liberalization policies, freedom for international capital flows, privatization, developments in communication and transportation technologies, securing business contracts, reducing risks aganist nationalization, regional integration and so on (Tandırcıoğlu and Özen, 2003: 107).

As stated in the related literature, foreign direct investment (FDI) is one of the crucial channels for technologicaltransfer into developing countries, specifically domestic firms in host countries (Newman et al., 2015: 170). Developing countries support FDI in order to obtain advanced technology from developed countries and, to create domestic innovation capability. Therefore, FDI can provide a method in which the technological gap between advanced and developing countries is decreased. One of the contributions of technological transfer (through direct investment to the country's economy) is to enable the production of imported products in host country, while simultaneously contributing to management knowledge and human capital (Kar and Tatlısöz, 2008: 36).

The aim of our study is to investigate whether the FDI is effective on providing technology transfer from other countries to Turkey. We assume that the FDI has a asymmetric impact on short-term and long-term technology transfer. For this purpose, we use a non-lineer econometric tecnique for analysis of the FDI impact on both local and foreign investor's techonolgy performence. However the FDI's technology transfer effect is usually analysed with lineer econometric tecniques and the impact of FDI is assumed to be symmetric for short and long-term in the local literature. Thus our study aims to contribute to the literature by using an empirically different econmetric technique than local literature.

[3]See: Globermann *et al.* (2000), Saggi (2002), Ganderberger *et al.* (2015)

[4]See: Markusen (1989), Grossman and Helpman (1991), Feenstra *et al.* (1992)

Both domestic investors and foreign investors are motivated to create innovation in the competition process with FDI for 1984-2017 periods. The patent applications number of domestic and foreign investors is employed as a proxy for technology transfer in our analysis.

The rest of the paper is organized as follows. Section 2 presents the literature review about technological transfer effect of FDI. Section 3 introduces the nonlinear autoregressive distributed lags model (NARDL). Data is introduced in Section 4.Section 5 presents the empirical results of the model. The study concludes within section 6.

2. LITERATURE REVIEW

Direct investments covers cross-border investments affecting the economic view in host countries. According to IMF definition, the owner of 10% or more of a company's capital in host countries is defined as foreign direct investments. FDI can be made in the form of equity holdings, reinvestment of earnings and other capitals. "Foreign investment is assumed to affect the domestic economy by bringing in much needed capital, new technologies, marketing techniques and management skills, and by bringing in secondary spillovers to the host economy that affects the performance of domestic firms" (Loukil, 2016: 31).

FDI is one of the basic channel leading to international technology transfer. Globermann et al. (2000), using Swedish patent data, investigate that FDI allows technology transfer for local firms. Saggi (2002) studies on whether the trade and FDI become a channel of international technology transfer. According to the result of study, foreign investors tend to make their international capital investments as FDI and so, FDI is deemed as a channel of international technology transfer. Kadah (2003) states that technological performance of host country is promoted via FDI, particularly if it takes a joint-venture form in host country. Fan et al. (2019) find that bilateral FDI increases comparative advantage through technology transfer in host and home countries.

FDI has taken over as a significant channel leading to innovation in a host country. Cheung and Lin (2004) have analyzed whether the FDI has an impact on the innovation performance of Chinese investors for 1995-2000 periods. The analysis is performed by panel data method and via three types of patent applications (invention, utility model and external design) representing innovation. They find that FDI has a positive impact on domestic patent applications, so it increases innovative performance of local investors. Chen (2007) analyses the impact of FDI on regional innovation capability (RIC) at both regional and firm level in China. The number of patent applications have been used as one of the variables representing RIC in the model. Although FDI investments enhance RIC, it does not have a huge impact on patent applications in Chinese firms. As stated in the study, this may be due to the fact that Chinese firms refrain from making patent applications to prevent information leakage. García et al. (2013) investigate the relationships between FDI and innovation performance of local firms in Spain. The evidence from the study indicates that FDI inflows into Spain do not occur ex-post innovation for Spanish firms.

In the related literature, the impact of FDI on innovation targets the technology performance of developing countries, because it is thought that FDI decreases the technology gap between developed and developing countries. Yıldız (2017) finds that FDI has a significant impact on innovation transfer in developing countries. Kinoshita (2000) studies on FDI's innovative impact on the Czhec manufacturing firms and finds that FDI has a positive innovative effect in electrical machinery and radio/TV sectors. Loukil (2016) investigates the non-linear relationship between FDI and innovation in developing countries and she finds a threshold value. She concludes that the development of economic policies for foreign investment is not enough for the FDI effect on innovation performance of developing countries. Arun and Yıldırım (2017) have analyzed whether foreign direct investments have created an innovation performance in Azerbaijan, Georgia and Turkey' economies. According to the results of analysis, the effect of FDI on innovation differs with regard to the countries. Thus, FDI is an important determinant for economic innovation level with Azerbaijan and Georgia, but it does not affect the Turkey's economic innovation level. Demir et al. (2018) analyzed the economic, social and political factors along with the transfer of technology, which affect foreign direct investments. The transfer of technology and economic factors impact foreign direct investments more effectively according to the findings of the authors. And foreign direct investments impact the transfer of technology, as well.

3. EMPIRICAL MODEL

In the literature, an error correction mechanism is employed to analyze how the variables with first degree integration will return to their long-term steady-state equilibrium after the deviations from short-term equilibrium (Granger 1981, Engle and Granger 1987). The Linear Error Correction Model (ECM) is expressed as follows:

$$\Delta Patent_t = \mu + \rho_{patent} Patent_{t-1} + \rho_{DYY} DYY_{t-1} + \sum_{i=1}^{p-1} \alpha_i \Delta Patent_{t-i} + \sum_{i=0}^{q-i} \beta_i \Delta DYY_{t-i} + \varepsilon_t \qquad (1)$$

Equation 1 is the linear Autoregressive Distributed Lag (ARDL) model which shows the linear and symmetrical relationship between the number of patents applications and foreign direct investments in the short term. In the linear ARDL Model, the variables may have cointegration between positive and negative values, even if they do not have a cointegration between themselves. This was expressed as "hidden correlation" by Granger ve Yoon (2002). Shin et al. (2014) based on this statement, in order to analyze the short and long-term asymmetric relationships between the variables, they first used the sum of the positive and negative changes of the variables:

$$DYY^+ = \sum_{j=1}^{t} \Delta DYY_j^+ = \sum_{j=1}^{t} \max(\Delta DYY_j, 0) \quad \text{ve} \quad DYY^+ = \sum_{j=1}^{t} \Delta DYY_j^+ = \sum_{j=1}^{t} \max(\Delta DYY_j, 0) \qquad (2)$$

In the Shin et al. (2014) model, the positive and negative changes can decompose via equation 2. Therefore, it is possible to examine whether the increase and decrease in the foreign direct investments have an asymmetric effect on the number of patents applications.

$$\Delta Patent_t = \mu + \rho_{patent} Patent_{t-1} + \theta^+ DYY_{t-1}^+ + \theta^- DYY_{t-1}^- + \sum_{i=1}^{p-1} \alpha_i \Delta Patent_{t-i} + \sum_{i=0}^{q-i} (w_i^+ \Delta FDI_{t-i}^+ + w_i^- \Delta FDI_{t-i}^-) + \varepsilon_t \qquad (3)$$

Equation 3 is a Non-Linear ARDL Model which shows the effects of asymmetry in short and long-term. Positive and negative partial disaggregations in equation are represented by plus and minus signs above the variables. The lags of dependent and independent variables are shown with p and q, respectively. The findings for the presence of asymmetric relationship are obtained with the Wald Test. According to this test, the rejection of the null hypothesis expressing the existence of symmetric relationship in the long term ($\theta^+ = \theta^-$) shows that there is an asymmetric relationship between the number of patent applications and foreign direct investments in the long term. Short-term error correction coefficients in equation are represented by w_i^+ and w_i^-. In the short term, the findings of the symmetry between the number of patents applications and foreign direct investments are also presented by the Wald Test. If the null hypotesis expressing the existence of symmetric relationship in the short term ($w_i^+ = w_i^-$) is rejected, it is concluded that there is an asymmetric relationship between these variables in the short term. According to the results of Wald Test, if there is a symmetric relationship between the number of patent applications and foreign direct investments in both short and long-term, then equation 3 becomes the equation 1 which is traditional ARDL Model. If there is a symmetric relationship in the short-term, while an asymmetric relationship in long term between the number of patent applications and foreign direct investments, the equation 3 is expressed as follows:

$$\Delta Patent_t = \mu + \rho_{patent} Patent_{t-1} + \theta^{+} DYY_{t-1}^{+} + \theta^{-} DYY_{t-1}^{-} + \sum_{i=1}^{p-1} \alpha_i \, \Delta Patent_{t-i} + \sum_{i=0}^{q-i} (w_i \, \Delta DYY_{t-i}) + \varepsilon_t \qquad (4)$$

According to the results of Wald Test, if the asymmetric relationship in the short-term and the symmetric relationship in the long-term between the number of patent applications and foreign direct investments is obtained, the equation 3 becomes as follows:

$$\Delta Patent_t = \mu + \rho_{patent} Patent_{t-1} + \rho_{DYY} DYY_{t-1} + \sum_{i=1}^{p-1} \alpha_i \, \Delta Patent_{t-i} + \sum_{i=0}^{q-i} (w_i^{+} \, \Delta FDI_{t-i}^{+} + w_i^{-} \Delta FDI_{t-i}^{-}) + \varepsilon_t \qquad (5)$$

The asymmetric response to the number of patent applications in the face of a one-unit positive (FDI_t^{+}) and negative (FDI_t^{-}) shock resulting from foreign direct investments is calculated through the positive and negative "Asymmetric Dynamic Accelerator":

$$m_h^{+} = \sum_{j=0}^{h} \frac{\partial PATENT_{t+j}}{\partial DYY_t^{+}} \quad ve \quad m_h^{-} = \sum_{j=0}^{h} \frac{\partial PATENT_{t+j}}{\partial DYY_t^{-}} \quad h=0,1,2,.. \text{ için} \qquad (6)$$

When $h \to \infty$, $m_h^{+} \to L_{DYY^{+}}$ and $m_h^{-} \to L_{DYY^{-}}$. In other words, in the long-term, the asymmetric dynamic accelerator variables converge positive and negative asymmetric long-term coefficients. Then the result of a shock to the system, how long the number of patents and foreign direct investments will return to the steady state equilibrium can be calculated via the asymmetric dynamic accelerator variables.

4. DATA

Our study analyzes whether the foreign direct investments (FDI) coming to Turkey create technological innovation between the periods of 1984-2017. The patent applications of resident and non-resident and, the sum of the both type of patent applications are used for measuring the technological transfers to Turkey. However, patent application numbers does not show the quality and the potential technology transfer to Turkey in the further periods. Thus, patent citiations also can be better measure for the quality of technological transfer and new value added of patents. Nevertheless, there is not patent citiations data of Turkey, hence we use the patent application numbers following the related literature. FDI also contain inward flows. Patent applications data are downloaded from WorldBank and FDI data are collected from Coordinated Direct Investment Survey (CDIS) database in IMF.

Descriptive statistics and stability analyzes of the data used in the our analysis are checked before analyzing to the NARDL model. The descriptive statistics can be seen in the table below.

Table 1: Descriptive Statistics

	FDI	*Residents Patent Applications*	*Non-Residents Patent Applications*	*Total Patent Applications*
Mean	0.1384	0.1123	0.0098	0.0737
Median	0.0581	0.1185	0.0308	0.1281
Standard Deviation	0.5062	0.1580	0.3827	0.2717
Skewness	0.2150	-0.0206	-1.8131	-1.5224
Kurtosis	3.8840	3.351	7.3382	6.0003
Observations	31	31	31	31

The skewness value of the series has positive value for FDI, but it is negative for three types of patent applications (residents, non-residents and total), in otherwords, FDI has a positive asymmetric distribution and three types of patent application shave a negative asymmetric distribution. Therefore, positive shocks on FDI are more effective than negative shocks while negative shocks have stronger effect than positive shocks on three types of patent applications. The kurtosis value of the all series is grater than 3. All series show "fat tail" characteristic. Our series also are named "leptokurtic series".

5. EMPIRICAL RESULTS

Non-stationary series cannot reach equilibrium in the long term and ignoring this problem in the model causes biases on the relationship between the variables. Therefore, unit root tests of foreign direct investments and patent applications (resident, non-resident total) are performed. By definition, the series containing the unit root is not stationary. The existence of the unit root in our variables are tested through ADF, PP, KPSS. The test results can be seen in table 2.

Table 2: ADF, PP and KPSS unit-root test results

Variables	*ADF*	*PP*	*KPSS*	*LEVEL*
FDI	-5.5700* (0)	-5.6000*(4)	0.1500*(5)	I(0)
Residents Patent Applications	-5.3870*(0)	-5.5727*(4)	0.3599*(4)	I(0)
Non-Residents Patent Applications	-3.7578* (0)	-3.7490* (2)	0.1132*(3)	I(0)
Total Patent Applications	-4.3586* (0)	-4.3792* (1)	0.0752*(0)	I(0)
Observations	31	31	31	31

Note: *, **and*** stand for the significance level 1%, 5% and 10% respectively. Values in parentheses show the appropriate number of lags.

The null hypothesis of ADF and PP test the existence of unit root in the series. However, the null hypothesis of KPSS tests that the series are stationary, that is, the series have not unit root. Our series have not unit root at level, in other words, the null hypothesis is rejected for level series indicating that all variables are stationary at level according to ADF, PP and KPSS tests results.

Economic time series generally include the effect of crisis or structural changes. Standart unit root tests do not consider structural breaks in time series. Zivot-Andrews test consider structural breaks in series and breakpoint years are determined endogenously in the test. The null hypothesis of Zivot-Andrews tests "variable has a unit root with a structural break". If test statistic is small than critical value, the null hypothesis of test is rejected.

Table 3: Zivot-Andrews unit-root test results

Variables		Model A		Model B		Model C	
FDI	*Test Statistics*	-5.9940 (2)		-5.7183 (2)		-6.0660 (2)	
	Break-point year	2001		2006		2004	
Residents Patent Applications	*Test Statistics*	-2.8094 (3)		-3.9131 (3)		-4.1050 (3)	
	Break-point year	2010		2008		2007	
Non-Residents Patent Applications	*Test Statistics*	-4.7012 (1)		-4.4795 (1)		-5.6432 (1)	
	Break-point year	2001		2004		2002	
Total Patent Applications	*Test Statistics*	-5.0095 (2)		-4.4159 (2)		-4.9102 (2)	
	Break-point year	2005		2003		2005	
Critical Values		1%	5%	1%	5%	1%	5%
		-5.34	-4.93	-4.80	-4.42	-5.57	-5.08
Observations		31	31	31	31	31	31

Note: Model A, Model B and Model C stand for intercept breakpoint, trend breakpoint and intercept-trend breakpoint, respectively.Values in parentheses show the number of lags.

Table 4: The results of short-term and long-term symmetry

	Long Term W_{LR}	***Short Term W_{SR}***	***Results***
FDI_resident	5.454** (0.031)	0.9061 (0.353)	NARDL with long-term asymmetry
FDI_nonresident	0.0066 (0.936)	7.403 ** (0.014)	NARDL with short-term asymmetry
FDI_total	0.5358 (0.473)	6.523** (0.019)	NARDL with short-term asymmetry
Observations	31	31	

Note: The estimations based on equation 3. W_{SR} and W_{LR} stand for Wald Test statistic testing short-term symmetry ($w_i^+ = w_i^-$) and long-term symmetry ($\theta^+ = \theta^-$), respectively. *, ** and *** show that the null hypotheses are rejected at 1%, 5% and 10% significance levels, respectively.

As can be seen from Table 3, there is strong evidence aganist unit root hypothesis with structural break for three types of patent applications. For three types of patent applications series, the unit root hypothesis is rejected at 5% and 1% significance levels, respectively. However, FDI series has unit root with structural break at 5% and 1% significance levels.

The result of short-term and long-term symmetrypresented atthe Table 4 and Table 5. Firstly, the existence of short-term and long-term symmetry is examined with the Wald Test and the results are shown in Table 4.

According to Wald Test results, there is a long-term asymmetric relationship between FDI and patent applications of residents and short-term asymmetric relationship between FDI and patent applications of nonresident and total applications. That is, if FDI input flows increase (positive shock) or decrease (negative shock), these shocks in FDI impact on asymmetrically patent applications of resident in the long-term. Conversely, a positive or negative shock on FDI have influence asymmetrically on patent applications of nonresident and total applications in the short-term.

Based on the result of Wald test in Table 4, we now estimate the best model for each type of patent applications. These models are shown in Table 5. Firstly, it seems that there is no autocorrelation and heteroscedasticity issues present in three models. Therefore when t_BDM and F_PSS statistics compare with critical values, the null hypothesis expressing the absence of symmetric co-integrated relationship is rejected for three models. So it can be inferred that there is an asymmetric co-integrated relationship between FDI and three types of patent applications in the long-term.

Table 5: Estimation of the asymmetric effects on patent applications

Patent Applications Of Resident- FDI		Patent Applications of Non-Resident-FDI		Patent Applications of Total- FDI	
(1)		(2)		(3)	
$President_{t-1}$	-0.2831** (0.017)	$Pnonresident_{t-1}$	-0.1592 (0.141)	$Ptotal_{t-1}$	-0.310** (0.037)
FDI^+_{t-1}	0.1681* (0.002)	FDI^+_{t-1}	-0.0463 (0.707)	FDI^+_{t-1}	0.0546 (0.566)
FDI^-_{t-1}	-0.0144 (0.928)	FDI^-_{t-1}	-0.0595 (0.830)	FDI^-_{t-1}	-0.0382 (0.870)
$\Delta President_{t-1}$	-0.1527 (0.362)	$\Delta Pnonresident_{t-1}$	0.0628 (0.777)	$\Delta Ptotal_{t-1}$	0.1453 (0.499)
ΔFDI^+_t	0.1786** (0.036)	ΔFDI^+_t	-0.1828 (0.362)	ΔFDI^+_t	-0.1012 (0.481)
ΔFDI^+_{t-1}	-0.0429 (0.571)	ΔFDI^+_{t-1}	-0.2242 (0.251)	ΔFDI^+_{t-1}	-0.1653 (0.273)
ΔFDI^-_t	-0.0792** (0.0483)	ΔFDI^-_t	0.5220 (0.3114)	ΔFDI^-_t	0.4028 (0.109)
ΔFDI^-_{t-1}	0.0114(0.937)	ΔFDI^-_{t-1}	0.8214** (0.030)	ΔFDI^-_{t-1}	0.4446*** (0.099)
Constant	1.1246** (0.044)	*Constant*	1.4875*** (0.071)	*Constant*	2.3101** (0.032)
L_{FDI^+}	0.594** (0.041)	L_{FDI^+}	-0.291 (0.701)	L_{FDI^+}	0.176 (0.595)
L_{FDI^-}	0.051 (0.926)	L_{FDI^-}	0.374 (0.831)	L_{FDI^-}	0.123 (0.867)
Observations	31	**Observations**	31	**Observations**	31
B-G (12)	0.9386	**B-G (12)**	0.8936	**B-G (12)**	0.9626
ARCH(12)	0.8585	**ARCH(12)**	0.6178	**ARCH(12)**	0.1565
t_BDM	-2.6142	**t_BDM**	-1.5361	**t_BDM**	-2.2405
F_PSS	7.5046	**F_PSS**	1.0071	**F_PSS**	2.3138

Note: In table $L_{DYY^+} = -\theta^+/\rho_{Patent}$ ve $L_{DYY^+} = -\theta^+/\rho_{Patent}$ are long-term asymmetric coefficients. The Breusch-Godfrey is autocorrelation test with 12 lags and this test stands for B-G(12). ARCH (12) refers to test for conditional heteroscedasticity applied to 12 lags. t_BDM and F_PSS tests of Peseran, Shin and Smith (2001) are cointegration tests and they have the critical value (t=-3.22 and F=5.73) for k=1 at 5% significance level. *,** and *** stand for the significance levels at 1%, 5% and 10%, respectively.

The asymmetric long-term effect of the FDI on patent applications of resident is seized by the coefficients related to L_{FDI^+} and L_{FDI^-}. The long-term positive asymmetry coefficients (L_{FDI^+}) is significance at 1% and conversely, the long-term negative asymmetry coefficients (L_{FDI^-}) is not significance. This means that remaining FDI flows to Turkey increase patent applications of local investors in the long-term. Furthermore, when FDI flows increase by 1%, patent applications of residents go up by 0.59% in the long-term. In the short-term, the asymmetric effect is shown by ΔFDI_t^+ ,ΔFDI_t^- ,ΔFDI_{t-1}^+ and ΔFDI_{t-1}^-coefficients. Both of coefficients are significant at 5%. Thus the positive shock of FDI causes to increase the patent application of residents (positive sign of the ΔDYY_t^+ coefficient), but the negative shock of FDI induces to reduce the patent applications of local investors (negative sign of the ΔFDI_t^- coefficient), in the short-term.

Second column of Table 5 shows the impact of FDI on the patent applications of non-residents investors. In the long-term, it seems that the FDI does not rely on innovative effect on foreign investors. However, while FDI is reducing, patent applications of non-resident increase in the short-term. If FDI decreases at 1%, patent applications of non-resident increase by 0.82%. Similarly, final column of Table 5 shows the FDI effect in sum. Total patent applications are sum of the resident and non-resident patent application numbers. The result of final model indicates that total patent applications are not affected by FDI into Turkey in the long-term. Nevertheless, negative shock coefficients (ΔFDI_{t-1}^-) are statistically significance at 10% for the short-term. Total patent applications increase by 0.44% when FDI decreases by 1% in the short-term.

CUSUM and CUSUMQ tests are applied for stability of the estimated models for patent numbers. CUSUM tests are based on cumulative calculation of error terms while CUSUMQ tests are calculated based on the square of error terms. CUSUM and CUSUMQ tests are calculated at 5% significance level for n observations. The test results can be seen in Figure 1. When the figures are examined, there are no observations outside the confidence interval. Therefore, we can be said that the calculated models are stable for the analyzed period.

On the other hand, the partial responses of patent applications against positive and negative foreign direct investment shocks are measured using the "Asymmetric Dynamic Accelerator" approach. Figure 2 shows the response of patent applications of residents to the shocks caused by FDI.

According to Figure 2, the patent applications of residents show a positive response to positive and negative shocks caused by FDI. Therefore Figure 1 indicates that positive shocks in FDI are more effective on the patent applications of residents than negative shocks. After approximately 2 periods (2 years), the asymmetric impact of a shock stemming from FDI on the patent applications of residents ends and the patent applications of residents reach a long-term steady-state point. The blue curve indicating the asymmetric effect moves over the curves representing the positive and negative shocksbecause the positive and negative shocks of FDI increase the patent application of residents.

The response of patent applications of non-residents to the shocks of FDI are shown in Figure 3.

Figure 3 shows that the negative shocks caused by FDI bring about a positive response of patent applications of non-residents while the patent applications of foreign investors has a negative response to positive shocks in FDI. Moreover the effect of negative shocks on patent applications of foreign investors is stronger than the effect of positive shocks in FDI. Thus the asymmetry curve is between the curves representing a positive and negative shocks of FDI. The asymmetric impact of a shock originating from FDI on the patent application of foreign investors ends and the patent applications of non-residents attain a long-term steady-state equilibrium station, after approximately 3 periods (3 years).

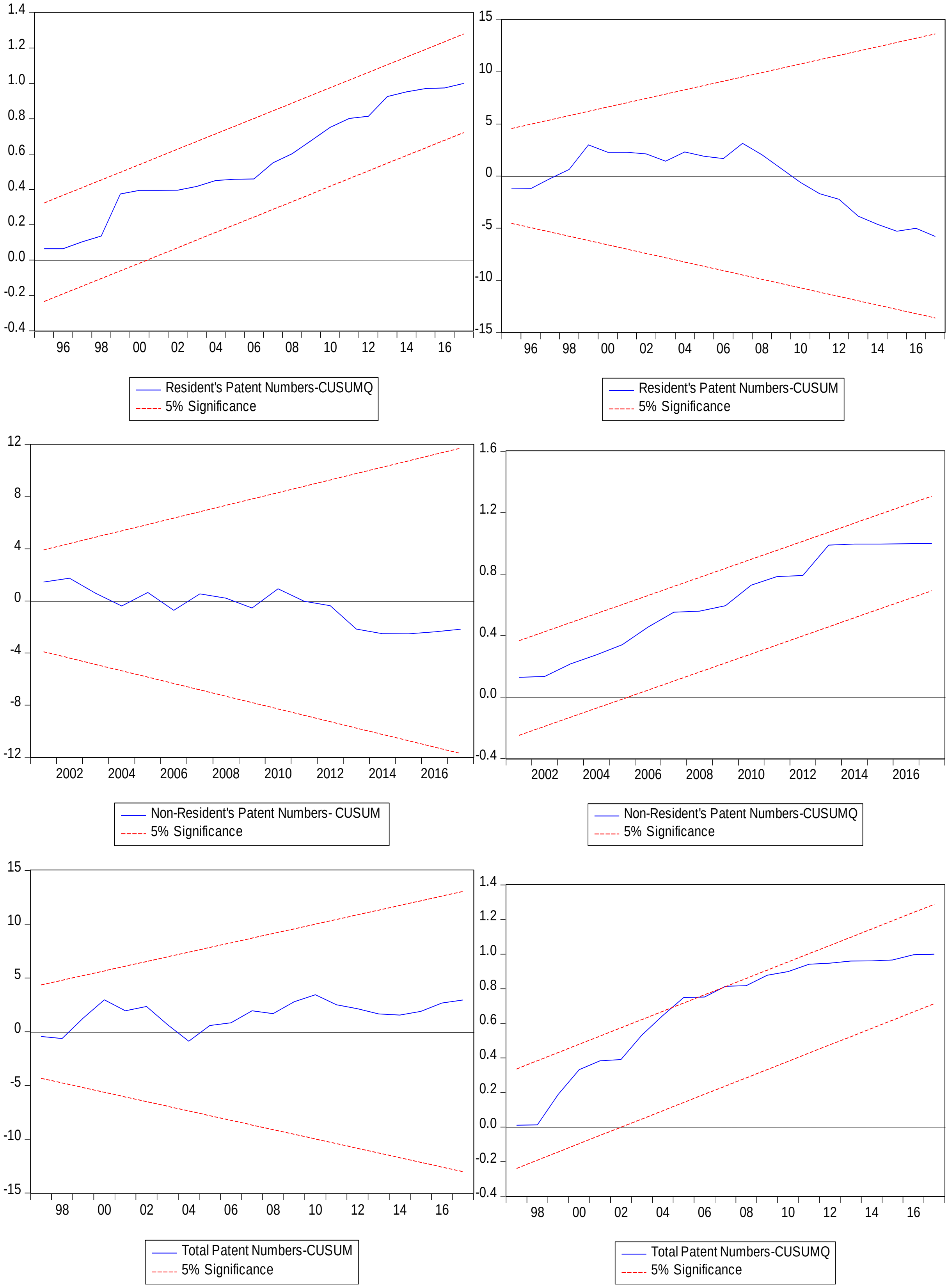

Figure 1: CUSUM and CUSUMQ tests of variables

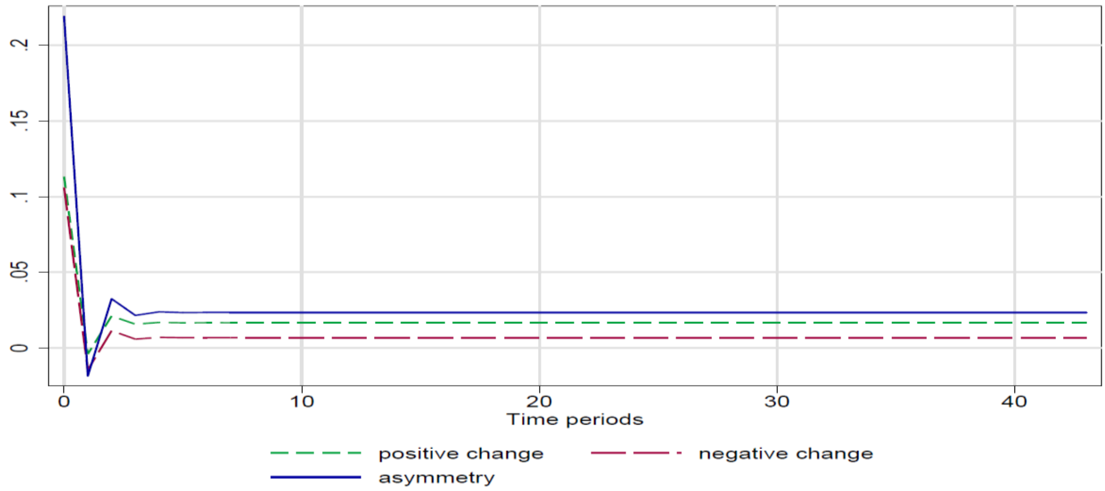

Figure 2: Cumulative effect of FDI on the patent applications of local investors

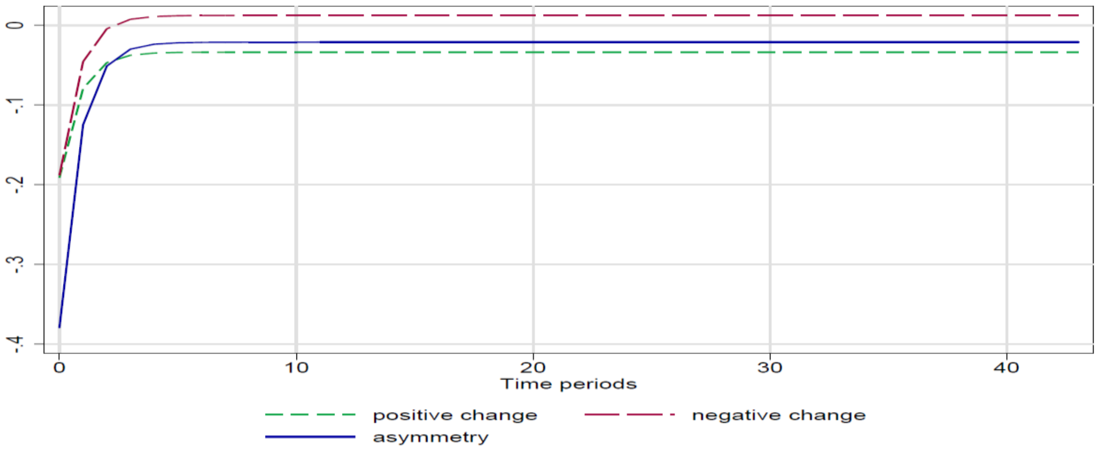

Figure 3: Cumulative effect of FDI on the patent applications of foreign investors

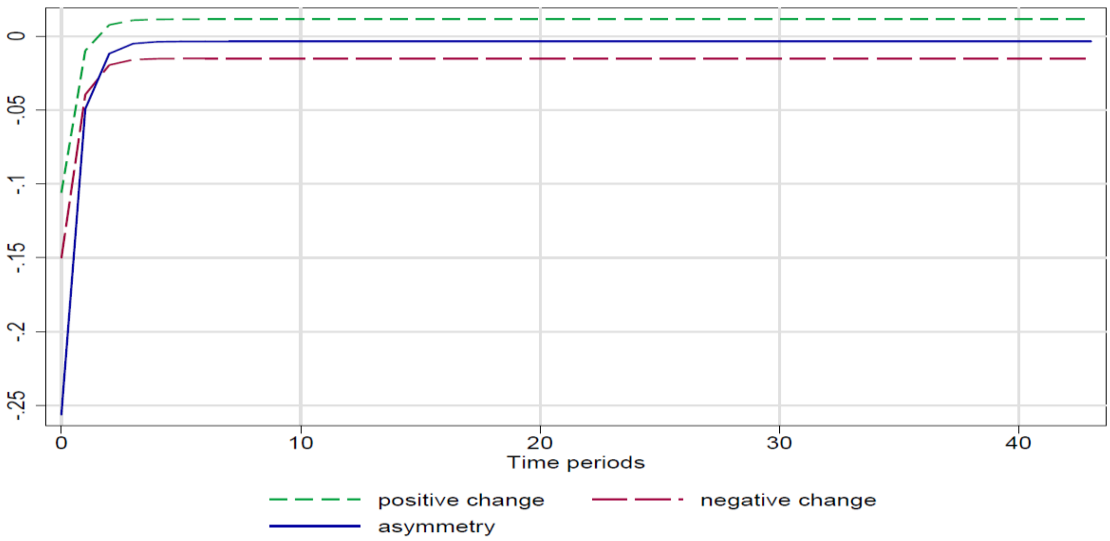

Figure 4: Cumulative effect of FDI on the total patent applications

Figure 4 also indicates the response of total patent applications against asymmetric FDI shocks.

Figure 4 also presents that the total patent applications give positive reaction against positive shocks of FDI and negative reaction to negative shocks of FDI. According to Figure 4, it seems that the positive shock of FDI has more impact on the total patent applications than the negative shock of FDI. Therefore, the asymmetry curve is over the curve representing the negative shock of FDI. Moreover, the asymmetry effect of FDI on the total patent applications ends and after approximately 3 periods (3 years), the total patent applications reaches the long-term steady-state condition.

6. CONCLUSION

The aim of our paper is to examine foreign direct investments in Turkey and their impact on innovative performance of local investors and foreign investors. We use three types of patent applications (residents, non-residents and total) representing innovative performance of local and foreign investors. Our analysis covers the periods of 1984-2017 and consists of yearly data. We use the non-linear autoregressive distributed lag (NARDL) model to calculate the asymmetric effects of FDI on patent applications. The NARDL model facilitates to decompose the positive and negative effects stemming from FDI inflows on patent applications. Firstly, we determine that the shocks caused by FDI give rise to long-term asymmetry or short-term asymmetry and find that there is a long-term asymmetric relationship between FDI and the patent applications of residents, short-term asymmetric relationship between FDI and the patent applications of non-resident and total. The results of NARDL model, positive asymmetry effects of FDI on patent applications of residents is significant in the long-term. On the other hand, the growing FDI inflows in Turkey increase patent applications of local investors in the long-term. In the short-term, both positive and negative asymmetry effect of FDI impact on innovative performance of local investors. Moreover, we find that FDI does not rely on innovative effect on foreign investors in the long –run. The negative asymmetry effect impact on the non-resident's patent applications in the short-term. The non-resident's patent applications increase while FDI is reducing in the short-term. The total patent applications are used as a sum of the residents and non-residents patent applications in our analysis. The final model results shows that FDI shocks does not affect both local and foreign investors in the long-term. However, in the short term, the negative FDI shock has a positive impact on total patent applications.

Our study has several important implications. First, the foreign direct investments to Turkey increases innovative performance of local investors, but do not have a huge impact on foreign investors. These results are not a surprise due to the technological gap between developed and developing countries. Therefore, FDI is more effective on innovation performance of domestic firms in developing countries. The economy policy of Turkey should be enhancing FDI, in order to increase the domestic producer's transfer of innovation. Moreover, the domestic investors should be encouraged to absorb new technologies. Second, the presence of asymmetric effects indicates that the effect of foreign direct investments on innovation transfer in the host country may be different in the short and long term. So, the result calls into question the relevance of symmetric econometric specification assuming a symmetric relationship between FDI and innovation.

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