# Joining Standards Organizations: The Role of R&D Expenditures, Patents, and Product-Market Position

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➢ Complex and system innovation requires collaborative efforts

➢ Standards are developed in a complex ecosystem of private, voluntary and open organizations

➢ Standards organizations (SO): formal standards development organizations (SDO); organizations that *only* promote fully developed standards; certification bodies; other informal industry-based consortia etc.

➢ Motivations of firm involvement in standards development: learning, problem-solving, value appropriation, influencing technology, anticipating regulation and networking (Leiponen, 2008; Vasudeva et al., 2014; Delcamp and Leiponen, 2014; Baron et al., 2014)

➢ We study firm-level determinants of intensity of SO participation

➢Most comprehensive and robust evidence to date on participation in ICT standardization

➢Consolidated longitudinal data on the world's 2,000 largest R&D performers matched with membership info from 180 standards organizations

➢Quantifying the intensity of participation in standards development

➢Robust evidence on the roles of R&D and product-market position in a firm's involvement in SOs

➢Causal effect of patent-position on SO participation

➢Impact of R&D bolstered by strong patenting intensity and product-market positions

➢ Positive interaction between patenting intensity and R&D: causal link identified using exogenous variation induced by policy change ("patent boxes")

➢ Critical role of a firm's product-market position in incentivizing participation: e.g., trademarking intensity, brand value and number of standard-compliant end product models

➢ Mechanisms: interaction between R&D and distinct IP assets contingent on SO types: patents only matter for participation in SDOs potentially subject to SEPs

➢ *Searle Center Database on Technology Standards and Standard Setting Organizations (SCDB)*: membership data in 180 standards organizations, 299,652 membership records, from 1997-2015 (Baron and Spulber, 2018)

➢ Membership obligations: disclosure of potential SEPs and making SEP licenses available to standards implementers

➢ *OECD Database on IP Bundles*: R&D expenditures, IP bundles, and financial info for the world's top 2,000 R&D investors: consolidated IP statistics accounting for 66% of all IP5 patent families, trademark ownership more dispersed (Dernis et al., 2015; Daiko et al., 2017)

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➢ *OECD IP Bundles (2015 & 2017)*: 1,633 firms with IP statistics 2010-2014

➢ We use industries in *OECD* data most relevant to ICT standardization

➢ Sample 1 (509 firms in 6 industries): > 15% firms have declared >1 SEPs;  > 10% firms listed as selling standard-compliant products; average no. of SO memberships per firm > 10

*Electrical and Electronic Equipment, Consumer Electronics, Broadcasting and Entertainment, Fixed Line Telecommunications, Mobile Telecommunications, Technology Hardware and Equipment*

➢ Sample 2 (832 firms in 11 industries): 49 of top 50 firms declaring SEPs, all of the top 50 SO members, 47 of top 50 producers of standard-compliant products
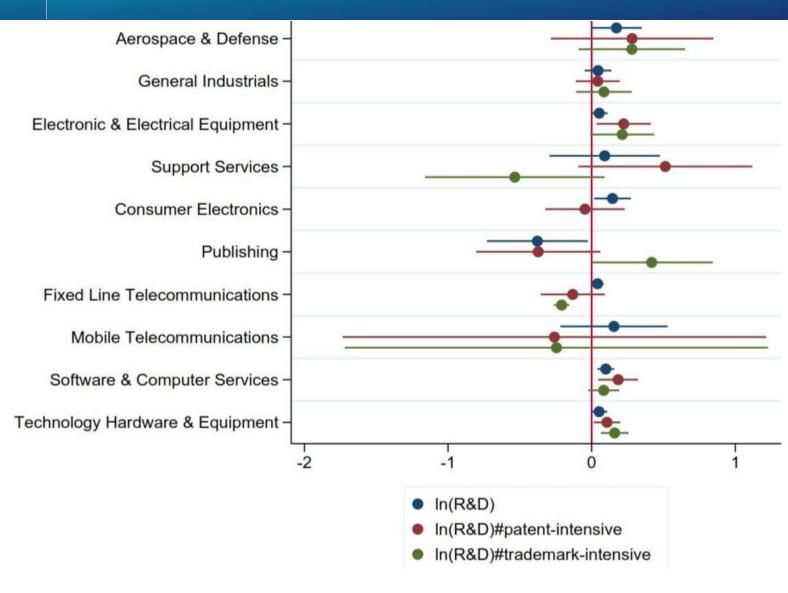
- Multivariate analysis of determinants of participation in standards organizations

- Explanatory variables: *ln* R&D expenditure, Patent_high, Trademark_high (above-median patent- and trademark- intensities), Patent/Trademark count, brand value, product count

- Control variables: employment, sales, capital intensity (firm and year fixed effects)

- Baseline model + Interaction model (interaction between R&D and IP positions)

- Panel fixed-effects regressions + controlling for regional trends (interaction terms between time and six regional dummies, incl. N. America, Europe, China, Japan, South Korea and other)

# Baseline Models (DV – *ln* Membership count; Fixed Effects)

| Independent variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| lnRD | 0.059*** | 0.033* | 0.027 | 0.017 | 0.018 |
| | (0.006) | (0.069) | (0.173) | (0.330) | (0.304) |
| PT_High#lnRD | | 0.134*** | | 0.096* | 0.089 |
| | | (0.006) | | (0.059) | (0.215) |
| TM_High#lnRD | | | 0.136*** | 0.095** | 0.089* |
| | | | (0.002) | (0.036) | (0.081) |
| PT_High#TM_High#lnRD | | | | | 0.014 |
| | | | | | (0.885) |
| lnEmployees | 0.062** | 0.040 | 0.042* | 0.032 | 0.033 |
| | (0.012) | (0.113) | (0.085) | (0.201) | (0.175) |
| lnSales | 0.036** | 0.032** | 0.030** | 0.029** | 0.029** |
| | (0.011) | (0.011) | (0.018) | (0.018) | (0.018) |
| lnCapital_Int | 0.158* | 0.069 | 0.076 | 0.037 | 0.038 |
| | (0.084) | (0.460) | (0.417) | (0.702) | (0.682) |
| Constant | -39.591 | -21.742 | -9.661 | -5.843 | -6.214 |
| | (0.106) | (0.361) | (0.680) | (0.801) | (0.790) |
| Year dummies | Yes | Yes | Yes | Yes | Yes |
| Regional trends | Yes | Yes | Yes | Yes | Yes |
| R-squared | 0.087 | 0.096 | 0.096 | 0.100 | 0.100 |
| Observations | 2,233 | 2,233 | 2,233 | 2,233 | 2,233 |
| Number of companies | 405 | 405 | 405 | 405 | 405 |

| Independent variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 |
|---|---|---|---|---|---|---|---|---|
| box_active | 0.228*** | 0.186** | 0.232*** | 0.186** | 0.259*** | -0.152* | 0.109 | -0.126 |
|  | (0.003) | (0.024) | (0.006) | (0.024) | (0.002) | (0.097) | (0.256) | (0.209) |
| box#av_RD |  | 0.000 | -0.000* | 0.000 | -0.000 | -0.000 | 0.000 | -0.000 |
|  |  | (0.140) | (0.057) | (0.320) | (0.108) | (0.962) | (0.188) | (0.990) |
| box#av_PT |  |  | 0.001*** |  | 0.001*** |  |  |  |
|  |  |  | (0.001) |  | (0.000) |  |  |  |
| box#av_TM |  |  |  | 0.000 | -0.009** |  |  |  |
|  |  |  |  | (0.983) | (0.030) |  |  |  |
| box#PT_High |  |  |  |  |  | 1.002*** |  | 1.023*** |
|  |  |  |  |  |  | (0.000) |  | (0.000) |
| box#TM_High |  |  |  |  |  |  | 0.181 | -0.079 |
|  |  |  |  |  |  |  | (0.123) | (0.516) |
| Constant | -33.318** | -31.459* | -38.583** | -31.460* | -41.631** | -9.348 | -25.527 | -11.466 |
|  | (0.044) | (0.058) | (0.021) | (0.058) | (0.013) | (0.577) | (0.134) | (0.502) |
| Year dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Regional trends | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| R-squared | 0.459 | 0.459 | 0.460 | 0.459 | 0.460 | 0.464 | 0.459 | 0.464 |
| Observations | 8,483 | 8,483 | 8,483 | 8,483 | 8,483 | 8,483 | 8,483 | 8,483 |
| Number of companies | 499 | 499 | 499 | 499 | 499 | 499 | 499 | 499 |

| Independent variables | Model 1 Standards developer | Model 2 | Model 3 Promoter | Model 4 | Model 5 Other | Model 6 | Model 7 SEP | Model 8 | Model 9 No SEP | Model 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| box_active | -0.221*** | -0.082 | 0.054 | -0.017 | 0.226*** | 0.217 | -0.026 | 0.243** | 0.052 | -0.172 |
| | (0.006) | (0.545) | (0.501) | (0.900) | (0.007) | (0.125) | (0.701) | (0.031) | (0.793) | (0.611) |
| box#av_RD | -0.001** | -0.002* | -0.000 | 0.000 | -0.000 | 0.000 | -0.001*** | -0.003*** | -0.000 | 0.002 |
| | (0.011) | (0.051) | (0.113) | (0.855) | (0.213) | (0.990) | (0.002) | (0.001) | (0.408) | (0.504) |
| box#av_PT | 0.002** | 0.000 | 0.000 | 0.001 | -0.001 | -0.000 | 0.002*** | -0.001 | -0.000 | 0.002 |
| | (0.048) | (0.976) | (0.931) | (0.618) | (0.609) | (0.861) | (0.005) | (0.472) | (0.899) | (0.555) |
| box#av_TM | 0.009** | 0.014** | 0.010*** | 0.016** | -0.006 | -0.009 | -0.006* | -0.010** | 0.002 | 0.005 |
| | (0.017) | (0.026) | (0.009) | (0.010) | (0.159) | (0.147) | (0.093) | (0.046) | (0.824) | (0.722) |
| box#av_RD#av_PT | | 0.000* | | -0.000 | | -0.000 | | 0.000*** | | -0.000 |
| | | (0.090) | | (0.742) | | (0.743) | | (0.005) | | (0.419) |
| box#av_RD#av_TM | | -0.000 | | -0.000 | | 0.000 | | 0.000 | | -0.000 |
| | | (0.385) | | (0.253) | | (0.482) | | (0.213) | | (0.770) |
| Constant | 28.043* | 27.364* | 16.786 | 16.974 | 18.925 | 19.038 | 11.871 | 10.827 | 21.782 | 22.669 |
| | (0.066) | (0.072) | (0.271) | (0.266) | (0.233) | (0.231) | (0.351) | (0.394) | (0.568) | (0.552) |
| | | | | | | | | | | |
| Year dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Regional trends | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| R-squared | 0.095 | 0.097 | 0.030 | 0.031 | 0.023 | 0.023 | 0.037 | 0.041 | 0.052 | 0.052 |
| Observations | 2,436 | 2,436 | 2,436 | 2,436 | 2,436 | 2,436 | 2,436 | 2,436 | 2,436 | 2,436 |
| Number of companies | 406 | 406 | 406 | 406 | 406 | 406 | 406 | 406 | 406 | 406 |

| Independent variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| lnRD | 0.060*** | 0.060*** | 0.056*** | 0.017 | 0.016 | 0.014 |
| | (0.005) | (0.006) | (0.009) | (0.353) | (0.369) | (0.437) |
| Top500 | | 0.026 | -0.269* | | | |
| | | (0.234) | (0.073) | | | |
| Prod_count | 0.007** | | | | | |
| | (0.014) | | | | | |
| PT_High#lnRD | | | | 0.091* | 0.097* | 0.108* |
| | | | | (0.090) | (0.078) | (0.062) |
| TM_High#lnRD | | | | 0.097** | 0.101** | 0.090* |
| | | | | (0.034) | (0.034) | (0.069) |
| Top500#lnRD | | | 0.046** | 0.009 | | 0.196** |
| | | | (0.050) | (0.871) | | (0.015) |
| Prod_count#lnRD | | | 0.001** | 0.002*** | | |
| | | | (0.013) | (0.003) | | |
| Producer#lnRD | | | | | 0.194 | |
| | | | | | (0.127) | |
| PT_High#Top500#lnRD | | | | | | -0.227** |
| | | | | | | (0.017) |
| TM_High#Top500#lnRD | | | | | | -0.026 |
| | | | | | | (0.778) |
| PT_High#Producer#lnRD | | | | | -0.157 | |
| | | | | | (0.244) | |
| TM_High#Producer#lnRD | | | | | -0.189** | |
| | | | | | (0.036) | |

➢ In contrast to earlier studies (e.g., Blind and Thumm, 2004; Rauber, 2014), we found robust positive effect of R&D on standards development

➢ R&D effect contingent upon appropriation mechanisms: patent-centric and product-centric appropriation strategies

➢ R&D and patents as strategic complements in standards development: more support for 'value appropriation' mechanism v.s. legal protection against misappropriation

➢ Complementary downstream capabilities important: trademarks, brand value and product counts have independent positive effects on SO participation of R&D-intensive firms

➢ Implications for standards and IPR policy