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Back to software "profitable piracy": the role of information diffusion

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Abstract

Can software piracy be profitable for a software editor? We tackle this issue in a simple model where software is an experience good and where the potential users can choose to adopt or pirate software or to delay their adoption. In that context, we show that a moderate piracy can be profitable for a software editor to foster users' adoption.

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1. Introduction

"If You're Going To Steal Software, Steal From Us"! As Paul McDougall has summarized Microsoft's attitude towards piracy in Information Week, an US professional IT-dedicated information website[1]. This opinion was grounded on a series of interviews and public declarations made by Jeff Raikes, former Microsoft business group president. In these, Raikes said: "We understand that in the long run the fundamental asset is the installed base of people who are using our products". While developing new technologies aimed at monitoring piracy (such as Windows Genuine Advantage program)[2], Raikes also declared: "You want to push towards getting legal licensing, but you don't want to push so hard that you lose the asset that's most fundamental in the business". Finally, while he estimates the piracy rate of all software in the US to be about 20 to 25%, Raikes claimed about pirates: "What you hope to do over time is convert them to licensing the software".

Whatever pirates' initial motives, such statements clearly evidence how piracy can be strategically used by a major software editor. Using a simple theoretical model, our motivation in this paper is to show in which conditions such strategy could be effective (i.e. profit-enhancing) for a software editor. While this paper primarily focuses on the software industry, such strategy can also be used by producers of digital goods (*e.g.* music, video, software) and thus relates to the huge theoretical literature about the existence of a so-called "profitable piracy" in the case of digital products. Because of the network externalities generated by digital products, and because of their specific cost function (high fixed cost and negligible marginal cost), a firm may find it profitable to distribute its product for free in order (notably) to increase buyers' valuation and to increase the price charged on regular consumers. For generic digital products, Gayer and Shy (2003) precisely analyze how peer-to-peer communities can be profitably used to enhance sales. In their model, potential adopters can either download or buy a digital good, these two goods are vertically differentiated and the downloaded product has a positive influence on the bought one (and conversely). Peitz and Waelbroeck (2006b) synthesize the literature in the case of digital products[3]. In the specific case of software, it has been first shown by Conner and Rummelt (1991) and then by Takeyama (1994, 1997) that in the presence of network externalities, software editors may tolerate a "moderate" rate of piracy of their products. Shy and Thisse (1999) extend this result to a duopoly setting and show how firms' incentives to tolerate piracy depend on the magnitude of the software network externality. This result has been further challenged by King and Lampe (2003) that pointed out that such trade-off could not be relevant in many cases. Yet, most of this literature emphasizes on one-shot games, where all potential users of a software decide simultaneously and once for all, whether to adopt or not. Doing so, such perspective neglects one key specificity of software goods: software are essentially

[1]See http://www.informationweek.com/news/security/showArticle.jhtml?articleID=198000211

[2]This program was launched in 2005 and diffused with the Microsoft XP Operation System. In the latest version of its product (Microsoft Vista), Microsoft implemented a new protection device ("Software Protection Platform"), claimed to be more efficient to fight against piracy (see https://partner.microsoft.com/40029548).

[3]See Varian (2005) for a general economic approach of copyright and piracy; see also Qiu (2006) for a general equilibrium analysis linking software production and copyright protection.

experience goods that users need to sample before they know the exact utility they can derive from them. In that respect, the diffusion of software has to be analysed as a sequential process. Externalities between agents are here strictly informational and come from the application of the "sample effect" – first identified by Peitz and Waelbroeck (2006a) – to the particular context of software market. Takeyama (2003) also considers that software are experience goods that need to be tested. Yet in this model, sampling is strictly personal (individual trial and error process) and there is no communication between agents about the quality of the software (see also Chepalla and Shivendu 2005).

We propose to come back to this debate about profitable piracy by stressing the particular relationship between information disclosure (about software quality) and piracy. Since users cannot perfectly assess the intrinsic quality of a software *ex ante* (experience goods), we consider a simple two-stage adoption setting where some early adopters can partially inform late adopters about the quality of the software, and where the firm can monitor various degrees of piracy of its products by implementing Digital Rights Management (DRM) tools. Within this setting, we show that a firm should accommodate a "moderate" piracy of its software to signal the quality of its software and hence increases its profits. Section 2 presents the model and establishes this result. Section 3 concludes.

2. The model

The firm. There is a single firm that produces software which provides both basic and advanced functionalities. The firm sells it at a price p_t at time $t, (t = 1, 2)$. To provide basic functionalities, the firm incurs a fixed cost C. The quality of advanced functionalities (denoted f) is a control variable for the firm. To keep things simple, we assume that the quality level can take two discrete values $f = 0$ (low quality, *i.e.* no advanced functionalities) and $f = \bar{f} > 0$ (high quality) which implies an additional fixed cost $\chi(0) = 0$ and $\chi\left(\bar{f}\right) > 0$ respectively. The firm can implement various DRM technical solutions to monitor the piracy of its product. This choice is captured by λ_t, ($\lambda_t \in [0, 1]$): "hackers" of the software have a probability λ_t of being detected. We assume that the level of monitoring is a control variable and that monitoring incurs no specific cost[4]. The objective of the firm is then to choose $\{p_1, p_2, \lambda_1, \lambda_2, f\}$ so as to maximize its intertemporal non-actualized profit, defined by:

$$\begin{aligned}\pi(p_1, p_2, \lambda_1, \lambda_2, f) = \ & m_1^b(p_1, p_2, \lambda_1, \lambda_2, f)p_1 \\ & + m_2^b(p_1, p_2, \lambda_1, \lambda_2, f)p_2 - C - \chi(f)\end{aligned} \tag{1}$$

where $m_t^b(\cdot)$ is the quantity of software sold at time t.

Potential users. There exist m potential users of the software that we assume uniformly distributed on the segment $[c, \bar{c}]$ where c_i figures the piracy cost of user i. This piracy cost is incurred at the time the software is pirated. Users' heterogeneity relates

[4] This is a working assumption: if we find that a moderate piracy may be profitable for the firm when monitoring is costless, the same conclusion would be reinforced as monitoring is costly. That is why we have chosen to skip such monitoring cost.

both to technical factors (different abilities to pirate a software) or to psychological factors (different degrees of risk aversion for being detected, ethical/moral factors). These potential users have the opportunity to adopt the new software at time 1 or at time 2, either by buying it or by pirating it. This population is called early adopters. When they do not adopt, they derive a utility $\bar{b}$ from the use of an old generation software (Reservation strategy). When they adopt the new software, they draw at each period an instantaneous utility b from using the basic functionalities of the software and f from using its advanced functionalities. Basic functionalities are perfectly observable while advanced functionalities are initially not (since software are typically "experience goods"). At time 1, the instantaneous utility of these advanced functionalities is evaluated by potential users at its expected value $E(f), \left(E(f) \leq \bar{f}\right)$. At time 2, the quality f is perfectly observed by agents who adopted the software at time 1. Information about quality is diffused among other agents and improves their estimation of the software's quality. This diffusion occurs through a word-of-mouth process, the efficiency of which depends on the number of early adopters (denoted m_1^a): it generates an externality from the early adopters to the remaining agents that we assume linear.

At time 1, the objective of any potential user i is then to choose his present and future strategies in order to maximize the expected intertemporal utility U_i^1. According to the values of the parameters $\bar{b}, b, E\left(f\right), c, \bar{c}$ and to the observed control variables of the firm $(p_1, p_2, \lambda_1, \lambda_2)$, these possible actions and related payoffs are summarized in Table I.

Table I: User i's strategies at time 1

User's strategy	Time 1 action	Time 2 action as planned at time 1	Expected intertemporal (non-actualized) utility at time 1
1.1	Buying	-	$2(b + E(f)) - p_1$
1.2	Piracy	-	$2(b + E(f)) - \lambda_1 c_i$
1.3	Reservation	Buying	$\bar{b} + b + E(f) - p_2$
1.4	Reservation	Piracy	$\bar{b} + b + E(f) - \lambda_2 c_i$
1.5	Reservation	Reservation	$2\bar{b}$

To make the choices non trivial, we assume *i)* $b \leq \bar{b}$, *i.e.* that the old software integrates both basic and advanced functionalities and *ii)* $\bar{b} \leq b + E(f)$, *i.e.* that there exists a non-negative price of the software such that all potential users do not choose once for all the Reservation strategy (user's strategy 1.5).

Since agents are not differentiated by their willingness to pay, the coexistence of buyers and non adopters at each time is excluded. Without any additional restriction, the set of the firm control variables then reduces from $(p_1, p_2, \lambda_1, \lambda_2, f)$ to $(p, \lambda_1, \lambda_2, f)$. Hence, at time 1, since users' expectations about the current and future quality of the software are the same, they always prefer to buy the software immediately than later (thus eliminating strategy 1.3). Moreover, since we have assumed no network externality, the firm will have no interest to allow piracy at time 2 because the additional "hackers" at time 2 cannot have any positive influence on profit. Then, the interest of the firm is to announce at time 1 that the level of monitoring at time 2 will be sufficiently high to break down incentives to pirate at time 2 (ensuring that user's strategy 1.4 is always dominated by strategy 1.2)[5]. Consequently, given their respective costs of piracy, potential users then select one of the three remaining strategies (1.1, 1.2 or 1.5).

Finally, there exist two possible distributions of users at time 1: total initial adoption (users are distributed among user's strategies 1.1 and/or 1.2) or partial initial adoption (users are distributed among user's strategies 1.2 and 1.5). These two distributions are the rational answers of potential users to the two strategies of the firm that we call Strategy A and Strategy B respectively. With Strategy A, the firm chooses its control variables $\{p, \lambda_1, \lambda_2, f\}$ such that high cost potential users choose to buy the software at time 1 while low cost ones choose to pirate it. With Strategy B, the firm determines its control variables such that high cost users choose Reservation at times 1 and 2 (user's strategy 1.5) whereas low cost agents choose piracy at time 1 (user's strategy 1.2). Here, the objective of the firm is to induce these agents who have chosen to reserve definitively at time 1 (user's strategy 1.5) to change their opinion with the new available information diffused by the early adopters. At time 2, the decisions of those agents who chose Reservation at time 1 are then detailed in Table II.

Table II: User i's strategies at time 2
when Reservation has been previously chosen at time 1

User's strategy	Time 1 action	Time 2 action	Expected intertemporal (non-actualized) utility at time 2
2.1	Reservation	Buying	$b + E(f) + (f - E(f))k(m_1^a/m) - p$
2.2	Reservation	Piracy	$b + E(f) + (f - E(f))k(m_1^a/m) - \lambda_2 c_i$
2.3	Reservation	Reservation	$\bar{b}$

Note that utilities are modified by the revision of the quality expectation. The magnitude of information diffusion depends i) on the proportion of early adopters (m_1^a/m) and ii) on a parameter k that measures the efficiency of the information diffusion process such that $0 \leq k \leq 1$. One can see that the expected utility of potential adopters would rise ($(f - E(f))k(m_1^a/m)$ would be positive) only if the early "hackers" have announced that the quality of advanced functionalities is high. Consequently, this case does not refer to the traditional case of network externalities. Here, agents may adopt the software, since they are made aware of the usefulness of the advanced functionalities from earlier adopters. The interaction with other agents is strictly informational and has no strategic motives.

There exist two variants of Strategy B. With Strategy B1, the optimal values selected by the firm for the control variables are such that all agents who chose Reservation at

[5]This remark also explains why the control variables p, λ_1 and λ_2 of the firm are known by potential users before they take any decision and why the announcement of these control variables is credible.

time 1 choose Buying at time 2. Yet, with Strategy B2, they split between buyers and "hackers". As they always correspond to non profit-maximizing outcomes for the firm, other cases are excluded.

The structure of the game. The actions of the firm and of the potential users can be depicted by a Stackelberg equilibrium where the firm plays leader:

- At time 0, the firm sets the profit maximizing level of $\{p, \lambda_1, \lambda_2, f\}$ as described by (1).
- At time 1, potential users formulate their intertemporal choices conditional to the information available about firm's the control variables $\{p, \lambda_1, \lambda_2\}$ and implement their decisions related to time 1.
- At time 2, non adopters revise their time 1 decisions, according to the diffusion of information about software quality at time 2 and implement these decisions for time 2.

The model is solved by backward induction. We are then able to prove the following proposition:

Proposition. *Through the implementation of fine-tuned protection devices, a strategy based on partial piracy may be profit-enhancing for the firm.*

Proof. see Appendix.

This proposition captures the following stylized fact: in some cases, it may be interesting for the firm to launch a new software with an initial adoption period where the rate of monitoring is not maximal. During this period, the firm tolerates piracy strategically. This stage helps the firm maximize the disclosure of verifiable information about the quality of its software at the early stage of the diffusion process. This stage also helps selling it during the later stages of the diffusion process. It should be noted that piracy is beneficial here only if there exists a limited number of "hackers": this number must be sufficient to diffuse as broadly as necessary information on quality of the new software, while not excessive. This is why the firm needs to use fine-tuned protection devices (allowed by DRM implementations) so as to precisely control the piracy of its product.

Yet, this situation occurs when some conditions are filled ($\bar{c} > 4(b - \bar{b} + E(f))$ and conditions [I] to [III] in the Appendix). In particular, these conditions reveal that low quality basic functionalities (b) or/and pessimistic expectations ($E(f)$) need to be challenged by the information revealed by hackers. At the same time, piracy costs ($\bar{c}$) should not be too low: if so, the information revealed by early adopters would encourage all those agents who did not adopt first, to pirate instead to buy further.

3. Concluding remarks

Microsoft's former executive pointed out that "If they [pirates] are going to pirate somebody, we want it to be us rather than somebody else". This paper provides some rationale for implementing such piracy-based strategy in a simple setting where potential users can learn about the quality of a software (experience good) and where the firm can implement gradual DRM strategies (differing by the attitude of the firm towards piracy). In particular, our paper emphasizes one challenging situation where a software editor has an incentive to tolerate piracy in an early stage so as to increase its user base and reveal information; while in a second stage it should increase its "fight" against piracy through more intense monitoring. In 2008, Microsoft switched to a new protection device called "Software Protection Platform" that he claimed to be more stringent against pirates. Everything else being equal, our model gives some insights to interpret such switch ex post. Unlike some previous work, our conclusion is here only grounded on *informational* externalities between users, leaving voluntarily aside other types of externalities (compatibility effects, etc.). Besides, our conclusions are not dependent on some particular assumptions about the costs associated to the implementation of the piracy strategy: obviously, implementing DRM technical solutions may imply different production costs since creating an increasingly "protected" software is more costly than producing a freely duplicable product. To avoid such exogenous dependence, we assumed that implementing all piracy policies imply the same cost. Yet, reintroducing such dependence would reinforce our result. Future research should now consider software distribution strategy within an extended framework that could integrate beta-testing, together with product versioning.

Appendix

Sketch of the proof.

For each strategy A, B1 and B2:

- We determine the condition(s) on the distribution of users that make possible the adoption of strategies A, B1 or B2 from the producer's side.
- We express the profit and the optimal value of the control variables $\{p^*, \lambda_1^*, \lambda_2^*, f^*\}$. For strategy B1, we define the condition on parameters such $0 < \lambda_1^* < 1$.
- Substituting the optimal values of the control variables in the condition(s) on the distribution of users, we determine the set of parameters for which each strategy is optimally used. We verify that the conditions on the distribution of users for strategy B1 are such that λ_1^* always takes an interior value.

Concluding the proof, we compare the strategies and find that there exist a non-empty range of parameters such that producers can rationally adopt B1 with $0 < \lambda_1^* < 1$.

Firm strategy A (all users adopt at time 1).

- With strategy A, the firm chooses driving potential users toward total adoption at time 1: potential users are then distributed among strategies 1.1 and 1.2, with

$$p \leq 2\left(b + E(f) - \bar{b}\right) \tag{2}$$

The distribution of users at time 1 is then depicted by Figure 1.

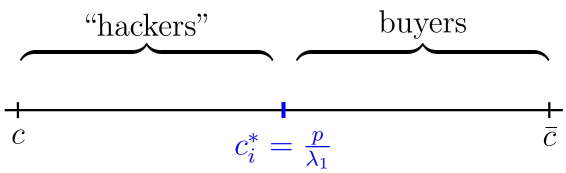

Figure 1: Distribution of users with strategy A

- According to (1), the profit is: $\pi^A(p, \lambda_1, \lambda_2, f) = [(\bar{c} - (p/\lambda_1))/(\bar{c} - c)]mp - C - \chi(\bar{f})$. From the FOC on the profit and given the interval definition of λ_1, we deduce that $\lambda_1^* = 1$ and $p^* = \bar{c}/2$. λ_2 has to be chosen such that potential users do not pirate at time 2, *i.e.* $1 - (b + E(f) - \bar{b})/\bar{c} \leq \lambda_2^* \leq 1$. Since agents only buy at time 1 without knowing the exact quality of the functionalities, the value $f^* = 0$ maximizes the profit π^A.

- Given the optimal value of p^*, condition (2) finally becomes:

$$\bar{c} \leq 4(b - \bar{b} + E(f))$$

Firm strategy B1 (partial adoption at time 1, only buyers at time 2).

- With strategy B1, the firm compels potential users to split between strategies 1.2 and 1.5 / 2.1. The values of the control variables of the firm $p, \lambda_1, \lambda_2, f$ are then such that:

$$p > 2\left(b + E(f) - \bar{b}\right) \tag{3}$$

$$c < \frac{2\left(b + E(f) - \bar{b}\right)}{\lambda_1} < \bar{c} \tag{4}$$

$$p \leq \frac{2(b + E(f) - \bar{b})(f - E(f)) + \lambda_1((\bar{c} - c)(b + E(f) - \bar{b}) + (f - E(f))kc)}{\lambda_1(\bar{c} - c)} \tag{5}$$

$$p \leq \frac{2\lambda_2(b + E(f) - \bar{b})}{\lambda_1} \tag{6}$$

The distribution of users at time 2 is then depicted by Figure 2.

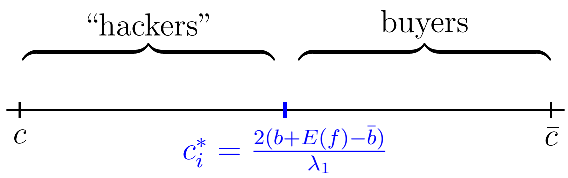

Figure 2: Distribution of users with strategy B1

- In this case, whatever the optimal price p^*, the firm has to persuade agents who have not adopted at time 1 to buy the software at time 2. For that, the software has to be endowed with high quality functionalities, *i.e.* $f^* = \bar{f}$. Formally, the profit is: $\pi^{B1}(p, \lambda_1, \lambda_2, f) = [(\bar{c} - ((2(b + E(f) - \bar{b}))/\lambda_1))/(\bar{c} - c)]mp - C - \chi(\bar{f})$. From the FOC, we deduce that: $p^* = \left[b + E(f) - \bar{b} + k\,(f - E(f))\right]/2$, $f^* = \bar{f}$, $\lambda_2^* = 1$ and $\lambda_1^* = 4(b + E\,(f) - \bar{b})(f - E\,(f))k/[(\bar{c} + c)(f - E\,(f))k - (\bar{c} - c)(b + E\,(f) - \bar{b})]$. Since all parameters are positive, λ_1^* is positive also. Then the corner solution $\lambda_1^* = 1$ is excluded if $4(b + E\,(f) - \bar{b})(f - E\,(f))k/[(\bar{c} + c)(f - E\,(f))k - (\bar{c} - c)(b + E\,(f) - \bar{b})] < 1$.

- Hence, when $(p, \lambda_1, \lambda_2, f)^*$ are put into (3), (4), (5) and (6) the following conditions emerge:

  $$k \geq \frac{3(b + E(f) - \bar{b})}{f - E(f)} \; \textbf{[condition I]}$$

  $$\bar{c} > \frac{(c - k(\bar{f} - E\,(f)))(b + E\,(f) - \bar{b} + k(\bar{f} - E\,(f)))}{(b + E\,(f) - \bar{b} - k(f - E\,(f)))} \; \textbf{[condition II]}$$

  One can verify that the combination of **[condition I]**, **[condition II]** finally makes always true the condition ensuring that λ_1^* takes an interior value $(4(b + E\,(f) - \bar{b})(f - E\,(f))k/[(\bar{c} + c)(f - E\,(f))k - (\bar{c} - c)(b + E\,(f) - \bar{b})] < 1)$. Finally, since providing high quality functionalities is costly, strategy B1 ensures a non negative profit and is then chosen by the firm if:

  $$\chi\left(\bar{f}\right) \leq \frac{m(b + E\,(f) - \bar{b} + k(\bar{f} - E\,(f)))^2}{4k(\bar{f} - E\,(f))} - C \; \textbf{[condition III]}$$

Firm strategy B2 (partial adoption at time 1, buyers and “hackers” at time 2).

- When strategy B2 is used, the firm chooses to distribute agents among user's strategies 1.2 and 1.5 / 2.1 and 2.2. This case occurs if conditions (3) and (4) still hold, as in Strategy B1 and if:

  $$\frac{2\left(b + E\,(f) - \bar{b}\right)}{\lambda_1} < \frac{p}{\lambda_2} \leq \bar{c} \tag{7}$$

  The distribution of users at time 2 is depicted by Figure 3.

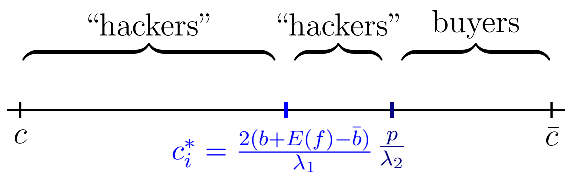

Figure 3: Distribution of users with strategy B2

- Formally, the profit is: $\pi^{B2}(p, \lambda_1, \lambda_2, f) = [(\bar{c} - (p/\lambda_2))/(\bar{c} - c)]mp - C - \chi(\bar{f})$. Whatever λ_1 (since λ_1 does not appear in the equation profit), the firm chooses the optimal values of $(p, \lambda_2, f)^*$ from the FOC, *i.e.* $p^* = \bar{c}/2$, $f^* = \bar{f}$ and $\lambda_2^* = 1$. λ_1^* has not an unique possible value but has to be chosen in the interval $[4(b + E(f) - \bar{b})/\bar{c}\ ,\ 4(b + E(f) - \bar{b})(\bar{f} - E(f))k/((\bar{c} - c)(\bar{c} - 2b - 2E(f) + 2\bar{b}) + 2(\bar{f} - E(f))kc)]$ to fulfill (4), (5) and (7).

- Given the optimal value of p^*, (3) becomes $\bar{c} > 4\left[b - \bar{b} + E(f)\right]$ while (4), (5) and (7) always hold since the optimal value of λ_1^* fulfills these conditions.

  Similarly to [**condition III**], strategy B2 is used by the firm if:

$$\chi(\bar{f}) \leq \frac{m\bar{c}^2}{4(\bar{c} - c)} - C \text{ [\textbf{condition IV}]}$$

Conclusion of the proof.

If $\bar{c} \leq 4\left[b - \bar{b} + E(f)\right]$, two strategies are available: strategy A and strategy B1. The comparison of profits shows that strategy A is always preferred by the firm to strategy B1 even if there is no costs incurred by the advanced functionalities. In this case, the firm tries to prevent piracy by choosing the maximum level of monitoring and chooses the software price such that all users adopt its software at time 1. Consequently, the firm sells a restricted version with the advanced functionalities disabled.

If $\bar{c} > 4\left[b - \bar{b} + E(f)\right]$, the firm chooses strategy B1 if [**condition I**], [**condition II**] and [**condition III**] hold. Here, the firm accommodates some piracy (with strategy B1, λ_1 takes an interior value) but provides an extended version of its software to foster delayed purchases. These "hackers" who have adopted the software at time 1 diffuse the information on the software quality to other potential users. Then, the firm is able to sell its software to the remaining potential users who are incited doing so by the usefulness of the advanced functionalities. If [**condition II**] does not hold, the optimal strategy is strategy B2 but only if [**condition IV**] holds. Lastly, in all the other cases, the firm will not produce the software (see Table III).

Table III: Possible equilibria and conditions on parameters when $\bar{c} > 4\left[b - \bar{b} + E(f)\right]$

<table>
<tr><td></td><td colspan="2">[condition I]
holds</td><td>[condition I]
does not hold</td></tr>
<tr><td rowspan="2">[condition II] holds</td><td>[condition III]
holds</td><td>[condition III]
does not hold</td><td rowspan="2">$\emptyset$</td></tr>
<tr><td>B1</td><td>$\emptyset$</td></tr>
</table>

<table>
<tr><td></td><td>[condition IV]
holds</td><td>[condition IV]
does not hold</td></tr>
<tr><td>[condition II]
does not hold</td><td>B2</td><td>$\emptyset$</td></tr>
</table>

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