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Firms' participation in the standard setting process

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Abstract

In this paper, I develop a structural model describing the firms’ decision whether or not to become a SSO member. I assume rational, profit maximizing firms that take this decision based on ex ante expectations about benefits from SSO membership. These depend, on the one hand, on the importance of a SSO’s standards and, on the other hand, on the firm’s influence on the standard setting process. The maximization of expected profits leads to the simple decision rule that firms participate in the standard setting process if their expected additional profit is positive. The expected profit contains two elements: the expected profits from standards built on the firm’s technology and the firm’s expected influence on the standard setting process. I extend the maximization problem of SSOs in Lerner and Tirole (2006) by introducing an influence parameter for firms that varies with respect to their R&D efforts and patent portfolios. Thereby, firms enter the SSO’s utility function with different weights. Firms can behave strategically by making upfront investments in R&D and by extending their patent portfolio in order to strengthen their influence and manipulate the standard setting process in their own favor.

I derive reduced form equations from the theoretical model for three decision variables: SSO membership, R&D investment and patent acquisitions. In order to calibrate my empirical model, I have to make assumptions about how firms form expectations. I premise that firms conduct market and competitor analyses in order to estimate their potential benefits from SSO membership. I use matching methods to create two reference groups for each firm: insiders and outsiders of the standard setting process. Expected benefits are then proxied by the difference in profits between the two groups.
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Maddalena Agnoli *

1 Introduction

The development of technology standards represents an interesting interplay between different actors of society. The objective of the benevolent social planner to find an equilibrium between interoperability and market competition meets the strategic, benefit maximizing behavior of participants in the standard setting process. Formalized technology standards are developed by standard setting organizations (SSOs) through collaboration of their members which might include private firms, government agents, as well as consumer associations. There is competition between SSO members who pursue their private objectives. For firms, the participation in the standard setting process goes along with certain costs which have to be weighted against the expected benefits. Since costs often have to be born ex ante, benefits are uncertain and can arise with a time delay. Yet, benefits can be considerable and persist over time for certain technology standards.

A rational firm maximizes its expected revenues which can be affected by SSO participation in several ways. Lerner and Tirole [2006] modeled this decision assuming that technology owners use the signal of SSO ”certification” of their technology in order to attract potential buyers. They choose their SSO strategically in order to maximize the positive signal from SSO certification, given the ex ante likelihood of certification. Firms can also extract revenues from technology ownership. The inclusion of a firm’s IPR in a technology standard can guarantee a steady future flow of royalties to the firm. Firms compete for having their IPR included in the standards in order to ensure future licensing revenues. Therefore, many firms devote a lot of effort to the standardization process (Chiao et al. [2007]). A part from membership fees, the participation in the standard setting process can demand important investments in R&D during the development stage of a standard. Chiao et al. [2007] describe standard development as a process which often takes place at an early stage of the technology development. IPR accumulation efforts can also occur in the lead time to SSO entry with the objective to gain negotiation power in the standard setting process and to

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include their technologies in the standards. Firms often propose competing solutions to a standardization problem due to their divergent technological core competencies. Therefore, firms which lack the necessary capabilities must make investments in order to develop relevant competencies (Kang and Motohashi [2012]). Bekkers et al. [2011] analyze the firms’ strategic behavior on patent inclusion in the standards, however, they note that their paper does not take into account strategic behavior such as the creation of patent portfolios, cross-licensing, licensing of patent bundles, agreements on future patents, etc. Yet, patent portfolios can serve as a negotiation tool in cross-licensing agreements and presumably as a motivation for the formation of alliances in the standard voting process. In their recent paper on transfers of standard essential patents (SEPs), Baron and Ciaramella [2017] show that prior to the declaration date buyers of SEPs are more likely to be SSO members.

In this paper, I analyze the relation between the firms’ decision to join standard setting organizations and their patent acquisition strategies. I develop a theoretical model that takes into account the simultaneous decisions of firms about SSO membership and patent acquisitions. SSO membership is motivated by potential additional revenues from the inclusion of the firms’ technologies in the SSO’s standards. Yet, these decisions are taken ex-ante and are therefore modeled as a function of expected revenues. They depend on the one hand on the importance of a SSO’s standards and on the other hand on the firm’s influence on the standards. Firms can behave strategically by building patent portfolios with the aim to strengthen their influence and manipulate the standard setting process in their own favor. I then test the implications of the theory empirically using data on SSO membership.

2 Theory

Consider a firm \( i \) that deliberates about whether or not to enter a SSO \( m \). The model describes three stages:

1. The firm decides whether or not to enter SSO \( m \) and chooses its optimal level of patent acquisitions.
2. The SSO decides whether or not to include technologies owned by the firm in its standards.
3. The firm chooses its optimal output and licensing behavior.

The model is solved by backwards induction, starting with stage 3.

\textit{STAGE 3: OPTIMAL PRODUCTION AND LICENSING}
Let $p_{it}$ be a subset of a firm $i$’s patent portfolio $P_{it}$ and $S_{mt}$ the set of existing standards of SSO $m$. Then $1_{p_{it} \in S_{mt}}$ indicates whether or not technology $p_{it}$ enters any standard in $S_{mt}$. The firm maximizes the following profit function:

$$
\Pi_{it} = \pi_{it}(q_{it}(P_{it}, R_{it}), L_{it}(P_{it}), 1_{p_{it} \in S_{mt}})
- C_{it}(q_{it}(P_{it}, R_{it}), L_{it}(P_{it}), R_{it}, dP_{it})
- 1_{imt} F_m ,
$$

(1)

$R_{it}$ represents R&D. $\pi_{it}$ denotes the firm’s revenues and depends on $1_{p_{it} \in S_{mt}}$ and indirectly on $P_{it}$ and $R_{it}$ through the firm’s output $q_{it}$ and issued licenses to its patents $L_{it}$. $C(.)$ is the firm’s cost function, $F_m$ are all additional costs of SSO membership and $1_{imt}$ indicates whether firm $i$ is a member of SSO $m$ at time $t$. The patent production function is the following:

$$
P_{it} = P_{i,t-1} + \gamma_i R_{it} + dP_{it},
$$

(2)

where $\gamma_i \geq 0$ describes the extend to which R&D translates in to patents and $dP_{it}$ denotes patent acquisitions. At the optimum:

$$
\frac{\partial \pi_{it}}{\partial q_{it}} = \frac{\partial C_{it}}{\partial q_{it}}
$$

(3)

$$
\frac{\partial \pi_{it}}{\partial L_{it}} = 0
$$

(4)

**STAGE 2: TECHNOLOGY SELECTION**

The SSO’s maximizes its utility function which is similar to the one in Lerner and Tirole [2006]:

$$
U_{mtp_{it}} = \alpha_{p_{it}} + E[\beta_{p_{it}}] + \mu_{mit} E[\Pi_{it}] ,
$$

(5)

where $\alpha_{p_{it}}$ denotes the publicly known "attractiveness" of technology $p_{it}$ for the standard users, while $\beta_{p_{it}}$ is only known by the firm, therefore $E[.]$ denotes the SSO’s expectations. $\Pi_{it}$ represents the firm’s profit. Unlike Lerner and Tirole [2006], I allow firms to have different weights in the SSO’s utility function by introducing the parameter $\mu_{mit}$. This parameter is a function of the SSOs member orientation $\theta_m$ (see Lerner and Tirole [2006])
as well as the firm’s technological capacity and patent portfolio relative to the other SSO members:

\[
\mu_{mit} = \theta_m \mathbf{1}_{mit} + \sum_{j \neq i} \mathbf{1}_{mjit} R_{jt} + \sum_{j \neq i} \mathbf{1}_{mjt} P_{jt} + \tau_i \mathbf{1}_{mit},
\]

(6)

where \( \mathbf{1}_{mit} \) represents an indicator of whether or not firm \( i \) is a member of SSO \( m \). \( \tau_i \) is a parameter that denotes other influence factors of the firm (e.g. the persuasiveness of the firm’s representatives in the SSO). The SSO accepts \( p_{it} \) if

\[
\alpha_{p_{it}} + E[\beta_{p_{it}}] + \mu_{mit} E[\Pi_{it}] \geq 0.
\]

(7)

Conditional on \( 1_{pit \in S_{mit}} = \{0, 1\} \), the firm obtains the profit \( \Pi_{it}^1 = \Pi_{it} | 1_{pit \in S_{mit}} = 1 \) or \( \Pi_{it}^0 = \Pi_{it} | 1_{pit \in S_{mit}} = 0 \). Denoting \( \pi_d^1 = \pi_d | 1_{pit \in S_{mit}} = 1 \) and \( \pi_d^0 = \pi_d | 1_{pit \in S_{mit}} = 0 \), it is assumed that \( \pi_d^1 | P_{it}, R_{it} \geq \pi_d^0 | P_{it}, R_{it} \).

**STAGE 1A: SSO MEMBERSHIP**

In stage 1, the firm decides whether or not to become a SSO member (1A) and chooses the optimal levels of \( R_{it} \) and \( dP_{it} \) (1B). The membership decision is taken by comparing the profit with SSO entry (E) and without (NE). The firm does not know the SSO’s utility of its technologies ex-ante, it only knows the probability distributions

\[
f(U_{mp_{it}} \geq 1 | \mathbf{1}_{mit} = 1) = f(\alpha_{p_{it}} + E[\beta_{p_{it}}] + \mu_{mit} E[\Pi_{it}] \geq 0)
\]

(8)

and

\[
f(U_{mp_{it}} \geq 1 | \mathbf{1}_{mit} = 0) = f(\alpha_{p_{it}} + E[\beta_{p_{it}}] \geq 0),
\]

(9)

since \( \mu_{mit} = 0 \) if \( \mathbf{1}_{mit} = 0 \). Note that \( \rho_{mit}^E > \rho_{mit}^NE \) and \( \frac{\partial \rho_{mit}^E}{\partial p_{it}} > 0 \). The firm decides to enter the SSO if its expected profit as a SSO member is higher than its expected profit outside the SSO, hence if

\[
\rho_{mit}^E \Pi_{it}^1 | \mathbf{1}_{mit} = 1 + (1 - \rho_{mit}^E) \Pi_{it}^0 | \mathbf{1}_{mit} = 1 \geq \rho_{mit}^NE \Pi_{it}^1 | \mathbf{1}_{mit} = 1 + (1 - \rho_{mit}^NE) \Pi_{it}^0 | \mathbf{1}_{mit} = 0
\]

(10)
or

\[
(p_{mit}^E - p_{mit}^{NE})[\pi_{it}^1 - \pi_{it}^0] \geq F_m.
\]  

(11)

**STAGE 1B: PATENT ACQUISITIONS**

The firm chooses its level patent acquisitions in stage 1. For theoretical purposes, I assume that the firm maximizes its expected profits with and without entry with respect to patent acquisitions up front.

\[
\begin{align*}
\max_{dP_{it}^E} & \pi_{it}^1(q_{it}(P_{it}^E, R_{it}^E), L_{it}(P_{it}^E)) + (1 - \rho_{mit})\pi_{it}^0 \\
- & C_{it}(q_{it}(P_{it}^E, R_{it}^E), R_{it}^E, dP_{it}^E) - F_m \quad \text{(12)}
\end{align*}
\]

\[
\begin{align*}
\max_{dP_{it}^{NE}} & \pi_{it}^1(q_{it}(P_{it}^{NE}, R_{it}^{NE}), L_{it}(P_{it}^{NE})) + (1 - \rho_{mit})\pi_{it}^0 \\
- & C_{it}(q_{it}(P_{it}^E, R_{it}^E), R_{it}^{NE}, dP_{it}^{NE}) \quad \text{(13)}
\end{align*}
\]

This leads to the first order conditions

\[
\begin{align*}
\pi_{it}^1 \frac{\partial p_{mit}^E}{\partial dP_{it}^E} + \rho_{mit} \frac{\partial q_{it}^*}{\partial dP_{it}^E} + \rho_{mit} \frac{\partial L_{it}^*}{\partial dP_{it}^E} & + \frac{\partial \pi_{it}^0}{\partial q_{it}^*} \frac{\partial q_{it}^*}{\partial dP_{it}^E} + \frac{\partial \pi_{it}^0}{\partial L_{it}^*} \frac{\partial L_{it}^*}{\partial dP_{it}^E} = 0 \\
- \pi_{it}^0 \frac{\partial q_{it}^*}{\partial dP_{it}^E} - \rho_{mit} \frac{\partial q_{it}^*}{\partial dP_{it}^E} & - \rho_{mit} \frac{\partial L_{it}^*}{\partial dP_{it}^E} - \frac{\partial \pi_{it}^0}{\partial q_{it}^*} \frac{\partial q_{it}^*}{\partial dP_{it}^E} - \frac{\partial \pi_{it}^0}{\partial L_{it}^*} \frac{\partial L_{it}^*}{\partial dP_{it}^E} = 0
\end{align*}
\]  

(14)

\[
\begin{align*}
\pi_{it}^1 \frac{\partial p_{mit}^{NE}}{\partial dP_{it}^{NE}} + \rho_{mit} \frac{\partial q_{it}^*}{\partial dP_{it}^{NE}} + \rho_{mit} \frac{\partial L_{it}^*}{\partial dP_{it}^{NE}} & + \frac{\partial \pi_{it}^0}{\partial q_{it}^*} \frac{\partial q_{it}^*}{\partial dP_{it}^{NE}} + \frac{\partial \pi_{it}^0}{\partial L_{it}^*} \frac{\partial L_{it}^*}{\partial dP_{it}^{NE}} = 0 \\
- \pi_{it}^0 \frac{\partial q_{it}^*}{\partial dP_{it}^{NE}} - \rho_{mit} \frac{\partial q_{it}^*}{\partial dP_{it}^{NE}} & - \rho_{mit} \frac{\partial L_{it}^*}{\partial dP_{it}^{NE}} - \frac{\partial \pi_{it}^0}{\partial q_{it}^*} \frac{\partial q_{it}^*}{\partial dP_{it}^{NE}} - \frac{\partial \pi_{it}^0}{\partial L_{it}^*} \frac{\partial L_{it}^*}{\partial dP_{it}^{NE}} = 0
\end{align*}
\]  

(15)

We know from the maximization in stage 3 that \( \frac{\partial \pi_{it}}{\partial L_{it}^*} = 0 \) and \( \frac{\partial \pi_{it}}{\partial q_{it}^*} = \frac{\partial C_{it}}{\partial q_{it}^*} \). Note further that:
\[
\frac{\partial \pi^1_{it}}{\partial q^*_{it}} = \frac{\partial \pi^0_{it}}{\partial q^*_{it}} 
\]  
(16)

\[
\frac{\partial \pi^1_{it}}{\partial L^*_{it}} = \frac{\partial \pi^0_{it}}{\partial L^*_{it}} 
\]  
(17)

\[
\frac{\partial C_{it}}{\partial P^E_{it}} = \frac{\partial C_{it}}{\partial P^{NE}_{it}} 
\]  
(18)

\[
\frac{\partial q^*_{it}}{\partial P^E_{it}} = \frac{\partial q^*_{it}}{\partial P^{NE}_{it}} 
\]  
(19)

Remember that due to the functional form (6), \(\frac{\partial \rho^{NE}_{mit}}{dP^{NE}_{it}}\) must be zero if \(1_{mit} = 0\). Simplification leads to

\[
(\pi^1_{it} - \pi^0_{it}) \frac{\partial \rho^{E}_{mit}}{dP^E_{it}} = \frac{\partial C_{it}}{dP^E_{it}} , 
\]  
(20)

if \(1_{mit} = 1\) and

\[
\frac{\partial C_{it}}{dP^{NE}_{it}} = 0 , 
\]  
(21)

if \(1_{mit} = 0\). Keep in mind that \(\pi^1_{it} - \pi^0_{it} > 0\) and that the influence of patent acquisitions on the probability of acceptance in a standard is positive if the firm is a member of the SSO, i.e. \(\frac{\partial \rho^{E}_{mit}}{dP^E_{it}} > 0\). Therefore, I conclude that

\[
dP^E_{it} > dP^{NE}_{it} . 
\]  
(22)

3 Data

Data on SSO membership have been taken from the Searle Center Database on Technology Standards and Standard Setting Organizations. During the last decade several efforts have been undertaken to collect data on SSOs (e.g. Bekkers et al. [2012]). The Searle Center Database is the first comprehensive database on several aspects of SSOs. Baron and Spulber [2015] describe the database which contains information on 598 SSOs, thereof 195
with information on institutional membership and 36 with information on SSO rules including rules on standard essential patents (SEPs), openness, participation and standard adoption procedures. The membership data of the Searle Center is based on the data provided on www.consortiuminfo.org and on membership information made available on the SSO websites. In order to create a panel structure of SSO membership, the Searle Center queried Internet Archives. Yet, not all SSOs make this information available and only institutional members (firms, universities, etc.) are recorded. I retrieved patent applications and transfers from the EPO database PATSTAT. Patent transfers are documented in the Legal Status Database. Since application data in PATSTAT contain only the applicant name of the last publication of an application, I use information on the publication sequence of patent applications in order to track earlier changes in ownership. For more information on tracking patent transfers see Ciaramella et al. [2017]. Finally, I use the Bureau van Dijk database Orbis for information on firm revenues, costs, number of employees and R&D expenditures. I group firms with the same global ultimate owner in order to identify intra- and inter-group patent transfers. Since firm names are not harmonized within and between the different databases, I use string matching methods to relate firms from the Searle Center Database and PATSTAT to the firms in Orbis. Therefore, I use SearchEngine, a string matching tool developed by Thorsten Doherr (Doherr [2017]). I first undertook some basic string cleaning and eliminated legal control names (e.g. "Corp."). Then I used the SearchEngine to match firm names based on the n-gram method. Matches are ranked by n-gram overlap and word frequency, where more frequent words receive a lower weight. Based on these results, I apply a fairly strict selection rule in order to avoid false positives. Finally, I use the global ultimate owner of firms from Orbis instead of the single firm matches, since the matching method often generates matched with several subsidiaries of one global firm. The resulting dataset is a panel of SSO-firm pairs from 1995 to 2017. During this period, 16,262 firms have entered a SSO.
Figure 1: Average number of inter-firm patent acquisitions before SSO entry

Figure 1 shows the average number of inter-firm patent transfers before the SSO entry year (period=0). Inter-firm patent trade is defined by patent transfers between firms that do not belong to the same global ultimate owner. Net transfers subtract sales from acquisitions. Both, patent acquisitions and sales increase towards the SSO entry year. However, in the four years before SSO entry, acquisitions outweigh sales. The simple regression of up-front net patent transfers on the period reveals as positive and significant correlation between the two variables, even after controlling for the year of SSO entry. Conditional on the SSO entry year, approaching the SSO entry by one year comes with a 5% increase of net patent transfers on average.

4 Empirical model

As a next step, I will test the implications of the theoretical model empirically. The theoretical model identifies several variables that might influence the firms’ decisions to acquire patents. The empirical model relates patent acquisitions on the firm level to the explanatory variables derived from the theory. The interest lies in the ex-ante investments of firms, i.e. before they enter a SSO.

\[
dP_{it} = f \left( \Delta \Pi_{it}, c_{it}^P, \frac{P_{it}}{\sum_{j \neq i} 1_{mjt} P_{jt}}, \frac{R_{it}}{\sum_{j \neq i} 1_{mjt} R_{jt}}, \alpha_{it}, \theta_{m}, 1_{mi,t+e}, 1_{mi,t+e} \Delta \Pi_{it}, 1_{mi,t+e} c_{it}^P, 1_{mi,t+e} \frac{P_{it}}{\sum_{j \neq i} 1_{mjt} P_{jt}}, 1_{mi,t+e} \frac{R_{it}}{\sum_{j \neq i} 1_{mjt} R_{jt}}, \alpha_{it}, 1_{mi,t+e} \theta_{m}, \varepsilon_{it} \right),
\]

(23)
where \( e > 0 \) and the expected value of \( \beta_{p_{it}} \) is assumed to be zero. \( \Delta \Pi_{it} \) is unknown ex ante. Therefore, I have to make some assumptions about how firms form their expectations. Supposing that firms conduct market and competitor analyses, I assume that firms compare the revenues of their competitors that own SEPs with those of firms that do not. Let \( T \) be the group of firms that have successfully implemented their IPR in a standard in the past and \( C \) a group of firms that have not. I denote the firms which are comparable to firm \( i \) within the respective groups \( x_i \in T \) and \( y_i \in C \), their technologies \( v_{x_i} \in V_{x_i} \), \( w_{y_i} \in W_{y_i} \) and the SSO’s existing standards \( Z_m \). Let \( X \) be a set of control variables, \( N \) the number of firm pairs and \( t_s \) the issuance date of the standard for which firm \( x_i \) holds a SEP.

\[
\Pi_{x_i,t_s+\epsilon} \mid 1_{v_{x_i} \in Z_m} = 0, X = \Pi_{y_i,t_s+\epsilon} \mid 1_{w_{y_i} \in Z_m} = 0, X
\]  

(24)

\[
\Pi_{y_i,t_s+\epsilon} \mid 1_{w_{y_i} \in Z_{sso}} = 1, X = \Pi_{x_i,t_s+\epsilon} \mid 1_{v_{x_i} \in Z_{sso}} = 1, X
\]  

(25)

Note that the left hand-sides of equations (24) and (25) are unknown. Under these assumptions, I proxy \( \Delta \Pi_{it} \) using difference-in-differences:

\[
\Delta \tilde{\Pi}_i = N^{-1}(\Pi_{x_i,t_s+\epsilon} - \Pi_{y_i,t_s+\epsilon}) - N^{-1}(\Pi_{x_i,t_s-\epsilon} - \Pi_{y_i,t_s-\epsilon}) ,
\]  

(26)

with \( \epsilon > 0 \).

\( \theta_m \) is measured using variables on SSO rules available in the Searle Center Database. Like Chiao et al. [2007], I consider the nature of membership, the nature of voting rules and the age of the organization. Additionally, information the openness of meetings as well as pricing and licensing rules of SEPs owned by SSO members and their bindingness are included.

Based on the theoretical model and descriptive statistics I expect the expected additional profit from SEP ownership to have a positive and significant effect on up-front patent acquisitions. The relative importance of a firm’s patent portfolio and R&D investments compared to other SSO members as well as the SSO’s member orientation should only have a positive effect if the firm enters the SSO in the future \( (1_{mi,t+\epsilon} = 1) \), since they should not influence the probability of SEP membership for SSO external firms.
References


