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Technological Uncertainty and Standardization Strategies: A Coopetition Framework

Cesare Antonio F. Riillo, Renaud Allamano-Kessler, Nader Asnafi, Vladislav V. Fomin, and Geerten van de Kaa

***Abstract*—Standards may be arrived at through various coordination mechanisms, including cooperation, coopetition, or competition. This article explores how technological uncertainty affects the coordination mechanism for standardization. The article is based on the Community Innovation Survey, a sizeable firm-level survey representative of the Luxembourgish economy. The econometric analysis finds evidence that firms facing technological uncertainty will choose for standardization through competition and coopetition.**

***Index Terms*—Competition, coopetition, standardization, technological uncertainty.**

I. Introduction

STANDARDIZATION is generally understood as an essential driver for long-term productivity, higher competitiveness growth [1]–[6], and innovation [7], [8]. The economics of innovations, the technology interactions, technological evolution, and forecasting are addressed in detail in [9]–[11]. Previous articles have investigated firm's standardization strategies [12] and provide evidence that technological uncertainty in the market is positively correlated with proactive standardization strategies. This supports the idea that a particular type of standardization strategy can reduce uncertainty in the market [12], [13]. Technological uncertainty arises when it is difficult to forecast the results of a specific technological development and/or the market acceptance of the technology being developed. In other words, it arises when knowledge of whether a technology is feasible, or how to achieve it in practice, is not readily available or deducible by a competent professional working in the field. Three strategies can be distinguished when it comes to standardization: standardization through cooperation, competition, or coopetition. For cooperation, the standard is arrived at in one committee where interested parties negotiate upon its contents. For competition, the standard is arrived at in the market because of a standards' battle. This battle that in some cases may result in market shift may be generated by disruptive firms rather than disruptive technologies [14]. Relevant and consequential problems seem to be a main and general driving force for the evolution of innovation in several industries. Firms have a strong incentive to find innovative solutions to unsolved problems, e.g., lung cancer, to achieve the prospect of a (temporary) profit monopoly and competitive advantage [15]. Coopetition lies in between these two extremes and refers to competitors cooperating in setting a standard. A good example is the companies involved in A-Team, an association of manufacturers and suppliers of Taiwan's bicycle industry that jointly attempt to achieve standardization in the bicycle industry. The A-Team firms focus on high value-added products in the global bicycle industry by competing and cooperating with each other in the innovation ecosystem [5].

Whereas it is commonly agreed upon that firms often choose to standardize due to technological uncertainty, it is unknown which type of standardization strategy is preferred in this case.

The main research question that the article aims to answer is: *What is the effect of technological uncertainty on the choice of a particular standardization strategy?*

To answer that question, we conduct an econometric analysis of Luxembourg companies' choice to participate in the standardization processes. In this article, standardization strategies are operationalized as follows: 1) cooperative strategy, when firm standardization efforts take place exclusively in official standards setting organizations, 2) competitive strategy, when standardization takes place exclusively within the firm, and 3) coopetitive strategy referring to a hybrid form of standardization within the firm and in standards setting organizations.

This article aims to extend the standardization literature by exploring which type of standardization strategy is chosen in light of technology uncertainty. Results based on representative survey data for Luxembourg show that firms facing higher technological uncertainty are more likely to adopt at least one proactive standardization strategies. Additionally, we find that competitive or coopetitive standardization strategy as opposed to a pure cooperative one. This surprising result is discussed considering existing literature and some propositions for future research are offered in the conclusions.

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II. Literature

In this section, we review the literature on determinates of standardization strategies at the firm level.[1] Departing from early works on firm competition strategies and network externalities [12], [16], the extant literature provides evidence that firms' standardization strategies can be chosen in response to specific properties of the market and competition. The most significant number of works on standardization strategies dealt with what we refer to as *de-facto* standardization (standardization through competition that occurs in the market). Various scholars have focused on factors that affect the chances that *de-facto* standards are selected (e.g., [17], [18]) and, more recently, the focus has shifted toward trying to explain platform success. For example, Cenamor [18] has studied the strategies that complementors can choose to try to reach competitive advantage. Scholars have also focused on de jure standardization (standardization through cooperation in committees such as ISO or IEEE). Various articles have also focused on a combination of these two extremes, which is referred to as coopetition. In the following paragraphs, we review the reasons why firms choose these three forms of standardization. Standardization through cooperation is seen as a particular form of collaboration in R&D. Large German manufacturing firms are more likely to join standardization committees than small firms [19]. The underlying reasons are related to returns to scale; participation in standardization activities can be costly; and SMEs can face obstacles before benefiting from positive feedbacks from standards and standardization [20]. Following articles confirm that firm size, exports, public procurement, and R&D expenditures are essential factors in participating in standardization activities [3], [21]. Being successful in product innovation and being engaged in standardization are significant positive predictors of companies' success in public procurement in Germany [3]. A study in South Korea shows that R&D cooperation with 1) suppliers and competitors has a positive effect on standardization of technology, 2) customers has a positive effect on diversification of products and pioneering a new market, and 3) universities has a positive effect on pioneering a new market and standardization of technology [4]. Recently, it has been shown that the more firms are oriented toward their competitors, the higher the likelihood that they intend to participate in the standardization process [6].

Patent intensity, on the contrary, is found to be negatively related to participating in standardization processes [22]. Blind and Mangelsdorf [21] study German SMEs' participation (companies with fewer than 500 employees) in national and international standardization processes and find an inverse U relationship between R&D and the probability of joining a standardization committee. Smaller firms may aim to access other companies' knowledge that participate in technical committees [23]–[25]. Firms with high intensity of R&D investment hesitate to participate in the standardization process to prevent their knowledge's unintended disclosure [22]. Recent panel data find convincing evidence that firm join official standardization after they introduced new products or services into the market [26].

Simultaneously, innovative firms join standardization to promote their Standard Essential Patents [27]. Standardization may result in knowledge spill overs [28]. Their relevance and the negative correlation between engagement and patent portfolios confirm the importance of access to external knowledge. The results suggest that companies may participate in standardization activities to increase their knowledge base aside from other motives. Various authors stress that interorganizational learning is one of the main reasons firms engage in standardization activities [28], [29].

Standardization through competition occurs when firms develop technology and try to establish a *de-facto* standard or dominant design. In this competition, the product configuration, i.e., selection and use of common components/modules of individualized products, can be used to accomplish total diversity (mass personalization) or standardized products (a limited set of products). For intermediate cases (between total diversity and standardized products), a new uncertain decision model was proposed in [30], where the aim was to find the optimal product configuration using redundancy and/or standardization strategy to minimize the total costs. The standardization (component/subsystem standardization) displayed better performance than the redundancy strategy and a flexible platform strategy effectively reduced the production costs [30]. Standardization seems to play an important role also for the services. The service standardization efforts in SMEs and their impacts on Malaysian small firms are discussed in [31].

The findings from 320 Chinese manufacturing firms indicate that both competitor and technology orientations exert positive effects on firms' intentions to participate in standardization [6]. Often, this results in fierce competition and the winner takes all markets. Examples include the battle between VHS and Betamax. Although the reasons behind the choice to establish a standard through competition are not thoroughly studied in the literature, it seems logical to assume that higher sales revenue and profits play a role. By choosing for pure competition, whoever wins the standards battle can accrue the most monopoly. However, the loser might quickly go bankrupt. So the stakes are high, and technological uncertainty can increase firms' chances of cooperation. For example, in the battle for digital audio records, Sony and Philips first chose a standardization strategy of pure competition. However, they eventually joined forces and set a successful standard: the CD. Forming an innovation ecosystem, the companies of Taiwan's A-Team aimed to establish standardization to achieve the functions of an industrial platform in the bicycle industry. Taiwan's A-Team focuses on high value-added products in the global bicycle industry by competing and cooperating with each other in the innovation ecosystem [5]. The latter cases exemplify standardization by coopetition. The term coopetition refers to a situation where competitors simultaneously cooperate and compete (e.g., [32], p. 14). The "traditional" dichotomies of strategies "compete" vs. "cooperate" as initially introduced by game theorists such as Axelrod [33] and also in the context of standardization by Besen and Farrel [34] and Shapiro and Varian [35] were

[1] See [63], [64] for a review of consequences of standardization at standards at firm level. See [65] for recent contribution on consequences of standards on creativity at individual level.

criticized for being too limited to explain cases where cooperation between competing firms was producing a "win-win" scenario ([32], p. 15).

Some articles (e.g., [36]–[43]) note the existence of coopetitive practices in *de-facto* standardization (VHS vs. DVD, HD DVD vs. Blu-ray, home RF vs WiFi, etc.). For example, Gnyawaly and Park [40] highlight the coopetitive strategy between Samsung and Sony in the liquid crystal display market in the TV industry. Both companies have benefited from their joint venture. Whereas scholars are reporting on the growing number of coopetitive relationships [32], few empirical articles exist to verify the benefits of coopetitive strategy or the motives for choosing this type of standardization strategy. Traditionally, and especially in the context of standardization, making a binary choice of either compete (by developing a product internally or boosting competitive strength) or collaborate (by jointly developing a standard) was framed, *ceteris paribus*, by the cost of deploying a chosen strategy. For a company to adopt the coopetition strategy, there is neither a widely accepted theoretical base to lean on nor readily available empirical justification of gain at the backdrop of "double cost" of taking the combinatory strategy.

The emergence of digital platform ecosystems is making the role of complementors increasingly relevant. Platform ecosystems are based on modular technologies that enable supermodular complementarities both in production and in consumption. Based on the generalised darwinism perspective, Coccia [9], [11] develops a theory of technological parasitism that looks at the interactions and coevolution between technologies and subsystem of technologies in term of host–parasite relationship. Symbiotic technologies, such as smartphone and rear camera, accelerate the development of overall system [10]. In [18], a contribution is made on platform ecosystems, open innovation, and market-based standardization by providing a holistic framework for the strategic decisions complementors need to take in order to build a competitive advantage in platform ecosystems. The authors of [18] propose, among others, that coopetitive networks will represent a source of complementor competitive advantage that becomes more significant as the platform ecosystem matures.

Overall, coopetition literature suggests that competitors can cooperate to reduce uncertainty in the market. However, previous articles on standardization strategies neglect the role of technological uncertainty or implicitly assumed that the uncertainty faced by the firms is the same for all firms. In next sections, the article explores if firms perceiving technological uncertainty are on average more likely to engage in some form of standardization strategy.

III. Methodology

A. Sample and Data

The data for the empirical analysis are collected combining different sources. The main source is the Community Innovation Survey (CIS) conducted in Luxembourg in 2010. CIS surveys are the primary source of official data for measuring innovation in Europe and they been used in previous articles to measure the effect of standardization on firms [3], [44], [45]. CIS provides reliable information on the characteristics of small and large firms in the manufacturing and services industries, and it is representative of the business economy. Country-specific questions for Luxembourg allow to infer whether they participated in technical committees during the period 2008–2010 (see Fig. 1in the appendix for the complete and original wording of the question). This information is combined with information about standards setting organizations to distinguish empirically between different standardization strategies.

TABLE I
Standardization Strategies

		Engagement in standards setting organizations	
		No	Yes
Standardization within the firm	No	Coexistence	Cooperation
	Yes	Competition	Coopetition

For each firm in the CIS, we checked if it is engaged in standards setting organizations, compiling data from ILNAS (Luxembourg Institute for Standardization, Accreditation, Safety, and Quality of Products and Services), ETSI data (European Telecommunication Standards Institute), and International Telecommunication Union. Luxembourgish companies cannot participate in official international standardization organizations such as CEN, ISO, CENELEC, and IEC if not participating in ILNAS. To summarize, the data are collected differently depending on the type of standardization studied. For the data on standardization within the firm, we used the data of CIS, and for the data on the standards setting organizations standardization, we used the data of ILNAS + ETSI+ IEC.

The sample is made of 1511 weighted observations (636 unweighted). After cleaning the dataset, the final sample reduces to 1505 weighed observations (636 unweighted). Following section describes variables used in the analysis and descriptive statistics are shown in Table II.

B. Measures of Variables

Standardization strategies (dependent variables)

Standardization activities can take place within or outside of the firms' boundaries. Looking at the place of standardization, we can distinguish four possible approaches. They are defined as follows and illustrated in Table I:

1) Coexistence strategy = no engagement in standardization.
2) Competitive strategy = exclusively standardization within the firm.
3) Pure cooperative strategy = exclusively standardization in standards setting organizations.
4) Coopetitive strategy = standardization within the firm and in standard setting organizations.

Firms can be rather passive toward standardization and passively accept standards developed somewhere else. This strategy is defined as *coexistence* strategy in our analysis (firm answers no to CIS question about *Participation in technical committees or groups* and it does not participate in formal standards setting organizations).[2]

[2]The analysis considers the following standard setting organization: ILNAS, CEN, ISO, CENELEC, IEC, and ETSI.

TABLE II
DESCRIPTIVE STATISTICS BY STANDARDIZATION STRATEGY AND VARIABLES DEFINITION

Description			
	Standardization strategies		
	Coexistence	*Competition*	*Coopetition*
Total in absolute number (and percentage)	1,004 (67%)	475 (31%)	26 (2%)
Technological Uncertainty: Extend of difficulty to predict technological developments (d)			
No (low-no relevant.)	712	268	26§
Yes (medium-high)	292	207	
Total	1,004	475	26
Number of employees 2010 (Cat)[1]			
10-19	48	9	10§
20-49	376	128	
50-99	335	161	
100-249	157	72	
+250	87	104	16
Total	1,004	475	26
International market (d)			
No exporting	229	87	26§
Exporting	775	388	
Total	1,004	475	26
Group status (cat)			
No group	575	137	26§
National group	135	102	
Int. group	294	236	
Total	1,004	475	26
Industries (nace code) (cat)			
C Manufacturing	777	401	26§
D E Utilities	14	16	
G Trade	221	78	
H Transportation	209	56	
J ICT	135	60	
K Financial	113	159	
M Professionals"	85	32	
Total	1,004	475	26
Competition			
Influence from new competitors			
No (low-no relev.)	439	245	15
Yes (medium-high)	565	230	12
Total	1,004	475	26
Outdated Product (d)			
No (low-no relev.)	722	349	26§
Yes (medium-high)	282	125	
Total	1,004	475	26
Price competition (d)			
No (low-no relev.)	126	71	26§
Yes (medium-high)	878	403	
Total	1,004	475	26
Quality competition (d)			
No (low-no relev.)	153	66	26§
Yes (medium-high)	851	408	
Total	1,004	475	26
Innovation activities (cat)			
No open innovation and No internal R&D (including missing)	778	279	11§
Only intramural R&D	69	34	
Only open innovation (at least one innovation cooperation)	109	80	15§
Both intramural R&D and open innovation	48	81	
Total	1,004	475	26
Patenting (d)			
Importance of patent (low- no relev.)	953	389	17
Importance of patent (high - medium.)	51	85	10
Total	1,004	475	26
Education(# empl. with at least bachelor) (cat)			
0-9 %	494	151	12§
10-49%	277	140	
+ 50%	233	184	14
Total	1,004	475	26

[1]Empl. is categorized to facilitate the reading of this table but in the regression is used as continuous variable. §Cells are merged because of statistical confidentiality, rounding can affects totals. (cat) = categorical viable and (d) = dummy variable.

If firms are proactive with respect to standardization, they can pursue standardization activities exclusively within the firms without sitting in standards setting organizations. This strategy is defined as "competitive" (firm answers yes to CIS question about *Participation in technical committees or groups* but does not participate in formal standards setting organizations). This category includes firms that are engaged in standards battle.

As opposed to competitive strategy, it may exist firms that adopt "pure cooperative" strategy. These are firms that exclusively participate in standards setting organizations (firm answers no to CIS and participate in formal standards setting organizations).

Finally, we define "coopetitive" strategy as the hybrid form of standardization within the firm and in standards setting organizations (firm answers yes to CIS question and participate in formal standards setting organizations).

Technological uncertainty (variable of interest)

After having defined the standardization strategies, this section operationalizes the concept of technological uncertainty based on the answer of the firms to the following CIS question: *To what extent do the following factors describe the context of competition in your main market? Technological developments are difficult to predict* (see Fig. 1 in the appendix for the complete and original wording of the question). Each firm is measured with value "1" if it perceives high or medium–high difficulty to predict technological development and "0" otherwise.

Other controls

Based on previous literature, this section shortly presents the control variables used in the econometric analysis. Table II reports precise definitions and some descriptive statistics.

Size

Compared to small businesses, larger companies have more resources (e.g., financial and human) invested in standardization activities. However, small businesses can benefit from the influence the content of the standards in their favor [46]. In our model, the size of the company is measured by the number of employees.

International market

Companies operating in international markets are more likely to undertake standardization processes to avoid fragmentation [19], [47]. In our article, the export is measured with a dichotomous variable denoted by a value of "1" if the company exports and "0" otherwise.

Group status

Along with size, a more complex organization requires a higher level of formalization and standardization. Being part of a group of companies increases the chances of undertaking standardization activities, especially at the internal level [48]. Different branches of the same group may coordinate their efforts to influence international standards [49]. Our analysis therefore distinguishes several situations as follows:

1) Companies belonging to a group of foreign companies.
2) Companies that are part of a national group of companies.
3) A company that is not an independent group.

Industries

Previous empirical studies indicate that firms participating in standardization activities are very heterogeneous in terms of economic activity. Two digits NACE codes, that is, the Statistical Classification of Economic Activities in the European Community, are used in the analysis to detect industry specificities.

Competition

The hypothesis of a correlation between competition and standardization is often advanced in the literature [50]. In this article, a series of dummy variables measure self-declared sources of

competition (*e.g.*, new competitors' threats, obsolescence of price–product competitiveness, and quality competition).

Innovation-related activities

Intramural and open R&D

Firm "openness" in conducting R&D is positively related to the propensity to join formal standardization activities [47]. Also, alliances [51] and the coordination of R&D [52] play a vital role in standards setting. Our analysis accounts for intramural R&D and open innovation activities (defined as at least on cooperation in innovation activities) and distinguishes four situations as follows:

1) No open innovation and no intramural R&D.
2) Only intramural R&D.
3) Only open innovation.
4) Both intramural R&D and open R&D.

Patenting

Many standardization organizations require the disclosure of relevant patents during the standardization process. This could reduce the likelihood of companies participating in standardization activities [21], [22]. The patent is a measure as a dummy binary having "1" if the patent is essential and "0" otherwise.

Education

Qualitative studies [53], [54] suggest that highly qualified (and often rare) staff must spend much time influencing standardization activities. The empirical analysis accounts for skills of labor force in terms of proportion of employees with university degree (between 0% and 9%, between 10% and 49%, and above 50%).

C. Model and Data Analysis Procedure

This section presents the model for the econometric analysis. We present a simple discrete choice model for empirically exploring the influence of variables (discussed in Section III-B) on the probability of adopting certain types of standardization strategies. The choice of the standardization strategy is studied by taking into account a set of covariates (e.g., company size, international market, group status, perceived competitiveness, innovation activities, and related industries). Perceived competitiveness can be understood as price competition and innovation-related activities. The model can be described as follows: NB_{ni} is the net benefit that the company n obtains by choosing solution i. It is assumed that the company chooses the alternative that provides the highest expected benefit. Dummy variables designate the selected strategy (y_{ni}) for each possible alternative:

$$y_{ni} = \begin{cases} 1, \; if \; NB_{ni} > NB_{nj}, \; i \neq j \\ 0, \; \text{otherwise.} \end{cases}$$

The net profit can be broken down into two parts: $NB_{ni} = V_{nj} + \varepsilon_{ni}$. V_{nj} is a function of the variables that are observed, whereas ε_{ni} captures all the factors that are not included in V_{nj} because they are not observed by the analyst, such as the corporate culture's management skills. $V_{nj} = V(x_{nj}, s_n)$ is a function of the observed attributes of the alternatives encountered by the company, which vary according to the alternatives j. s_n is the observed attributes of firms that vary from alternatives not changed by choice such as firm size or industry type.

TABLE III
STANDARDIZATION STRATEGIES BY TECHNOLOGICAL UNCERTAINTY

Strategies	Technological uncertainty		Total
	Low	High	
Coexistence	72	56	67
Competition	27	40	31
Coopetition	1	4	2
Cooperation	0	0	0
Tot.	100	100	100

In our model, the attributes of the alternatives are not directly observed. This is not necessarily a significant concern as Luxembourg companies are not responsible for joining the national technical committees. The observed attributes are retained for the analysis model presented in sequence. The probability that the company chooses the strategies *i* is formalized as follows:

$$\begin{aligned} P_{ni} = & \text{ Prob } (NB_{ni} > NB_{nj}, \; \forall \, i \neq j) \\ & \text{Prob } (V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}, \; \forall \, i \neq j) \\ & \text{Prob } (\varepsilon_{nj} - \varepsilon_{ni} < V_{nj} - V_{ni}, \; \forall \, i \neq j) \, . \end{aligned}$$

Different hypotheses concerning the distribution of $\varepsilon_{nj} - \varepsilon_{ni}$ generate different models (e.g., logit and probit). The company may decide to undertake a standardization activity. Alternatively, companies can be fully engaged in a coopetitive standardization strategy. Another possible alternative is that companies choose to adhere to cooperative standardization strategy. There are three feasible strategies in this research framework, and the multinomial logit is considered the most appropriate. In the multinomial logit, the probability that the firm n chooses the strategy i is equal to $p_{ni} = \frac{e^{(\beta' x_{ni})}}{\sum_j e^{(\beta' x_{nj})}}$, where x_{nj} is the vector of the observed variables relating to the alternative j and β_m is the vector of the coefficients. To verify the multinomial logit's robustness, potential alternative models (e.g., bivariate probit, and ordered logit) are implemented and discussed in Section V.

IV. RESULTS

We discuss results presenting first descriptive figures and then we turn attention to the econometric analysis. Table III documents the positive association between proactive standardization strategies and technological uncertainty. The proportion of firms engaged in competition and cooperation is higher among firms that report high technological uncertainty (40% and 4%, respectively) compared to firms facing low uncertainty (27% and 1%, respectively). Quite surprising no firm in our sample is pursuing pure cooperation strategy. We discuss this finding in Section V. Descriptive statistics of other variables are shown in Table II.

We discuss here the econometric results of a multinomial logit that links firm's characteristics with the firm's choice of a standardization strategy. This is appropriate because standardization strategy can assume nominal values: coexistence, competition, and coopetition. As first step, to simplify the

TABLE IV
MULTINOMIAL LOGIT ESTIMATES

		Standardization Strategies		
	Variables	*Coexistence*	*Competition*	*Coopetition*
Tech. uncertainty	Tech. uncertainty	base	0.818***	1.633**
			(0.003)	(0.014)
Size	Employment	base	0.00275***	0.00425**
			(0.007)	(0.024)
	Employment ^{2}	base	-0.000000699**	-0.000000789
			(0.045)	(0.158)
International Market	Intern. market	base	-0.106	0.765
			(0.725)	(0.370)
Group Status	No group	base	base	base
	Nat. group		0.855***	1.491
		base	(0.005)	(0.148)
	Int. group	base	0.652**	0.0658
			(0.032)	(0.953)
Industries	Manufacturing	base	base	base
	Utilities	base	1.742***	-14.14***
			(0.002)	(0.000)
	Trade	base	0.781*	-0.457
			(0.054)	(0.646)
	Transportation	base	0.415	-14.91***
			(0.285)	(0.000)
	ICT	base	0.186	-0.973
			(0.678)	(0.273)
	Financial	base	1.708***	-0.702
			(0.000)	(0.754)
	Professionals	base	0.365	-1.627
			(0.521)	(0.281)
Competition	New comp.	base	-0.196	-0.499
			(0.434)	(0.539)
	Outdated Product	base	-0.620**	-0.816
			(0.028)	(0.372)
	Price	base	-0.443	0.0000890
			(0.293)	(1.000)
	Quality	base	0.438	-0.514
			(0.277)	(0.440)
Innovation activities	No open - no R&D	base	base	base
	Open innovation	base	-0.183	-0.313
			(0.721)	(0.793)
	Internal R&D	base	0.405	0.169
			(0.252)	(0.865)
	Open # R&D	base	1.074	1.431
			(0.121)	(0.309)
	Patent	base	1.311***	0.551
			(0.002)	(0.439)
Labour force education	0-9%	base	base	base
	19-49%	base	-0.309	2.395***
			(0.374)	(0.009)
	+ 50%	base	0.284	3.549***
			(0.486)	(0.001)
Constant		base	-2.257***	-7.041***
			(0.000)	(0.000)
Mc Fadden'R2			0.204	
Obs.			636	
Weighed obs.			1505	
Overall accuracy (% of observation correctly predicted)			73.9	

Note: Technological uncertainty is a self-reported assessment on the extent of the difficulty to predict technological developments "1" if it perceives high or medium–high difficulty to predict technological development and "0" otherwise. Estimations account for survey weights; Robust p-values in parentheses $^{***}p < 0.01$, $^{**}p < 0.05$, $*p < 0.1$.

analysis, cooperation is not considered because this strategy is absent in our sample. Table IV reports the model estimates of a multinomial logit where competition and coopetition are compared to coexistence of the base line. Table V shows the average marginal effects—AME—the change in the probability of choosing each feasible standardization strategy compared to coexistence strategy. Before discussing the results in detail, we note that the model fits the data relatively well (Mc Fadden R^2 is 0.204). Indeed, Mc Fadden [55] suggests that the pseudo R^2 of the logit model cannot be directly compared to the R^2 calculated

TABLE V
AVERAGE MARGINAL EFFECTS MULTINOMIAL LOGIT

		Competition vs. Coexistence (ref.)	Coopetition vs. Coexistence (ref.)
	VARIABLES	dy/dx	dy/dx
Tech. uncertainty	Tech. uncertainty	0.133***	0.0164
		(0.006)	(0.116)
Size	Employees	0.000420***	0.0000381
		(0.008)	(0.103)
International Market	Intern. market	-0.0231	0.00956
		(0.655)	(0.289)
Group Status	No group	base	base
	Nat. group	0.139**	0.0208
		(0.016)	(0.346)
	Int. group	0.113**	-0.00292
		(0.036)	(0.817)
Industries	Manufacturing	base	base
	Utilities	0.336***	-0.0418
		(0.002)	(0.106)
	Trade	0.132**	-0.0207
		(0.049)	(0.425)
	Transportation	0.0809	-0.0418
		(0.172)	(0.106)
	ICT	0.0362	-0.0242
		(0.563)	(0.328)
	Financial	0.322***	-0.0318
		(0.000)	(0.394)
	Professionals	0.0676	-0.0326
		(0.438)	(0.259)
Competition	New comp.	-0.0296	-0.00569
		(0.484)	(0.631)
	Outdated Products	-0.0951**	-0.00665
		(0.027)	(0.540)
	Price	-0.0785	0.00335
		(0.304)	(0.720)
	Quality	0.0758	-0.0132
		(0.211)	(0.370)
Innovative activities	Open innovation	0.0129	0.00254
		(0.843)	(0.771)
	Internal R&D	0.0998*	0.00287
		(0.084)	(0.771)
	Patent	0.249***	-0.00294
		(0.003)	(0.746)
Labour force education	0-9%	Base	Base
	19-49%	-0.0584	0.0172*
		(0.288)	(0.054)
	+ 50%	0.0299	0.0373*
		(0.677)	(0.068)
Observations		636	
Population size		1505	

Note: Estimations account for survey weights, Robust p-values in parentheses $***p < 0.01$, $**p < 0.05$, $*p < 0.1$; Note: dy/dx for factor levels is the discrete change from the base level.

for the linear models. R^2 in the range [0.2 to 0.4] indicates a "good" model fitting for nonlinear models. The overall accuracy (i.e., the percentage of correctly classified observations) is 73.9, ranging from 90% for coexistence strategy to 22.2% for coopetition (see also the confusion matrix in Table VII in Appendix). More parsimonious specifications with lower R^2 and accuracy are discussed in Section V and reported in Table VI in appendix.

After discussing the overall adequacy of the model, we focus now on the impact of the technological uncertainty and our variable of interest on standardization strategies. As shown in Table IV, the coefficients are positive and statistically significant at conventional level for both competition and coopetition (0.818; p-value 0.003 and 1.633, p-value 0.014, respectively). Looking at the marginal effects in Table V, the probability to engage in competition standardization strategy compared to coexistence increases of 13.3 percentage points among firms reporting uncertainty in technology (AME = 0.133; p-value = 0.006). In case of coopetition, firms reporting uncertainty in technology standardization strategy register and increase of 1.6 percentage points (AME = 0.133; p-value = 0.006). The effect of uncertainty on proactive standardization is sizeable when compared with the total proportion of firm engaged in

standardization reported in Table III (31% for competition and 2% per coopetition). Results indicate that *uncertainty in technology's future trajectory is positively associated with both competition (internal standardization only) and coopetition (internal and external standardization) strategies.*

The AME of technological uncertainty in predicting coopetition standardization deserves further discussion because it may not look statistically significant and of lower magnitude compared to the effect of technological uncertainty in predicting standardization. As reported in Table IV, the multinomial logit, the estimated coefficient of technological uncertainty, is large and statistically significant (coeff. $= 1.633$, p-value $= 0.014$).[3] Second, when testing for the statistical difference between the uncertainty coefficient in the equation competition and equation coopetition, there is no statistically difference (Adjusted Wald test $F(1635) = 1.51$; Prob $> F = 0.219$)). This suggests that in our sample, the association between *uncertainty and coopetition is not dissimilar to the association between uncertainty and cooperation.* Roughly speaking, these results suggest that uncertainty "pushes" coopetition and competitive with the same intensity. Finally, we note that the p-value (0.116) is close to the traditional value of 0.10 that is conventionally adopted as the threshold to sort statistical significance.

The interpretation we give to the choice of a coopetitive standardization strategy is that this type of strategy is more useful when technological trajectories are uncertain. A standardization strategy is considered to facilitate market coordination, and participation standardization can better predict (and possibly influence future market trends). This result is justified concerning the literature on coopetition, which suggests that competitors can cooperate to protect themselves from the future and that everyone does their share of the pie [40]. A short discussion of the results of the analysis for the other control is reported in appendix for completeness.

V. Discussion

This section discusses the robustness of the chosen model. We perform several robustness tests. The multinomial logit model is estimated using different size's measure to account for possible nonlinearity (i.e., we used five dummy variables [10]–[19], [20]–[49], [50]–[99], [100]–[249], [250, …]). The results do not change significantly.

The model is adjusted using the different categories (excluding utilities and transport and reclassifying the sector according to its technology intensity) to assess the influence of industrial classifications. Reclassification is done by distinguishing the high and low technology sector from the low knowledge sector [56]. Again, the results do not change significantly.

Concerned about the stability of the coefficients, the estimation of the most parsimonious specifications of the multinomial logit model is presented in Table VI. Overall coefficients do not vary considerably. The specification in Table IV remains our favorite because of higher R^2 and overall accuracy. Note that also the R^2 adjusted for the number of variables used in the specification is higher for the preferred specification.

Other discrete choice models are implemented to facilitate the comparison between the models. The marginal effects are described in Table VIII. The logit model describes the probability of implementing a standardization strategy. Since all companies with a cooperative standardization strategy are active in a competitive standardization strategy, the model coefficients can be compared directly to the coefficients describing an internal strategy's strategy. Similarly, the results do not change significantly.

The multinomial logit assumes that the error terms are distributed along with a logistic distribution. As a robustness check, a multinomial probit that assumes the normal distribution of errors is implemented. The results are similar to the multinomial logit.

The multinomial logit assumes no specific order of achievable standardization strategies. However, some observers might interpret the three standardization strategies as realizing the latent variable *attitude towards standardization* in the manner of the *standardization maturity model*. In this sense, the three possible strategies can potentially be ordered. If this were the case, a model of ordinal choice might be appropriate. To verify this robustness, we test an adjusted ordered logit model whose AMEs are given in Table VIII. The results for the ordered logit are not too different from the results of the multinomial logit.

Additional tests are performed on the ordered model. Indeed, the ordered logit model assumes that the coefficients that describe the competitive (internal) standardization strategy and the standardization coopetitive strategy are the same. This hypothesis is known in the literature as the parallel regression hypothesis [57]. The significant test statistic provides evidence that this assumption is violated jointly by all covariates. Since the three standardization strategies' exact order is partially debatable and the parallel regression assumption does not hold, the nominal result model (multinomial logit) is preferred.

A property of the multinomial logit model is the independence of irrelevant alternatives (IIA). This means that the relative chances of choosing between two alternatives are the same regardless of the other alternatives available or the attributes of alternatives [58]. Formal testing for multinomial logit IIA is not recommended due to unreliable results [57], [59].

In our analysis, the IIA test problem in the multinomial logit is exacerbated by the use of survey data and sample weights. Thus, to verify the robustness of the multinomial model's result, the choice of the standardization strategy is modeled within the framework of the bivariate probit that does not have an IIA. The company faces two distinct but correlated choices in the bivariate probit: the competitive standardization strategy (yes or no) and the cooperative standardization strategy (yes or no). The bivariate probit model without the independence assumption of IIAs provides comparable results with the multinomial logit (see Table VIII). Overall, these results increase confidence in the adequacy of the multinomial logit shown in Table V.

[3]Many researchers report that in nonlinear models the coefficient of a variable can be statistically significant but the marginal effect is not. This is because of the nonlinearity of the models (see [Online]. Available: https://www.statalist.org/forums/forum/general-stata-discussion/general/1329201-marginal-effects-significance-vs-original-model-effects-significance).

After various robustness tests, we can conclude that the model and the results are robust to other models and specifications.

VI. Conclusion

This article highlighted the determinants of different standardization strategies for a firm based on theoretical considerations and previous empirical studies. Based on a dedicated database, the analysis was the first to document strategic positions of standardization (coexistence or competitive standardization or coopetitive standardization). Our econometric analysis showed that firms facing technological uncertainty were more likely to adopt proactive standardization strategies than other firms. Firms were more likely to embrace standardization when competition was characterized by uncertainty about future technologies, which could be interpreted as evidence that firms could work together to reduce the uncertainties associated with turbulent economic environments [60]. Available evidence suggested also that uncertainty was positively associated with coopetition and competition with the same intensity.

Our results show that most companies are not involved in standardization. This may sound surprising but they are perfectly in line with the *"barrier model"* of standardization [20]. Before engaging in standardization outside of the firms' boundaries, firms have first to master internal standardization. Standardization outside of the firms require substantially high efforts (and incur higher costs) of coordination than internal standardization and lack theoretical or empirical base for strategizing or for deriving expected gains. Recalling the analogy of R&D/standardization within and outside of the firms, we note that 75% of firms in Luxembourg are reporting no R&D investments, 3% only external R&D, 14% only internal, and 8% both internal and external R&D. Other countries show similar patterns [61], [62].

As far as standardization is concerned, this coopetitive enterprise standardization strategy is becoming a new competitive standardization solution for companies. This coopetition strategy reduces uncertainty in the market, including both product and process innovation. It is a tool to reduce technological uncertainty. For example, firms operating in a market with uncertain future technology trajectories are much more likely to engage in standardization activities. Besides, size and competitive standardization show a U-shaped inverse relationship. Professional qualification is positively correlated with a cooperative standardization strategy.

Managers can reduce technological uncertainty by participating in standardization and market competition. To do this, they can choose to build a cooperative standardization strategy. Managers can use this result to develop and coordinate new business strategies and new cooperative standardization strategies. For example, companies wishing to increase their participation in standardization activities need to pay particular attention to education of the work force, including standardization education. The article results are valid for decision-makers in the profiling of companies most likely to participate in standardization or, more generally, more engaged in standardization.

In interpreting these results, it is essential to consider that the sample of available data is relatively small, especially in case of firms that implement coopetitive strategies. Additionally, Luxembourg is a small economy of open services and that the standardization of services has not reached the importance comparable to standardization for manufacturing. Besides, the National Standards Institute only started its activities recently. Although potential reverse causality problems cannot be excluded entirely with available cross-sectional data, the dataset's richness and the robustness controls suggest the results' overall validity. The availability of panel data and possibly transnational datasets could improve the understanding of standardization strategies.

We conclude the section discussing additional explanations to the patterns observed and offering some formal propositions to be verified in future researches. Unobserved factors may moderate and confound the relations between technological uncertainty and standardization that we documented. Possible unobserved factors are market position of the firm (e.g., market leader and follower) and ubiquity of technology (e.g., players of different industries) needed to set standards for a new product. For example, standards for self-driving car may require engagement of firms active both in the information technology and in automotive industry. Other example is the Internet of Things that engages diverse stakeholders. For these reasons, we conclude setting two propositions for future research as follows:

1) If a standard can be developed within one industry and a firm is a leader, then the firm chooses competitive standardization strategy.
2) If many industries are needed to set a standard and a firm is follower, then the firm chooses coopetitive standardization strategy.

Appendix
Controls Variables

Size

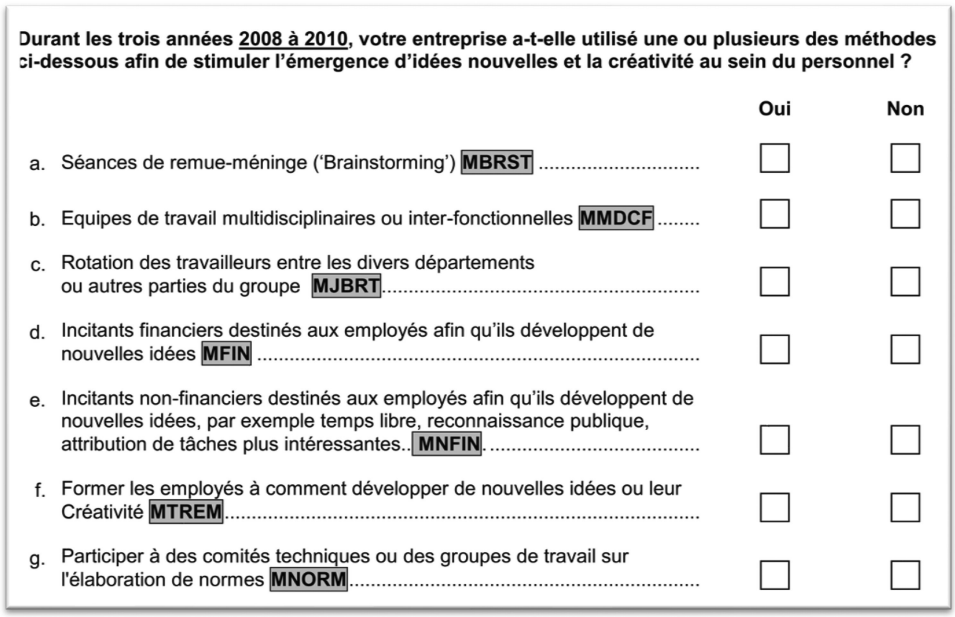
Compared to a coexistence strategy, the propensity to implement a competitive standardization strategy increases with size. Interestingly, the relationship between size and internal normalization appears as an inverted U. The maximum is reached when the company has nearly 250 employees. The propensity then decreases. We interpret this result as evidence that competitive standardization (internal) is not enough to meet the needs of companies beyond a certain threshold.

After this threshold, companies opt for a coopetitive standardization strategy (including engagement in standard setting organization). Having the strategy without normalization due to the reference, the propensity to implement a coopetitive strategy increases linearly with size. The AME of employment on the probability of engaging in a cooperative standardization strategy has a p-value of 0.104.

Overall, the results show that employment is generally positively related to all standardization strategies.

International market

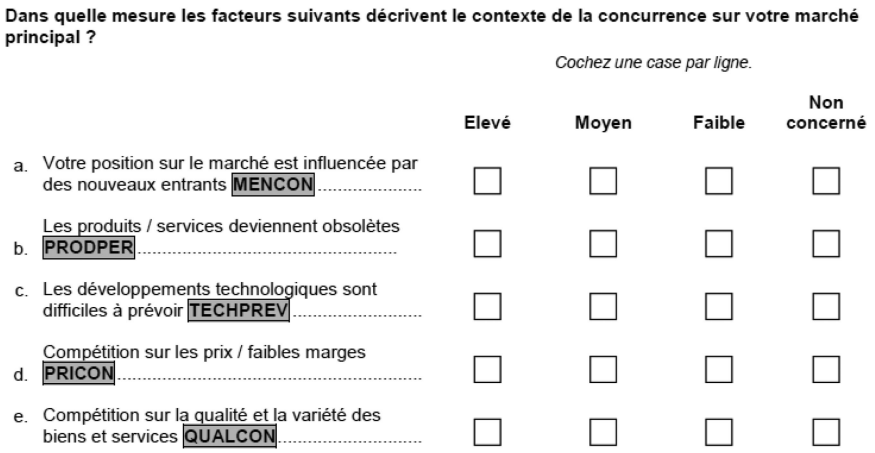
Luxembourg companies with their main market abroad are no more likely to engage (in standardization activities) than domestically active companies. As expected, being part of a group of companies (national and international) increases the likelihood of competitive standardization activities. Internationally, the company should opt for a cooperative strategy to guard against



Durant les trois années 2008 à 2010, votre entreprise a-t-elle utilisé une ou plusieurs des méthodes ci-dessous afin de stimuler l'émergence d'idées nouvelles et la créativité au sein du personnel ?

	Oui	Non
a. Séances de remue-méninge ('Brainstorming') MBRST	☐	☐
b. Equipes de travail multidisciplinaires ou inter-fonctionnelles MMDCF	☐	☐
c. Rotation des travailleurs entre les divers départements ou autres parties du groupe MJBRT	☐	☐
d. Incitants financiers destinés aux employés afin qu'ils développent de nouvelles idées MFIN	☐	☐
e. Incitants non-financiers destinés aux employés afin qu'ils développent de nouvelles idées, par exemple temps libre, reconnaissance publique, attribution de tâches plus intéressantes.. MNFIN	☐	☐
f. Former les employés à comment développer de nouvelles idées ou leur Créativité MTREM	☐	☐
g. Participer à des comités techniques ou des groupes de travail sur l'élaboration de normes MNORM	☐	☐

Fig. 1. Community innovation survey question about standardization activity.



Dans quelle mesure les facteurs suivants décrivent le contexte de la concurrence sur votre marché principal ?

Cochez une case par ligne.

	Elevé	Moyen	Faible	Non concerné
a. Votre position sur le marché est influencée par des nouveaux entrants MENCON	☐	☐	☐	☐
b. Les produits / services deviennent obsolètes PRODPER	☐	☐	☐	☐
c. Les développements technologiques sont difficiles à prévoir TECHPREV	☐	☐	☐	☐
d. Compétition sur les prix / faibles marges PRICON	☐	☐	☐	☐
e. Compétition sur la qualité et la variété des biens et services QUALCON	☐	☐	☐	☐

Fig. 2. Community innovation survey question about technological uncertainty.

competition because internationally everything changes and the competition too. However, companies might be interested in opting for a standardization coopetitive strategy, both to guard against international competition and simultaneously prepare a competitive strategy for why not compete and innovate in the international market.

Group status

Companies that are part of a group, both if national and international, are more likely to engage in competitive standardization (here, intracompany standardization). In case of competitive strategy, being part of national or international group is influential even if group status is jointly tested [adjusted Wald test; $F\,(2634) = 1.41$ prob. $> F = 0.24$)].

Industries

Commercial and financial firms are more likely to implement competitive (internal only) standardization strategies relative to the manufacturing and utility industries. Luxembourg companies engaged in public services and transport are very unlikely to participate in cooperative standardization activities. The two variables of the sector have a negative AME with a p-value of 0.11. Even though the standards are particularly relevant for ICT, ICT companies are no more involved in our sample than other companies in standardization activities.

Competition

Table V shows that the perceived competition is characterized by obsolescence of products and services, the decline of a competitive (internal only) strategy diminished. On the contrary, the probability of cooperative standardization is not affected. Although it is unlikely that a company will invest in a competitive standardization strategy when its products are obsolete, cooperative standardization can help predict and partially be part of the obsolescence process. Other measures of competition are

TABLE VI
MULTINOMIAL LOGIT ESTIMATES (ALTERNATIVE SPECIFICATIONS)

	Competition vs Coexistence (ref.)	Coopetition vs Coexistence (ref.)	Competition vs Coexistence (ref.)	Coopetition vs Coexistence (ref.)	Competition vs Coexistence (ref.)	Coopetition vs Coexistence (ref.)	Competition vs Coexistence (ref.)	Coopetition vs Coexistence (ref.)	Competition vs Coexistence (ref.)	Coopetition vs Coexistence (ref.)
Technological uncertainty.	0.633***	1.947***	0.765***	1.900**	0.767***	1.881***	0.797***	1.922***	0.818***	1.633**
	(0.004)	(0.000)	(0.004)	(0.015)	(0.005)	(0.009)	(0.003)	(0.006)	(0.003)	(0.014)
Emp10			0.00286***	0.00408**	0.00261***	0.00378**	0.00231**	0.00340**	0.00275***	0.00425**
			(0.002)	(0.012)	(0.007)	(0.025)	(0.021)	(0.038)	(0.007)	(0.024)
$Emp10^2$			-0.000000669**	-0.000000765	-0.000000675**	-0.000000759	-0.000000568	-0.000000628	-0.000000699**	-0.000000789
			(0.030)	(0.131)	(0.038)	(0.147)	(0.102)	(0.221)	(0.045)	(0.158)
Intern. market			0.110	0.782	-0.0549	0.585	-0.128	0.503	-0.106	0.765
			(0.721)	(0.364)	(0.855)	(0.506)	(0.677)	(0.570)	(0.725)	(0.370)
No group			base	base	base	base	base	base	base	base
Nat. group			1.080***	1.896	0.912***	1.824*	0.870***	1.738	0.855***	1.491
			(0.001)	(0.110)	(0.002)	(0.075)	(0.004)	(0.101)	(0.005)	(0.148)
Int. group			0.800***	0.650	0.781***	0.623	0.638**	0.484	0.652**	0.0658
			(0.004)	(0.608)	(0.005)	(0.607)	(0.030)	(0.690)	(0.032)	(0.953)
Manufacture.			base	base	base	base	base	base	base	base
Utilities			1.462***	-14.77***	1.546***	-13.29***	1.752***	-14.98***	1.742***	-14.14***
			(0.005)	(0.000)	(0.004)	(0.000)	(0.002)	(0.000)	(0.002)	(0.000)
Trade			0.292	-0.896	0.523	-0.696	0.745*	-0.428	0.781*	-0.457
			(0.421)	(0.307)	(0.161)	(0.451)	(0.062)	(0.679)	(0.054)	(0.646)
Transport			-0.0846	-15.23***	0.225	-13.57***	0.453	-15.12***	0.415	-14.91***
			(0.808)	(0.000)	(0.529)	(0.000)	(0.234)	(0.000)	(0.285)	(0.000)
ICT			0.108	0.00440	0.196	0.152	0.430	0.434	0.186	-0.973
			(0.748)	(0.995)	(0.580)	(0.827)	(0.226)	(0.560)	(0.678)	(0.273)
Financial			1.272***	0.0103	1.475***	0.281	1.847***	0.693	1.708***	-0.702
			(0.001)	(0.995)	(0.000)	(0.876)	(0.000)	(0.698)	(0.000)	(0.754)
Professionals			0.555	-0.245	0.508	-0.221	0.572	-0.185	0.365	-1.627
			(0.189)	(0.839)	(0.269)	(0.853)	(0.269)	(0.883)	(0.521)	(0.281)
New compt.			-0.174	-0.449	-0.202	-0.500	-0.180	-0.461	-0.196	-0.499
			(0.476)	(0.600)	(0.416)	(0.586)	(0.471)	(0.612)	(0.434)	(0.539)
Outdat. prod.			-0.440	-0.473	-0.589**	-0.622	-0.613**	-0.688	-0.620**	-0.816
			(0.106)	(0.611)	(0.038)	(0.517)	(0.031)	(0.473)	(0.028)	(0.372)
Price			-0.266	-0.0539	-0.346	0.0507	-0.372	-0.0150	-0.443	0.0000890
			(0.528)	(0.955)	(0.415)	(0.953)	(0.396)	(0.986)	(0.293)	(1.000)
Quality.			0.401	-0.741	0.417	-0.733	0.464	-0.650	0.438	-0.514
			(0.298)	(0.287)	(0.278)	(0.268)	(0.251)	(0.336)	(0.277)	(0.440)
No open inn. and no int. R&D			base	base	base	base	base	base	base	base
Open inn.					0.123	-0.112	-0.125	-0.491	-0.183	-0.313
					(0.816)	(0.916)	(0.799)	(0.685)	(0.721)	(0.793)
Internal R&D					0.574	0.239	0.365	0.0177	0.405	0.169
					(0.105)	(0.821)	(0.307)	(0.987)	(0.252)	(0.865)
Open#R&D					0.890	1.374	1.017	1.661	1.074	1.431
					(0.209)	(0.328)	(0.136)	(0.272)	(0.121)	(0.309)
Patent							1.303***	1.334*	1.311***	0.551
							(0.001)	(0.058)	(0.002)	(0.439)
0-9%									Base	base
10-49%									-0.309	2.395***
									(0.374)	(0.009)
+50%									0.284	3.549***
									(0.486)	(0.001)
Constant	-0.977***	-4.645***	-2.110***	-5.070***	-2.210***	-5.219***	-2.368***	-5.376***	-2.257***	-7.041***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)
LL	-1037.4		-902.4		-873.9		-857.1		-845.0	-1037.4
McFadden'R2	0.0223		0.150		0.176		0.192		0.204	0.0223
McFadden's Adj. R2	0.0139		0.0789		0.0832		0.0933		0.0962	0.0139
Overall accuracy	.67		0.71		0.72		0.73		0.74	

not associated. However, the adjusted Wald test shows that the competition variables are jointly statistically significant at 0.244 for coexistence strategies vs. competitive strategies (internal), i.e., $F\ (5.631) = 2.60$ prob. $> F = 0.0$ and for coexistence strategies vs. coopetitive strategies, $F\,(5631) = 2.48$ prob. $> F = 0.0308$. This means that higher perceived competition increases the chances of adopting active standardization strategies.

Intramural R&D, open R&D, and patenting

Innovation-related activities do not increase the likelihood that Luxembourg companies will embark on a cooperative standardization strategy. Similar pattern is observed for competition strategy with the notable exception of the use of patent that is strongly associated with competition strategies.

Education

Ceteris paribus, companies with a higher percentage of educated labor, are more likely to adopt a coopetitive standardization strategy but not competitive. One possible explanation is that competitive standardization strategies can be implemented without highly skilled employees. On the other hand, participation in cooperative standardization processes requires highly qualified expertise. Businesses need a lot of educated people to participate and contribute to a standardization process.

TABLE VII
CONFUSION MATRIX OF FULL MODEL

		Predicted Coexistence	Competition	Coopetition	Total	% obs. correctly classified
Observed	Coexistence	60.0	6.7	0.0	66.7	90
	Competition	17.9	13.5	0.1	31.5	42.9
	Coopetition	0.7	0.7	0.4	1.8	22.2
	Overall					73.9

Note: The model predicts the probability for each outcome. The outcome with the highest probability is retained as predicted strategy.

TABLE VIII
AVERAGE MARGINAL EFFECTS (ALTERNATIVE DISCRETE CHOICE MODELS)

		Multinomial Probit with IIA		**Multinomial Logit**		**Ordered Logit**		**Bivariate Probit**	
		Competition vs Coexistence (ref.)	Coopetition vs Coexistence (ref.)	Competition vs Coexistence (ref.)	Coopetition vs Coexistence (ref.)	Competition vs Coexistence (ref.)	Coopetition vs Coexistence (ref.)	Competition vs Coexistence (ref.)	Coopetition vs Coexistence (ref.)
	Technological uncertainty	0.120**	0.0184*	0.117**	0.0199	0.125***	0.0154**	0.116**	0.0237**
		(0.018)	(0.086)	(0.025)	(0.123)	(0.004)	(0.037)	(0.018)	(0.027)
Size	Employment	0.000474***	0.0000562**	0.000524***	0.0000466	0.000357**	0.0000388**	0.000401**	0.0000583**
		(0.008)	(0.031)	(0.008)	(0.122)	(0.011)	(0.018)	(0.019)	(0.018)
International Market	Intern. market	0.00688	0.0127	0.00464	0.0117	0.0171	0.00199	-0.00348	0.0213**
		(0.905)	(0.182)	(0.937)	(0.303)	(0.736)	(0.731)	(0.951)	(0.035)
Group Status	No group	base	base	base	base	base	base	base	base
	Nat. group	0.111*	0.0307	0.110	0.0270	0.156***	0.0163*	0.0942	0.0563**
		(0.088)	(0.165)	(0.100)	(0.335)	(0.008)	(0.065)	(0.127)	(0.017)
	Int. group	0.130**	-0.00435	0.130**	-0.00333	0.121**	0.0118**	0.123**	0.00242
		(0.035)	(0.721)	(0.040)	(0.830)	(0.032)	(0.034)	(0.042)	(0.798)
Industries	Manufacturing	base	0	base	base	base	base	base	base
	Trade	0.128*	-0.0271	0.136*	-0.0242	0.0922	0.00947	0.113*	-0.00679
		(0.054)	(0.225)	(0.053)	(0.421)	(0.133)	(0.190)	(0.078)	(0.691)
	ICT	0.0310	-0.0310	0.0296	-0.0281	-0.00837	-0.000715	0.0268	-0.0236
		(0.649)	(0.180)	(0.672)	(0.336)	(0.899)	(0.898)	(0.679)	(0.149)
	Financial	0.305***	-0.0403	0.297***	-0.0368	0.196**	0.0252*	0.298***	-0.0313
		(0.001)	(0.170)	(0.002)	(0.403)	(0.018)	(0.057)	(0.001)	(0.201)
	Professionals	0.0557	-0.0408	0.0567	-0.0377	0.00465	0.000406	0.0446	-0.0281
		(0.516)	(0.117)	(0.530)	(0.267)	(0.954)	(0.954)	(0.591)	(0.208)
Competition	New comp.	0.0221	-0.00878	0.0215	-0.00754	0.0126	0.00152	0.0309	-0.0141
		(0.629)	(0.416)	(0.653)	(0.610)	(0.766)	(0.767)	(0.485)	(0.232)
	Outdated Products	-0.107**	-0.00624	-0.105**	-0.00821	-0.103**	-0.0115**	-0.118***	-0.000509
		(0.021)	(0.542)	(0.028)	(0.549)	(0.018)	(0.032)	(0.008)	(0.958)
	Tech. uncertainty	0.120**	0.0184*	0.117**	0.0199	0.125***	0.0154**	0.116**	0.0237**
		(0.018)	(0.086)	(0.025)	(0.123)	(0.004)	(0.037)	(0.018)	(0.027)
	Price	-0.0846	0.00782	-0.0844	0.00506	-0.0699	-0.00938	-0.0893	0.0124
		(0.311)	(0.454)	(0.339)	(0.656)	(0.333)	(0.393)	(0.269)	(0.211)
	Quality	0.0509	-0.0152	0.0482	-0.0179	0.0130	0.00153	0.0522	-0.0190
		(0.489)	(0.331)	(0.529)	(0.342)	(0.843)	(0.840)	(0.447)	(0.205)
Innovative activities	Open	-0.0262	0.00416	-0.0284	0.00382	-0.0200	0.00247	-0.0275	0.00542
		(0.700)	(0.651)	(0.692)	(0.725)	(0.764)	(0.701)	(0.677)	(0.554)
	R&D	0.0972*	0.00477	0.0994*	0.00390	0.0863*	0.0126*	0.0994*	0.00474
		(0.090)	(0.628)	(0.092)	(0.753)	(0.096)	(0.054)	(0.074)	(0.590)
	Patent	0.244***	-0.00659	0.250***	-0.00413	0.216***	0.0343**	0.251***	-0.00202
		(0.003)	(0.498)	(0.004)	(0.712)	(0.001)	(0.039)	(0.001)	(0.835)
Labour force education	0-9%	base	base	base	base	base	base	base	base
	19-49%	-0.0732	0.0214**	-0.0704	0.0216*	-0.0166	-0.00161	-0.0546	0.0163*
		(0.231)	(0.024)	(0.277)	(0.052)	(0.768)	(0.771)	(0.350)	(0.097)
	+ 50%	0.0477	0.0485**	0.0523	0.0467*	0.102	0.0126	0.0649	0.0356**
		(0.564)	(0.022)	(0.547)	(0.072)	(0.174)	(0.175)	(0.414)	(0.046)

Note: Estimations account for survey weights; estimates are performed excluding utilities and transports firms. Due to paucity of observation in this sector the multinomial probit has some difficulties to converge. Robust p-values in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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