ICT Standardization and use of ICT standards: a firm level analysis

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Abstract - **Standards perform some fundamental economic functions and their relevance for ICT is acknowledged by firms, researchers and policy-makers. This paper investigates the driving forces of formal ICT standards setting (i.e. standardization). Previous quantitative studies have neglected that ICT standards use and engagement in ICT standardization are related activities. Leveraging upon a unique module of the ICT usage survey 2013 for Luxembourg, the analysis explicitly takes into account the use of formal ICT standards on a large representative sample of firm. While previous analyses find that larger firms are more likely to participate in standardization, the results of the analysis suggest that size has a complex pattern. Small firms for whom ICT standards are particularly relevant could overcome the barriers that prevent other firms to benefit from standardization. Additionally, the paper investigates the relationship between the professional use of social network and ICT standards and standardization. The use of social networks is positively correlated with the adoption of ICT standards but not with the participation.**

Keywords—ICT Standardization, ICT standards, social networks, size, recursive bivariate probit

I.   1. INTRODUCTION

Standards perform some fundamental functions such as interoperability, quality assurance, information and measurement (see, for example, (David & Greenstein 1990; Swann 2000; Blind 2004)). Without standards, different IT devices could not be able to communicate each other's, strongly limiting the development of ICT sector. For example, the GSM permitted communication in different European countries facilitating the development of mobile market in Europe. Standardization, the process of developing the standards, is recognized by policy-makers as a useful tool for innovation competitiveness and growth (EU Commission (2008) 133; CEN-CENELEC 2012). Scholars often regard standardization as a tool to facilitate coordination among economic players (Farrell & Saloner 1988) or a tool to persuade end users to adopt a firm's specific technology (Lerner & Tirole 2006). Acemoglu, Gancia and Zilibotti (Acemoglu et al. 2012) consider standardization and innovation as competing engine of growth. Standards development is an important phenomenon. In 2000, at least 60,000 experts are involved in international standardization organizations (Mattli &

Büthe 2011 p.139). However, despite the generally recognized benefits of standards and standardization, not many firms are engaged in standardization activities. Recent data show that only 11% of a representative sample of Dutch firms participates in a formal standardization process (Blind et al. 2012). In Luxembourg, almost 2% of firms are engaged in standardization process, in 2010 (Blind & Mangelsdorf 2013). Considering the economic impact of standards and standardization, especially in ICT sector, a better understanding of the drivers of standardization participation is important to design proper policies aiming to increase the participation of new and different players. Indeed, attracting a large plurality of players can be particularly relevant for setting successful standards for complex and interconnect systems. For example, intelligent transport systems, requires ICT players and automotive producers; mobile money transfer requires engagement of banks.

Some explanation can be advanced for the low engagement in standardization activities. One reason is that standards resulting from the formal standardization process are not excludable from competitors. A company not participating in the process can access and benefit from the standards without the cost of participating to the standardization (i.e. free riding). Moreover, participating in a standardization process can require considerable resources that can be particularly scarce for SMEs that are the large majority of firms (Blind & Mangelsdorf 2013; Le Gall & Prager 2011). Aside possible free riding and scarcity of resources, other factors can possibly explain the relatively scarce engagement into standardization activities. De Vries, Blind, Mangelsdorf, Verheul and van der Zwan (De Vries et al. 2009) theoretical model the sequence of barriers that SMEs face before benefiting from use of standards and the barriers for participating in standardization. This research contributes to literature arguing and empirically testing that ICT standards use and participation in standardization can be related activities. Firms whose core business is affected by the standards have more incentives to participate and influence the process of writing these standards.

Building upon previous studies on the profile of standardization players (Riillo 2013; Riillo 2014) and on the dedicated standardization module of ICT usage survey for Luxembourg, current research aims to increase understanding of ICT standardization participation adding two main contributes. First, based on a representative sample of the economy (SMEs and large firms of service and manufacturing sectors), this research explicitly explores the participation in formal ICT standardization taking into account explicitly the use of ICT standards for the production. Second, this is the first quantitative work that explores whether the use of social network (a possible proxy for openness to external interaction) is related with the use of ICT standard and ICT standardization.

The rest of the paper is organized as follows: a brief literature review presents the main results of previous studies in Section 2. Section 3 describes the data for the analysis. The econometric analysis is presented in Section 4. The paper concludes with some final remarks.

II.   PREVIOUS RESEARCH

Compared to the importance of standards, the research on firms that contribute to shape the standards is relatively scarce. The rest of the section reviews the main results of the studies quantitatively investigating the characteristics of firms participating in standardization process.

In the French manufacturing sector, (Haudeville & Wolff 2004) find evidence that market structure and competition of the sector and firm specific characteristics (e.g. size, export activities, R&D expenditures and patent) have a positive impact on the decision of jointing standardization process of France's standardization institute. Considering the standardization as a particular form of R&D collaboration, Blind (Blind 2006) develops and tests some hypotheses about the decision of German manufacturing companies to participate in standardization processes at a national, European and international level. The author finds evidence that large companies are more likely to join standardization committees than small companies, due to economies of scale. The cost of participating in standardization activities is rather a fix cost and SMEs can face several barriers before benefiting from standards and standardization (De Vries et al. 2009). Moreover, R&D expenses and exports intensity present an inverted U-shape relationship with participation decision. This result suggests that a certain level of knowledge is needed to benefit from participating in the formal standardization process. However, companies with high R&D are less likely to participate to avoid unintended spillover. The intensity of exports follows a similar pattern of R&D expenditure.

Blind and Mangelsdorf (Blind & Mangelsdorf 2008) focus on service companies in Germany and confirm that company size, the export activities, and R&D expenditures are all important drivers of participation in standardization activities. Interestingly, the competition environment is not statistically significant at conventional levels. Blind and Thumm (Blind & Thumm 2004) investigate a small sample of European firms and find evidence that patent intensities of companies are negatively related with the likelihood to join standardization processes. Moving from the Knowledge Bases View (Grant 1996), Blind. and Mangelsdorf (Blind & Mangelsdorf 2013) investigate empirically participation in standardization as a particular type of "alliance". More precisely, the authors study the participation of German SMEs (i.e. less of 500 employees) of electrical engineering and machinery industry to national, European and international standardization process. The inverted U shape relationship between R&D and the likelihood to join standardization process is confirmed. SMEs aim to access to the knowledge of other firms participating to technical committees (i.e. external knowledge) but high R&D performers are reluctant to participate in standardization to prevent disclosing their knowledge. The relevance of incoming knowledge spillovers and the negative correlation with the patent portfolios confirm the importance to access external knowledge. Interestingly, the competition appears to have no impact at the conventional statistical level of significance. Gauch and Blind (Gauch & Blind 2010) investigate open innovation as a driver for participation on a sample of the participants of 5th European Framework Program (e.g. firms, research institute). In their data, the authors find that different modes or the extent of knowledge sourcing activity have no impact on the likelihood of firm participation.

Recent studies explore the likelihood of participation on the representative sample in Nederland (Blind et al. 2012) and Luxembourg (Riillo 2014). Distinguishing between external formal standardization (e.g. participating in CEN, ISO) and internal company standardization (e.g. elaboration of company standards, Riillo (Riillo 2014) implements a multinomial model to simultaneously investigate the choice of internal and external standardization strategies with respect to internal and external dimensions. Results show that firms with many educated employees and operating in a market with uncertain future technological trajectories are considerably more likely to engage in standardization activities. Blind and colleagues (Blind et al. 2012) argue that standardization is one form of "alliance" and along the "open innovation" framework (Chesbrough 2006) investigate the "openness" of the firm as important explanation of participation to standardization process. Results suggest that firms participate in standardization activity aiming to increase their own knowledge base. Moreover the analysis shows that firms cooperating with different actors are more likely to join standardization. The authors conclude that standardization represents a specific form of collaborative knowledge-sharing and knowledge-creating strategy.

From a methodological point of view, previous research generally implements a binary response model that links the probability that an event occurs and a set of factors (Greene 2008). The event is the engagement of the firm and the factors are the characteristics of the firms. Some of these characteristics (i.e. R&D intensity) are generally used as proxy for the specific hypothesis of interest for the researcher and the others are used as controls (i.e. firm turnover).

Reviewing the set of variables explaining the likelihood of the firm to participate in standardization, it is important to notice that no previous study has quantitatively explored the use and implementation of standards as antecedent of the engagement in standardization.

Additionally, the review of the literature shows that no study explored the possible relationship between the use of social media (a possible proxy for openness to external interaction) and ICT management and engagement.

a.   Use and participation

ICT standardization is expanding beyond traditional bounds and different players are concerned with ICT standardization even if their core business is not ICT. For example, car manufacturers are involved into the development of intelligent transport systems (ITS) and banks are engaged into standardization of communication standards for money transfers. This paper explores the

possibility weather the use of ICT standards and the process of shaping the ICT standard (i.e. standardization) are related choice. Of course, a firm does not necessary need to participate into standardization activities to implement ICT standards. However, the engagement in standardization is more likely if the firm has already some experience with the standards or has implemented some of them. Moreover, if the economic activity is influenced by the standards, the firm is more like to contribute shaping these standards. Firms whose products have to be comply with some standards, are particularly interested to monitor and possible influence the standards setting (i.e. participate in standardization). Moreover, the firm culture and the strategic choices of top management can influence simultaneously both the decision to use ICT standards and the decision to engage in standardization activities. Therefore, this research argues that when investigating the participation to standardization is important to consider as well the use of standard and empirically tests this intuition.

III. 3. DATA DESCRIPTION

The quantitative analysis leverages on a dedicated module on ICT standardization of ICT usage survey 2013 in Luxembourg (ICT 2013). The ICT survey is the main official data source for ICT related activities in Luxembourg. The survey is conducted by the National statistical office and it is representative of Luxembourgish economy, including manufacturing, ICT sector and services (but excluding financial sector). The survey has large response rate (82.3%) and collects information about firms' characteristics, the market perception and ICT usage (STATEC 2015). The survey is made of two parts: first part is common to all European Countries; the second part is country-specific. The ICT 2103 for Luxembourg includes a module about ICT standards and standardization. Question F1a reads as: Does your enterprise use any formal ICT standards (e.g. ISO, CEN CENELEC, ETSI) producing its main products or services? Question F2a reads as: Is your enterprise currently participating into the elaboration of ICT standards in recognized body (e.g. ISO, CEN CENELEC, ETSI) Firms can answer "yes" or "no" to these questions. These questions, jointly with the information about firms' characteristics and perception of market condition, enable the joint analysis of standard use and participation in ICT standardization. As shown in Table 2, almost 16% of the firms are using ICT standards and almost 6 % are participating into standardization process.

Additional question about use of social media enriches further the analysis. Question B12 reads as: In January 2013, did your enterprises use Social networks (e.g. Facebook, Linkedin, Xing, Viadeo, Yammer, etc) for internal or external purposes?

The bivariate cross-tabulation in Table 1 shows that social network is positively correlated with use of ICT standards and participation in ICT standardization. Among firm using social networks, 22,58 % are using ICT standards and 9,15% are participating in standardization.

TABLE 1 SOCIAL NETWORK, USE OF ICT STANDARDS AND PARTICIPATION IN ICT STANDARDIZATION

		Use of standards		Participating in standardization	
		no	yes	no	yes
Social network	no	86,89	13,11	94,73	5,27
	yes	77,42	22,58	90,85	9,15

Source: ICT 2013; figures are %. Weighted total of observations is 1796

The detailed definition and the descriptive statistics of the variables used in the econometric analysis are reported in Table 2

TABLE 2 VARIABLE DEFINITION AND DESCRIPTIVE STATISTICS

Variable	Mean	Std. Dev.
Participation (participation in elaboration of ICT standards)		
No	0.935	0.247
Yes	0.065	0.247
Use (use of formal ICT standards)		
No	0.840	0.366
Yes	0.160	0.366
Ln Employee 2013	3.319	0.909
Social networks		
No use	0.707	0.455
Use (For internal or external purpose)	0.293	0.455
Group (being part of a conglomerate)		
No	0.681	0.466
Yes	0.319	0.466
Competition		
Intense	0.408	0.492
Moderated	0.492	0.500
Limited- Very limited	0.100	0.300
Sectors		
Low Tech (Nace rev.2: 10-17, 18 excluding 18.2; 32 excluding 32.5)	0.035	0.185
Medium-Low Tech(Nace rev.2: 18.2; 19; 22-24; 25 excluding 25.4; 30.1; 33)	0.036	0.188
High-medium Tech(Nace rev.2: 20-21; 25.4; 26; 27-29; 30 excluding 30.1; 32.5)	0.016	0.125
KIS -Knowledge-intensive Services- (Nace rev.2: 50-51; 58-63;69-75; 78; 80)	0.200	0.400
LKIS -Less knowledge-intensive- services (Nace rev.2: 45-47; 49; 52-53; 55-56;68; 77;81-82)	0.462	0.499
Construction (Nace rev.2: 41-44)	0.250	0.433
Market position		
Leader	0.263	0.440
Challenger	0.559	0.497
Follower	0.178	0.383

IV.   4. ECONOMETRIC ANALYSIS

The econometric analysis is performed in two steps.

First, in line with all previous researches, the ICT participation in standardization and the use of ICT standard are investigated as separated events in the frame of the probit model (Greene 2008). This is modellization is appropriate because both use and participation are dichotomous.

Second, suspecting that the use of ICT standard and participation in standardization are related and unobserved factors (e.g. firm culture) could affect the results of the first step, the participation and the use are jointly investigated in the frame of the recursive bivariate probit model (Greene, 2003). In this model, the errors of the equation explaining the participation are correlated with the errors of the equation explaining the use of ICT standard. Moreover, the use of ICT standards is included in the right–hand side of the participation equation.

In formula:

$$y_1^* = x_1' \beta_1 + \gamma y_2 + \varepsilon_1, \qquad y_1 = 1 \text{ if } y_1^* > 0,$$
$$0 \text{ otherwise}$$

$$y_2^* = x_2' \beta_2 + \varepsilon_1, \ \ y_2 = 1 \ \text{ if } y_2^* > 0, \qquad 0 \text{ otherwise}$$

$$E[\varepsilon_1 | x_1, x_2] = E[\varepsilon_2 | x_1, x_2] = 0$$

$$\text{Var}[\varepsilon_1 | x_1, x_2] = \text{Var}[\varepsilon_2 | x_1, x_2] = 1$$

$$\text{Cov}[\varepsilon_1, \varepsilon_2 | x_1, x_2] = \rho$$

Where $y_1 = 1$ if the firm participates, $y_2 = 1$ if the firm use the standards.

To facilitate the comparison, Table 3 reports the marginal effect and some regression statistics of both steps of the analysis (due to space constrains, only marginal effects are reported because more easy to interpret. Tables with the regression coefficients are available upon request). Regressions 4-5 presents results of the joint analysis while regression 1-3 present the results of the analysis when participation and use are separated.

Regression (1) shows the marginal effect on participation of different variables: size, use of social network, being part of a group, competition intensity and sector definition accounting for innovation inclination. The results show that size positively influences likelihood of participation but the use of social network and competition intensity are not statistically significant. One possible explanation is that the use of social networks gives no particularly advantage to firms aiming to participate to standardization process. Firms active in high-medium technological sector are more likely to participate to standardization process than firms active in construction sectors. Other sectors show a similar pattern, but with lower magnitude. Only exception is the low tech sector that is not statistically different from construction sector at conventional level.

Regression (2) shows the drivers of use of ICT standards. Size and use of social network have both a relevant impact on the use of ICT standards. This fact suggests that professional use of social network is correlated with the use of ICT standards. A possible explanation is that firms using social network are more able to collect information outside the firms and being more aware of the benefits of the standards, they are more likely to adopt ICT standards. Being part of a group and operating in high-medium tech sector have a positive impact too. Other variables are not statistically significant at conventional level. Interestingly, competition variables are not statistically significant at conventional level, confirming the results of (Blind & Mangelsdorf 2008; Blind & Mangelsdorf 2013).[2]

Regression (3) extends the regression (1) including the use of ICT standards as determinant of the participation in standardization. The rationale is that firms whose core business is affected by the standards have more incentives to participate and influence the process of writing these standard. Indeed, results of regression (3) shows that the use of ICT standards has a large and statistically significant effect while the size and being part of a group are not any more statistically significant at conventional level. Additionally, firms facing moderate competition are less likely to join standardization process than firms experiencing intense competition.

Regressions 4-5 show the main results of the recursive bivariate model that accounts for the correlates disturbances between use of ICT standards and participating in ICT standardization. The ρ is positive (0.629) and statistically different from 0 (95% confidence interval is 0.436 - 0.767). This fact suggests that it is more accurate to investigate use and participation jointly than separately.

Regression (4) shows the drivers of participation in ICT standardization. Size and being part of a group are again statistically significant but the use of social network remains not statistically significant at conventional level. The impact of sector and competition dummies follows the same pattern of regression (3). Sector more inclined to innovation activities are more likely to participate to standardization process than firms active in construction sectors. Firms facing moderate competition are less likely to join standardization process than firms experiencing very intense competition. For identification issues, the market position variable is included in the equation explaining the standardization engagement. (A possible economic interpretation is that market challenger and followers are willing to participate to formal standardization to challenge the products of the leader that are the dominant design on the market. In markets with a private dominant design, the use of formal standards could be not relevant.) The robustness of the results with respect to this variable is checked with a sensitivity analysis. First, regressions 1-3 are re-estimated including the market position, and the main results do not change significantly. Additionally, the use

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[2] The joint Wald test rejects the hypothesis that competition levels are jointly different from 0.

and the participation are modelled as two seemingly unrelated probit regressions (Greene 2008) with the same set of covariates. Two bivariate models are estimated, once including the market position and once omitting it. Results of the sensitivity analysis, available upon request, show that market position variable do not perturb substantially the main results of the recursive bivariate model that remains the preferred model.

Regression (5) confirms the results of regression (2). Size and use of social network influence the use of ICT standards. Firms in high-medium tech and KIS sector remains more likely to use ICT standards. Competition

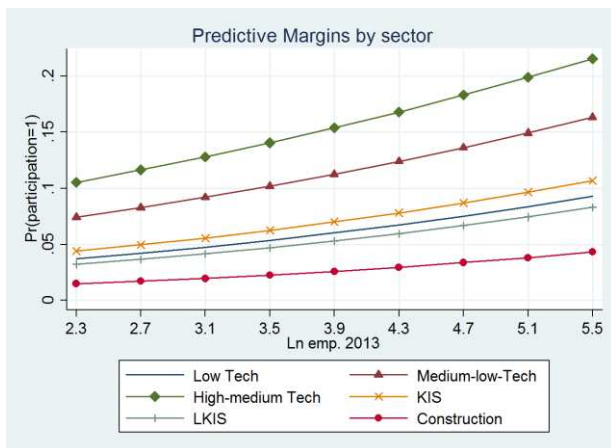intensity is not statistically significant at conventional levels.

The econometric analysis concludes presenting graphically how the average probability of the firms to participate to ICT standardization changes according the size and the sector. As clearly shown in Figure 1, the size increases the probability of participation in any industry sector. Manufacturing sectors with innovation inclinations are the most likely sectors involved in standardization activities. High knowledge intensity service sector, low tech, low knowledge intensive and finally the construction sector are following behind. This ranking is constant in each size level.

TABLE 3 AVERAGE MARGINAL EFFECTS (DY/DX) AND MODEL STATISTICS

	Probit	Probit	Probit	Bivariate Probit	
	(1) Pr (part. =1).	(2) Pr (use =1).	(3) Pr (part. =1).	(4) Pr (part. =1) - pmarg1-	(5) Pr (use =1) - pmarg2-
Ln employees	0.021*** (0.005)	0.047*** (0.008)	0.006 (0.004)	0.014*** (0.005)	0.047*** (0.008)
Social network	0.021 (0.013)	0.070*** (0.021)	0.002 (0.011)	0.013 (0.013)	0.068*** (0.021)
Group	0.047*** (0.014)	0.123*** (0.021)	0.012 (0.011)	0.034** (0.014)	0.126*** (0.022)
Competition					
Intense	base	base	base	base	base
Moderated	-0.017 (0.012)	0.014 (0.018)	-0.021** (0.010)	-0.018* (0.010)	0.017 (0.018)
Limited-Very limited	-0.024 (0.017)	-0.018 (0.029)	-0.017 (0.017)	-0.020 (0.016)	-0.015 (0.029)
Sectors					
Construction	base	base	base	base	base
Low Tech	0.041 (0.027)	0.030 (0.050)	0.029 (0.025)	0.031 (0.024)	0.031 (0.051)
Medium Low Tech	0.079** (0.037)	0.083 (0.054)	0.063* (0.034)	0.078** (0.038)	0.090* (0.053)
High- Medium Tech	0.143** (0.065)	0.149* (0.079)	0.073** (0.036)	0.116* (0.059)	0.158* (0.082)
KIS	0.048*** (0.017)	0.048* (0.028)	0.034** (0.016)	0.040** (0.016)	0.051* (0.028)
LKIS	0.033*** (0.012)	-0.013 (0.021)	0.030** (0.013)	0.024** (0.011)	-0.010 (0.021)
Use ICT standard			0.278*** (0.029)	0.047* (0.027)	
Market position					
Leader				base	
Challenger				-0.001 (0.011)	
Follower				0.002 (0.016)	
Model statistics					
Log pseudo likelihood	-733.1	-1343	-525.6	-1837	
ρ				0.629	
95% ρ CI				0.436 - 0.767	
Observations	1,757	1,757	1,753	1,721	
Weighted pop.	3419	3418	3412	3338	

Source: ICT 2013. Note: dy /dx for factor levels is the discrete change from the base level; pmarg1 is the marginal predicted probability of success Pr(part=1); pmarg2 is the marginal predicted probability of success Pr(use=1) Standard errors in parentheses *** p<0.01. ** p<0.05. * p<0.1

FIGURE 1 PREDICTIVE MARGINS OF THE RECURSIVE BIVARIATE PROBIT MODEL OF REGRESSION (4).

Source: ICT 2013.

V.   5. FINAL REMARKS

This paper sheds some lights on the reasons that are driving the participation in formal ICT standardization. Leveraging upon a unique module of the ICT usage survey, the analysis is the first to explicitly take in into account the use of formal ICT standards.

While previous analyses find that larger firms are more likely to participate to standardization, the results of the analysis suggest that this relation is more complex. Small firms for whom ICT standards are particularly relevant could overcome the barriers that prevent other firms to benefit from standardization. Standards developing organization aiming to increase the participation in standardization process should focus their efforts to firms using (or at least buying) the standards.

Aside difference in size, results show that firms of different sectors are likely to contribute to standardization, but the probability varies considerably. The standardization process is dominated by manufacturing firm with innovation inclination and service firms with high knowledge intensity are following behind. Standardization is attracting firms of different industry sector with different intensity. If diversity is important for successful standardization complex interconnect systems, the results suggest that there is considerable room for improvements.

Additionally, the paper explores the relationship between the professional use of social network, the adoption of ICT standards and the participation to standardization. The use of social networks is positively correlated with the adoption of ICT standards but, rather surprisingly, not with the participation. If the use of social networks decreases geographical barriers and facilitate collaborative work, but firms using social networks are not more likely to engage in standardization, then the standardization process is not fully exploiting all the opportunities offered by social networks[3].

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[3] However, even if imprecise, it can be instructive to compare the impact on the social network of CEN-CENELEC and EPO - European Patent Office. It appears that the first has 1788 "followers" in Twitter and 1202

Possibly, communication efforts of standards development organization are not sufficient and/or firms are not willing to use social network for standardization purposes. Further analysis on this topic is strongly advisable. This analysis focused only on formal standardization (i.e. ETSI), future research could include engagement in ICT standards setting in consortia, whose role is increasingly important in the standardization arena. Finally, when interpreting these results, it is important to consider that Luxembourg is a small and open economy dominated by services. Future research including a cross-country comparison can increase our understanding of standardization activities.

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