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The Impact of Structural Reforms on Telecommunications Performance

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Abstract The paper investigates to what extent regulation, competition and privatization affect Telecommunications performance for 30 OECD countries over the period 1975–2013. This study explores the difference between separate and joint effects among these structural reform variables, in the concept of a dynamic model, taking also into account the difference between short run and long run effects. We argue that regulation has a more aggressive effect on performance when it is combined with the other two structural reform variables in both models.

Keywords Performance · Structural reforms · Telecommunications · Panel data · Dynamic GMM

JEL Classifications L1 · L51 · L96 · C2

1 Introduction

Telecommunications industry has undergone profound structural changes regarding its market structure. For most OECD countries the industry was vertically integrated and state-owned whereas over the last decades the market has been liberalized giving the opportunity for other private companies to enter the market and provide Telecommunications services.

Over the last two decades, several interesting studies, such as Ros (1999), Laffont and Tirole (2000), Boylaud and Nikoletti (2001), Wallsten (2001), Gual and Thrillas (2004), Estache et al. (2006), Kim et al. (2011), Paleologos and Polemis (2013), Lestage et al. (2013) and Hausman and Ros (2013), Agiakloglou and Bloutsos (2011), Agiakloglou and Gkouvakis (2015), Agiakloglou and Yiannelis (2005); Agiakloglou and Karkalakos (2009) have tried to assess to what extent competition, regulatory and privatization affect the performance of the Telecommunications Industry. The objective of most of these studies was to detect the main drivers of Telecommunications performance either at macro or at micro

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economic level, taking into account occasionally indicators that express structural reforms. Hence, in contract to what has been done empirically so far, this study tries to capture the dynamic effects of these structural reforms variable along with some other macroeconomic and financial variables.

The purpose of this study is to fill the research gaps by combining certain (structural) determinants from a macro and micro economic perspective. For this reason, we formulate a number of research questions including inter alia the following: How do regulatory reforms affect the overall performance of the telecommunications sector? How does competition stimulate industry output? In what way privatization determines the level of investments of the sector? Does regulation have a stronger effect on performance when it's implemented with other reforms such as competition and/or privatization? Lastly, what policy implications could be drawn in order to enhance the performance of the telecommunications industry?

This study contributes the literature in many ways. Firstly, unlike previous studies (see for example Ros 1999; Wallsten 2001, 2004; Li and Lyons 2012), devoted on this topic we try to assess the linkage and the possible spillover effects between regulation, competition and privatisation and the level of telecommunications performance by using superior measures of the effectiveness of regulation and competition (Fiorio and Florio 2013; Pompei 2013). For this reason, we use the most up to date regulation and competition indices provided by the OECD. Secondly, this is the first study that we use the regulation components of the FRASER Index of Economic Freedom to examine the impact of credit (financial), labour and business regulation, on telecommunications performance in the 30 OECD sample countries. The use of the FRASER index, allows greater insight into this issue and this is one of the novelties of this paper. It is noteworthy that FRASER index has been used in similar empirical studies in order to quantify the effects (see for example Psillaki and Mamatzakis 2017; Polemis and Stengos 2017; Polemis 2016; Mamatzakis et al. 2015) of credit and labour regulation on a specific sector of economic activity. Thirdly, it uses an updated data set covering the most recent period where regulation and competition policies are high in the political agenda of many OECD countries. To the best of our knowledge no other researcher has conducted similar estimations with the precise countries and data period.

The paper is organized as follows. Section 2 presents the data set and the variables used in the relevant econometric methodology, while Section 3 reports and analyzes the empirical results. Finally, the concluding remarks as well as some policy implications are reported on Section 4.

2 Data and Model Description

Telecommunications performance is usually measured with a cost function or a production function. However, in this paper we use four proxies: a) the number of telephone mainlines per 100 inhabitants (LINE). The telephone main lines constitute fixed telephone lines that connect a subscriber's terminal equipment to the public switched telephone network and that have a port on a telephone exchange. Integrated services digital network channels and fixed wireless subscribers are also included, b) the total revenue from all Telecommunications services (REV), c) the full-time equivalent Telecommunications employees per 100 lines (EMPL). The latter provides a measure of labor efficiency (Wallsten 2001). However, from a theoretical standpoint it is not clear how beneficial reforms would affect this indicator since structural reforms may induce the incumbent either to eliminate excess staff or to increase employment

as it improves its network, and d) the total investment in Telecommunications services (INV). These variables are obtained from the World Telecommunications / ICT Indicators database (June 2014) published by the International Telecommunications Union (ITU) for 30 OECD countries over the period 1975–2013.[1]

It is worth mentioning that most of the used indicators are primarily productivity measures of volume in a demand driven model. However, volume can be regarded as a component of performance (Polemis and Stengos 2017). We must argue though, that these indicators have some limitations since telecommunications performance does not only capture measures of productivity and cost but has a broader definition including also other elements such as the quality and access to service, the prices charged for telecommunications services as well as certain financial parameters. It is worth mentioning that potentially useful measures of performance such as quality of service could not be estimated because of a lack of data. Similarly, we would like to have investigated the impact of reforms on the prices charged for telecommunications services, but there is a lack of sufficient comparable data across our sample of countries (specifically for the developing OECD countries) to carry out such an analysis. The latter could be alternatively measured by structural indicators such as market concentration, product quality, and product diversity. However, due to data unavailability the estimation of these indices was not possible. The same approach is followed in the studies by Ros (1999), Wallsten (2001), Gutierrez and Berg (2000) and Bortolotti et al. (2002) who also use a demand function in order to assess performance in the telecommunications sector.

The RRI is calculated by the methodology of Conway and Nicoletti (2006), taking into account several other elements of market structure and has been used in certain other empirical studies (see, for example, Li and Lyons 2012, Pompei 2013, Nesta et al. 2014). The RRI indicator presents detailed information allowing one to capture the industry-specific trends of reforms in the telecommunications sector. It takes the value from zero to six and is computed as a weighted average of three sub-components indicators regarding entry regulation (legal conditions of entry into trunk, international and mobile telephony market), public ownership (percentage of shares in the Public Telecommunications Operator (PTO) owned by the government, percentage of shares in the largest firm in the mobile telecommunications sector owned by the government) and market structure (market share of new entrants in the trunk, international and mobile telephony market), by assigning a cardinal measure to variables that are in itself ordinal (Polemis and Stengos 2017; Fiorio and Florio 2013).[2] In this sense, the Regulatory Reform Index measures anti-competitive regulations in order to quantify the level of competition in the industry. A high (low) score in the RRI is attributed to countries characterized by a more (de) regulated sector (Conway and Nicoletti 2006). Lastly, this indicator is built by means of a bottom-up approach based on information about existing laws and regulations and guarantees a high level of comparability across the surveyed countries. The RRI captures regulatory management practices that are imposed on network telecommunications sector, by measures of the governance of the bodies that design, implement and enforce these regulations. The indicator measures the de jure policy setting. It is worth mentioning that instances where laws or regulations are poorly implemented by regulatory

[1] The OECD sample countries are the following: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States.

[2] For the purposes of calculating the indicator the market share of new entrants has been normalised to be between 0 and 6 with 6 being the smallest market share over all

authorities or where authorities implement a policy (e.g. publish a report) without being obliged by law are thus do not captured (Beiter et al. 2014).

Table 1, reports a complete set of summary statistics for all the variables used in the econometric analysis. We have a total of 1170 observations, namely, 30 panels (countries) times 39 years (1975–2013), and the panel data set is strongly balanced.

Furthermore, two other sets of variables are employed to explain the behavior of these indicators. The first set of variables is based on the level of regulation, competition and privatization, as an effort to capture the impact of structural reforms. For this purpose we use: a) for regulation the Regulatory Reform Index, b) for competition two dummy variables, COMP_INTER and COMP_MOB, accounting for the competitive conditions prevailing in fixed and mobile market segments, respectively and c) for privatization a dummy variable, PRIV, taking the value of one when the percentage of shares in the PTO owned by the government is less than 50% and zero otherwise.[3,4] The data for all of the above variables is obtained directly from OECD regulation database for the period 1975 to 2013.[5] We must stress though that structural measures such as concentration ratio of the four/eight largest companies in the sector (CR-4/CR-8) or the Hirschman-Herfindahl index (HHI) would give a better approximation of the level of competition in the telecommunications industry instead of the use of two dummy variables. However, the lack of sufficient and comparable data across the sample countries prevented us from the use of these indicators. Lastly, regarding the privitization dummy variable, we must acknowledge that a government that owns less than 50% of the shares of a company may still be the controlling shareholder (i.e. minority shareholding). The serious lack of data regarding the controlling shareholder of the PTOs among the OECD countries led us to incorporate the specific dummy variable. Besides the use of dummy variables as measures of market competition and privitization in network industries is in alignment with the existing empirical studies (see among others Polemis and Stengos 2017; Fiorio and Florio 2013).

The second set of variables covers some macroeconomic indicators such as the GDP per capita (GDP), accounting for the level of economic growth, the level of exports as a percentage of GDP (EX), measuring the level of openness of the economy, and the FRASER index, which takes into account the degree of economic risk. The FRASER index consists of five factors: i) size of government, ii) legal system and property rights, iii) access to sound money; iv) freedom to trade internationally and v) regulation of credit, labour, and business. These are weighted to form a composite index, with 0 indicating the lowest and 10 the highest level of economic freedom. In addition, we include some demographic and financial variables, such as the level of population density (POP), the share of the population living in urban areas (URBAN) and the real interest rate (IR). Data for the aforementioned variables is drawn from the World Development Indicators Database available from the World Bank and the Fraser Institute.

[3] The Market structure Sub-Index for competition and the Public ownership sub-index for privatization was not used for multicollinearity issues. Specifically, the competition dummy variables take the value of one if competition exists in each of the three market segments and zero otherwise (monopoly or duopoly).

[4] Specifically, the competition dummy variables take the value of one if competition exists in each of the two market segments and zero otherwise (monopoly or duopoly).

[5] From 2008 onwards the OECD does not provide data for the RRI on an annual basis. Therefore, for the period 2009–2013 the mean imputation method was used in order to fill the missing observations (Schenker and Taylor 1996).

Table 1 Summary statistics

	INV	LINE	EMPL	REV	PRIV	RRI	COMP_TRUNK	COMP_INTER
Statistical measures								
Observations	1010	1166	1029	1052	1146	1170	1158	1170
Cross sections	30	30	30	30	30	30	30	30
Mean	21.69	38.79	0.97	23.07	0.38	3.86	0.43	0.42
Median	21.43	41.44	0.65	22.76	0.00	4.55	0.00	0.00
Maximum	31.93	74.76	11.72	43.92	1.00	6.00	1.00	1.00
Minimum	16.32	1.74	0.11	18.26	0.00	0.55	0.00	0.00
Standard deviation	1.96	17.07	1.24	2.01	0.49	2.12	0.50	0.49
Coefficient of variation	0.09	0.44	1.28	0.09	1.29	0.55	1.16	1.17
Skewness	1.23	−0.34	5.69	1.86	0.49	−0.29	0.27	0.33
Kurtosis	7.80	2.30	40.58	15.71	1.24	1.42	1.07	1.11
Cross correlations								
INV	1.00							
LINE	0.02	1.00						
EMPL	−0.21	−0.51	1.00					
REV	0.94	0.17	−0.36	1.00				
PRIV	0.26	0.08	−0.29	0.36	1.00			
RRI	−0.27	−0.36	0.45	−0.48	−0.56	1.00		
COMP_TRUNK	0.16	0.47	−0.40	0.36	0.39	−0.90	1.00	
COMP_INTER	0.10	0.45	−0.43	0.29	0.34	−0.84	0.89	1.00
COMP_MOB	0.05	0.39	−0.39	0.25	0.32	−0.74	0.75	0.79
GDP	−0.08	0.77	−0.25	0.02	−0.13	−0.18	0.34	0.28
POP	0.27	−0.06	−0.33	0.25	−0.07	−0.01	0.04	0.14
EX	−0.59	0.04	−0.04	−0.50	−0.07	−0.09	0.17	0.24
IR	−0.05	0.21	−0.19	−0.03	0.05	0.00	0.01	−0.03
FR	0.11	0.66	−0.43	0.28	0.35	−0.57	0.58	0.50
IND	0.07	−0.49	0.35	−0.08	−0.10	0.39	−0.42	−0.41
URBAN	−0.01	0.56	−0.30	0.06	−0.03	−0.23	0.27	0.26

	COMP_MOB	GDP	POP	EX	IR	FR	IND	URBAN
Statistical measures								
Observations	1158	1080	1146	1080	1080	1080	1146	1146

Table 1 (continued)

	COMP_MOB	GDP	POP	EX	IR	FR	IND	URBAN
Cross sections	30	30	30	30	30	30	30	30
Mean	0.41	10.17	2.33	17.02	5.51	7.61	31.45	86.72
Median	0.00	10.13	2.32	16.83	5.42	7.90	29.11	85.96
Maximum	1.00	10.50	3.01	22.52	12.16	8.32	39.11	89.48
Minimum	0.00	9.86	1.81	13.51	−4.27	6.07	25.77	85.40
Standard deviation	0.49	0.21	0.35	2.56	3.83	0.59	4.70	1.34
Coefficient of variation	1.20	0.02	0.15	0.15	0.70	0.08	0.15	0.02
Skewness	0.36	0.17	0.23	0.26	−0.52	−0.80	0.48	0.78
Kurtosis	1.13	1.70	1.97	2.02	3.14	2.61	1.55	2.10
Cross correlations								
INV								
LINE								
EMPL								
REV								
PRIV								
RRI								
COMP_TRUNK								
COMP_INTER								
COMP_MOB	1.00							
GDP	0.25	1.00						
POP	0.11	−0.12	1.00					
EX	0.23	0.16	0.10	1.00				
IR	0.02	0.03	−0.09	−0.10	1.00			
FR	0.46	0.57	−0.06	0.11	0.26	1.00		
IND	−0.43	−0.45	0.14	−0.16	−0.14	−0.40	1.00	
URBAN	0.25	0.52	−0.07	−0.04	0.19	0.33	−0.20	1.00

The model employed in this study follows the specification of Wallsten (2001). However, we extend this analysis in several ways. First, Wallsten (2001) uses a dummy variable to assess regulatory regimes taking the value of one if there is a separate regulator and zero otherwise. The problem, however, with this dummy variable is that it does not capture to what extent regulatory reforms have been applied in each country. Hence, it is better to use the RRI, which measures the level of regulation in Telecommunications in each country and can be obtained directly from the OECD database. As mentioned before, the RRI is calculated by the methodology of Conway and Nicoletti (2006), taking into account several other elements of market structure and has been used in certain other empirical studies (see, for example, Li and Lyons 2012; Pompei 2013; Nesta et al. 2014). Second, Wallsten (2001) uses the number of wireless operators in the country, not owned by the incumbent, as a competition indicator, a variable that does not reflect the actual competitive conditions, since it does not take into account the information regarding the structural conditions of the industry, such as, for example, market shares and barriers to entry. Taking, however, the aforementioned dummy variables for competition, derived directly from the OECD database, we aim to absorb better information regarding the real market level of competition. Lastly, the proposed by Wallsten (2001) dummy variable, which was taking the value of one for all the years after the year that a firm was privatized and zero otherwise, seems not to address very well the level of privatization, as opposed to the PRIV dummy variable, obtained, as well directly, from the OECD database, since it does not capture the extent of privatization, but simply indicates whether the government sold part of the firm.

The fixed-effects model is given by the following equation:

$$Y_{jit} = a_0 + a_1 RRI_{it} + a_2 COMP\_INTER_{it} + a_3 COMP\_MOB_{it} + a_4 PRIV_{it} + a_5 X_{it} + \gamma_t + u_i + \varepsilon_{it} \quad (1)$$

where $j = 1, 2, 3, 4$ denotes the four dependent variables, i.e., LINE, REV, EMPL and INV, for all countries (i) at time t and the errors (ε_{it}) are uncorrelated to each other.[6] X_{it} is a vector of control variables described above. The γ_t stands for the time fixed effects and u_i are the country fixed effects that control for differences across countries (e.g differences in technology used in the production process, economic conditions, regulatory legislation, competition policies, etc). The inclusion of time fixed effects controls for changing technology and preferences over time since the last decade there has been major structural changes in telecommunications sector (e.g convergence of fixed-line, mobile and broadband services, etc). Finally ε_{it} is the idiosyncratic error term that is assumed to be i.i.d.

To account for cross effects among the structural reform variables, model (1) is extended by adding three more independent variables:

$$\begin{aligned} Y_{jit} &= a_0 + a_1 RRI_{it} + a_2 COMP\_INTER_{it} + a_3 COMP\_MOB_{it} + a_4 PRIV_{it} + a_5 X_{it} \\ &+ a_6 \left(RRI_{it}{}^{*} COMP\_INTER_{it}\right) + a_7 \left(RRI_{it}{}^{*} COMP\_MOB_{it}\right) + a_8 \left(RRI_{it}{}^{*} PRIV_{it}\right) + \gamma_t + u_i + \varepsilon_{it} \end{aligned} \quad (2)$$

where RRI_{it}*$COMP\_INTER_{it}$ and RRI_{it}*$COMP\_MOB_{it}$ are the cross terms of regulation and competition in the fixed and mobile market segment respectively and RRI_{it}*$PRIV_{it}$ is the variable that captures the cross effect of regulation and privatisation. The objective in this case, as indicated by Wallsten (2001), is to explore further the effect of regulation on Telecommunications performance by capturing possible interactions with competition and privatization. As argued by Wallsten (2004) regulations, regulators,

[6] Specifically for the dependent variable INV the nominal interest rate (IR) is added to the model as an independent variable.

regulated industries and politics interact in complicated ways that affect the development of the industry as well as the rest of the economy.

3 Empirical Results

The empirical findings of the dynamic GMM specifications (with and without the cross terms) are depicted in Table 2. As it is evident, nearly all the estimated coefficients are statistically significant with the proper signs. More specifically, regulation affects negatively the number of telephone lines, meaning that a more deregulated industry, in which case the value of RRI is small, increases the number of subscribers and therefore the level of Telecommunications performance. In addition, both competition indicators, i.e., COMP_INTER and COMP_MOB, have positive effect on main lines indicating that a competitive market structure is associated with more lines and therefore better performance of the industry. With respect to their magnitude it is interesting to note that the competition in the fixed-line segment has larger impact on main lines than the competition in the mobile relevant market. Privatization, PRIV, has also significant effect, although the sign of its coefficient is positive in contrast to Wallsten (2001). Moreover, we argue that in absolute terms the effect of regulation on the performance of the industry is more aggressive when competition and privatization interact with the regulation (−0.021 compared to −0.009).

The use of the other dependent variable REV, provides similar results as of the use of the dependent variable LINE with respect to the structural reform variables, except for the impact of privatization. Specifically, as can be seen from Table 2 (column 3) the coefficient of PRIV is negative, whereas in the presence of the cross terms becomes positive (column 4), a result that Wallsten (2001) has also indicated. Hence, it seems that the effect of privatization on revenues is vague. The overall effect of RRI on revenues based on Model (2) is larger, in absolute terms, taking into account the cross terms, than the effect without the cross terms obtained from Model (1), i.e., −0.252 versus −0.191 respectively, meaning that the effect of regulation on the total revenues of the industry is more aggressive when competition and privatization are present.

The next dependent variable is employment in Telecommunications Industry. In this case the estimated coefficients of regulation and competition have the anticipated signs and they are statistically significant for both models. However, the other structural reform variable PRIV has positive effect on employment. It is worth mentioning that the overall effect of RRI on the number of employees based on Model (2) is nearly the same, in absolute terms, as the separate effect obtained by Model (1), i.e., −0.061 versus −0.060 respectively.

Moreover, interesting results are also obtained using total investment in Telecommunications services. The negative sign of the RRI index is also reported in other similar studies (see, for example, Gutierrez 2003; Cadman 2007; Paleologos and Polemis 2013) indicating that a decrease in the relevant index, leads to an increase in the level of investment activity. This result is explained by the fact that a more deregulated environment attracts investment, since investors are usually looking for a stable social, political and economic environment, characterized by the absences of arbitrary administrative action, sudden shifts in policy or market conditions (Paleologos and Polemis 2013). Similarly to the other specifications, the overall effect of regulation on investment, taking into account the cross terms, is greater, in absolute terms, than the separate effect of Model (1), i.e., −0.190 versus −0.147 respectively.

Table 2 Empirical results

	Telephone mainlines per 100 inhabitants		Total revenue from all Telecommunications services		Full-time equivalent Telecommunications employees per 100 lines		Total investment in Telecommunications services	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
LINE(−1)	0.655***	0.707***	–	–	–	–	–	–
	(0.043)	(0.049)						
REV(−1)	–	–	−0.411***	−0.421***	–	–	–	–
			(0.006)	(0.007)				
EMPL(−1)	–	–	–	–	0.112***	0.087*	–	–
					(0.015)	(0.077)		
INV(−1)	–	–	–	–	–	–	0.127***	0.179***
							(0.031)	(0.019)
RRI	−0.009*	−0.021*	−0.191**	−0.252*	−0.061***	−0.060***	−0.147*	−0.190*
	(0.007)	(0.016)	(0.097)	(0.186)	(0.020)	(0.007)	(0.115)	(0.166)
COMP_INTER	0.020*	0.026***	0.417*	−1.123	0.008	0.506	−0.209	0.250
	(0.013)	(0.004)	(0.276)	(0.878)	(0.037)	(0.512)	(0.207)	(0.472)
COMP_MOB	0.005	0.007***	0.687**	2.008**	0.241***	1.404***	0.494*	0.699
	(0.015)	(0.009)	(0.310)	(1.083)	(0.073)	(0.401)	(0.422)	(1.013)
PRIV	0.070***	0.001***	−0.022	−0.085	0.300***	0.303**	0.060***	1.174***
	(0.018)	(0.004)	(0.093)	(0.217)	(0.055)	(0.145)	(0.022)	(0.281)
GDP	0.141**	0.097*	3.678***	3.927***	0.473***	0.787**	1.021*	2.646***
	(0.070)	(0.071)	(0.512)	(0.699)	(0.146)	(0.333)	(0.887)	(0.671)
POP	0.0001***	0.001	0.005	−0.001	0.026***	0.029***	0.011*	0.011*
	(0.001)	(0.001)	(0.008)	(0.010)	(0.004)	(0.006)	(0.008)	(0.008)
EX	−0.003***	−0.003**	−0.015	−0.022	0.014***	0.008*	−0.029*	−0.025**
	(0.001)	(0.002)	(0.011)	(0.020)	(0.003)	(0.006)	(0.017)	(0.011)
IR	–	–			–	–	−0.004	−0.013***
							(0.009)	(0.006)
FRASER	0.002	0.006	1.119***	0.795***	0.081*	0.095*	0.304*	0.131***
	(0.010)	(0.015)	(0.171)	(0.233)	(0.045)	(0.070)	(0.251)	(0.017)
IND	−0.005*	−0.001	−0.140***	−0.111**	0.084***	0.013	0.088***	0.017
	(0.003)	(0.003)	(0.046)	(0.061)	(0.009)	(0.019)	(0.036)	(0.034)
URBAN	0.014***	0.009**	−0.060***	−0.059*	−0.092***	−0.096***	−0.010	0.021
	(0.004)	(0.004)	(0.022)	(0.036)	(0.021)	(0.029)	(0.024)	(0.025)

Table 2 (continued)

	Telephone mainlines per 100 inhabitants		Total revenue from all Telecommunications services		Full-time equivalent Telecommunications employees per 100 lines		Total investment in Telecommunications services	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
RRI*COMP_INTER	–	0.004	–	0.347*	–	−0.143	–	−0.073
		(0.011)		(0.206)		(0.148)		(0.126)
RRI*COMP_MOB	–	0.0001	–	−0.322*	–	0.233***	–	0.209*
		(0.018)		(0.230)		(0.092)		(0.174)
RRI*PRIV	–	−0.022***	–	−0.059	–	−0.209**	–	−0.369***
		(0.007)		(0.084)		(0.101)		(0.081)
Diagnostics								
Observations	718	718	677	677	691	691	540	540
S.E of regression	0.039	0.039	0.756	0.745	0.292	0.311	0.264	0.301
Instrument rank	30	30	30	30	30	30	27	27
Sargan-Hansen test	21.301	16.853	21.723	12.909	23.091	13.635	10.845	6.313
	[0.32]	[0.39]	[0.29]	[0.68]	[0.23]	[0.62]	[0.76]	[0.89]

The dependent variables are in natural logarithms. Robust standard errors are in parentheses. The numbers in square brackets are the *p*-values. Significant at *** 1%, ** 5% and * 10% respectively. The use of fixed effects over random effects is justified by the Hausman test

The best fitted model in all four specifications includes one time period lag of the dependent variable. The advantage of having a time lag of the dependent variable as independent variable into the estimated model has two major effects. First, it deals indirectly with the concept of endogeneity generated by the presence of several control variables, such as regulation, competition and privatization and second, it captures short run and long run effects that cannot be identified by a static model.[7] The potential endogeneity problem is associated with the use of the structural reform variables (regulation, competition and privatization) which are treated as (endogenous) covariates in our models.[8] This could be explained by the fact that although it has been grounded that structural reform variables affect telecommunications performance (see among other Wallsten 2001; Li and Lyons 2012) there is a possibility that the direction of causality might also be reversed. Moreover, it is almost certainly the case that privatization and competition are not randomly determined among the OECD countries throughout the period, thus raising the concern that the coefficients of privatization and competition are biased. However, this may not be as much of a concern with the other structural reform variable (regulation).

As a consequence, an OLS estimator would tend to underestimate the effect of these control variables on telecommunications performance such as employment and revenues respectively. Endogeneity can be a problem because, if omitted variables jointly affect both the dependent and control variables, then the coefficient estimates for the explanatory variables may be biased (Hausman and Ros 2013). Generally, it should be stated that whenever endogenous regressors are used as control variables in a model (as often would be the case), OLS estimators must be avoided and the use of other estimation techniques are favourable (i.e IV or GMM) .

To provide a credible identification strategy that would address this issue and allow interpreting the results in a causal way we followed two alternative approaches. Firstly, we used lagged values of the structural reform variables as regressors and checked to see the sensitivity of our results to that choice. Our results remained fairly robust to whether we used current or lagged values of these regressors as independent variables. Therefore, we feel that the issue of endogeneity is not as severe in our case.[9] Secondly, we used the GMM estimator that controls for the endogeneity (Hansen 1982; Arellano and Bond 1991). This estimator takes into account the unobserved time-invariant bilateral specific effects, while it can deal effectively with the potential endogeneity arising from the inclusion of several control variables (Polemis 2015). It is worth mentioning that the GMM approach is just one estimation strategy along with the others. To be more specific, it is a form of instrumental variable (IV) approach, which is more efficient than any other econometric method because it uses a richer set of instruments.[10] However, it is well documented in the literature (see for example Parey and Waldinger 2011) that the IV approach can be severely biased in particular if instruments are weak and if many instruments are used for one endogenous variable (i.e. there are many over identifying restrictions).

All underlying estimated equations pass a battery of diagnostic tests. Specifically, the instrument rank is greater than the number of estimated coefficients, while the reported

[7] It is worth mentioning that among GMM procedures, the estimators by Arellano and Bond (1991) are the most widely used in empirical analysis, as pointed out by Gutierrez (2003).
[8] We greatly thank an anonymous referee for raising this issue.
[9] The results are available from the authors upon request.
[10] IV methods are typically used to address the generic problems encountered in OLS regressions such as omitted variable bias, measurement error and simultaneity or reverse causality.

Sargan-Hansen test indicates that the instrument list satisfies the orthogonallity conditions in all of the four specifications, since the null hypothesis that the over-identifying restrictions are valid cannot be rejected. However, the most interesting result is that the short run effect of RRI is always larger, in absolute terms, for all dependent variables in the presence of interaction terms than without them, i.e., for LINE is −0.0389 versus −0.009, for REV is −0.286 versus −0.191, for EMPL is −0.179 versus −0.061 and finally for INV −0.423 versus −0.147. In addition, the long run effect has different impact on each of the four dependent variables.[11] For example, in the case of LINE this effect is almost 3 and 3.5 times greater than the short run effect of the first period based on Models (1) and (2) respectively, denoting that the number of main lines will increase substantially in the long run. In contrast, this result is totally reversed in the case of REV, where total revenues of the Industry are expected to decrease by 30% in the long run for both models, since the sign of the coefficient of the lagged dependent variable is negative and their magnitudes are almost the identical for both specifications. On the other hand, it turns out that the long run effect on employment depends on the model specification. Model (1) declares that employment of the industry is expected to increase further in the long run by 13%, whereas Model (2) suggests that employment is expected to decrease by 8%, taking into consideration the interaction terms. This result is in alignment with other empirical studies claiming that the effect of structural reforms on employment is rather unambiguous (see for example, Wallsten 2001; Ros 1999). Finally, in the case of investment the long run effect indicates the overall investment activity of the Telecommunications Industry will increase by 15% and 22% using Models (1) and (2) respectively.

4 Concluding Remarks and Policy Implications

The impact of structural reforms on network industries such as telecommunications is an important research topic since it has attracted the attention of influential economists and numerous studies have been devoted on this subject over the last fifteen years.

This study follows a dynamic approach in order to thoroughly examine the impact of structural reforms (i.e regulation, competition and privatization) on the overall performance of the OECD telecommunications industry. The empirical findings suggest that structural reform variables have significant effect on Telecommunications performance. In particular, the sign of the coefficient of privatization on employment is positive. This result probably reflects the opposing impact on employment by this structural reform variable, since privatization may induce firms to increase efficiency by reducing employment or may induce firms to increase employment to improve service. Competition has positive effect on all four specifications of performance indicating that a competitive market structure is associated with a better performance of the Telecommunications industry. Meanwhile, several other variables such as, for example, GDP and the level of economic risk, expressed by the FRASER index, do also explain statistically significant Telecommunications performance.

Lastly, this study finds empirical support for institutional reforms that will help the policy makers and government officials in their efforts to increase performance of the industry. First,

[11] The long run effect is calculated as $1/(1-\gamma)$ times the value for the coefficient of every independent variable, where γ is the estimated coefficient of the lagged dependent variable for each of the four specifications. In the case of regulation the long run effect is derived by multiplying the above expression by either the estimated coefficient of RRI, which denotes the short run effect of the first period, obtained by Model (1) or by the sum of the estimated coefficients of RRI including the coefficients of the interaction terms obtained by Model (2).

regulation has stronger impact on performance when competition and privatisation are present than in the case where these interaction terms are absent. This effect can be implemented by adopting policies aiming at the removal of entry barriers and dealing effectively with concerted practices by the incumbents that hinder the level of competition. Second, in contrast to previous studies, empirical evidence of this research suggests that the long run effect on the performance of this industry will be greater, a concept that it is known as the multiplier effect. As a consequence, policy makers should pursue strategies toward the long run rather than the short run impact of the structural reform elements on Telecommunication performance.

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