Paper to be presented at
the DRUID16 20th Anniversary Conference
Copenhagen, June 13-15, 2016

Inefficiencies in Essential Patent Pool Formation; Are Pool Administrators also involved?

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Jelcodes:L15,K0

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Introduction

In the last decade, technology standards have grown rapidly in policy importance and economics impact. The growth is aggressive in industries where the pace of technology is fast and there is higher demand for building a common platform and guarantee interoperability among the new products.[1] In industries such as telecommunication, IT, computing and etc., technology standards have played a crucial role in successfully presenting new products to the market (Shapiro, 2001). The market size associated with technology standards is huge and vastly growing. Estimates in 2004 report the US sales of devices based on technology standards to be at least $100 billion annually (Clarkson, 2004). These altogether illustrate technology standards an important and attractive topic to study.

Since nearly all the advanced technologies are patented, building standards involves complex interactions with IP holders. Therefore, parties seeking to commercialize products based on the standard would need to acquire license from relevant patentees. Considering the huge- and growing- number of *essential patents*[2] in hi-tech industries, obtaining licenses independently can act as a big obstacle in commercializing new products.

Patent pools have emerged as a solution to reduce the costs of navigating through the *patent thicket*. Pooling patents refers to a joint licensing program in which patent holders decide to transfer their IP rights to a third party in order to bundle the rights and license them as a package. By bundling the IP rights and creating the opportunity of one-stop shopping, patent pools have alleviated the problem of multiple marginalization and reduced the royalty rates (Gallini, 2010). These organizational forms are considered among successful solutions for the inefficiencies involved with markets for technologies.

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[1] As most famous examples of technology standards, one can think of *DVD, USB, MPEG, 4G* and etc.

[2] From the legal perspective, an essential patent for a particular standard is a patent which the standard adopters should either "*license or infringe it*". Therefore, acquiring the license is "essential' to use the standard.

Almost all modern pools have been built around the standardization purposes (Layne-Farrar & Lerner, 2011). However, these pools have not been formed by the IP holders themselves. Due to the complexities involved with identifying the essential patents, gathering the IP holders, marketing the standard and licensing procedures, all the recent standards have been formed by professional patent *pool administrators*. Patent pool administrators are third-party agents that facilitate pool formation and oversee its operations. They are expected to smooth the pool formation procedure and the standard adoption, by reducing the negotiation and waiting cost for the IP holders and the search and licensing cost for the licensees.

Nevertheless, some stakeholders believe the pool formation process is "becoming increasingly politicized" and "less capable of producing timely standards" (Simcoe, 2012; see also Lamely, 2007). Discussions on some recent failed pool formation attempts have made this standpoint a hot topic among practitioners. Besides pool formation failures, some licensees have also accused the patent pools to include patents which are not essential in reality (Baron & Delcamp, 2011).[3] This is in line with the recent observed trend in dramatic increase of the pool sizes, a phenomenon which is known as *pool inflation.* As an example, "*MPEG-4 Visual part 2"* patent pool started in 2004 with 77 patents but it currently includes 1225 patents claimed to be essential.

A common premise links all these inefficiencies to the patent holder sides, which try to lobby and increase their patents' share inside the pool to increase their royalty rate. This causes pool inflations when the pool formation is successful and pool failures when the conflicts cannot be resolved. In this article, I try to study the potential role of pool administrators in the

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[3] Baron & Delcamp (2011) report this as a patent misuse defense in many patent infringement cases, e.g. the defense by disc replicator ODS in its litigation MPEGLA over the MPEG2 patent pool.

inefficiencies involved with pool formation process, which is -to the best of my knowledge- absent in the related literature. I believe that this is an important issue given the market power which pool administrators have gained. Although there are more number of pool facilitating and administering companies emerging, however most renowned pool standards are formed by few prominent companies.[4] Therefore, it reasonable to assume that given their central role, their strategies may contribute to these inefficiencies.

To study the potential role of pool administrators, I develop a simple model of pool formation where there is information asymmetry between the pool administrator and patent holders on the essentiality of the patents for the standard. By determining the optimal strategies of the pool administrator, I try to show how the environmental conditions, may affect the pool formation strategies of the pool administrator. In particular, I focus on the conditions where the pool forming strategies may cause inefficiencies in the standardization process. The results show that pool forming strategies by the pool administrator may contribute to failures in standard setting process. Also, the pool administrator may find it optimal to announce more patents as essential and act lax in evaluating the patents in the industries where the pace of technology is faster or in the environments where essentiality assessments are less accurate. The results can be interesting from policy point of view; they suggest that the role of pool administration could have been underestimated in the technology adoption process. Thus, employing proper regulations on the administrating party may result in a more efficient technology selection/adoption both for patent holders and licensees.

[4] The major pool administering companies are considered MPEG LA, Via Licensing Corporation, SISVEL, the Open Patent Alliance, 3G Licensing and ULDAGE.

The rest of this paper is organized as follows: in the next section, I briefly discuss the pool forming process for technology standards. Third section describes related literature. The fourth section presents a model of pool formation, where the results of the model are discussed in section five. Section six concludes.

How Essential Patent Pools are Created?

The start of standard setting efforts is initiated in standard developing organizations (SDOs) where the basic dimensions of a technical standard are being discussed, developed and announced to address the needs of potential technology adopters. Generally, SDOs will consider multiple (substitute) technologies that may fulfill the objectives of the standard and settle on a choice. The final decision of the SDO will be announced as the definition of the new technology standard. Afterwards, a professional pool facilitator/ administrator will be in charge of detecting and packaging the essential patents for implementing the standard. Usually the pool administrator announces a call for essential patents and those patent holders claiming to posses essential patents approach the specialized pool administrator. Since having essential patents in the standard's patent pool will generally generate rents for the patent holder, firms -as expected- over-claim their patents' essentiality. The pool admin will be responsible to run the essentiality evaluation procedure and then, facilitate the negotiations among the essential patent holders. Members in the committees will discuss and set other arrangements of the pool including royalty rate, revenue sharing rule, licensing policies and etc. After launching the standard, pool administrator will be in charge to market the packaged patents, detect the potential licensees, collect the licensing fees and distribute it among the members. In reality, however, things may be much more complicated.

Assessing the patent essentiality may be very complicated. With the "legal" definition, an essential patent for a particular standard is a patent that will be necessarily infringed by the implementation of the standard (so the patent is either being licensed or infringed by the users of the standard). However, the concept of essentiality can also be dependent on other factors such as the rules of the institutions developing the standard. For example, some standard pools consider a "commercial essentiality" definition. A commercially essential patent may not be necessarily essential for the standard from legal perspective, but is crucial for successful commercialization of the standard.[5] In most cases the essentiality is assessed by an evaluator appointed by the pool admin. This evaluator -based on the criteria defined by the pool- will announce whether a patent is essential to the standard and may be included to the corresponding pool, or not.

In practice, regardless of which essentiality definition being adopted, evaluating the patent essentiality can be very difficult. First of all, essentiality in reality is not a zero/one concept and may be considered as a range (Carlson, 1999). Also, in practice, when an essentially claimed patentee litigates an infringement case, courts' decisions on the patent essentiality may be dependent on various considerations. Legal environmental factors such as the rules of the standard setting organization and antitrust considerations may affect the courts' decision (Allekotte & Blumenröde, 2010).

In some countries with stricter IP protection, to prove an infringement over an essential patent, the IP holders only need to demonstrate that a certain commercialized device is "in compliance with a given standard" and, further, that their patent covers an essential feature of

[5] Patents related to fast forward function in DVD standard are examples for commercially essential patents. This function was not a part of DVD standard, but no manufacturer could make a DVD player without fast forward function. So, the relevant patents were added as commercially essential.

that standard. The advantage of this approach for the owners of essential patents is that they are not required to show how technically a device is infringing their patent-which can be very difficult for complex hi-tech applications.

The [accused] infringer may raise antitrust defense claiming that patentee is misusing its market-dominant position. If a patentee refuses to grant its patents -to licensees or to a pool- the accused infringer may argue that the patent was needed to enter the market and the patentee has prevented the competition.

The courts' decision on these arguments may very well depend on the antitrust regulations of the environment. Besides these, as any ordinary litigation case, the strength of the IPR regime can also affect the essentiality in practice. So, in the real process, the patent evaluators consider these factors when deciding if a patent should be included in a pool or not.

Another issue adding to the complexity is strategic actions of the players in the pool formation. Some studies have shown that the founding members of a pool manage to include their patents easier than new comers (e.g. Baron & Delcamp, 2011, Layne-Farrar & Lerner, 2011). Also, in some cases, licensees have accused pools to have "overly lax" evaluation procedure and include patents that are not truly essentially (Baron & Delcamp, 2011).

As the final issue, the pool administrators may enjoy a market power. When a pool administrator has managed a first version of the pool for a standard (i.e. has formed he pool and licensing program), it is more likely that the next version of the standard, or other standards in the similar field be also given to the same pool administrator. This may be due to the knowledge and proficiency that these firms gain in dealing with network of patent holders, important licensee's and other industry level factors in that field.

What seems obvious from the above is the complex nature of the essential patent pool formation. However, there has been interesting studies trying to improve our understanding from this complex process which I discuss in the next section.

Literature Review

The literature on patent pools and technology standards had not attracted much attention from economists until recently. However, after the rise of technical standards as a crucial element in high-tech industries, patent pools- as the basis for standard setting process- have emerged as an important topic for economic analysis (Chaio et. al., 2007: Layne-Farrar and Lerner, 2011).

Literature has already discussed the role of patent pools on consumers and licensees, mostly highlighting the effect of pools on reducing the overall royalty rates (Gallini, 2010: Gilbert & Katz, 2006). These studies underline the role of patent pools in reducing the problem of marginalization by bundling the IP rights and creating the opportunity of one-stop shopping for the potential licensees.

On the interaction of the standards and firms, the literature has mostly attacked the subject from the patentee's point of view. There are various patentee-side issues already studied by the scholars, among them are patentees' joining rule (outsider's dilemma), firms' choice of SSO, patenting behavior and disclosure policies.

Aoki and Nagaoka (2004), model pool participation and show that manufacturing firms can be better off by opting to stay out of the pool. Layne-Farrar and Lerner (2011) study the determinants of joining rule for standards' patent pools and empirically confirm the results of Aoki and Nagaoka (2004).

The impact of standards on the patenting behavior of firms is also a well established topic in the literature. Baron and Pohlmann (2010) report that the existence of a patent pool increases the patenting activity even after the pool's formation. Also the characteristics of the declared patents are different for the insider firms comparing the new entrants (Baron and Declamp, 2011). Bekkers et al. (2011) show that firms with higher voting weight and involvement in a SDO, are also more likely to declare essential patents.

Lerner and Tirole (2006) model the choice of patent holders among SSOs which suit them the most. Their work is supported empirically by Chaio et al. (2007) which links SDO's orientation towards technology with their disclosure policies and test it based on a data of SDOs.

Another patentee side issue addressed by the literature is patents' value when they are associated with patent pools and standards (endorsement effect). Studies show that market value of patents which are included in the standard's pool is higher comparing their similar twins outside the pool (Declamp, 2010; Rysman and Simcoe, 2008)

Inefficiencies of standard setting process are also a small part of the patentee side analysis in the literature. However, most relevant studies focus on the role of patentee-side factors as the cause of inefficiency in this procedure. Köhler et al. (2011) find evidence of strategic patent filing delays for essential patents. The study shows that when a standard is in its drafting phase, [potentially] essential patents are pending significantly longer than similar patents in the control group. Authors interpret this as a time buying strategy to achieve maximum conformity with standards' specifications. Baron and Pohlmann (2010) suggest that existence of informal consortia prior to standard formation can reduce inefficient coordination problems. Simcoe (2012) highlights the concern that SDOs are "increasingly politicized" and " incapable of producing timely standards". By building a model of standard setting, Simcoe (2012) tests the predictions of model using a data on an internet standard setting and finds evidence that the conflicts inside the pool caused by the rapid commercialization of internet, has slowed down standardizations process.

Although the literature has shed light on many aspects of paten pools, the role of pool administrating side seems to be still missing in the literature. This paper adds to the literature by including pool administrating party in the picture and studying its implications on the potential inefficiencies associated with pool formation.

Model

I propose a model of pool formation for a specific standard with asymmetry of information among the pool administrator (hereafter the PA) and the patentees. The information asymmetry is on the level of patents' essentiality for the corresponding standard. In the first stage, the PA can form the pool with lower profit or take the game to the second stage where higher profits are attainable but with uncertainty. I start with determining the agents.

Agents

There are three risk-neutral agents in the game; two patentees and one pool administrator (PA). Each patentee owns a single patent. Patents differ only in their level of *true essentiality* for the corresponding standard. True essentiality level -denoted by *e*- is a continuous variable indicating the essentiality of the patent for the standard. So, patents with higher values of *e* are more essential for implementing the standard. True essentiality of patents (e) is assumed to be uniformly distributed between [0,1]. In the beginning of the game, the patents' true essentiality is only known by patent holders.

Since essentiality in practice is a dichotomous concept, I assume that there is a threshold on the true essentiality level which patents above that will be considered *essential* by the courts. I show this threshold by $e^* \in (0,1)$, which is commonly known by the agents from the beginning of the game. Based on this assumption, I define:

Definition 1 *A patent is essential to the standard if it's true essentiality level is equal or greater than* e^*.

In the other words, if a patent with a true essentiality level below this threshold (i.e. $e < e^*$), is not included in the standard's patent pool, standard adopters would not face the risk of litigation by the patent holder simply because the courts will not consider the case as an infringement case.

On this basis, I define the patentee's *types* as below:

Definition 2 *There are two possible types for a patent* $\theta \in \{\underline{\theta}, \overline{\theta}\}$. *The types are defined as:* $\left\{\begin{matrix} \overline{\theta} & if\ e \geq e^* \\ \underline{\theta} & if\ e < e^* \end{matrix}\right\}$. *Type of the patentees are considered the same as the type of patent they hold.*

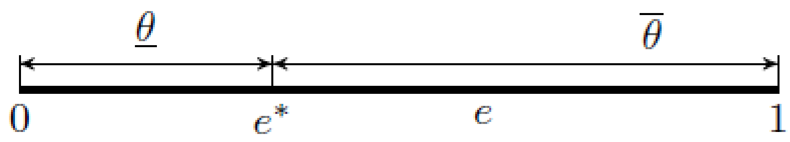

Figure 1 True essentiality levels and the patentee types

The type of patents $\theta \in \{\underline{\theta}, \overline{\theta}\}$ also represents patentees' outside options out of this particular pool forming effort$(0 < \underline{\theta} < \overline{\theta})$. Note that here, the only dimension that the patents differ is their essentiality level for the standard. Therefore, outside this game, *essential* patents may enjoy the opportunity to be included in a pool formed by another pool administrator -besides the non-standard licensing- where the non-essential patents only have non-standard licensing opportunity. This distinction is the cause for the difference in the outside options. The outside option of the pool administrator is set to zero. I also assume that only PA can form the pool.

Patent Pool's Profit

I assume that in case of infringement for an essential patents $(\overline{\theta})$, litigation happens and succeeds with probability one. Therefore, technology adopters will have to license *all* the essential patents in order to be able use the standard. So the pool will be attractive for the technology users if it provides them with the "one-stop shopping" opportunity (i.e. the pool contains all the essential patents).

Definition 3 *A pool formation is successful if it contains all the essential patents* $(\overline{\theta})$ *of the game.*

According to above, for a successful implementation of the standard, no $\overline{\theta}$ type patents should be missing in the standard's patent pool, because then the essential outsider would successfully litigate the standard users.[6] As defined above, PA will have to include all the $\overline{\theta}$ patents of the game in order to form the pool successfully. When there is no $\overline{\theta}$ patents in the game (i.e. both patentees are $\underline{\theta}$) PA can form the pool successfully with only one of the non-essential patents, since in this case, there is no $\overline{\theta}$ patents left out of the pool.[7]

The pool's profit is attainable only when the pool formation is successful. I define the pool's profit as follows.

$$\pi^t(\theta^1, \theta^2) = \begin{Bmatrix} \delta^t \pi > 0 & successful\ poor\ formation \\ zero & otherwise \end{Bmatrix} \quad (1)$$

π is a fixed value standing for the maximum amount of achievable profit, δ^t is the discount rate which represents the waiting costs and losses in the patent pool's profit due to delays in implementing the standard. In the first stage (t= 0), there is no waiting cost since zero δ^0 =1, but increases to $\delta \in (0,1)$ in t = 1.

Since the model considers the legal definition of essentiality, in this analysis, I neglect non-essential patents which may cause quality improvements or cost reductions. I assume that

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[6] Essential patents outside the pool have been introduced as a source of failure in implementation of technical standards (Aoki and Nagaoka, 2004). In line with many works in the literature, I only consider complete patent pools in this model.

[7] The intuition to build the pool with one patent in the model is that the PA has already some critical mass of relevant patents (e.g. from the previous generation of the standard) and is searching for the essential patents for the new generation. Therefore, it can build the pool even with one patent adding to the previous stock of patents. The crucial issue would be not to miss any essential patents.

when the pool formation is successful, the generated profit is fixed, common knowledge and positive. I also assume that:

$$\delta^t \pi > 2\overline{\theta} \qquad (2)$$

This implies that the PA can always receive positive payoff for building the pool. This assumption guarantees pool creation to be always profitable for the PA, regardless of the type of patentees and stage of the game.

Timing of the Game

In the beginning of t = 0, two patentees enter the pool formation game and approach the pool administrator claiming essentiality. Each patentee holds a single patent with a randomly drawn essentiality level- i.e. $e \in [0,1]$. In the beginning of the game, there is complete information asymmetry on the type (essentiality) of the patents. I denote the true types of the patentees with (θ_1, θ_2) in this model.

The PA has two choices two build the pool. It can either *act lax* in checking the essentiality and include both patentees without paying the waiting cost and going to through the essentiality evaluation (i.e. form the pool in t = 0) or take the process to the essentiality assessment in t = 1. If PA decides to form the pool without evaluating the essentiality, it should offer both patentees at least equal to their (over)claimed outside option $(\overline{\theta}, \overline{\theta})$ to join the pool. If not, the game goes to the essentiality assessment process in t = 1.

If PA chooses to go to essentiality evaluation, it imperfectly learns the types in the beginning of t = 1, and the information asymmetry reduces. In order to build the pool based on this learning, PA offers each patentee a compensation to join the patent pool. I denote PA's offers for the first and second patentee with the notation (θ'_1, θ'_2).[8]

If the pool formation is successful, PA will take the generated profit paying each patentee with offered payoff. If not, the game ends with each agent receiving their outside option. I assume that the asymmetry totally dies at the end of the game.

Due to the equation (2), PA is always able to guarantee a successful pool formation by providing both firms with $\theta'_i = \overline{\theta}$. With this strategy, the pool will contain all the essential patents of the game - in case they exist- with certainty. This is implicitly like treating both patents as essential regardless of essentiality evaluation results. However with this offer, a non-essential patentee -if present in the game- will take the information rent, which could have been attainable for the PA. The tree of the game is presented in figure 2.

[8] If PA decides to exclude a patentee *i* from the pool, it can just fix the offer at $\theta_i^{'} = 0$

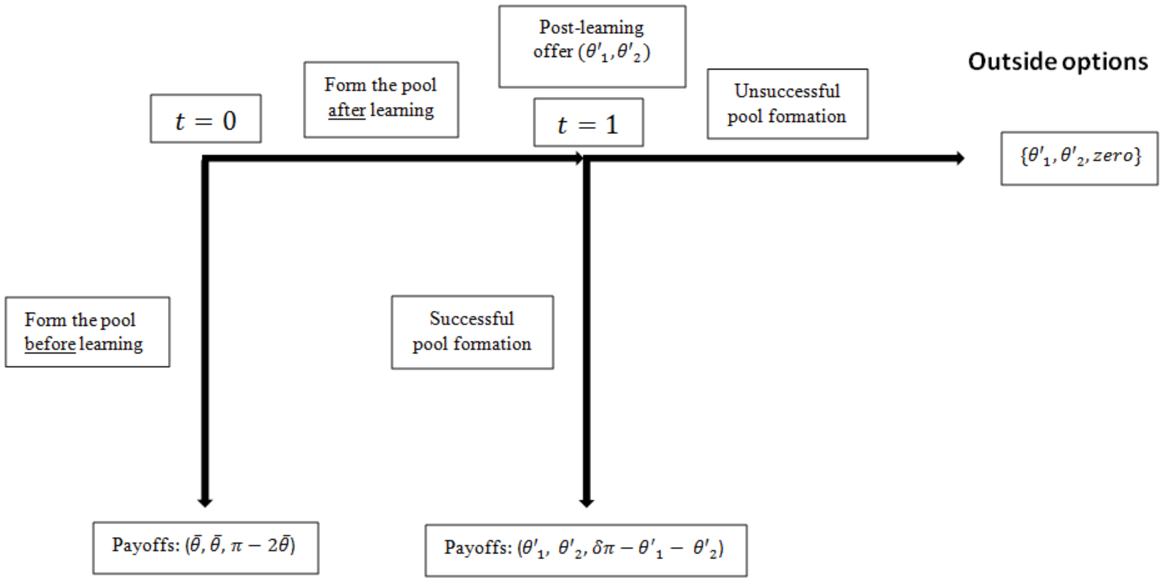

Figure 2 Timing of the game

Payoffs

As mentioned above, agents can take their share from the pool profit, only if the pool formation is successful. If pool formation in *t* is successful, the patentees will take their compensation (θ'_i) and the PA will receive $R_t = \delta^t\pi - \theta'_1 - \theta'_2$. If pool administrator does not manage to form a successful essential patent pool in *t* = 1, the game ends with all agents receiving their outside option. Table 1 summarizes the payoffs in each stage.

	Success in t = 0	Success in t = 1	t=2 & outside
Pool Administrator	$R_{t=0}^{\bar{\theta}\bar{\theta}} = \pi - 2\bar{\theta}$	$R_{t=1}^{\theta'_1\theta'_2} = \delta\pi - \theta'_1 - \theta'_2$	*zero*
Patentee 1	$\bar{\theta}$	θ'_1	θ_1
Patentee 2	$\bar{\theta}$	θ'_2	θ_2

Essentiality evaluation

Assessing the essentiality takes place in the second stage (t=1), if PA decides to learn the patentees' type before making them the offer in t=0. Starting the t = 1, pool administrator -and patentees- imperfectly learn the true essentiality level of the patents (e). In the learning process, for a patent with a true essentiality level of $e_i = \tilde{e}$, the administrator realizes an essentiality level in the interval of $\hat{e}_i \in [\tilde{e} - \Delta, \tilde{e} + \Delta]$. The *realized essentiality* by PA is denoted $\hat{e}_i$ and uniformly distributed over the interval $[\tilde{e} - \Delta, \tilde{e} + \Delta]$. Here, Δ is the parameter of error, which determines the quality of learning. Higher values of Δ represent bigger error in the essentiality evaluation. I assume that there is no cost of learning for the patentees and PA. However, the learning process takes the time from t = 0 to t = 1 which induces the waiting cost. Figure 3 gives an overview on the learning procedure and realized essentiality interval.

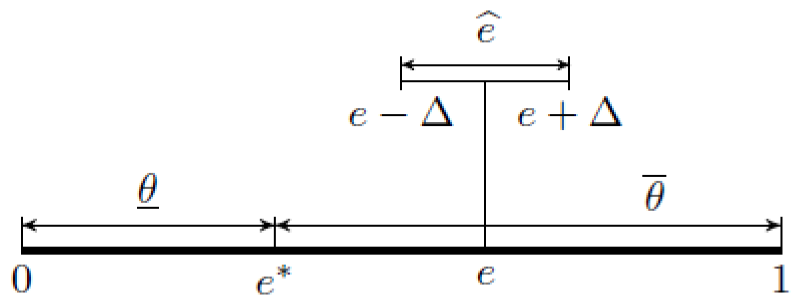

Figure 3 The realized essentiality interval in the learning procedure

Model Results

I offer a backwards solution for the game from the viewpoint of PA. Since the last node where PA can take a decision is in t = 1, I start with PA's optimal strategy in this node.

Optimal strategy for PA in t =1.

At the end of t = 1, PA will try to create the pool based on the updated beliefs (due to learning). The crucial point is that if the PA mistakenly excludes a $\overline{\theta}$ from the pool, the pool will not be implemented. Since the learning occurs in the beginning of the t = 1, PA has already the posterior beliefs - resulted from the essentiality evaluation- on the type of the patentees. I show these beliefs with $p_i^t \in [0,1]$ which stand for PA's belief that patentee i is non-essential (i.e. the type is $\underline{\theta}$).

In the beginning of the game in t = 0, due to the symmetry among patentees, PA has identical beliefs about them. So the prior belief (probability of the patentee i to be $\underline{\theta}$) is:

$$p_i^{t=0} = prob(e < e^*) = F(e^*) = e^* \qquad (3)$$

Where F is the cumulative distribution function. In the t = 1 and after the learning, the beliefs will depend on the realization of $\hat{e}$. Since the error of learning is Δ, for any realized value of $\hat{e} < e^* - \Delta$, the patentee's true essentiality level lies in the interval of $[0, e^*)$ which means the patent is non-essential ($\underline{\theta}$) with certainty. That is to say:

$$prob(e < e^* | \hat{e} < e^* - \Delta) = 1 \qquad (4)$$

With a similar argument, we get:

$$prob(e < e^* | \hat{e} \geq e^* + \Delta) = 0 \qquad (5)$$

Accordingly, the detection is perfect in the above cases. However, when the realized essentiality is in the interval of $\hat{e} \in [e^* - \Delta, e^* + \Delta)$, there is no perfect detection. This is the grey interval for which the corresponding beliefs are calculated as below:

$$prob(e < e^* | \hat{e} \in [e^* - \Delta, e^* + \Delta)) = \int_0^{e^*} f(e | \hat{e} \in [e^* - \Delta, e^* + \Delta)) f(e) de = \frac{e^* - \hat{e} + \Delta}{2\Delta} \qquad (6)$$

Thus, the posterior beliefs in the three intervals can be summarized as follows:

$$P_i^{t=1}: \begin{cases} 1 & if\ \hat{e} \in [0, e^* - \Delta] \\ \frac{\Delta + e^* - \hat{e}}{2\Delta} & if\ \hat{e} \in [\, e^* - \Delta, e^* + \Delta \,] \\ 0 & if\ \hat{e} \in [\, e^* + \Delta, 1 \,] \end{cases} \qquad (7)$$

Figure 4, shows the posterior beliefs in t = 1 with respect to the realized essentiality level.

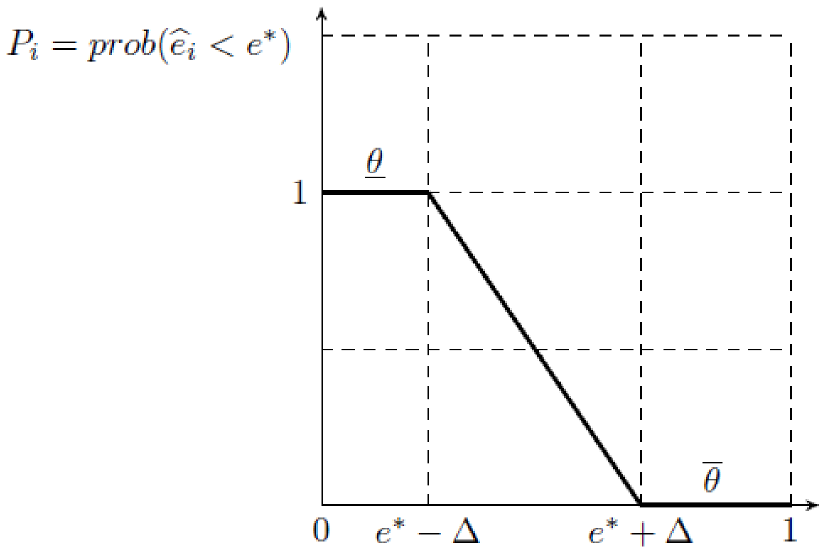

Figure 4 Posterior beliefs with respect to realized essentiality level

Accordingly and based on the definition of successful pool formation, I define "lax evaluation" and "failure" for a pool formation process as follows:

Definition 4 *For the pool formation by the PA I define:*

(i) Lax evaluation: when PA builds the pool in t=0 with no essentiality evaluation.

(ii) Failure: when PA dose not successfully build the pool in the game.

For the sake of simplicity and without loss of generality, I assume that $P_1^{t=1} \geq P_2^{t=1}$ in rest of the game solution. At *t* = 1, PA may successfully build the pool with either one or both patentees. Considering that $P_1^{t=1} \geq P_2^{t=1}$, PA has five decisions ($D_i \in \{0,1\}$) to potentially form the pool. I have summarized the decisions in the table below.

PA's decision in *t* = 1	**PA's payoff if pool is formed**
$D_1 = 1 \rightarrow$ PA offers $(\bar{\theta},\bar{\theta})$	$R^{\bar{\theta}\bar{\theta}} = \delta\pi - 2\bar{\theta}$
$D_2 = 1 \rightarrow$ PA offers $(\underline{\theta},\bar{\theta})$	$R^{\underline{\theta}\bar{\theta}} = \delta\pi - \underline{\theta} - \bar{\theta}$
$D_3 = 1 \rightarrow$ PA offers $(\underline{\theta},\underline{\theta})$	$R^{\underline{\theta}\underline{\theta}} = \delta\pi - 2\underline{\theta}$
$D_4 = 1 \rightarrow$ PA offers $(0,\bar{\theta})$	$R^{0\bar{\theta}} = \delta\pi - \bar{\theta}$
$D_5 = 1 \rightarrow$ PA offers $(0,\underline{\theta})$	$R^{0\underline{\theta}} = \delta\pi - \underline{\theta}$

Accordingly, in *t* = 1, PA maximizes its expected payoff by choosing one of the decisions above. To make the optimal decision, PA solves the following optimization problem:

Pool administrator's problem in t=1

$$\max_{D_1, D_2, D_3, D_4, D_5} \; D_1\left(R^{\bar{\theta}\bar{\theta}}\right) + D_2\left(R^{\underline{\theta}\bar{\theta}}\right)p_1 + D_3\left(R^{\underline{\theta}\underline{\theta}}\right)p_1p_2 + D_4\left(R^{0\bar{\theta}}\right)p_1 + D_5\left(R^{0\underline{\theta}}\right)p_1p_2$$

$$s.t.: D_1 + D_2 + D_3 + D_4 + D_5 = 1 \qquad (8)$$

To solve the pool administrator's problem in *t* = 1, I start with two lemmas.

Lemma 1. *In t = 1, it is never optimal for the pool administrator to offer* $(\underline{\theta},\bar{\theta})$ *or* $(\underline{\theta},\underline{\theta})$.

Proof: PA will offer $(\underline{\theta},\bar{\theta})$ *or* $(\underline{\theta},\underline{\theta})$ if and only if the expected payoffs in these strategies exceed the others.

PA will play $(\underline{\theta},\overline{\theta})$ if and only if $(\delta\pi - \overline{\theta} - \underline{\theta})\, p_1 \geq \delta\pi - 2\overline{\theta}$ and $(\delta\pi - \overline{\theta} - \underline{\theta})\, p_1 \geq$ $(\delta\pi - 2\underline{\theta})\, p_1 p_2$ and $\left(\delta\pi - \overline{\theta} - \underline{\theta}\right) p_1 \geq (\delta\pi - \underline{\theta}) p_1 p_2$ and $\left(\delta\pi - \overline{\theta} - \underline{\theta}\right) p_1 \geq (\delta\pi - \overline{\theta})\, p_1$. The latter equation requires $\underline{\theta} < 0$ which is a contradiction.

Also, PA will play $(\underline{\theta},\underline{\theta})$ if and only if the payoff for this strategy is higher than others. This requires $\left(\delta\pi - 2\underline{\theta}\right) p_1 p_2 > (\delta\pi - \underline{\theta}) p_1 p_2$, which again requires $\underline{\theta} < 0$, a contradiction.

For sake of ease in use of notation, I label the profit ratios as $A = \frac{R^{0\overline{\theta}}}{R^{0\underline{\theta}}}$ and $B = \frac{R^{\overline{\theta\theta}}}{R^{0\overline{\theta}}}$. The optimal decision regime is dependent to the relation between A & B. To clarify this relation, I formulate another lemma as follows.

Lemma 2. *When the pool formation is profitable* $(i.e.\, \delta^t \pi > 2\overline{\theta})$, *A is always greater than B.*

Proof. The proof is straight forward and comes directly from subtracting the terms a.

$$A - B = \frac{\delta\pi - \overline{\theta}}{\delta\pi - \underline{\theta}} - \frac{\delta\pi - 2\overline{\theta}}{\delta\pi - \overline{\theta}} = \frac{\overline{\theta}^2}{\left(\delta\pi - \underline{\theta}\right)(\delta\pi - \overline{\theta})} + \frac{\underline{\theta}(\delta\pi - 2\overline{\theta})}{\left(\delta\pi - \underline{\theta}\right)(\delta\pi - \overline{\theta})} > 0$$

For the sake of simplicity - and without loss of generality, I assume A>0.5>B. The optimal decision regimes can be depicted as follows.

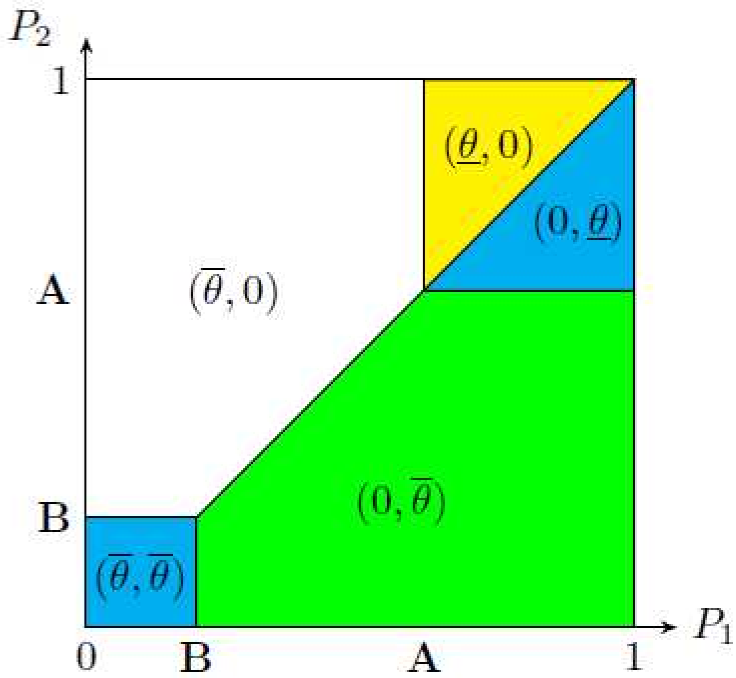

Figure 5 PA's optimal decision regime after learning

Proposition 1. *When PA decides to form the pool after learning (in t = 1), the probability of failure is always positive.*

Proof. Failure happens when an essential patentee is not included to the pool. This may only happen in the interval where the essentiality is not assessed with certainty. According to (7) PA faces the risk of wrong type detection in the interval of $[e^* - \Delta, e^* + \Delta]$. However, if the true essentiality is below e^*, a wrong detection will not result in a *failure* since in this case, a non-essential ($\underline{\theta}$) patentee is mistakenly added to the pool (this may only reduce the PA's payoff). Thus, the PA faces the risk of failure only in the interval$[e^*, e^* + \Delta]$. In this interval, PA may mistakenly detect an essential patent as non-essential and exclude it from the pool. Accordingly, the probability of failure for different intervals can be shown as follows:

$$prob(failure|e) = \begin{cases} zero & 0 < e < e^* \\ failure(e) & e^* \leq e < e^* + \Delta \\ zero & e^* + \Delta \leq e < 1 \end{cases} \qquad (9)$$

When $e \in [e^*, e^* + \Delta)$, PA will fail to successfully form the pool only if mistakenly detects the patent as $\underline{\theta}$. As depicted in the figure (5), when $p_i \geq B$, pool admin considers the patentee as $\underline{\theta}$ (recall that p_i is the PA's belief on the patentee i to be $\underline{\theta}$) and offers her zero or $\underline{\theta}$. So the failure happens when the belief on an essential patentee ($e^* \leq \hat{e} < e^* + \Delta$) is mistakenly $p_i^{t=1}(\hat{e}) > B$. Plugging for the posterior belief from (7) we can calculate the $prob(p_i^{t=1}(\hat{e}) > B)$ as:

$$prob(p_i^{t=1}(\hat{e}) > B) = prob\ (\hat{e} < e^* + \Delta - 2\Delta B) = prob(\hat{e} < e^* + \Delta(1 - 2B)) \qquad (10)$$

This means that the PA considers a patent as $\underline{\theta}$ when its realized essentiality ($\hat{e}$) is below $e^* + \Delta(1 - 2B)$. I denote this threshold with $\hat{e}^*$ ($\hat{e}^* = e^* + \Delta(1 - 2B)$). Accordingly, the probability of failure caused by learning error on a single patent evaluation is:

$$failure(e) = prob(\hat{e} < \hat{e}^*, e \geq e^*) \qquad (11)$$

$$failure(e) = prob(\hat{e} < \hat{e}^* | e \geq e^*).prob(e \geq e^*) \qquad (12)$$

According to the distribution of $\hat{e}$, the probability of failure for a single firm can be written (see appendix for the calculations regarding the distribution of $\hat{e}$ and equation 13):

$$failure\ (e) = \frac{\Delta(3-4B)(1-e^*)}{2(1-e^*-\Delta)} \qquad (13)$$

which is always greater than zero. Therefore, PA's strategy to take the game to t=1 can contribute to a failure in the pool formation.

Proposition 2. *The probability of failure in t=1*

(i) increases with the error of learning.

(ii) increases with essential patents' outside option.

(iii) decreases with e^*- i.e. the legal strictness on essentiality.

Proof. The first and third results directly come from equation (13). The second result can be achieved also by equation (13) and considering that $\frac{\partial B}{\partial \theta} < 0$.

Solving the pool formation backwards, the pool administrator, will be able to calculate only the *expected* payoff in the second stage. This will depend on the updated beliefs, waiting cost and the size of error among other variables. However, the payoff for the first stage of the game is known by the PA with certainty. Therefore, in the first stage PA will need to compare the expected payoff of the second stage with the certain payoff of the first stage and choose about its strategy:

Pool administrator's problem in t=0

$$\max_{z \in \{0,1\}} [E_{t=1}(R_{t=1}), R^{\overline{\theta\theta}}]$$

Where $z \in \{0,1\}$ is PA's decision on whether to take the game to the second stage or not.

Proposition 3. *Under proper conditions (waiting cost and learning error sufficiently high), PA's optimal decision is to include all the patents to the pool, regardless of their essentiality.*

Proof. See the appendix.

Discussion and Conclusion

Along with the growing importance of technology standards, essential pool administrators are also becoming increasingly importance. In practice today, there is no modern technology standard being implemented outside the professional pool administrating companies. Although there has been an upsurge in the academic studies focusing on the standards, the role of the pool facilitating party has been neglected - or underestimated- in the literature. Things may become more interesting if one believes that the strategies of the pool facilitating/ administrating party, may have contributed to the inefficiencies involved with standard setting procedure.

According to proposition 1, when PA goes through the essentiality evaluation, there is a non-negative probability of failure. Obviously, this comes from the nature of imperfect learning. So even in the cases where pool administrators outsource the essentiality evaluation to independent examiners, the effect stays. This reason of failure is different from the common reason in the literature which assume patentee-side issues to be the drivers of failures. Also, proposition 2 summarizes factors which increase the probability of failure. The first factor - i.e. the error of learning- is straight forward. The second factor -i.e. value of patents- assigns higher failure rates when essential patents have higher outside options. These are relevant for the recent failed pool formation cases in advanced ICT industries, which due their technological complexities, it is extremely difficult to assess the essentiality (higher learning error). Also patents have higher commercial values outside the pool. The results can explain some degrees of contribution from pool administrators' side to these failures.

Moreover, proposition 3 states cases where the pool administrator is better off by acting lax and including non-essential patents to the pool. In reality, pool administrators have already been alleged of being "overly lax" in the essentiality evaluation procedures. Proposition 3 may be able to explain the reasons that this concern exists among stakeholders; with high pace of technology in hi-tech industries, waiting and delays almost translates to losing the market to competitors (very high waiting cost). When this combines with higher errors in essentiality evaluation (again the cases in hi-tech patents), the pool administrator would find it optimal to skip both the waiting cost and the risk of failure and include non-essential patents to the pool to lunch it faster. A trend which is already observable in some parts of hi-tech industries known as the patent pool inflation. Figure 6 summarizes the discussion based on environmental factors. From the findings, I expect factors such as value of essential patents, strictness of IP law and pace of technology to explain - and predict -some of the inefficiencies in pool formation. For example, I expect pool inflation to be a more serious issue in those areas of ICT industry (which has high waiting cost and learning error) that patents have lower outside options.

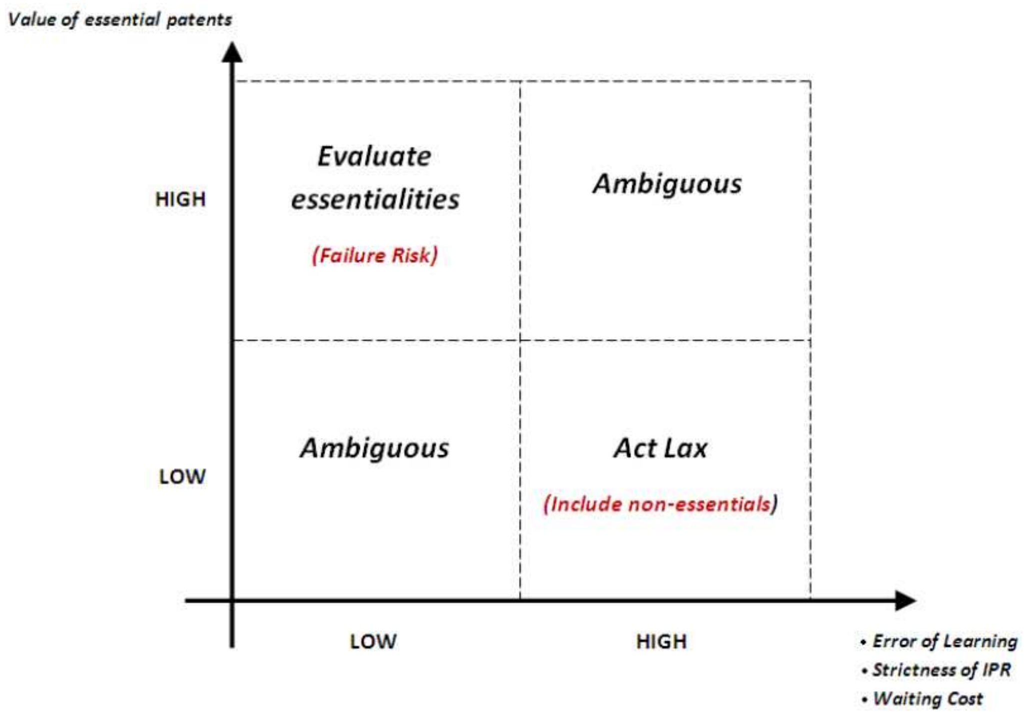

Figure 6 Inefficiencies rising from pool administrator side based on environmental factors

I do not intend to exaggerate the potential role of the pool administrating party on inefficiencies. Obviously, IP holders have a bigger role in the inefficiencies caused in pool formation. However, it is very difficult to measure the magnitude of the effects potentially caused by the administrator and moreover, to compare it with the role of other sources of inefficiencies in the literature (e.g. distributional conflicts among firms).

Also, there are some shortcomings in the model that I am aware of them. The model assumes a very powerful pool administrator whom can include or exclude the patentees without further constraints. The administrator's market power caused by the experience of pool formation in specific areas of the industry and the body of knowledge that it posses, plays a key role in this assumption. Also, the model assumes that the patentees are eager to be included in the pool and does not considering the outsider strategy. This is an assumption which is realistic for the case of many important patent pools but may not be always the case.

To conclude, I believe the next step of the study should focus on validating the findings of the model. Besides potential empirical analysis, this may be achievable by designing proper experiments to investigate the behaviors of practitioners and the stakeholders of technology standards.

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Appendix

A. Distribution function of $\hat{e}$

For the proposition 1, the failure probability is:

$$failure(e) = prob(\hat{e} < \hat{e}^* | e \geq e^*) prob(e \geq e^*) \quad (14)$$

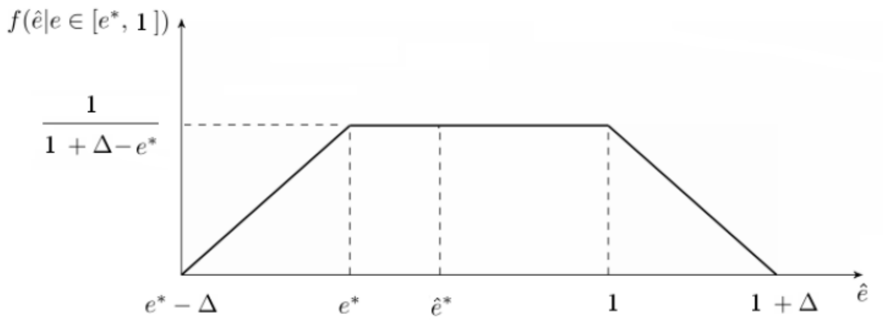

Figure 7 The distribution of $\hat{e}$

To calculate the $prob(\hat{e} < \hat{e}^* | e \geq e^*)$, I use the distribution of $\hat{e}$ for the interval of $e \in [e^*, 1]$. Figure 7 shows the distribution function. The height of the trapezoid is calculated as:

$$F(\hat{e}|e \in [e^*, 1]) = \int_{e^*-\Delta}^{1+\Delta} f(\hat{e}|e \in [e^*, 1]) d\hat{e} = 1 \rightarrow h = \frac{1}{1+\Delta-e^*} \quad (15)$$

The distribution for the intervals on e are as follows:

$$f(\hat{e}) = \begin{cases} \frac{\hat{e}-(e^*-\Delta)}{\Delta(1+\Delta-e^*)} & if\ \hat{e} \in [e^*-\Delta, e^*] \\ \frac{1}{(1+\Delta-e^*)} & if\ \hat{e} \in [e^*, 1] \\ \frac{(1+\Delta)-\hat{e}}{\Delta(1+\Delta-e^*)} & if\ \hat{e} \in [1, 1+\Delta] \end{cases} \quad (16)$$

Considering the above, $prob(\hat{e} < \hat{e}^* | e \geq e^*) = \frac{\Delta(3-4B)}{2(1-e^*-\Delta)}$ and we are done.

B. Proof for proposition 3.

The administrator can always guarantee a certain payoff by forming the pool successfully in the first stage. PA's payoff with pre-learning offer ($\overline{\theta}$,$\overline{\theta}$) at t = 1 is

$$R_{t=1} = \pi\text{-}2\overline{\theta} \qquad (17)$$

However, the payoff in case PA takes the game to t = 1 is not certain and depends on the real essentiality level of the patents. Below, I calculate PA's expected payoff at t = 1.

As we have from equation (10), there is a threshold on the axis of observed essentiality signal ($\hat{e}$) that PA treats the patentees below that as non-essential ($\underline{\theta}$). I show this threshold by $\widehat{e^*}$. From equation (10) this threshold is equal to:

$$\widehat{e^*} = e^* + \Delta(1 - 2B) \qquad (18)$$

To calculate PA's expected payoff in t=1, I divide the $\hat{e}$ axis into two separate intervals, I_1: $[0, e^*)$ and I_2: $[e^*$,1]. (Figure 8)

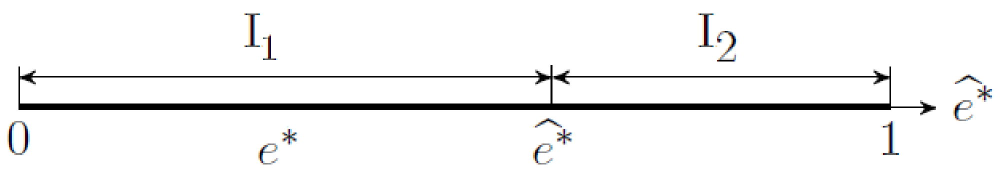

Figure 8

PA will treat all the patentees with $\hat{e} \in I_2$ as $\overline{\theta}$ and the rest as $\underline{\theta}$. I also define $\tilde{p}$ as the probability of wrong detection when the patentee is $\overline{\theta}$. As previously mentioned, $\tilde{p}$ is the probability that the pool will not be created successfully in t = 1 due to the error of learning and so is formulated as:

$$\tilde{p} = prob(e > e^* | \hat{e} < \widehat{e^*}) \qquad (19)$$

So, one can imagine four conditions with this setup, about the location of $\widehat{e_1}, \widehat{e_2}$ inside the two intervals:

Case	$prob(success)$	Payoff if success
$\widehat{e_1}, \widehat{e_2} \in I_1$	$(1-\tilde{p})^2$	$\delta\ (\pi - \underline{\theta})$
$\widehat{e_1} \in I_1, \widehat{e_2} \in I_2$	$(1-\tilde{p})$	$\delta\ (\pi - \overline{\theta})$
$\widehat{e_1} \in I_2, \widehat{e_2} \in I_1$	$(1-\tilde{p})$	$\delta\ (\pi - \overline{\theta})$
$\widehat{e_1}, \widehat{e_2} \in I_2$	1	$\delta\ (\pi - 2\overline{\theta})$

Considering the four cases above, PA's expected payoff for t=1 can be formulated as:

$$\begin{aligned} E_{t=1}(R_{t=1}) = {} & prob(\widehat{e_1}, \widehat{e_2} \in I_1).(1-\tilde{p})^2.\delta\ (\pi - \underline{\theta}) \\ & + prob(\widehat{e_1} \in I_1, \widehat{e_2} \in I_2).(1-\tilde{p}).\ \delta\ (\pi - \overline{\theta}) \\ & + prob(\widehat{e_1} \in I_2, \widehat{e_2} \in I_1).(1-\tilde{p}).\ \delta\ (\pi - \overline{\theta}) \\ & + prob(\widehat{e_1}, \widehat{e_2} \in I_2).\ \delta\ (\pi - 2\overline{\theta}) \end{aligned} \qquad (20)$$

And PA will find it optimal to take the game to t=1 if and only if:

$$E_{t=1}(R_{t=1}) \geq R_{t=1}^{\overline{\theta\theta}} \qquad (21)$$

From $\underline{\theta} < \overline{\theta}$ it follows that $\pi - \underline{\theta} > \pi - \overline{\theta} > \pi - 2\overline{\theta}$. Also, from (7) and (16) we get that if learning error converges to zero ($\Delta \to 0$), then $\hat{e} \to e$ and $\widehat{e^*} \to e^*$. Consequently, the probability of failure ($\tilde{p}$)will converge to zero $\tilde{p} \to 0$. Considering equation (20), with sufficiently low waiting cost (i.e. sufficiently high δ), PA's expected payoff in t=1 will exceed its payoff in t=1 (equation 21). So in this case, the expected payoff for going to the learning phase will exceed the certain payoff of forming the pool in t=0.