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Information and Communication Technologies (ICTs) and Corruption Level: Empirical Evidence from Panel Data Analysis[1]

Bilgi ve İletişim Teknolojileri (BIT) ve Yolsuzluk Düzeyi: Panel Veri Analizinden Ampirik Kanıt

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Abstract

In recent years, there have been great interest for solving corruption problems associated with public and private sector. On the other hand, nowadays the rapid development of technology related to transformation in the ICT technologies is observed from many sources in the literature. In this process, implementations of anticorruption policies have been helped by these technologies. In addition to this support, the empirical analyses on relationships between ICT and corruption are still scarce. In this regard, this paper focuses whether ICT technologies reduces corruption, adopting univariate and multivariate models with panel data in 177 countries for the period 2002-2012. It assumes that developments in ICT technologies of countries determine greatly their level of corruption in terms of public institutions. Moreover, we employ four ICT indicators, including internet, cell phone, computer and fixed broadband and two corruption indexes. The results indicate that all of these technologies cause a decrease in the two corruption indexes. On the other hand, we also include four more instrumental variables to check the robust of our models. In this regard, the results showed that trade openness and FDI have a negative and statistically significant relationship with the corruption while poverty and inflation have a positive, statistically significant effect on the corruption.

Keywords: ICTs, Corruption, Panel Data Analyses

Öz

Son yıllarda literatürde kamu ve özel sektörle ilişkili yolsuzluk problemlerinin çözümü üzerine yapılan çalışmalara olan ilginin arttığı görülmektedir. Diğer taraftan; günümüzde BİT'lerdeki (Bilgi İletişim Teknolojileri) dönüşüm ile ilişkili teknolojideki hızlı gelişme literatürde yapılan çalışmalardan gözlemlenmektedir. Bu süreçte, bu tür teknolojiler yolsuzluğa karşı uygulanan politikalara destek olmuştur. Bu desteğe ek olarak, BİT ve yolsuzluk arasındaki ilişkiyi inceleyen ampirik çalışmaların hala az bulunur olduğu görülmektedir. Bu bağlamda; 2002-2012 dönemi için 177 ülkede tek değişkenli ve çok değişkenli panel veri analizleri kullanan bu çalışma BİT teknolojilerinin, bir ülkenin yolsuzluk düzeyini azaltıp azaltmadığı konusuna odaklanmıştır. Çalışma, ülkelerin BİT teknolojilerindeki gelişmelerin kamu kurumları açısından yolsuzluk seviyesini belirlediğini varsaymaktadır. Ayrıca çalışma; internet, cep telefonu, bilgisayar ve sabit genişbandın dahil olduğu dört BİT göstergesi ve iki yolsuzluk endeksini modellerinde kullanmıştır. Analiz sonuçlarına göre; modellere dahil edilen BİT teknolojilerinin tüm çeşitlerinin iki yolsuzluk endeksinde bir azalışa neden olduğu gözlenmiştir. Diğer taraftan; çalışmadaki modellerin sağlamlığını kontrol etmek için dört araç değişken daha modellere dahil edilmiştir. Bu bağlamda; yoksulluk ve enflasyon değişkenlerinin yolsuzluk üzerinde istatistiksel olarak anlamlı pozitif yönde etkisi varken; ticari açıklık ve doğrudan yabancı sermaye yatırımları değişkenlerinin yolsuzluk üzerinde istatistiksel olarak anlamlı negatif yönde bir etkisinin olduğu sonucuna ulaşılmıştır.

Anahtar Kelimeler: Bilgi İletişim Teknolojileri, Yolsuzluk, Panel Veri Analizi

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Introduction

The concept of corruption that has generally several different types distinguishes with changing harmful results at different times and places of the world (Bardhan, 1997: 1320). For example, potential problems about malfunction public institutions may cause severe losses in the investment, entrepreneurship and innovation (Mauro, 1995: 681). In view of these effects on the countries, understanding the determinants of corruption is important for many economists. Therefore, there are quite a few empirical studies, showing what determinants of corruption are (Serra, 2006; Fiorino and Galli, 2010; Elbahnasawy and Revier, 2012; Iwasaki and Suzuki, 2012). Therefore, there have been great interest for solving corruption problems associated with public and private sector. On the other hand, nowadays the rapid development of technology related to transformation in the ICT technologies is observed. In this process, implementations of anticorruption policies have been helped by these technologies. When analyzed these areas, the empirical analyses on relationships between ICT and corruption are still scarce. We hypothesized that ICT could reduce corruption, using univariate and multivariate models with panel data in 177 countries during the period 2002-2012. The paper proceeds as follows: section 2 discusses the literature review about ICTs' and possible determinants and indicators of the corruption; section 3 explains data and methodology of the paper; we obtain and discuss the estimation results in section 4; and finally, the last section concludes.

1. Literature Review

When looking at the empirical literature on the determinants of corruption, there are many known studies (Koyuncu and Bhattacharyya, 2007; Topal and Ünver, 2016; Türedi and Altıner, 2016). Additionally, for these determinants, ICT may affect corruption through rising transparency and control of corruption in the public institutions. In this regard, ICT penetration can help to decrease abuse of administrative power by government employees with low cost. On the other hand, it can also create a transparency environment for public information, and develop social capital through increasing interactions in the individual area (Shim and Eom, 2009: 102). For example, e-government associated with developments in the ICT's that causes the reduction of costs provides an important solution for corruption troubles in many countries (Bertot, Jaeger and Grimes, 2010: 265).

When examined in terms of the effect of ICT on corruption, there are few studies in the empirical literature. For example, Lio, Liu and Ou (2011) analyze how internet adoption affects corruption across 70 countries in the period 1998-2005. The results of their analysis found that internet adoption had a negative effect on corruption. Furthermore, Charoensukmongkol and Moqbel (2014) found a negative relationship between ICT and corruption in 42 countries for period of 2003-2007 (see also Mistry and Jalal, 2012; Elbahnasawy, 2014).

This paper also benefits from previous papers that examine four determinants of corruption, broadly defined as trade openness, poverty, inflation rate and FDI in the literature. In this section, we will therefore outline general effects of these four variables for corruption. Firstly, the literature on trade openness has become an increasingly rich subject, and also trade openness can be measured as ratio of total trade (exports and imports) to GDP. There are also strong evidences for relationship between trade openness and corruption in several dimensions. For example, it is classified theoretically into three channels to express this relationship. These channels identifying in microeconomic theory are trade policy, competition effect of foreign producers and international investors (Bonaglia, De Macedo and Bussolo, 2001: 28). In these channels, it is believed, more open economies have lower corruption levels because of further foreign competition. In other words, when the economy is a closed economy, rents is an important source for public officials in the trade area (Larrain and Tavares, 2004: 218). On the other hand, there are many studies found a negatively and statistically significant relationship between trade

openness and corruption in the empirical literature (Torrez, 2002; Koyuncu and Bhattacharyya, 2007; Türedi and Altıner, 2016). Secondly, one of complex problems on corruption is poverty rates. When analyzed to reduce poverty both in past and current period, it is believed that there are both cause and effect relationship between poverty and corruption (Viisimaa, 2008: 2). Human Development Index represents a reasonable proxy for poverty. In this regard, some studies discussing the empirical relationship between them found that the interactions of poverty level with corruption is both positive and significant. For instance, Topal and Ünver (2016) investigated the determinants of corruption for fragile eight countries from 2002 to 2014 period. Accordingly, their empirical results found that there is a negative relation between HDI and corruption. Thirdly, generally, unstable and high inflation can lead to increase uncertainty about paying for goods and therefore to make difficult to describe whether officer have attempted corrupt behavior (Braun and Di Tella, 2004: 79). Therefore, it can be expected that it is possible to find a positive relationship between inflation and corruption. For example, Evrensel (2010) demonstrates that higher levels of inflation rates result in corruption (see also Akça, Ata and Karaca, 2012; Türedi and Altıner, 2016). Finally, when examined foreign direct investment literature, many studies tested connection between foreign direct investment and economic growth (Borensztein, De Gregorio and Lee, 1998; Li and Liu, 2005). FDI plays a very important role in the growth process of countries. On the other hand, economic growth decreases corruption levels in the countries (Bai, Jayachandran, Malesky and Olken, 2013). Thus, economies for attracting FDI have improved considerably investment environment. In this regard, there are empirically a strong relationship in literature that FDI has negative effect on corruption (Robertson and Watson, 2004; Larrain and Tavares, 2004).

2. Data and Methodology

This paper examined the impact of ICT penetration on corruption by using four ICT indicators and two different corruption indicators. The period of this paper is between 2002 and 2012. By using unbalanced panel data, we estimated the following multivariate fixed time effect models (FEM);

$$CORRUPTION_{it} = (\alpha + \tau_t) + \beta_1 ICT_{it} + \beta_2 OPENNESS_{it} + \beta_3 POVERTY_{it} + \beta_4 INFLATION2_{it} + \beta_5 FDI1_{it} + u_{it} \quad (1)$$

and the following multivariate random time effect models (REM);

$$CORRUPTION_{it} = \alpha + \beta_1 ICT_{it} + \beta_2 OPENNESS_{it} + \beta_3 POVERTY_{it} + \beta_4 INFLATION2_{it} + \beta_5 FDI1_{it} + (\tau_t + u_{it}) \quad (2)$$

where it subscript stands for the i-th country's observation value at time t for the particular variable. α is the intercept term and τ_t represents time-specific effects which affect all countries in the same way (i.e., τ_t is variant across time but not across countries). u_{it} is idiosyncratic error term of the regression model.

In this paper, corruption is the dependent variable in all our models in which two different corruption variables are included to evaluate the sensitivity of empirical results in analyses. Our assumption is that results may vary largely across types of corruption variable. If the results hold across different corruption variables, it will be an indication of their robustness. The list of definitions and data sources of dependent variables are given in Table 1 below. In the context of this paper, firstly, CORRUPTION1 that reflects the level of corruption in a country is calculated by multiplying control of corruption variable of Worldwide Governance Indicators (WGI) with minus one. According to WGI, the control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5. Scores closer to 2.5 means lower level of corruption and scores closer to -2.5 means higher level of corruption. Since CORRUPTION1 variable is calculated by multiplying control of corruption variable with minus one, higher scores in this

variable show higher degree of corruption and lower scores in this variable demonstrates lower degree of corruption. Secondly, on the other hand, CPI1 that means the degree of corruption in a country is calculated by multiplying corruption perception index variable of Transparency International with minus one. Since CPI1 variable is computed by multiplying corruption perception index variable with minus one, this suggests that higher scores in this variable demonstrate higher degree of corruption and lower scores in this variable show lower level of corruption.

Table 1: List of Dependent Variables

Variables	Definition	Source
CORRUPTION1	CORRUPTION1= -1*(Control of corruption)	The Worldwide Governance Indicators - www.govindicators.org
CPI1	CPI1= -1*(Corruption perception index)	Transparency International - https://www.transparency.org/research/cpi/cpi_early/0/

Our explanatory variables and main hypothesis were chosen in the light of previous studies found in the literature. ICT penetration in above models is represented by four variables. Definitions and data sources of ICT penetration variables are given in Table 2 below.

Table 2: List of ICT Variables

Variables	Definition	Source
INTERNET	Percentage of individuals using the Internet	World Telecommunication/ICT Indicators Database of UN Database http://data.un.org/Data.aspx?d=ITU&f=ind1Code%3aI99H#ITU
CELLPHONE	Mobile-cellular telephone subscriptions per 100 inhabitants.	http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx
COMPUTER	Personal Computers per 100 people.	http://www.nakono.com/tekcarta/databank/personal-computers-per-100/
FXBROADBAND	Fixed broadband subscriptions (per 100 people)	International Telecommunication Union, World Telecommunication/ICT Development Report and database.

The expected association between four proxies of ICT penetration and two proxies of corruption is negative. ICT penetration tends to improve transparency environment in the public institutions through decreasing abuse of administrative power (Shim and Eom, 2009: 102). This is the reason why there is a negative expectation. We also introduced four more determinants of corruption into our analysis to see how robust our finding is. Definition and data source of other independent variables besides ICT variables are given in Table 3 below.

Table 3: List of Independent Variables

Variables	Definition	Source
OPENNESS	Trade (% of GDP)	WDI
POVERTY	POVERTY= -1*(Human Development Index)	http://hdr.undp.org/en/data
INFLATION2	Inflation, GDP deflator (annual %)	WDI
FDI1	Foreign Direct Investment, Percentage of Gross Fixed Capital Formation	UNCTAD

We explain the following further the independent variables and discusses their expected signs. In addition to ICT variable, we presented four more determinants of corruption to seek the relationship between corruption and ICT: (1) openness degree of an economy (OPENNESS); (2) poverty degree of an economy (POVERTY); (3) inflation degree of an economy (INFLATION2); (4) foreign direct investment degree of an economy (FDI1). The variables included in our models were not chosen at random, but on the contrary we chosen them in the light of previous studies found in the literature, the availability of the data and our main hypothesis.

OPENNESS indicates the degree of trade openness of an economy. It is measured as percentage ratio of total foreign trade (exports plus imports) in GDP.

An open economic environment without trade restrictions may prevent government-induced corruption because of decreasing bureaucratic obstacles because these obstacles is an opportunity to bribe public officials (Koyuncu and Bhattacharyya, 2007: 17). Therefore, we expect a negative association of OPENNESS with level of corruption in a country. POVERTY reflects the poverty level in an economy. It is calculated by multiplying human development index values with minus one. As known higher human development index value means higher human development level and thus lower poverty level in a country. Since POVERTY variable is computed by the product of human development index values with minus one, its higher value means higher poverty level and its lower value means lower poverty level. Therefore, if the rise in poverty decreases economic growth, falling income of people must correspondingly increase corruption levels (Bai, Jayachandran, Malesky and Olken, 2013). Thus, we expect a positive association of POVERTY with level of corruption in a country. INFLATION2 reflects the three things; namely degree of uncertainty in an economy, political instability, and economic instability. Theoretical literature accepted that there is a relationship between inflation and corruption. The higher and unstable inflation rates lead to deterioration real income level in the society, hence the rising illegal activities increases corruption (Türedi and Altıner, 2016: 106). Hence, it can be expected that there is a positive relationship between INFLATION2 and corruption. FDI1 is foreign direct investment and is measured as percentage of gross fixed capital formation. An open economy in which free trade policies is applied doesn't have trade barrier, and thus there is no opportunities to bribe public officials and sources of rents (Larrain and Tavares, 2004: 218). Hence, we expect to find a negative relationship between FDI1 and corruption.

Before proceeding to evaluate the empirical results, it will be better to check the correlation between two corruption variables and four indicators of ICT. Table 4 provides correlation coefficients and P-values for each particular variable pairs. As in the table, correlation coefficient values between CPI1 variable and four ICT proxies (i.e., INTERNET, CELLPHONE, COMP1, and FXBROADBAND) are negative and vary from -0.83 to -0.39 while correlation coefficient values between CORRUPTION1 variable and four ICT proxies are negative and vary from -0.81 to -0.37. Also, all of them are highly statistically significant.

Table 4: Correlation Matrix

	CPI1	CORRUPTION1	INTERNET	CELLPHONE	COMP1	FXBROADBAND	OPENESS	POVERTY	INFLATION2	FDI1
CPI1	1.0000									
P-value	-									
CORRUPTION1	0.9834	1.0000								
P-value	*0.0000*	-								
INTERNET	-0.7921	-0.7759	1.0000							
P-value	*0.0000*	*0.0000*	-							
CELLPHONE	-0.3924	-0.3740	0.6411	1.0000						
P-value	*0.0000*	*0.0000*	*0.0000*	-						
COMP1	-0.8345	-0.8197	0.8809	0.5217	1.0000					
P-value	*0.0000*	*0.0000*	*0.0000*	*0.0000*	-					
FXBROADBAND	-0.6992	-0.6811	0.8791	0.5799	0.8656	1.0000				
P-value	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	-				
OPENESS	-0.2937	-0.2877	0.2424	0.3470	0.2763	0.2211	1.0000			
P-value	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	-			
POVERTY	0.7657	0.7808	-0.7101	-0.4174	-0.7220	-0.6115	-0.2117	1.0000		
P-value	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	-		
INFLATION2	0.4042	0.4101	-0.3880	-0.2454	-0.3737	-0.3628	-0.1695	0.3372	1.0000	
P-value	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	-	
FDI1	-0.1289	-0.1186	0.0623	0.1882	0.1065	0.0928	0.6669	-0.0813	-0.0658	1.0000
P-value	*0.0008*	*0.0020*	*0.1052*	*0.0000*	*0.0056*	*0.0157*	*0.0000*	*0.0345*	*0.0869*	-

3. Estimation Results

The results of multivariate estimations, reported in Table 5, indicate four different ICT indicators and two distinct corruption proxies. Hausman test is used

for the selection between fixed time effect model (FEM) and random time effect model (REM), and decision is made at 5% significance level. According to Hausman test results, except Model 6, in all FEM models are selected. As a part of robustness test, multivariate estimation results indicate the following;

1.) Estimation results using INTERNET as independent variable in Model 1 and Model 5 indicate that: all coefficients of INTERNET proxy for ICT variable are statistically significant and have the expected negative sign for both models, indicating that ICT penetration in the form of percentage of individuals using the internet seems to decrease corruption degree in an economy. 2.) Estimation results using CELLPHONE as independent variable in Model 2 and Model 6 indicate that: all coefficients of CELLPHONE proxy for ICT variable are statistically significant and have the expected negative sign for both models, indicating that ICT penetration in the form of mobile-cellular telephone subscriptions per 100 inhabitants seems to decrease corruption degree in an economy. 3.) Estimation results of COMP1 proxy for ICT variable as independent variable in Model 3 and Model 7 indicate that: all coefficients of COMP1 are statistically significant negative coefficients in both models, indicating that ICT penetration in the form of personal computers per 100 people seems to decrease corruption degree in an economy. 4.) Estimation results using FXBROADBAND as independent variable in Model 4 and Model 8 indicate that: all coefficients of FXBROADBAND proxy for ICT variable are statistically significant and have the expected negative sign for both models, indicating that ICT penetration in the form of fixed broadband subscriptions per 100 people seems to decrease corruption degree in an economy.

According to empirical results in terms of other variables in the model, estimates of the coefficient of OPENNESS variable are negative and statistically significant at least at the 10 percent level level in all eight models. Thus, corruption level in that particular economy decreases when the level of trade openness of an economy increases. The estimated coefficient of the POVERTY variable is highly statistically significant and have the anticipated positive sign in all models. This result supports the proposition that poverty is the one of the main reasons for the wide-spread presence of corruption in a country. The coefficient of the INFLATION2 variable is highly statistically significant and gives the expected positive sign in all models. This result points out that economies with higher uncertainty, political and economic instability are more prone to corrupt activities. The coefficient of the FDI1 variable is statistically significant and takes the anticipated negative sign in five out of eight models. This result means that economies with higher FDI experience less corrupt activities. Meantime, in regard to robustness, our results are robust in the sense that our primary finding remains valid no matter which proxy is used for ICT and corruption in our models.

Conclusion

This study investigates the effect of ICT on corruption level in a country. In order to test this relationship, the study use four different proxies for ICT and two distinct indicators for corruption level. The data used in analyses are unbalanced data and cover the years between 2002 and 2012. To our best knowledge, this is the first study examining the association between ICT and corruption with so many indicators of ICT and corruption.

The main finding of the study is that countries with higher ICT penetration (in the form of percentage of individuals using the internet, in the form of mobile-cellular telephone subscriptions per 100 inhabitants, in the form of personal computers per 100 people, and in the form of fixed broadband subscriptions per 100 people) experience lower level of corruption. This result remains valid once we added other peculiar determinants of corruption into our models. Also, our results are robust in the sense that our primary finding do not alter no matter which proxy is used for ICT and corruption in our models.

Table 5: Multivariate Estimation Results

	Dependent Variables							
	CORRUPTION1 Model 1	CORRUPTION1 Model 2	CORRUPTION1 Model 3	CORRUPTION1 Model 4	CPI1 Model 5	CPI1 Model 6	CPI1 Model 7	CPI1 Model 8
C	**1.29532**	**2.59479**	**2.2216**	**1.8423**	**-1.7937**	**1.7741**	**0.1834**	**-0.4120**
Std. Error	0.07566	0.08401	0.1821	0.1008	0.1731	0.1788	0.3981	0.2244
Prob.	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.6452	0.0667
INTERNET	**-0.02797**				**-0.0645**			
Std. Error	0.00089				0.0019			
Prob.	0.00000				0.0000			
CELLPHONE		**-0.00316**				**-0.0039**		
Std. Error		0.00072				0.0011		
Prob.		0.00000				0.0005		
COMP1			**-0.0232**				**-0.0536**	
Std. Error			0.0011				0.0023	
Prob.			0.0000				0.0000	
FXBROADBAND				**-0.0515**				**-0.1180**
Std. Error				0.0025				0.0054
Prob.				0.0000				0.0000
OPENNESS	**-0.00083**	**-0.00097**	**-0.0009**	**-0.0009**	**-0.0024**	**-0.0034**	**-0.0015**	**-0.0025**
Std. Error	0.00027	0.00034	0.0004	0.0003	0.0006	0.0007	0.0009	0.0007
Prob.	0.00230	0.00400	0.0247	0.0049	0.0000	0.0000	0.0779	0.0002
POVERTY	**0.77135**	**3.47006**	**2.4198**	**2.2695**	**0.7180**	**8.0679**	**4.4616**	**4.3851**
Std. Error	0.13074	0.15651	0.2567	0.1524	0.2986	0.2880	0.5615	0.3410
Prob.	0.00000	0.00000	0.0000	0.0000	0.0163	0.0000	0.0000	0.0000
INFLATION2	**0.01045**	**0.01702**	**0.0130**	**0.0169**	**0.0177**	**0.0310**	**0.0251**	**0.0307**
Std. Error	0.00139	0.00168	0.0026	0.0020	0.0029	0.0037	0.0056	0.0042
Prob.	0.00000	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
FDI1	**-0.00080**	**-0.00092**	**0.0008**	**-0.0006**	**-0.0011**	**-0.0017**	**-0.0003**	**-0.0008**
Std. Error	0.00032	0.00039	0.0012	0.0004	0.0007	0.0009	0.0025	0.0008
Prob.	0.01070	0.01820	0.4778	0.0982	0.0828	0.0479	0.8905	0.3062
Num. Of Obs.	1783	1815	*737*	*1430*	*1589*	*1615*	*730*	*1328*
Num. Of Countries	176	177	*67*	*171*	*174*	*175*	*67*	*169*
R-square	0.706776	0.54445	*0.7916*	*0.6691*	*0.7418*	*0.5548*	*0.7907*	*0.6917*
F-statistic	283.9407	143.33630	*182.5950*	*190.5914*	*301.2261*	*401.0877*	*179.8237*	*196.2582*
Prob (F-statistic)	0.0000	0.00000	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0000*
Hausman Statistics	270.505038	27.53871	*120.5741*	*104.9887*	*119.3485*	*9.6418*	*88.1661*	*67.4048*
Prob (Hausman-Stat.)	0.0000	0.00000	*0.0000*	*0.0000*	*0.0000*	*0.0860*	*0.0000*	*0.0000*
Selected Model	*FEM*	*FEM*	*FEM*	*FEM*	*FEM*	*REM*	*FEM*	*FEM*

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