Competition and investment in communication networks and services. Evidence from OECD countries

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Abstract

This paper means to add to empirical research on the relationship between competition and firm-level investments in communication networks and services. We explore the moderating action of two measures that can accompany market competition, i.e. privatization and promotion of service-based competition. In addition, we investigate the linearity of the impact of competition on investment, i.e. whether market rivalry fosters investment only under a threshold level (i.e. rivalry escape effect). The empirical analysis is carried out on a sample of incumbents from 27 OECD countries (1993-2008 period). After having attempted to detect the presence of potential breakpoints in the country-level investment series, firstly we have investigated the causality relationship between individual policy measures and incumbent's investment. Afterward, in order to explore the interactions among privatization, competition and service based competition, we specify a micro-econometric model of investment. Estimates are obtained through dynamic panel methods. Our findings can be summarized as follows. Aggregate investment exhibits a highly country specific pattern. No strong causality linkages have been found between stand-alone reform and firm level investment. Neither privatization nor competition in isolation play a significant role. The most relevant explaining factor has been found to be service based competition, which is likely to reduce the incumbent's incentives to invest, unless a certain degree of rivalry has already emerged in the markets, especially in fixed communications.

Keywords: investment, competition, telecommunication, incumbent, privatization

JEL classification code: L32, L51, L96

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1. Introduction

During the last 25 years, liberalization, incentive price regulation, access regulation and privatization, as attempts to improve the performances of communication industries, have been debated in detail and implemented in different countries. More recently, the attention of policy makers and scholars has increasingly shifted to policy measures that have the potential to foster investment in advanced networks and services. Despite the breadth of analysis and discussion, little consensus has emerged on the appropriate policy mix.

This paper means to add to empirical research on this topic. The analysis focuses upon the relationship between competition and firm-level investments in networks and services. Firstly, we investigate the linearity of the impact of competition on investment, i.e. whether market rivalry fosters investment only under a threshold level. Secondly, we explore the moderating action of two measures that can accompany market competition, i.e. privatization and promotion of service-based competition. The empirical analysis is carried out on a sample of incumbents from 27 OECD countries (1993-2008 period). Since the sample is relatively small-sized and exposed to risks of endogeneity or spurious correlation, robustness checks are particularly relevant here. We have then decided to adopt an empirical strategy that relies upon a multiplicity of methods. First of all, as a preliminary exploration, for some countries we have analyzed the investment time series in order to detect potential structural breaks in the investment patterns. Secondly, we explore the causality relationship between investment rate and policy measures. Finally, an investment model is specified according to the micro-econometric approach, and estimates are obtained through dynamic panel methods (e.g. GMM and Within-group; see Bond and Van Reenen 2007).

The paper is organized as follows. After a very short description of the main reforms that have been undertaken in OECD countries (Section 2), we review the previous empirical studies on competition, regulation and investment (Section 3). The research question and empirical strategy are discussed, in order to explain our modeling choices and to illustrate the sample, models and variables (Section 4). We then report and discuss the empirical findings (Section 5). Finally, some concluding remarks are presented (Section 6).

2. Reforms in OECD countries: a summary

The present Section offers some synthetic information on the sequence of major institutional changes that have occurred in the communication industries of industrialized countries over the last two decades.

It is well known that early liberalization experiments occurred in the USA, UK and New Zealand (1984, 1985 and 1988, respectively). Since 1990, all the governments of other OECD economies have progressively opened markets to new entrants (Table 1). Liberalization was generally anticipated by the withdrawal of public sector from the telecommunications industry. With the exception of the US and Canada, the telecommunication enterprises of OECD countries were traditionally owned by the State. During the Nineties, and after the UK privatization (1984), most OECD countries launched privatization programmes. Turkey was the last country to open to private shareholders in 2005. A large group of governments have preferred to partially privatize telecommunications operators (13 out of 25 countries refrained from transferring the control rights to private investors or financial markets).

In all the countries, liberalization was accompanied by the institution of Independent Regulatory Agencies (IRAs). Asymmetric regulation was intended to pave the way to competition. Nevertheless competition has found it hard to take off. Entrants suffered particularly serious difficulties in the deployment of own fixed access facilities (i.e. facility-based competition, FBC). As a remedy, additionally to interconnection obligations, regulators started implementing local loop unbundling (LLU) since mid-Nineties, (i.e. service-based competition, SBC). LLU firstly emerged with the 1996 US Telecommunication Act, which enforced unbundling obligations for the network elements of incumbent local exchange carriers (ILECs). European Union (EU) soon adopted a regulation on unbundled access to the local loop (EC 2887/2000; in force since January 2001). A few European countries mandated LLU in anticipation with respect to the EU (e.g. Germany in 1996, Denmark in 1998, Netherlands in 1999).

Since its early occurrences, LLU as a pro-competition measure, has been debated in detail. When technological and market opportunities emerged for the supply of high-speed always-on services, policymakers and scholars have been arguing that the sector reforms should be

assessed against their potential to create favorable conditions for the deployment of broadband network systems. Today, most experts tend to recognize that mandated access to the access network elements can foster competition in the short run, but it could be inappropriate to ensure long-term competition through investment. Nevertheless, access regulation and LLU are still the dominant regulatory paradigms in most OECD countries. Only the US regulatory frameworks evolved quite radically. In 2005 the Federal Communications Commission (FCC) cancelled the obligations to unbundle networks in the market for broadband services (Bauer and Bohlin, 2008).

Table 1 – Privatization and liberalization in the sample countries

	Liberalization – voice trunk service	Liberalization – voice mobile service	Privatization	Full privatization	Unbundling obligations
Australia	1991	1991	1997	-	1999
Austria	1999	1995	1998	-	1997
Belgium	1999	1995	1995	-	2000
Canada	1990	1991	private		1997
Czech Rep.	2002	1997	1995	2005	2003
Denmark	1995	1991	1994	1998	1998
Finland	1991	1991	1998	-	1997
France	1998	1990	1997	-	2001
Germany	1999	1991	1996	-	1996
Greece	2002	1993	1996	-	2001
Hungary	2002	1994	1993	1999	2001
Ireland	1999	1995	1996	2001	2000
Italy	1999	1994	1997	2002	2001
Japan	1988	1985	1986	-	1997
Korea	1998	1994	1992	2002	2001
Mexico	1997	1997	1990	1991	-
Netherlands	1997	1994	1994	2006	1999
New Zealand	1988	1987	1991	1991	2007
Norway	1999	1991	1999	-	2000
Poland	2002	1996	1998	2003	2003
Portugal	2000	1993	1995	-	2000
Spain	1996	1995	1987	1997	2000
Sweden	1991	1986	2000	-	2000
Switzerland	1998	1998	1998	-	2003
Turkey	2007	1998	2005	-	2005
UK	1985	1985	1984	1984	2000
USA	1984	1983	private		1996

Sources: Conway, P. and G. Nicoletti (2006) Product Market Regulation in non-manufacturing sectors in OECD countries: measurement and highlights. *OECD Economics Department Working Paper* No.530; Company annual reports; OECD Communication Outlook.

3. Survey of empirical analyses on reforms and investment

After having summarized the main theoretical predictions on restructuring measures (particularly, SBC) and investment, this Section reviews the pre-existing studies that have empirically analyzed these topics. The Section concludes by sketching the analysis that will be presented in the following Sections against the received evidence.

The development of more advanced communication networks should be regarded as innovation efforts that are instrumental in differentiating the service offered. Theories on the effect of liberalization, privatization and service-based competition on innovation can be synthesized as follows.

Firstly, the seminal research by Aghion et al. (2005) showed that the incentives to provide quality-enhancing innovations strengthen if the market rivalry increases from null (very low) to low or medium levels, as in recently liberalized communications, (i.e. firms try to escape rivalry).[3] At higher levels of competition, however, a Schumpeterian effect emerges. In other words, the relationship between competition and innovation is better described as an inverted u-shaped function.

Secondly, the privatization of formerly State-owned communication enterprises occurred in coincidence with liberalization reforms. As a result, its effects should be investigated jointly with the impact of competition (i.e. competition is an accompanying measure of privatization). As Hart et al. (1997) revealed, absent competition, private providers are likely to experience incentives to improve the service quality that are similar to the incentives of State-owned enterprises. Nevertheless, private monopolists have inferior innovation performances because they experience excessively high incentives to reduce costs. Instead, if the market is open to consumer choice, the privatized provider is rewarded for quality-enhancing efforts and is punished for any quality deterioration arising from its cost-reducing efforts. As a consequence, the private firm supplies the first-best quality of service.

[3] In addition, competition in selected markets could be sufficient to provide the provider with greater incentives to invest in service differentiation, due to reputation spillovers from regulated to competitive markets (Weisman, 2005).

Finally, theories do not provide equally clear-cut predictions on the relationship between SBC and investment. Some ambiguities in the literature on LLU and access regulation still remain, even though new models and results have been recently provided in this area (Cambini and Jiang 2009). In short, cost-based access prices and facility-sharing obligations shift the investment risk from entrants to incumbent (Jorde et al. 2000; Pindyck 2007).[4] This result motivates why SBC should be intended to be a temporary measure that allows the entrants to climb the first rung of an investment ladder, and to learn about the customer preferences (Cave and Vogelsang, 2003). Consistently with this paradigm, dynamic access price regulation, in the fashion of rising access charges, has been proposed to foster FBC and to encourage the entrant to roll out its own network (Bourreau and Dogan, 2006). To this aim a critical condition is the regulatory commitment not to reduce access charges ex-post, while it is still unclear when access regulation should be removed to leave room to FBC (Avenali et. al 2010).

Early empirical works used country-level data to analyze the impact of privatization and liberalization on investment and other performance indicators (e.g. efficiency, profitability, employment), in developing and, less frequently, developed countries. Li and Xu (2004) analyzed a comprehensive panel data set (162 countries observed from 1990 to 2001) and found that privatization and competition spur investments, especially in conjunction. Wallsten (2001) explored the effects of privatization, competition, and regulation on the industry performances in 30 African and Latin American countries from 1984 through 1997. He found that competition increases the number of mainlines and privatization has a positive effect only if it is accompanied by the institution of an independent regulator. The positive effect of privatization and competition was confirmed also by Fink et al. (2003), which analyzed 86 developing countries over the 1985-1999 period. A comprehensive reform program, involving

[4] In other words a free option not to invest is granted to new entrants. Pindyck (2007) pointed out that the disadvantage suffered by the incumbent entails private costs (i.e. for the incumbent shareholders) and social costs (i.e. for consumers, due to the incumbent's diminished incentives to sustain sunk investment in innovation). He developed a real option analysis, which shows that the investment NPV is reduced if the new entrants are enabled to rent at TELRIC price the incumbent's facilities, and concluded that the TELRIC price should account for the incumbent's lost option value.

liberalization, privatization and the institution of an independent regulator produced the largest gains.

A different approach has been followed by Bortolotti et al. (2002), who used firm-level data to examine the financial and operating performance of 31 communication companies from 25 nations, i.e. 14 developed and 11 developing countries. All the enterprises had been fully or partially divested by the State via public share offering over the period 1981–1998. The authors showed that neither privatization nor competition affected firm-level investment.

Most recent empirical research is centered on access regulation, and LLU particularly. Both country and firm level evidence is now available. Some empirical studies have provided evidence of FBC advantages in terms of broadband diffusion. For instance, Distaso et al. (2006) have examined 14 European countries and discovered that FBC seems to be a key driver of the broadband uptake. Instead SBC seems to play a less significant role and to act jointly with the market structure. Lower LLU prices have a more pronounced positive effect on broadband diffusion, the lower the industry concentration. Denni and Gruber (2007), have analyzed the US and have confirmed that SBC has a positive role only initially on diffusion rate of broadband infrastructure. In the long term FBC has played a more important role.

Firm-level analyses of the impact of LLU and forward looking cost rules by now have offered mixed evidence. Chang et al. (2003) showed that a lower access price promotes a greater deployment of digital technology among the ILECs. Willig (2006) also confirmed that the prices for unbundled elements are negatively related to the investment of incumbents. The results are interpreted according to the "escape-rivalry" effect (Aghion et al. 2005), i.e. unbundling obligations lead to a greater competitive stimulus that in turn induces the incumbents to protect market shares by investing in the network. By contrast, Hausman and Sidak (2005) showed that unbundling regulations curb the incumbent's investment. They carried out case studies of five countries, and documented that mandatory unbundling grants a 'free option' to new entrants and fails to provide a stepping-stone to FBC. Mandatory unbundling was likely to attract 'fly-by-night' firms that were primarily interested in short-term margins and eschewed long-term development of rival networks, also because regulators were

not perceived as truly committed to previous promises to evolve from UNE-based competition to FBC. Similarly, the papers that analyze the regulatory frameworks of European countries have not confirmed the benefits of SBC regulatory approach (i.e. investment ladder theory). Waverman et al. (2007), after having estimated the demand for broadband lines in 12 European countries, have simulated the relationship between LLU and investment in broadband platforms. Their analysis has shown that lower LLU prices have created the conditions for LLU-based operators to gain market shares. However, SBC comes at the price of FBC, i.e. the development of alternative broadband facilities. Friederiszick et al. (2008) have used a sample of 180 firms from 25 European countries in 1996-2007 years. They have confirmed that LLU, as a tough entry regulation of fixed-line communications, has hindered the entrants' investment, and does not have any measurable impact on incumbent. A similar evidence has been provided by Grajek and Röller (2009). They have constructed a sample that includes more than 70 fixed-line operators from 20 EU countries during the 1997-2006 period. In particular, entry regulation of fixed-line communications has a quite articulated impact; both the incumbent and individual entrants are less likely to develop the network, even though the overall investment of entrants increases (i.e. a greater number of firms enter the market). Moreover the regulatory environment of European countries is found to suffer from commitment difficulties. Regulators respond to the incumbent's increasing infrastructure investment by further easing the access. This in turn is likely to undermine the incumbents' incentives to invest in infrastructure in the first place.

Altogether the results obtained by empirical studies about access regulation cast doubt on the hypothesis that SBC may represent a move towards a more intense development of advanced facilities and towards FBC.

In spite of the interest of recent analyses, it should be recognized that we do not yet have a compact and robust body of evidence (Cambini and Jiang, 2009). Friederiszick et al. (2008) and Grajek and Röller (2009) are superior to other available studies insofar as they model the investment dynamics, and control for the endogeneity of regulation variables. In addition, while previous studies generally suffered from the lack of reasonable time series, they observe the investment pattern along 10 years. Our empirical analysis means to continue in the direction

firstly indicated by the two mentioned investigations along two lines, which will be illustrated in details in the next Section.

- The investment model is specified according to a micro-econometric approach (see Bond and Van Reenen 2007), and estimates are obtained through dynamic panel techniques (GMM and Within-group Least Squares).[5]
- We are aware of the potential limitations currently suffered by structural models of the reform-investment relationship. Samples are inevitably small-sized, the reform indicators are likely to be mutually collinear and endogenous to the firm's conducts and performances. These problems motivate our choice to make some efforts to preliminarily investigate the dynamics of fixed investments, i.e. whether they exhibit breakpoints or Granger causality linkages with the reforms.

4. Research questions and empirical methods

This paper is an attempt to answer to the following research questions.

- Does market rivalry significantly spur the incumbent's investment? Is this relationship linear, or does any threshold effect emerge?
- Is privatization really complementary to competition, that is, does it strengthen the competitive stimuli to invest?
- Do LLU and SBC inhibit the incumbent's investment?

The empirical strategy that we have adopted consists of a multiplicity of methods.

First, we try to obtain a very preliminary evidence on the occurrence of exogenous structural breaks in the investment performance of countries over the last years. Since time span for firm-level data is limited, we have decided to stay at an aggregate level and to analyze six European countries (Denmark, France, Germany, Italy, Netherlands and Spain), by now. Data are observed from 1975 to 2004 (source: ITU). We have then completed the series up to 2007 from

[5] In this respect our work is close to Cambini and Rondi (2009), which investigated the relationship between investment and price regulation in the European energy sector, by estimating an investment model that closely follows the micro-econometric literature.

OECD Communication Outlook 2009[6]. To run the analysis, we have employed the test of multiple breakpoints in the mean of the series, allowing for a maximum of two breaks, developed by Bai and Perron (1998, 2003).

Second, a Granger causality is carried out to determine whether the reforms, i.e. privatization, liberalization and SBC, have caused the incumbent's investments or vice versa. This is also helpful to test the exogeneity of reform indicators. Estimates are obtained by the means of two dynamic panel data methods, the corrected Least Square Dummies Variable (LSDVc), proposed by Bruno (2005), and the Difference Generalized Method of Moments (GMMd), proposed by Arellano and Bond (1991). They can be seen as relatively complementary, because they rely, respectively, on the assumptions that the explanatory variable is exogenous, and the sample is not too limited in size[7].

Finally, a structural investment equation is specified according to the micro-econometric literature on investment (Bond and Meghir, 1994). The GMMd estimator takes into account the endogeneity of independent variables but it does not perform very well in small sample. Unfortunately, the LSDVc method cannot be used to estimate the Bond-Meghir equation, due to the presence of a squared lagged dependent variable. We then complement the GMMd estimates with Within Group (WG) estimates.

4.1 Data and variables

We have collected data on financial and economic indicators for the incumbents of 27 OECD countries over the 1993-2008 period. The dataset is an unbalanced panel of 29 incumbents (i.e. 2 firms are from the US and Telia-Sonera is analyzed as a separate enterprise from Telia and Sonera). The panel is unbalanced, because information is missing for many firms in early years, as it is shown in Table 2.

[6] This explains why we have only 6 countries in the sample for this first analysis. Indeed, for these countries data are homogeneous between the two sources.

[7] The LSDVc estimator differs from the traditional Within Group (WG) technique, because it takes into account the endogeneity of lagged dependent variable.

Table 2 – Sample

State	Firm	Firm years
Australia	Telstra	1995-2008
Austria	Telekom Austria	1998-2008
Belgium	Belgacom	1997-2008
Canada	Bell Canada	1994-2008
Czech Republic	Cesky Telecom	1998-2008
Denmark	TDC	1995-2008
Finland	Sonera	1997-2001
France	France Telecom	1996-2008
Germany	Deutsche Telekom	1994-2008
Greece	Ote	1995-2008
Hungary	Matav	1996-2008
Irland	Eircom	1999-2006
Italy	Telecom Italia	1998-2008
Japan	NTT	1998-2008
Korea	Korea Telecom	1997-2008
Mexico	Telmex	1994-2008
Netherlands	KPN	1995-2008
New Zealand	Telecom New Zealand	1995-2008
Norway	Telenor	1998-2008
Poland	TPSA	1998-2008
Portugal	Portugal Telecom	1994-2008
Spain	Telefonica	1998-2008
Sweden	Telia	1997-2001
Sweden/Finland	Teliasonera	2002-2008
Switzerland	Swisscom	1995-2008
Turkey	Turk Telekom	2005-2008
Uk	British Telecom	1993-2008
Usa	SBC	1993-2008
	Verizon	1993-2008

Table 3 reports the definition and sources of our variables. Our key variable is *I/K*, i.e. the investment rate. It is computed as the ratio between intangible and tangible investment and the lagged level of tangible and intangible assets. The baseline structural investment model includes other financial indicators: the cash flow rate, *CF/K*, the debt rate, *D/K*, and the sales rate, *S/K*. They are defined as the ratio between, respectively, the cash flows originated by operating activities, current and non-current liabilities, sales and the lagged level of tangible and intangible assets. *Priv*, i.e. the percentage of shareholding owned by private investors or financial markets; is our measure of privatization. Information on financial indicators and ownership has been sourced from the financial reports of firms and from Datastream.

Table 3 – List of variables

Variable	Definition
I	Total tangible and intangible investment
K	Total tangible and intangible assets
CF	Cash flow from operating activities
D	Total current and non-current liabilities
S	Total sales
Priv	private shareholding (%)
Lib	6 - "entry barrier" indicator
Comp	6 - "market power" indicator
Nett	Market share new entrants in trunk telephony (%)
Neal	Market share new entrants in access lines (%)
Unb	Dummy = 1 if unbundling is mandatory
DSL	Ratio between Total Broadband subscribers using DSL technology and Total broadband subscribers

Sources: Conway, P. and G. Nicoletti (2006) Product Market Regulation in non-manufacturing sectors in OECD countries: measurement and highlights. *OECD Economics Department Working Paper* No.530; Company annual reports; Datastream; OECD Communication outlook.

We have gathered additional information on the reforms from reports and datasets provided by the OECD. *Lib* and *Comp*, i.e. our liberalization and overall competition indicators, have been constructed from the elementary indicators that make up the OECD regulatory index for telecom sector (see Conway and Nicoletti, 2006). Particularly, the two relevant elementary indicators are the variable that represents legal barriers to entry ("entry barrier") and the variable that represent the new entrants' market shares in mobile services and fixed trunk and international services ("market power") The "entry barrier" indicator ranges from 0 (free entry) to 6 (legal monopoly). Our measure of liberalization, *Lib*, is defined as the complement of "entry barrier":

$$Lib = 6 - \text{"entry barrier"}$$

Similary, the "market power" indicator ranges from 0 (low) to 6 (high). Our overall competition indicator, *Comp*, is defined as:

$$Comp = 6 - \text{"market power"}$$

In order to have a more precise measure of competition in the fixed telephony market, we define the variable *Nett* (new entrants in trunk telephony market) as the market shares of entrants in the

trunk market.[8] Though the relevant information is incomplete, for a sub-sample we have also succeeded in collecting information on the entrants' market shares in the market for fixed access lines from the OECD Communication Outlooks.[9] The indicator of access market rivalry, *Neal* (new entrants in access lines), doesn't include unbundled or resold lines.

In order to measure the competitive pressure exerted by alternative platforms (i.e. a relevant factor for FBC), an indicator of broadband diffusion using DSL technology is constructed.

$$\text{DSL} = \frac{\text{Total fixed broadband subscribers [using DSL technology]}}{\text{Total fixed broadband subscribers}}$$

The LLU indicator, Unb, is a binary variable that is set equal to 1 if the country is enacting a regulation that obliges the incumbent to unbundle the access networks.[10]

Given these two last variables, we construct our measure of SBC as:

$$Sbc = \text{Unb} * \text{DSL}$$

Table 4 reports the descriptive statistics of the variables while Table 5 the correlation matrix.

Table 4 – Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
I/K	319	0.149	0.074	0.037	0.451
CF/K	319	0.246	0.091	-0.075	0.596
D/K	319	1.226	2.000	0.055	28.233
S/K	319	0.854	0.282	0.292	1.968
Priv	356	0.711	0.322	0	1
Lib	331	5.009	1.853	0	6
Comp	330	2.668	1.331	0	5.55
Nett	330	25.003	18.894	0	68.8
Neal	255	6.241	9.742	0	68
Sbc	316	0.379	0.368	0	1

[8] Some studies have disaggregated the market share of entrants according to unbundling-based and facilities based market share (Jung et al., 2008). Unfortunately, the OECD Communications Outlook does not report this kind of information for all the countries.

[9] Missing values for individual years in the time series were computed through linear interpolation; 7% of the 255 sub-sample observations were constructed in this way.

[10] The recent studies that analyze the impact of access regulation and unbundling on incentives to invest have used the Plaut's regulatory index (Friederiszick et al., 2008, Grajek and RÖller, 2009). This index is explicitly constructed to account for the influence that a regulatory intervention may have on firms' investment activities. Unfortunately, it's available only for all the sample countries over the 1997-2006 period.

Table 5 – Correlation matrix

	I/K	CF/K	D/K	S/K	Priv	Comp	Sbc	Lib	Nett	Neal
I/K	1.000									
CF/K	0.337	1.000								
D/K	0.396	0.062	1.000							
S/K	0.552	0.672	0.375	1.000						
Priv	-0.197	-0.083	-0.023	-0.157	1.000					
Comp	-0.116	-0.115	0.139	0.003	0.392	1.000				
Sbc	-0.285	-0.134	0.001	-0.065	0.100	0.392	1.000			
Lib	-0.146	-0.072	0.098	0.123	0.339	0.683	0.409	1.000		
Nett	-0.078	-0.034	0.184	0.074	0.319	0.913	0.243	0.563	1.000	
Neal	-0.199	-0.060	-0.006	-0.031	0.449	0.509	0.236	0.396	0.406	1.000

4.2 Models

In order to test whether our interest variables (i.e. Z, reform indicator) Granger-cause the incumbent's investment or investment Granger-causes the reforms, we estimate the following two equations:

$$\frac{I_{i,t}}{K_{i,t-1}} = \alpha_1 \frac{I_{i,t-1}}{K_{i,t-2}} + \beta_1 Z_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{i,t} , \quad (1)$$

$$Z_{i,t} = \gamma_1 Z_{i,t-1} + \delta_1 \frac{I_{i,t-1}}{K_{i,t-2}} + \mu_i + \lambda_t + \omega_{i,t} , \quad (2)$$

where μ_i and λ_t are the unobservable country-specific and time-specific characteristics and $\varepsilon_{i,t}$ and $\omega_{i,t}$ are the i.i.d. disturbance terms. We have estimated a different specification, which also includes the two lags for both dependent and independent variable, but the enlarged specification has been always rejected by tests on GMMd or LSDVc coefficients. In addition, the two lags models have not provided results different from the results reported by Table 7.

As anticipated, we have used the GMMd estimator. In this context, we make the weakest assumption possible and consider, in addition to the lagged dependent variable, all the reform variables as potentially endogenous. In other words, we have employed lagged values in t-2 and t-3 as instruments for both types of variables in the set of equations (1) and (2). We have also resorted to an alternative procedure, i.e. the LSDVc estimator.

The structural investment equation is a version of the Euler-equation model (Bond and Meghir, 1994). The dynamics of investment rates is derived from the dynamic optimization of profit

problem in the presence of symmetric, quadratic adjustment costs. The following expression is the baseline model:

$$\frac{I_{i,t}}{K_{i,t-1}} = \rho \frac{I_{i,t-1}}{K_{i,t-2}} + \beta_1 \left(\frac{I_{i,t-1}}{K_{i,t-2}} \right)^2 + \beta_2 \frac{CF_{i,t}}{K_{i,t-1}} + \beta_3 \frac{D_{i,t}}{K_{i,t-1}} + \beta_4 \frac{S_{i,t}}{K_{i,t-1}} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (3)$$

where μ_i and λ_t are the unobservable country-specific and time-specific characteristics and $\varepsilon_{i,t}$ and is the i.i.d. disturbance terms. The lagged dependent variable is present in the model to take into account the persistence of series and the squared lagged dependent variable accounts for the adjustment costs[11]. The debt and cash flow rates are also included to take into account the financial sourcing. In particular, the cash flow variable is included to account for capital markets imperfections and asymmetric information problems that may cause investment decisions to be constrained by the amount of internal funds. The term related to sales controls for increasing returns to scale and imperfect competition and can be eliminated from the Euler equation only under perfect competition. The GDP per capita variable is included in the baseline model as a control variable, to take account the economic cycle. The baseline model is augmented to include the reform variable, either linearly or in cross products: *Priv, Comp (or Nett) and Sbc*.

The equation (3) is estimated both by WG and GMMd estimators. The LSDVc estimator is inappropriate here because of the presence of squared lagged dependent variable, an additional endogenous variable.

[11] The adjustment cost accounts for the empirical failure of models which assume the change of input factors to be costless and immediate. The costs of adjustment are assumed to be strictly convex and differentiable, which will tend to smooth the adjustment of quasi-fixed factors to new information, since a series of small adjustments is assumed to be cheaper than a single large change in the level of these inputs (Bond and Meghir, 1994)

5. Results

Table 6 presents the results of Bai and Perron (2003) test of two breakpoints in the mean of the series. The dependent variable is the total telecommunication investment (USD millions) deflated by the consumer prices index (2005 USD).

Table 6 – Breakpoints in investment series at country-level: Bai and Perron (2003) test

		Break 1	**Break 2**
	β_1	β_2	β_3
		1980	**1995**
Denmark	863***	642***	1175***
	(69)	(81)	(84)
		1980	
France	12497***	7669***	
	(449)	(496)	
		1986	**1996**
Germany	10142***	17784***	8886***
	(747)	(1108)	(1080)
		1987	**1992**
Italy	6215***	12189***	8144***
	(307)	(583)	(420)
		1988	**1997**
Netherlands	1295***	2126***	2632***
	(107)	(171)	(166)
		1988	**1992**
Spain	3236***	8109***	5420***
	(408)	(866)	(568)

Note: Standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. $\beta_1, \beta_2, \beta_3$ denote the mean prior to the first breakpoint, the mean between the first and the second breakpoints, and the mean after the second breakpoint, respectively. Data are in 2005 USD millions.

Only one breakpoint is detected for France, while for the other countries two breakpoints are detected. The results indicate that all countries have experienced a first significant breakpoint in their real telecommunication investment in the 80s. The breakpoint detected for Denmark and France is the same (1980) and the post-break levels are, for both countries, lower than before it. Instead, the breakpoints detected for the other countries have occurred in the late 80s: 1986 for Germany, 1987 for Italy, 1988 for Netherlands and Spain. For these countries, the post-break levels are higher than before it and this could be associated to the programs of digitalization of the fixed network launched by the incumbents during those years.

The second breakpoints have occurred at different times in the 90s and are characterized by a fall in the investment, with the exception of Denmark and Netherlands. Denmark's investment

has shifted from a mean of 642 to 1175 after the 1995. The privatization process (1994) or the fixed market liberalization (1995) could be related to this breakpoint. Less prominent is the positive shift observed for Netherlands: investment has risen from 2126 to 2632 after its break year of 1997, the fixed market liberalization's year. The second breakpoints detected for Germany (1996), Italy (1992) and Spain (1992) are associated with a decline in the investment, as a consequence of the ending of the digitalization of the network. We could conclude that for these countries, the reform of the telecom sector did not significantly affect investment.

As a preliminary conclusion and looking forward to a broader investigation of time series, differences between countries emerge. For countries that have experienced breakpoints during the reforms of the telecom sector (Denmark and Netherlands), fixed market liberalization is more frequently associated with the detected potential breakpoints and the post-break investment levels are higher than before it.

In order to further investigate the relationship between investment behavior and sector reforms, we have carried out a causality analysis by focusing on incumbents. The results that have been obtained from the Granger models are presented in Table 7.

The bivariate model does not show any robust causality pattern, either direct or reverse, between investment and reform measures. While LSDVc estimates of the *I/K* coefficients in reverse models of *Comp* and *Neal* are significantly different from 0, the GMMd estimates are not significant at standard levels. These findings are interesting in two respects. First, they will help us to specify and to estimate the structural models, insofar as they allow us to exclude that the reform variables are endogenous to investment, with the possible exception of *Comp* and *Neal*. We have thus cautiously assumed that all the competition variables are endogenous, and have treated them accordingly in the structural investment models. Second, they offer a preliminary hint about the weakness of the relations between incumbent's investments and reforms, at least when reforms are considered individually.

Table 7 –Results from Granger causality analysis

Investigated relationship	*GMMd*	*LSDVc*
Direct causality links		
Priv→I/K	-0.003	0.003
	(0.045)	(0.024)
Comp→ I/K	0.014	0.004
	(0.018)	(0.007)
Nett→ I/K	0.126	0.012
	(0.140)	(0.039)
Neal→ I/K	-0.559	0.058
	(1.045)	(0.099)
Sbc→ I/K	-0.029	0.018
	(0.021)	(0.016)
Reverse causality links		
I/K → Priv	0.080	0.077
	(0.127)	(0.078)
I/K → Comp	-1.337	-0.944**
	(0.837)	(0.438)
I/K → Nett	-0.184	-0.090
	(0.194)	(0.118)
I/K → Neal	0.004	0.240***
	(0.112)	(0.073)
I/K → Sbc	-0.497	-0.253
	(0.533)	(0.330)

Note: standard errors in parentheses. ***, ** and * indicate, respectively, significance levels of <1%, <5% and <10%.

In order to gauge a more deep picture of incumbent's investment conducts we have to consider the results from micro-econometric model. Table 8 and Table 9 report the estimates of dynamic investment model, using as competition variable respectively *Comp* and *Nett*.

First of all, we discuss the estimates obtained for "baseline variables", that is: lagged investment rate, squared lagged investment rate, cash flow, debt and sales. It's quite encouraging that the sign, significance and sometimes the magnitude of the estimated coefficients are in line with the results obtained by most of empirical works on investment (Bond and Meghir, 1994). In addition they are rather stable across specifications (Table 8 and 9) and do not change greatly when different estimators are used (WG and GMMd). Moreover, when we have tested a restriction on coefficients and we have estimated the restricted model (columns 2a-2b in Table 8 and columns 4a-4b in Table 9), generally they keep their sign, significance and, in some cases, magnitude.

Table 8 –Dynamic investment model (*Comp* model)

	Unrestricted model		*Restricted model*	
	(1a)	(1b)	(2a)	(2b)
	(WG)	(GMMd)	(WG)	(GMMd)
$(I/K)_{t-1}$	0.430***	0.472	0.461***	0.780
	(0.142)	(1.387)	(0.137)	(2.084)
$(I/K)_{t-1}^2$	-0.632**	-0.805	-0.678**	-1.152
	(0.298)	(2.940)	(0.291)	(4.786)
D/K	0.005*	0.005	0.005*	0.003
	(0.003)	(0.007)	(0.003)	(0.004)
CF/K	0.116	-0.073	0.106	0.223
	(0.080)	(0.484)	(0.076)	(0.213)
S/K	0.117***	0.230**	0.116***	0.183**
	(0.029)	(0.098)	(0.028)	(0.073)
Priv	-0.031	0.072		
	(0.056)	(0.205)		
Comp	-0.024*	0.038	-0.009	0.001
	(0.013)	(0.073)	(0.007)	(0.028)
$Comp^2$	0.004	-0.001		
	(0.004)	(0.020)		
Priv * Comp	-0.003	-0.053		
	(0.017)	(0.069)		
Sbc	-0.036*	-0.097	-0.046**	-0.105
	(0.021)	(0.127)	(0.020)	(0.147)
Sbc * Comp	0.012*	0.036	0.014**	0.040
	(0.006)	(0.045)	(0.006)	(0.047)
Ln(gdpcap)	0.040	-0.270	0.022	-0.434
	(0.075)	(0.434)	(0.075)	(0.708)
Time dummies	Yes	Yes	Yes	Yes
N	253	222	253	222
Ar (1)		-1.972		-1.688
p-value		0.049		0.091
Ar (2)		-0.736		-1.017
p-value		0.462		0.309
Hansen		7.421		13.773
p-value		0.829		0.131
$H_0 : comp^2=$	F(3, 28) = 1.97	Chi2(3) = 0.63		
priv=privcomp=0	Prob > F = 0.14	Prob > chi2 = 0.90		

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions.

Table 9 – Dynamic investment model (*Nett* model)

	Unrestricted model		*Restricted model*	
	(3a)	(3b)	(4a)	(4b)
	(WG)	(GMMd)	(WG)	(GMMd)
$(I/K)_{t-1}$	0.429***	0.772***	0.459***	0.771***
	(0.134)	(0.248)	(0.139)	(0.212)
$(I/K)_{t-1}^2$	-0.629**	-1.441***	-0.688**	-1.414***
	(0.285)	(0.524)	(0.286)	(0.445)
D/K	0.005*	0.004	0.005*	0.004*
	(0.003)	(0.002)	(0.003)	(0.002)
CF/K	0.108	0.124	0.098	0.117
	(0.080)	(0.120)	(0.077)	(0.113)
S/K	0.116***	0.192***	0.115***	0.196***
	(0.029)	(0.055)	(0.029)	(0.044)
Priv	-0.042	-0.049		
	(0.036)	(0.102)		
Nett	-0.088	0.346	-0.011	0.321
	(0.106)	(0.241)	(0.087)	(0.346)
$Nett^2$	0.089	-0.156		
	(0.136)	(0.399)		
Priv * Nett	0.002	-0.601*	-0.057	-0.631
	(0.113)	(0.350)	(0.091)	(0.514)
Sbc	-0.028	-0.082***	-0.032*	-0.080**
	(0.017)	(0.031)	(0.016)	(0.038)
Sbc * Nett	0.098*	0.335***	0.089*	0.318**
	(0.050)	(0.129)	(0.047)	(0.149)
Ln(gdpcap)	0.044	-0.016	0.034	0.024
	(0.079)	(0.338)	(0.079)	(0.365)
Time dummies	Yes	Yes	Yes	Yes
N	253	222	253	222
Ar (1)		-2.504		-2.539
p-value		0.012		0.011
Ar (2)		-0.692		-0.459
p-value		0.489		0.646
Hansen		2.982		6.421
p-value		0.996		0.779
$H_0 : nett^2=priv=0$	F(2, 28) = 2.17	chi2(2) = 0.28		
	Prob > F = 0.13	Prob > chi2 = 0.87		

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions.

The series is estimated to be persistent (i.e. the coefficient of the lagged dependent variable is significant) and the costs of adjustment are found to be convex, (i.e. the coefficient of squared lagged dependent variable is significant and negative). Moreover, the coefficient of sales is positive and significant, consistently with highly imperfect competition in the product markets. Financial structure seems to play any role: the coefficients of cash flow and debt are not significant. The coefficients in the *Nett* model are more significant than those in the *Comp* model, and this means to indicate that competition in the fixed market is a more relevant explaining factor than a general measure of competition, as *Comp*.

Secondly, we comment the results obtained from unrestricted model (columns 1a-1b in Table 8 and columns 3a-3b in Table 9) with respect to our interest variables. Privatization and the squared competition variable ($Comp^2$ or $Nett^2$) are never significant. The cross term between privatization and competition is not significant in the *Comp* model (Table 8), while the WG and GMMd estimates exhibit different signs in the *Nett* model, even though the GMMd coefficient results to be significant. Similarly, the estimated coefficients of competition variable (*Comp* and *Nett*) have different signs between the two estimators, but they are not significant, with the exception of the *Comp* model. Unrestricted model offers the most valuable results in respect to variables represent *Sbc*, both in isolation and in interaction with *Comp* or *Nett*. Particularly, *Sbc* coefficient has been found to be negative and significant, while the cross term with competition is likely to have a positive and significant effect on incumbent's investment. In other words, we have found that *Sbc* is more likely to have a negative effect on incumbent's incentives to invest if product market competition is very low. Indeed, its impact is milder the more competitive are the markets.

As anticipated, we have then proceeded to restrict the WG and GMMd models for both specification (Table 8 and 9). We have tested the hypothesis that those variables that are different from zero at a 25% or greater significance level (p-value equal to or greater than 0.25) are zero. The test results are reported in the last rows of Table 8 and 9. As in both models, we have accepted the null hypothesis, we have estimated the restricted models. The *Comp* restricted model has been obtained by excluding *Priv*, $Comp^2$ and *Privcomp* variables (the null hypothesis

has been accepted with a p-value equal to 0.14 for WG estimates and 0.9 for GMMd estimates). Similarly, the *Nett* restricted model has been obtained by excluding *Priv* and $Nett^2$ variables (the null hypothesis has been accepted with a p-value equal to 0.13 for WG estimates and 0.87 for GMMd estimates). Let us now illustrate our final results (columns 2a-2b in Table 8 and columns 4a-4b in Table 9). Competition does not play an autonomous and significant role, whether it is described by *Comp* or *Nett* variable, as well as the squared competition variable. Privatization has been excluded from both *Comp* and *Nett* models while the hypothesis of a positive effect of the interaction between privatization and competition could not be accepted. As a matter of facts, the cross term has been excluded from the *Comp* model while it results to be not significant in the *Nett* model. Estimates of the restricted model converge to demonstrate that *Sbc* is the major determinant of the investments made by the incumbent. Particularly, investment rate is likely to decrease if *Sbc* increases, that is unbundling obligations are adopted and the diffusion of alternative platforms (e.g. CaTV) is very low. The cross products with competition are invariably positive and significant different from zero, with the only exception of GMMd estimates of *Comp* model. Thus, as we have already emphasized, the incumbent's incentives to invest are negatively affected by *Sbc* unless some degree of rivalry has already emerged in the product markets.

In conclusion, our results reveal that competition in the fixed market does not seem to directly affect incumbents' investment. Particularly we have not found the evidence of the so-called u-shaped relationship between investment and competition. As far as the accompanying measures are concerned, there is not any robust evidence that privatization interacts either positively or negatively with competition. Not only, privatization is unlikely to influence investment under monopoly market structure. Even in more competitive markets, private ownership does not seem to determine a more intensive investment conduct. In other words, our empirical results do not support the hypothesis that state-owned monopolist provider have superior innovative performance than private provider, because of excessively high tendency to reduce costs of the latter. The most remarkable results concern the role of SBC. In a quite robust way SBC has been

found to reduce incumbents' incentives to invest, unless product markets (in particular the market for fixed services) exhibit already some degree of competition.

6. Conclusions

This paper means to investigate the relationship between the incumbents' investment and reforms of the telecom sector in OECD countries. Our empirical strategy consists of a multiplicity of methods. First of all, we have analyzed the potential breakpoints in a subsample of country-level investment series. Countries have been found to differ as far as the investment dynamics are concerned. While Denmark and Netherlands have experienced structural breaks in their investment series around the opening of the markets, France, Germany, Italy and Spain have not experienced any significant change point in the mean of their investment series during the recent period of reforms. Subsequently, we have focused on incumbent investment in order to understand if significant changes have occurred after reforms at firm level. We are also willing to learn about the causes of breakpoints. We have started our firm analyses in a bivariate framework, that is the causality linkages between individual reform and incumbent's investment. Granger causality analyses have offered a preliminary hint on the weakness of the relations between incumbent's investments and reforms, at least when reforms are considered individually. Finally, we have estimated a structural model of investment, according to a micro-econometric approach. We have enlarged the baseline model to include competition, privatization and SBC variables. In order to strengthen the findings we rely upon to different measures of competition in product markets and different estimation methodology. Privatization does not seem to affect incumbent's investment by itself and in combination with competition. At the same time, we did not obtain any evidence of an effect of competition intensification, all other things being equals. Neither a Schumpeterian effect nor a rivalry escape attitude seem to emerge. Competition is likely to foster investment only in one scenario, that is when LLU is enforced and competitors have not roll-out their own networks. At the same time, if markets do not exhibit any significant degree of rivalry, SBC reduces significantly incumbent's investment. The result on the negative effect of SBC is in line with recent empirical analyses and provides a

confirmation to the view that mandatory unbundling grants a 'free option' to new entrants. However, the inhibiting effect fades away if competitors are present and have gained not negligible market shares. Further analyses and reflections on the interplay of competition and SBC are in agenda. Similarly, we intended to extend the analysis of structural breaks to all the sample countries and we also want to enlarge the analysis of structural breaks in a panel data model (see De Wachter and Tzavalis, 2004).

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APPENDIX

Fig. 1 – Structural breaks analysis for countries' investment data

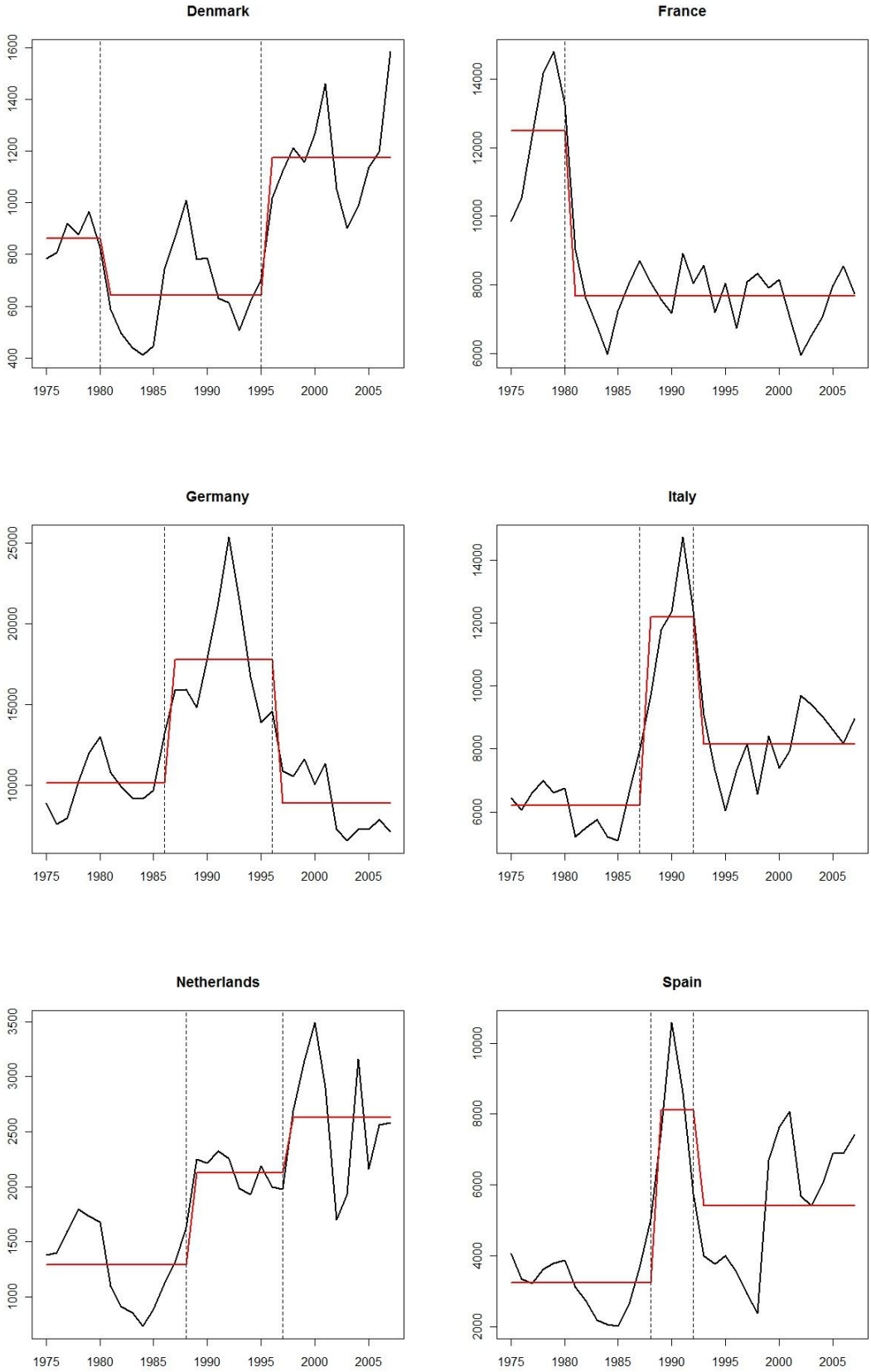

Table 10 – Granger causality analysis : estimation of direct causality relation / continuing

	GMMd (1)	LSDVc (2)	GMMd	LSDVc	GMMd	LSDVc	GMMd	LSDVc
$(I/K)_{t-1}$	0.274**	0.692***	0.271**	0.680***	0.280*	0.678***	0.405***	0.689***
	(0.117)	(0.131)	(0.126)	(0.124)	(0.165)	(0.126)	(0.116)	(0.135)
$Priv_{t-1}$	-0.003	0.003						
	(0.045)	(0.024)						
$Comp_{t-1}$					0.014	0.004		
					(0.018)	(0.007)		
Lib_{t-1}			-0.003	-0.001				
			(0.006)	(0.002)				
Sbc_{t-1}							-0.029	0.018
							(0.021)	(0.016)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	261	290	261	290	261	290	247	278
Ar (1)	-3.474		-3.471		-3.132		-2.812	
p-value	0.001		0.001		0.002		0.005	
Ar (2)	-0.732		-0.759		-0.575		-0.881	
p-value	0.464		0.448		0.565		0.378	
Hansen	2.831		2.814		4.669		1.632	
p-value	0.243		0.245		0.097		0.442	

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). (1) AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions. (2) Bootstrapped standard errors are based on 50 replications. Coefficients from the Arellano-Bond (1991) estimator are used as initial parameters. The chosen approximation is O(1/NT^2).

/ continued.

	GMMd (1)	LSDVc (2)	GMMd	LSDVc
$(I/K)_{t-1}$	0.267*	0.686***	0.139	0.645***
	(0.137)	(0.133)	(0.136)	(0.158)
$Nett_{t-1}$	0.126	0.012		
	(0.140)	(0.039)		
$Neal_{t-1}$			-0.559	0.058
			(1.045)	(0.099)
Time dummies	Yes	Yes	Yes	Yes
N	261	290	164	205
Ar (1)	-3.379		-2.045	
p-value	0.001		0.041	
Ar (2)	-0.596		-2.017	
p-value	0.551		0.044	
Hansen	3.035		0.526	
p-value	0.219		0.769	

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). (1) AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions. (2) Bootstrapped standard errors are based on 50 replications. Coefficients from the Arellano-Bond (1991) estimator are used as initial parameters. The chosen approximation is O(1/NT^2).

Table 11 - Granger causality analysis : estimation of indirect causality relation / continuing

	(Priv) GMMd (1)	(Priv) LSDVc (2)	(Comp) GMMd	(Comp) LSDVc	(Lib) GMMd	(Lib) LSDVc	(Sbc) GMMd	(Sbc) LSDVc
$Priv_{t-1}$	0.688***	0.763***						
	(0.064)	(0.032)						
$Comp_{t-1}$			0.933***	0.832***				
			(0.115)	(0.038)				
Lib_{t-1}					0.836***	0.693***		
					(0.139)	(0.053)		
Sbc_{t-1}							0.187	0.491***
							(0.225)	(0.074)
$(I/K)_{t-1}$	0.080	0.077	-1.337	-0.944**	-2.067	-0.897	-0.497	-0.253
	(0.127)	(0.078)	(0.837)	(0.438)	(2.266)	(1.018)	(0.533)	(0.330)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N							219	250
Ar (1)	-2.273		-2.716		-2.238		-2.229	
p-value	0.023		0.007		0.025		0.026	
Ar (2)	-0.803		-0.113		1.291		1.324	
p-value	0.422		0.910		0.197		0.185	
Hansen	2.601		6.861		3.435		0.966	
p-value	0.272		0.032		0.180		0.617	

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). (1) AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions. (2) Bootstrapped standard errors are based on 50 replications. Coefficients from the Arellano-Bond (1991) estimator are used as initial parameters. The chosen approximation is O(1/NT^2).

/ continued.

	(Nett) GMMd (1)	(Nett) LSDVc (2)	(Neal) GMMd	(Neal) LSDVc
$Nett_{t-1}$	0.938***	1.189***		
	(0.138)	(0.119)		
$Neal_{t-1}$			0.594	3.162***
			(0.477)	(0.000)
$(I/K)_{t-1}$	-0.184	-0.090	0.004	0.240***
	(0.194)	(0.118)	(0.112)	(0.073)
Time dummies	Yes	Yes	Yes	Yes
N	235	264	129	167
Ar (1)	-2.934		-0.960	
p-value	0.003		0.337	
Ar (2)	-0.701		-0.776	
p-value	0.483		0.438	
Hansen	4.175		0.604	
p-value	0.124		0.739	

Note: standard errors in parentheses. ***, **, and * indicate, respectively, significance levels of <1%, <5% and <10%. All estimates include year dummies (coefficients are omitted from the table). (1) AR(1) and AR(2) are tests of the null hypothesis of, respectively, no first- or second-order serial correlation. Hansen is a test of the validity of the overidentifying restrictions. (2) Bootstrapped standard errors are based on 50 replications. Coefficients from the Arellano-Bond (1991) estimator are used as initial parameters. The chosen approximation is O(1/NT^2).