Supplementary material for the article:

Standards, Consortia, and Innovation

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Linkages between standards and informal consortia

Consortia Name	MatchStandard	Incl	NPE Share	Consortia Name	MatchStandard	Incl	NPE Share	Consortia Name	MatchStandard	Incl	NPE Share
EPCglobal	EN300220	No	0.00	WiMax	IEEE802.16	Yes	0.15	MPEGIF	ISO/IEC14496-14	Yes	0.00
DVB	EN300468	No	0.00	Cable Laboratories	IEEE802.1Q	Yes	0.09	MPEGIF	ISO/IEC14496-15	Yes	1.00
DVB	EN301192	No	0.00	FCIA - Fibre Channel Industry Association	IEEE802.1Q	No	0.09	MPEGIF	ISO/IEC14496-16	No	0.00
DVB	EN301199	Yes	0.00	MEF	IEEE802.1X	No	0.00	MPEGIF	ISO/IEC14496-18	Yes	0.00
DVB	EN301790	No	0.00	IETF	IEEE802.21	Yes	0.15	MPEGIF	ISO/IEC14496-19	No	0.00
DVB	EN301958	Yes	0.00	(GEA	IEEE802.3	No	0.00	ISMA	ISO/IEC14496-2	Yes	0.14
EPCglobal	EN302208	No	0.00	AUTOSAR	IEEE802.3/ISOIEC8802-3	No	0.15	MPEGIF	ISO/IEC14496-2	No	0.14
DVB	EN302304	No	0.00	FCIA	IEEE802.3/ISOIEC8802-3	No	0.15	MPEGIF	ISO/IEC14496-20	No	0.00
DVB	EN302307	No	0.00	HGI	IEEE802.3/ISOIEC8802-3	No	0.15	ISMA	ISO/IEC14496-3	Yes	0.14
DVB	EN302583	No	0.00	IETF	IEEE802.3/ISOIEC8802-3	Yes	0.15	MPEGIF	ISO/IEC14496-3	Yes	0.14
DVB	EN302755	No	0.00	MEF	IEEE802.3/ISOIEC8802-3	No	0.15	MPEGIF	ISO/IEC14496-4	Yes	0.67
DVB	ES200800	Yes	0.00	ODVA	IEEE802.3/ISOIEC8802-3	No	0.15	MPEGIF	ISO/IEC14496-5	Yes	0.18
IETF	ES201108	Yes	0.50	OIF	IEEE802.3/ISOIEC8802-3	No	0.15	MPEGIF	ISO/IEC14496-6	Yes	0.11

IETF	ES202050	Yes	0.25	Rapidio	IEEE802.3/ISOIEC8802-3	No	0.15	TAHI	ISO/IEC14543-2-1	No	0.00
IETF	ES202212	Yes	0.25	IETF	IEEE802.5/ISOIEC8802-5	No	0.09	IETF	ISO/IEC15444-1	No	0.10
WORLD DAB FORUM	ETS300401	Yes	0.00	INCITS	ISO/IEC10118-2	No	0.00	IETF	ISO/IEC15444-12	No	0.00
DVB	ETS300814	Yes	0.00	INCITS	ISO/IEC10118-3	Yes	0.00	IETF	ISO/IEC15444-2	No	0.00
DVD	ETSIEN300468	No	0.00	INCITS	ISO/IEC10536-3	No	0.00	IETF	ISO/IEC15444-3	Yes	0.00
IETF	G.711	Yes	0.25	INCITS	ISO/IEC10918-1/ITU-TT.81	Yes	0.00	IETF	ISO/IEC15444-5	No	0.00
IETF	G.722	Yes	0.00	TOG	ISO/IEC10918-1/ITU-TT.81	No	0.00	EPCglobal	ISO/IEC15693-2	No	0.00
IETF	H.263	Yes	0.08	INCITS	ISO/IEC11172-1	No	0.00	EPCglobal	ISO/IEC15693-3	No	0.00
IMTC	H.323	Yes	0.00	DVD	ISO/IEC11172-2	No	0.00	EPCglobal	ISO/IEC18000-1	No	0.00
IMTC	H.324	No	0.00	INCITS	ISO/IEC11172-2	No	0.00	EPCglobal	ISO/IEC18000-2	No	0.10
IETF	IEC618341	No	0.00	DVD	ISO/IEC11172-3	No	0.17	EPCglobal	ISO/IEC18000-3	No	0.00
TOG	IEEE1003.1/ISOIEC9945	Yes	0.00	INCITS	ISO/IEC11172-3	Yes	0.17	EPCglobal	ISO/IEC18000-4	No	0.00
PICMG	IEEE1101.1	Yes	0.00	INCITS	ISO/IEC11693	No	0.00	EPCglobal	ISO/IEC18000-6	Yes	0.06
OCP-IP	IEEE1149.1	Yes	0.00	INCITS	ISO/IEC11694-1	No	0.00	AIM	ISO/IEC18000-6	No	0.06
BPMI	IEEE1226.5	No	0.00	INCITS	ISO/IEC11770-3	No	0.00	AIM	ISO/IEC18000-7	No	0.00
OMG	IEEE1226.5	No	0.00	INCITS	ISO/IEC11889-1	Yes	0.00	EPCglobal	ISO/IEC18000-7	Yes	0.00
PWG	IEEE1284	Yes	0.00	INCITS	ISO/IEC11889-2	Yes	0.00	ECMA	ISO/IEC18092	No	0.00
1355 Association	IEEE1355	No	0.00	INCITS	ISO/IEC11889-3	Yes	0.00	EUROSMART	ISO/IEC18092	No	0.00
1394TA	IEEE1394	Yes	0.09	INCITS	ISO/IEC11889-4	Yes	0.00	NFC Forum	ISO/IEC18092	Yes	0.00
AUTOSAR	IEEE1394	No	0.09	DMPF	ISO/IEC13818-1/ITU-TH.220.0	No	0.17	INCITS	ISO/IEC19794-3	No	0.00
DVD	IEEE1394	No	0.09	DVD	ISO/IEC13818-1/ITU-TH.220.0	No	0.17	INCITS	ISO/IEC19794-6	Yes	0.00

HAVi	IEEE1394	No	0.09	INCITS	ISO/IEC13818-1/ITU-TH.220.0	Yes	0.17	ECMA	ISO/IEC23651	No	0.00
PWG	IEEE1394	No	0.09	DVD	ISO/IEC13818-2/ITU-TH.262	No	0.13	GS1 - (Formerly EAN)	ISO/IEC24730-2	No	0.00
ODVA	IEEE1588/IEC61588	Yes	0.00	INCITS	ISO/IEC13818-2/ITU-TH.262	Yes	0.13	ECMA	ISO/IEC28361	No	0.00
ACCELLERA	IEEE1800/IEC62530	No	0.50	TOG	ISO/IEC13818-2/ITU-TH.262	No	0.13	TAHI	ISO/IECDIS29341	No	0.00
ACCELLERA	IEEE1801	Yes	0.00	DVD	ISO/IEC13818-3	No	0.11	UPnP Forum	ISO/IECDIS29341	Yes	0.00
Homeplug	IEEE1901	No	0.00	INCITS	ISO/IEC13818-3	Yes	0.11	ECMA	ISO/IECDIS29500	No	0.00
IVI	IEEE488.1/IEC60488-1	No	0.00	INCITS	ISO/IEC13818-7	No	0.00	3GPP2	Q.703	No	0.00
ASTM	IEEE802.11/ISOIEC8802-11	No	0.15	EUROSMART	ISO/IEC14443-1	No	0.00	DVB	TS102474	No	0.00
Bluetooth	IEEE802.11/ISOIEC8802-11	No	0.15	INCITS	ISO/IEC14443-1	No	0.00	DECT Forum	TS102527	No	0.00
DLNA	IEEE802.11/ISOIEC8802-11	No	0.15	NFC Forum	ISO/IEC14443-1	No	0.00	DVB	TS102584	No	0.00
ewc	IEEE802.11/ISOIEC8802-11	No	0.15	EUROSMART	ISO/IEC14443-2	No	0.40	DVB	TS102611	No	0.00
HGI	IEEE802.11/ISOIEC8802-11	No	0.15	INCITS	ISO/IEC14443-2	Yes	0.40	TV Anytime Forum	TS102822	No	0.00
IETF	IEEE802.11/ISOIEC8802-11	No	0.15	NFC Forum	ISO/IEC14443-2	No	0.40	DVB	TS102825	No	0.00
Wi-Fi Alliance	IEEE802.11/ISOIEC8802-11	Yes	0.15	EUROSMART	ISO/IEC14443-3	No	0.33	IMS FORUM	TS123002	No	0.14
100VG-Anylan Forum	IEEE802.12	No	0.00	INCITS	ISO/IEC14443-3	Yes	0.33	3GPP2	TS123401	No	0.22
IETF	IEEE802.12/ISOIEC8802-12	No	0.00	NFC Forum	ISO/IEC14443-3	No	0.33	3GPP2	TS123402	No	0.29
Bluetooth	IEEE802.15.1	No	0.00	EUROSMART	ISO/IEC14443-4	No	0.33	3GPP2	TS133402	No	0.00
WiMedia Alliance	IEEE802.15.3	Yes	0.33	INCITS	ISO/IEC14443-4	Yes	0.33	DRM	TS201980	No	0.00
DISA	IEEE802.15.4	No	0.00	NFC Forum	ISO/IEC14443-4	No	0.33	IETF	V.44	No	0.00
IETF	IEEE802.15.4	No	0.00	ISMA	ISO/IEC14496-1	Yes	0.09	3GPP2	X.509	No	0.00
TAHI	IEEE802.15.4	No	0.00	MPEGIF	ISO/IEC14496-1	No	0.09	ASTM	X.509	No	0.00

ZigBee	IEEE802.15.4	No	0.00	ISMA	ISO/IEC14496-10	Yes	0.00	Cable Laboratories	X.509	Yes	0.00
IETF	IEEE802.16	No	0.15	MPEGIF	ISO/IEC14496-10	No	0.00	ISMA	ISO/IEC14496-10/ITUH.264	Yes	0.06
			0.00	MPEGIF	ISO/IEC14496-12	Yes	0.20				0.00

Table 8: Linkages between standards and informal consortia and NPE share

Robustness check substituting pre-sample means for fixed effects

We apply the methodology developed by Blundell et al. (1999) to control for unobserved fixed effects. The authors confirm the assumption that unobserved fixed effect can be expressed as a linear function of observable pre-sample means. The authors suggest substituting the pre-sample averages of the dependent variable for the group fixed effect. They show that the pre-sample mean of the dependent variable is a sufficient statistic for the unobserved fixed effect. We make use this approach as an additional regressor to control for heterogeneity. Analogous to our previous analysis, we set the period of observation from 2002 to 2009, and use the information on citation-weighted patent files from 1992 to 2001 for calculating pre-sample means. We control for the same variables and operate the same sample restrictions as in the main models of our empirical tests. As our dependent variable is over-dispersed with respect to a poisson distribution and we no longer include group fixed effects, we now opt for a negative binomial regression. This allows us to further add standard dummies. The results are displayed in table 9. The coefficients of the consortia membership as well as consortia size are consistent with the fixed effect poisson models. Our estimations provide significant results for the consortia variables in all models. Furthermore the coefficients of the pre-sample means are positive and significant in all specifications, which indicates that controlling for unobserved heterogeneity of the patent behavior is important.

	Model 1	Model 2
DV= patent files	*Coeff./ std.err*	*Coeff./ std.err*
Lag1.patent files	2.29E-06 (2.08E-07)	2.33e-06*** (2.31E-07)
Consortium-Member	0.956*** (0.170)	
ConsMember_Rent Seeking	-5.420*** (1.096)	
Relative consortia size		1.733*** (0.274)
Relative consortia size_Rent Seeking		-12.426*** (1.549)
Lag1.sales	-7.62e-06 *** (1.43E-06)	-7.13e-06*** (1.41E-06)
IPC control	-8.96e-06 *** (2.08E-06)	-7.43e-06 *** (2.05E-06)
All SEP declaration	0.003*** (5.46E-06)	0.003*** (5.52E-06)
Pre-sample means	1.92e-07*** (3.32E-08)	2.32e-07*** (3.64E-08)
Cons	2.116*** (0.601)	2.093*** (0.587)
Wald chi2	1206.45	1248.79
Log likelihood	-17247.148	-17240.242
Observations	1774	1774
Groups	277	277

Note: All models are estimated with the conditional random-effects poisson estimator with robust clustered standard errors (reported in parentheses). Standard errors are robust to arbitrary heteroskedacity and allow for serial correlation through clustering by firm. ***, **,and * imply significance at the 99%, 95%, and 90% levels of confidence, respectively.

Table 9: Robustness analysis with mean scaling and negative binominal estimation

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Patent files	1												
2	Consortium-member	-0.1013	1											
3	Consortium Member X Rent Seeking	-0.0938	0.9152	1										
4	Lag1Standard-event	-0.0948	0.3474	0.3104	1									
5	IPC_control	-0.0051	-0.1929	-0.1786	-0.0397	1								
6	All SEP-declarations	0.0033	0.0226	0.0195	-0.0154	0.1373	1							
7	Lag1.Firmsize (employees)	-0.0115	0.0291	0.0167	-0.0025	-0.0412	-0.0272	1						
8	Lag1.Tobin'sQ	-0.0346	-0.0155	-0.0155	-0.0302	0.0029	0.0102	-0.4524	1					
9	Standard adoption	-0.0142	-0.019	-0.0168	0.0038	0.0281	-0.009	-0.0167	0.0017	1				
10	Accreditations cumulated	-0.1027	0.3065	0.2261	0.3007	-0.0158	0.0116	0.0823	-0.159	-0.0228	1			
11	References cumulated	-0.1151	0.1141	0.1302	0.0916	0.12	0.0065	0.0243	-0.091	0.1121	0.4516	1		
12	Version age	-0.1647	-0.0774	-0.038	-0.1764	0.1265	-0.0157	-0.0116	-0.0565	-0.0639	0.0852	0.4685	1	
13	Pre-sample patent files	0.7761	-0.1095	-0.1005	-0.0812	0.0683	-0.0033	0.0169	-0.1038	-0.0137	-0.0997	-0.113	-0.1476	1

Note: All correlation coefficients above |0.2| are significant at $p < 0.05$

Table 10: Variable correlations

PSM Sampling for comparable standards

Our goal is to identify a comparable sample of companies which contribute to standards where we have not identified a consortium. Propensity score matching (PSM) is a widely used approach to estimate causal treatment effects. We therefore apply a logit based propensity score matching algorithm to identify a common support region for both samples. In a first step we search for variables that explain why companies join standard consortia. It is important to only use variables that are unaffected by the treatment (Heckman et al., 1999). We therfore only employ variables that are measured before standard release. We conduct a propensity match analysis to identify firm specific variables that may influence a firm's decision to join a consortium. In a first step we compute the technological distance of a firm compared to all other firms that contribute to the standard by comparing IPC classes of a firm's declared standard essential patents. Secondly we compute the standard importance to a firm by dividing a the average number of citation weighted patent files identified for the the specific standard by the average number of citation weighted patent files related to all standards. Thirdly we compute the industry distance by identyfying the SIC class per standard where most of the standard contributers are classfied in and compare if the particular firm of observation operates in that particular SIC industry class. Finally we compute the similarity of a firm's patent portfolio (using the IPC classifications) to the patent portfolio of other firms that contribute to the particular standard. In addition we test the average number of employees of the focal firm. The technology distance to a standard and the average number of employees are significantly correlated to consortium participation. (table 11).

DV= consortium membership	Coeff./ std.err
technology distance	-6.09*
	(9.424)
average employees	0.004* **
	(0.002)
standard importance	-0.054
	(0.146)
industry distance	0.546
	(0.451)
patent portfolio similarity	-0.175
	(0.452)
_cons	-2.607
	(0.638)
observation	256
Log likelihood	-16.858501
Pseudo R2	0.178

Table 11: propensity score match logit regression

Figure 4 shows results of our PSM graph of treated (company exists) and untreated (consortium does not exists) goups. We apply the nearest neighbor matching method where we identify matching partners of treated and untreated standards. We use a matching with replacement, where we allow matching an untreated standard observation more than once. This method is especially efficient when

we have very different propensity scores as evidence in figure 4. Matching high with low values would result in bad matches. We overcome this problem by allowing replacement which on the other hand increases the variance of the estimator (Smith and Todd, 2005).

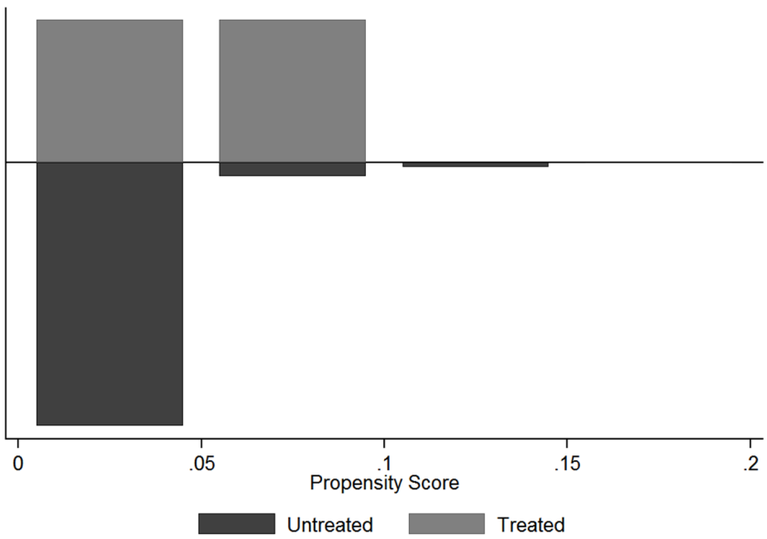

Figure 4: psm matching results

We conduct a sample statistic test after our propensity score matching. Table 12 shows that there is no remaining significant differences between the technology distancae and the number of employees anymore. The difference of all other variables remains to be insignificant after the matching.

Variable	Unmatched Matched	Mean Treated	Control	%bias	%reduct bias	t-tes t	t p>t
technology distance	Unmatched	0.033	0.004	21.3		2.23	0.026
	Matched	0.033	0.004	0	100	0.81	0.449
average employees	Unmatched	53,068.000	38,439.000	52.7		2.65	0.008
	Matched	53,068.000	38,439.000	0	100	-1.09	0.319
standard importance	Unmatched	1.247	1.442	-9.9		-0.16	0.874
	Matched	1.247	3.187	-98.1	-892.5	-0.79	0.46
industry distance	Unmatched	139.630	-160.560	40.9		0.58	0.562
	Matched	139.630	-257.590	54.1	-32.3	1.11	0.31
patent portfolio similarity	Unmatched	0.443	0.586	-32.1		-0.56	0.575
	Matched	0.443	0.944	-112.6	-250.4	-1.04	0.394

Table 12: Sample statistics, matched and unmatched samples