Technology Adoption in Standard Setting Organizations: A Model of Exclusion with Complementary Inputs and Hold-up

Emanuele Tarantino

University of Bologna and TILEC

The Economics of IP, Software and the Internet
Toulouse, 14th January 2011

Standard Setting Organizations (SSOs)

SSOs are organizations devoted to the definition of technological standards.

Examples of standards certified by SSOs are:

- ADSL (standard for data communications technology over copper lines);
- 802.11 or “Wi-Fi” protocol (standard for wireless communications among electronic devices);
- DDR SDRAM (standard for RAM technology).

Rysman and Simcoe (2007) provides evidence on the focal role played by SSOs in coordinating the path of technological adoption in the information and communication technology sector.

Integrated firms and stand alone developers: competing interests

Integrated firms participate to SSOs because of the benefits that derive from coordination among industry participants. They have clear interest in paying low rates for standard's technologies, while competing on the product market.

IPR developers join an SSO primarily because having a patented technology deemed essential to a new standard can help insure a long stream of licensing revenue.

In the SSOs of two *antitrust cases* (FTC v. Rambus and EC v. Qualcomm) conflicts between vertically integrated firms and pure upstream IPR developers.

Objective of this work

- The project studies integrated operators' incentives to adopt patented technologies for the production of a final good.
- It is analyzed how market competition and licensing decisions interact with the process of technology adoption.

Main results

- *Vertically integrated firms may* ***inefficiently*** *exclude a superior technology provided by an upstream stand-alone firm.*
- *A policy of early licensing commitments makes the standardization process more efficient.*

Hold-up and cross-licensing

Licensing negotiations take place after the adoption of a certain technology by industrys operators; thus a standard hold-up problem arises that affects the results of the adoption choice.

To fix the contractual inefficiency caused by the hold-up problem, vertically integrated firms can exchange respective technologies by signing cross-licensing agreements.

Cross-licensing not possible with the pure upstream firm because it is not active on the product market.

Trade-off

The trade-off of keeping out efficient technology for producers:

+ It allows vertically integrated firms to reduce marginal cost of production.

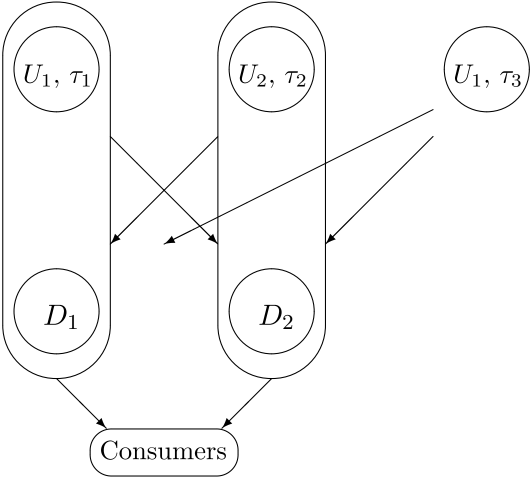
– It allows the upstream firm to hold integrated companies up and squeeze part of their profits.

The model

Return

Competing Platforms:

$\mathcal{P}(\tau_1, \tau_2)$, $\mathcal{P}(\tau_1, \tau_3)$.



The model - Upstream market

Upstream market:

- Three firms: U_1 and U_2 are vertically integrated, U_3 operates upstream only.
- Each upstream firm owns one patented technology, τ: τ_2 and τ_3 are substitute, but τ_3 is superior to τ_2. τ_1 is complement to the other two.
- There are two competing platforms, $\mathcal{P}$: $\mathcal{P}(\tau_1, \tau_2)$ and $\mathcal{P}(\tau_1, \tau_3)$.
- R&D process investments are sunk.

The model - Downstream

Downstream market:

- Two firms, D_1 and firm D_2, both vertically integrated.
- Firms produce an homogenous good and compete in quantities facing linear demand ($P = 1 - q_1 - q_2$).
- Downstream marginal cost is determined by two components:
  1. The royalties paid by manufacturers to acquire upstream technology;
  2. Marginal cost $c \in (0, 1)$. Standardization implies that firms pay a marginal cost equal to $\sigma c < c$. Also, if a firm employs the technology of 3 then its marginal cost is discounted by $\epsilon \in (0, 1)$.

		Firm 2	
		$\mathcal{P}(\tau_1, \tau_2)$	$\mathcal{P}(\tau_1, \tau_3)$
Firm 1	$\mathcal{P}(\tau_1, \tau_2)$	$\sigma c, \sigma c$	$c, \epsilon c$
	$\mathcal{P}(\tau_1, \tau_3)$	$\epsilon c, c$	$\epsilon \sigma c, \epsilon \sigma c$

Licensing contracts

Upstream firms license their patents by means of public and non-discriminatory contracts, and by using royalty rates (linear pricing case) or two-part tariffs. Side payments not allowed.

Two licensing regimes:

1. Independent licensing: licensors set royalty rates independently.

2. Cross-licensing: licensors set royalty rates cooperatively (specialized firm cannot cross-license).

Technology choice

Technology choice taken *non-cooperatively* by firm 1 and firm 2, by comparing the profits raised under $\mathcal{P}(\tau_1, \tau_2)$ and $\mathcal{P}(\tau_1, \tau_3)$.

		Firm 2	
		$\mathcal{P}(\tau_1, \tau_2)$	$\mathcal{P}(\tau_1, \tau_3)$
Firm 1	$\mathcal{P}(\tau_1, \tau_2)$	$\Pi_1(\sigma), \Pi_2(\sigma)$	$\Pi_1(\epsilon), \Pi_2(\epsilon)$
	$\mathcal{P}(\tau_1, \tau_3)$	$\Pi_1(\epsilon), \Pi_2(\epsilon)$	$\Pi_1(\epsilon, \sigma), \Pi_2(\epsilon, \sigma)$

I do not impose that the use of the same bundle of inputs, or technology platform, is mandatory to industry's participants. Thus, two types of scenario can arise: "technology standard" or "competing platforms".

Welfare analysis

The welfare analysis is conducted by assuming that a benevolent planner decides the technology to be employed by comparing the value of total welfare associated with the four possible cases of technology adoption.

Timing

▸ Return

1. *Technology choice stage*: downstream firms choose a production technology and sink a fixed investment cost equal to I.
2. *Pricing scheme and royalty setting stage*: upstream firms whose technology is adopted downstream choose the pricing scheme (independent licensing/cross-licensing) and the royalty rate. Consequently, each downstream firm decides whether to pay the royalty rate (and produce) or give up production.
3. *Product market competition stage*: active firms set quantities.

Assume that the fixed cost I is big enough to make the technology choice irreversible once the licensing stage is reached and let the hold-up problem arise.

Game with linear pricing

Layne-Farrar and Lerner (2008) shows that linear royalties are used by a vast majority of patent pools' members to license-out their technology. Two strategic effects determine licensing rates under linear pricing:

- *The horizontal double marginalization or Cournot effect*, which is caused by the complementarity between the technologies required to produce the final good. Indeed, when pricing their technology independently licensors do not take into account the negative externality they exert on downstream firms (Cournot (1838)).
- *The raising rival's costs effect*, which is related with the incentive that the downstream competing vertically integrated firms have to increase their rivals' costs as to push them out of the market (see Salop and Scheffman (1983, 1987)).

Technology choice

Proposition 1

Assume that side payments are not allowed and that the choice of the technology is taken by vertically integrated firms, then the unique Nash Equilibirum of the adoption game features:

i. The employment of $\mathcal{P}(\tau_1, \tau_2)$ as technology standard $(S2)$ if $\sigma \leq \tilde{\sigma}(c, \epsilon)$;

ii. The employment of competing platforms $(CP32)$ if $\sigma > \tilde{\sigma}(c, \epsilon)$.

Remark: the adoption of standard $\mathcal{P}(\tau_1, \tau_3)$ is not an equilibrium.

▸ Figure 2, panel (a)

Technology choice: comments

		Firm 2	
		$\mathcal{P}(\tau_1, \tau_2)$	$\mathcal{P}(\tau_1, \tau_3)$
Firm 1	$\mathcal{P}(\tau_1, \tau_2)$	$\Pi_1^{S2} > 0, \Pi_2^{S2} > 0$	$\Pi_1^{CP23} > 0, \Pi_2^{CP23} > 0$
	$\mathcal{P}(\tau_1, \tau_3)$	$\Pi_1^{CP32} > 0, \Pi_2^{CP32} > 0$	$\Pi_1^{S3} > 0, \Pi_2^{S3} = 0$

- On the one hand, if the cost-savings generated by having a technology standard are sufficiently important, then the employment of τ_2 is a dominant strategy to firm 2.
- On the other hand, if the cost-savings generated by having a technology standard become less important then the use of τ_2 not dominant to firm 2. However, firm 2 still anticipates that in the case of a joint adoption of $\mathcal{P}(\tau_1, \tau_3)$ it gains a nil payoff.

Welfare analysis

The following game is solved by the planner:

1. *Technology choice stage*: the benevolent planner chooses production technologies.

2. *Pricing scheme and royalty setting stage*: upstream firms whose technology is adopted downstream choose the pricing scheme (independent licensing/cross-licensing) and the royalty rate. Consequently, each downstream firm decides whether to pay the royalty rate (and produce) or give up production.

3. *Product market competition stage*: active firms set quantities.

Welfare analysis

Lemma 1

Assume that the choice of the technology is taken by a benevolent planner, then at the equilibrium she would employ:

i. $\mathcal{P}(\tau_1, \tau_2)$ as technology standard $(S2)$ in:
$\{(\epsilon,\sigma)| \quad \sigma \in (0, \bar{\sigma}(c,\epsilon))\} \setminus \{(\epsilon,\sigma)| \quad \sigma \in (\bar{\bar{\sigma}}(c,\epsilon), \min\{\bar{\sigma}(c,\epsilon), 1\})\}$;

ii. $\mathcal{P}(\tau_1, \tau_3)$ as technology standard $(S3)$ in:
$\{(\epsilon,\sigma)| \quad \sigma \in (\bar{\sigma}(c,\epsilon), 1)\} \setminus \{(\epsilon,\sigma)| \quad \sigma \in (\max\{\bar{\sigma}(c,\epsilon), \bar{\bar{\bar{\sigma}}}(c,\epsilon)\}, 1)\}$;

iii. Competing platforms $(CP32)$ in:
$\{(\epsilon,\sigma)| \quad \sigma \in (\bar{\bar{\sigma}}(c,\epsilon), \min\{\bar{\sigma}(c,\epsilon), 1\})\} \quad \cup \quad \{(\epsilon,\sigma)| \quad \sigma \in (\max\{\bar{\sigma}(c,\epsilon), \bar{\bar{\bar{\sigma}}}(c,\epsilon)\}, 1)\}$.

▸ Figure 2, panel (b)

Technology choice and efficiency

Proposition 2

The decision of the vertically integrated organizations to exclude firm 3 from the technology standard may give rise to inefficient market outcomes.

▸ Figure 2, panel (c)

Remark. The proposition shows that the balance between the productive efficiency of the upstream firm technology and the contractual efficiency of cross-licensing can generate inefficient outcomes.

Policy of ex-ante licensing commitments

Framework where the royalty rate stage precedes technology choice (firm 2 and firm 3 compete for the employment of their technologies). ▸ Timing

Proposition 3

Assume that active licensors set royalty rates before their technologies have been employed by a manufacturer, then the Nash equilibrium of the adoption game features the employment of $\mathcal{P}(\tau_1, \tau_3)$ as technology standard and is efficient.

Exclusion in alternative frameworks

The adoption of $\mathcal{P}(\tau_1, \tau_2)$ as technology standard depends on the profitability of cross-licensing to integrated firms and the severity of the hold-up problem.

- *If licensing firms would adopt two-part tariffs*, the results of the model would carry over.
- *If the number of vertically integrated firms would increase*, then the per-firm profits generated by cross-licensing would decrease and make it more difficult to sustain an equilibrium with cross-licensing.
- *Were the number of upstream firms endowed with the efficient technology to increase*, then the exclusionary result would remain.
- *If the framework would embed integrated firm 2 facing the competition of a stand-alone downstream firm, D_1, and that τ_1 and τ_3 would be provided by two upstream stand-alone firms, (U_1 and U_3)*, the profitability for D_1 of using the technologies of firm 2 and firm U_1 would greatly reduce.

Policy Conclusions

Standard setting consortia should adopt a policy of early-licensing commitments, because it would kill the hold-up problem and allow integrated companies to design the standard efficiently. This result provides an argument in support of the idea that SSOs' participants should be left free to discuss the royalties on patented technologies before a specific standard configuration has been decided.

SSOs dominated by integrated firms are expected to sponsor a technology standard if standardization's benefits are strong (e.g., adoption of IEEE 802.11n Wi-Fi protocol by IEEE). If standardization is less effective, then manufacturers' coordination effort more likely to fail (e.g., in the telecommunications industry the CDMA2000 and the WCDMA technologies coexist on the market).

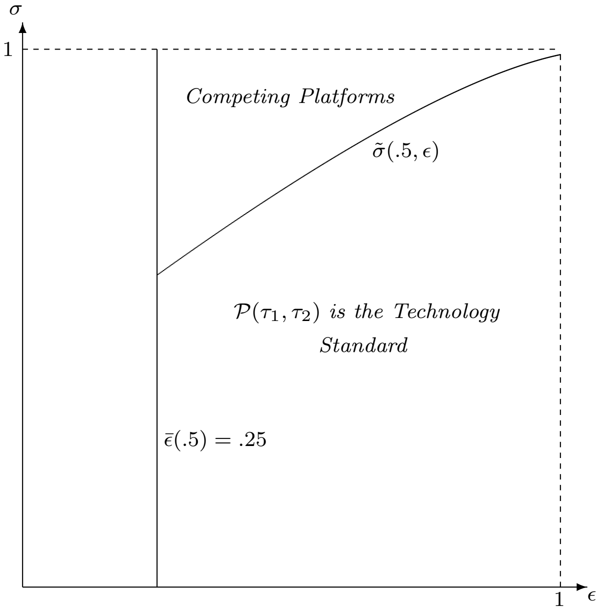
Main contribution and related papers

- Study of "exclusionary effects" in the choice of a technology platform. Previous literature focused on the analysis of licensing decisions and market structure in setting with complementary inputs without modeling a technology choice stage (Schmidt (2008) and Schmalensee (2008)).

- As part of a wider research agenda, this is an application of a more general problem, that is the analysis of vertical foreclosure in settings with complementary inputs (Tarantino and Reisinger (2010)). Instead, the literature on foreclosure has typically focused on settings with substitute inputs (Rey and Tirole (2007)).

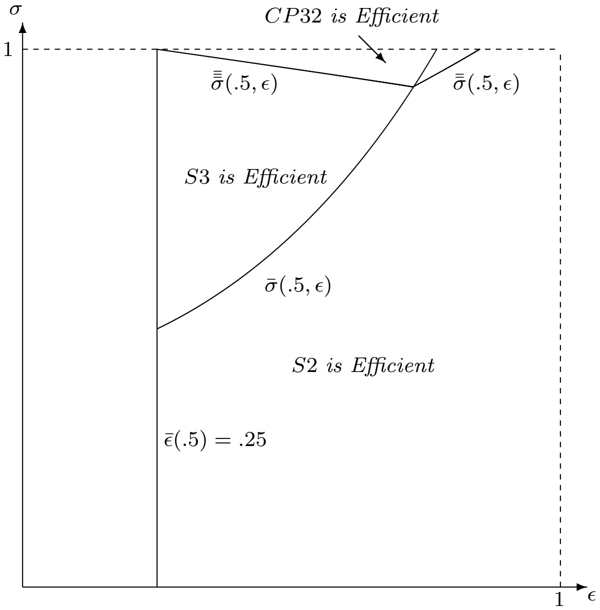
Technology choice - c=1/2

Return



Welfare analysis - c=1/2

Return



Inefficient exclusion - c=1/2

Return