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Can open sourcing lead to inferior standards?

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ABSTRACT

I investigate the effect of open source on standardization outcomes in a market with positive network externalities. In a closed source world, it seems reasonable to assume that the probability of a standard being chosen is positively correlated with its quality. Open source may weaken or invert this relationship by giving Bertrand competition losers a second chance. It however follows that though open source leads to more competition and more standardization, the chosen standard will be the same as when open source is not an option.

JEL Classification: H41, L12, L86, L96

Keywords: open source software, FLOSS, standardization, network externalities, competition

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1 Introduction

Traditionally, software was not only produced for sale on a market, but also through a community model where software products and their blueprints, the source code, were shared. Anyone was free to take the existing software, extend it, and sell it with or without the extensions. This is called *open source*. Traditional open source was however prone to free riding, and in the end, free riding firms crowded out much of the community effort. During the 1980s, an institutional innovation was made that revived the community model: the infective open source license. Under this license, any product based on a community product must become a community product itself.

It is perhaps no surprise that infective licenses has proven popular among software enthusiasts. However, firms have also managed to make profits within the terms of the license, and have even put their own commercially developed products under it. Because this effectively amounts to giving away the product for free, they must find open source-related profits to be larger than the profits from the product's commercial sale.

Software markets typically display network externalities: the utility consumers derive from software increases in the number of other users. Combined with large fixed costs for software development and almost zero marginal costs for producing copies, this often leads to a relatively small number of firms operating in a given software market. While lack of competition may harm consumers through higher prices, a small number of products benefits them through more standardization and consequentially larger network externalities.

Many firms thus compete for software markets in which only one or a few of them will become dominant players. One would expect that the outcome, i.e. which firm will become dominant, is related to product quality. Losing firms will on average have developed inferior products relative to competition winners. However, losing firms also have the lowest opportunity costs for open sourcing, and are consequentially the most likely to do so. If they get a second shot at becoming dominant market players by open sourcing, society will more often standardize on an inferior product then it would otherwise do. I call this the *inferior standards hypothesis*. This paper investigates if this hypothesis is likely to be true. It follows that it is indeed the inferior firm that has the strongest incentive to open source, but that the mass of consumers will not change to the inferior product. Thus open source does not lead to inferior standards.

The paper is structured as follows. First, I summarize previous research on open source and connect the theory to actual cases of open sourcing. Then, I present a model of competition on a software market with network externalities to which I add open sourcing behavior by firms. The last section concludes.

2 Open source – an overview

There are a few previous papers on markets in which both closed and open source products compete. The ones closest to my own are probably those of Casadesus-Masanell and Pankaj Ghemawat (2006) and of Jean-Michel Dalle and Nicolas Jullien (2003). Both papers feature competition between an inferior closed source incumbent and a superior open source entrant. The existence of network externalities makes it hard for the entrant to gain market share. Jürgen Bitzer (2004) adapts a Hotelling model to show that more software heterogeneity (e.g. in the form of incompatibilities) leads to less competitive pressure from open source on the closed source incumbent. Klaus Schmidt and Monika Schnitzer (2003) recognize the potential for underinvestment in open source software, but make a case against public subsidies for its development.

Open source software, or OSS, is typically available at its zero marginal cost, while proprietary software often is not. This is reminiscent of the literature on mixed oligopolies in which a private, profit maximizing firm competes with a public welfare maximizing firm. In a symmetrical, unrestricted and homogeneous mixed oligopoly, the public firm should crowd out the private one completely. This effect has been dubbed the *Cournot Paradox* by Lorenz Nett (1993). Similarly, one could expect OSS to drive out proprietary software in the absence of network externalities, even though profit maximizing firms may stay in existence by producing OSS instead.

OSS is often characterized as being developed by a community of intrinsically motivated volunteers. A significant proportion of OSS however has proprietary and commercial origins. Half of all open source workers are directly or indirectly supported by corporations, while one-third of the world's largest software companies were involved in significant open source activities in 2001 (Maurer and Scotchmer 2006, pp. 16-17). At the same time, the number of core OSS developers is not keeping pace with industry growth (Open Source Think Tank 2007), possibly because the pool of voluntary OSS developers has been exhausted. The large and increasing role that firms play in the production of OSS is an argument against looking at open source as being produced by public welfare maximizing entities. Instead we should take the perspective of the profit maximizing firm when considering open source. Which incentives do they have to support its further development?

At first sight, it seems strange that a for-profit firm would give away its product for free. An enlarged community of users may lower development costs and raise consumer utility, but that in itself will hardly make any firm hard cash if it cannot charge for its products. Most open source-related profit opportunities derive from the positive network externalities that software packages typically display. A primary revenue category is the sale of complementary proprietary products (cf. Maurer and Scotchmer 2006, IIc). The network effect on the complementary product offsets the loss of revenue from the open sourced product. The firm may for example release only part of its source code, so that it serves as a free but inferior substitute with positive network externalities on the firm's proprietary product (Mustonen 2005). It may sell product related services or bundle its open sourced software with its other products (West and Dedrick 2001, p. 100). A dual license allows the firm to price-discriminate between users, giving away free copies to those consumers who would not have bought the product in any case, while discouraging free-riding competitors at the same time.[1]

Profits for open source firms are typically much smaller than for successful oligopolistic proprietary players. However, standardization losers with small (expected) market shares face low opportunity costs for open sourcing (cf. Lerner and Tirole 2002, pp. 225-227). They can

1 A dual license allows the source to be used and spread under either one of two licenses. Usually, one is an infective open source license. This license is attractive for consumers, who do not make derivative works, as well as for members of the development community, who are likely to prefer publishing derivative work under an infective license as well. The other license is a proprietary one, for which the owner can charge a licensing fee. Unlike the open source license, the proprietary license allows the software to be included in other firms' proprietary packages. In this way, the firm can differentiate between individuals who most likely would not have bought the product anyway (but provide valuable feedback and network effects), and firms that continue to pay licensing fees.

profitably switch from selling the product itself to supplying complementary goods to their now open sourced product. Alternatively, they may sell the product to the open source community.

Open sourcing is not always rational in the narrow sense of the word. Sometimes, open sourcing takes place to hurt the profits of a competitor. Doing so may give the open sourcing firm's future threats more credibility and may deter the competitor from entering other markets in which it is active as a proprietary player.

Let us consider how well the theory applies to actual corporate decisions on open sourcing by looking shortly at nine prominent cases. Sun Microsystems created a dual-licensed twin of its ill-fated *StarOffice* suite, *OpenOffice*, which now successfully competes with Microsoft's *Office*. In 2005, Sun removed the proprietary license, and completely open sourced it (OpenOffice.org Community Council 2005, West 2003 p. 1276). Sun also released its operating system for servers and workstations *Solaris* under an open source license after it came under threat from both Windows and Linux (West 2003 p. 1276). The company put the *Java Development Kit* under an open source license as well (Sun 2007). This may be related to Microsoft's earlier decision to stop shipping *Java* with Windows, and to remove *Java* support from its *Internet Explorer* browser.

Microsoft's successful standard setting has driven the open sourcing of other software as well. The origins of the *Mozilla Firefox* browser can be traced back to Netscape's famous *Netscape Communicator*, which lost a standardization battle with Microsoft's *Internet Explorer* and was subsequently open-sourced (West and Dedrick 2001, p. 100). In 2003, IBM, HP and Sun started to sponsor the project to ensure both future development and compatibility with their own Unix systems (West and Gallagher 2006, p. 324).

IBM has also sponsored other open source development, and released some of its key technologies under an open source license, possibly as a way to become more independent of Microsoft (West and Dedrick 2001, p. 104; West 2003, pp. 1269, 1272-1274; West and Gallagher 2006, p. 326). Google is sponsoring open source in a similar way and may use it as a tool to compete with Microsoft.

Two well known examples are *MySQL* and *Qt*. The MySQL AB *MySQL* database is dual-licensed. Initially it discriminated between its users on the basis of platform: Unix and Linux users were offered an open source license, while Windows users were offered a proprietary one (Välimäki 2003). Later it switched to a classic dual licensing scheme. Although the open sourcing of *MySQL* was not strictly speaking caused by a lost standardization battle, it can thank a large part of its standard-setting success to its open source license. TrollTech started dual-licensing its *Qt* toolkit after the open source community threatened to write a competing program (Weber 2004, pp. 239-241). In 2007, TrollTech announced that it will actively cooperate with the open source community on a cross-platform multimedia framework.

The 3D modeling program *Blender* was bought by the open source community after its previous owner went bankrupt (Blender Foundation 2007). The community managed to raise the required EUR 100 000 in just seven weeks, refuting standard economic theory on the supply of public goods and the free-rider problem. Having lost in proprietary competition, it is now the dominant open source modeling program (Slashdot 2007).

The cases above are not representative of open source in general, because both community driven projects and firms that have decided against open sourcing, have been omitted. Still, we can see some patterns in corporate open sourcing decisions. In four out of the above nine cases, strategic considerations played a role. In seven cases, market share, and thus standardization were a driving force. It indeed seems to be the case that firms open source under pressure from strong competitors. Yet significantly, in none of the cases where the firm failed to capture a large market share in a proprietary form, has it succeeded to do so as open source.

3 A benchmark model

To investigate the inferior standards hypothesis, I develop a model with homogeneous consumer preferences and strictly positive network externalities. Consumers are rational and forward-looking, but cannot coordinate their choices. Consumer behavior is largely the same as in the model of Ramon Casadesus-Masanell and Pankaj Ghemawat (2006), which features downward-sloping demand functions and myopic consumers.

Two firms choose to develop software for a market which will exist for a large number of T periods. One of the firms (A) manages to create the better product with quality $\alpha = 1$. The other firm (B) ships a product with quality β, such that $0 < \beta < 1$. Firms A and B also have initial market shares p and $1 - p$ before the first period, which can be thought to have emerged while consumers were still much in the dark about relative qualities and the likely market outcomes.

Firms have no marginal costs for selling extra copies of their software (cf. Bitzer 2004). Thus their per-period profit (after development) equals price P times their market share. Firms cannot cross-subsidize their product and sell it at a negative price, for example by bundling it with other software. Also, they cannot discriminate between their own and their competitor's customers. Even if a firm has a zero market share, it (or its software) stays in existence and continues to be a potential alternative for consumers.

There are several Nash equilibria in which the firms can end up. To begin with, there are two Bertrand equilibria (COMP) in which both firms compete and undercut the other's prices. Because the products' utilities are not identical, one of the firms will have to set a zero price, while the other's price is still positive. The other firm can then marginally undercut its competitor and gain the entire market. In the following period, the winning firm's market share is larger, and it can raise its prices because of the increased network externality (MON). Firms are thought to understand the above, and set equilibrium prices from the first period onward, rather than reacting to each other in a stepwise period-by-period fashion. The number of Bertrand equilibria is two because either firm can win the competition phase.

The third equilibrium arises when both firms collude (COL) and charge the full utility of their customers. Note that unlike in iterative prisoners' dilemma games, the payoff from the competition path is higher in the periods after the first. If it ever pays to compete, it pays to do so in the first period. Thus, given that collusion occurs in the first period, the firms do not have an incentive to deviate from it later. It also means that the game is stationary after the first period, and that the assumption of a large number of T periods is equivalent to a two-period game where the first period has a small weight.

I rule out by assumption a collusion equilibrium in which both firms cooperate to sell the superior product, or where one of the firms pays the other to stop selling its product. I cannot imagine real-world instances of such an equilibrium which would not invite entry of free-riding competitors, give the previously dominated firm an incentive to compete, or violate anti-trust law.

To determine which equilibrium is chosen, we first have to look at the consumers' utility functions. Consumers maximize the sum of utility gained from software use minus the sum of prices they pay at each period *t*:

$$\sum_t U_t - P_t. \quad (1)$$

The per-period utility *U* for the respective products is dependent on product quality, the size of the externality ϕ (with $\phi > 0$), and on the respective user bases:

$$U_A = 1 + \phi \cdot p \quad (2)$$

$$U_B = \beta + \phi \cdot (1 - p). \quad (3)$$

From the utility functions (2) and (3), we then derive the prices under collusion, as well as prices after one of the firms has captured the whole market. They can be seen from Table 1.

Collusion	***A* monopolist (*p*=1)**	***B* monopolist (*p*=0)**
$P_{ACOL} = U_A = 1 + \phi \cdot p$	$P_{AMON} = U_A - U_B = 1 - \beta + \phi$	$P_A = 0$
$P_{BCOL} = U_B = \beta + \phi \cdot (1 - p)$	$P_B = 0$	$P_{BMON} = U_B - U_A = \beta - 1 + \phi$

Table 1: collusive and monopolistic prices for firms A and B.

If it were the case that consumers could coordinate on their choice of software package, they would effectively be able to negotiate a price somewhere between zero and $1 - \beta$ with firm *A*. However, I do not believe such coordination to be feasible in reality, and I therefore rule out such behavior from the model by assumption. For a consumer to switch to a different software package, he must therefore believe that to be his dominant strategy, i.e. to yield the highest utility irrespective of what other consumers do. If switching is not the dominant strategy, consumers will stick to their original software and market shares will not change. This is equivalent to saying that consumers' individual decisions are too small to affect the market, and that software use is path-dependent.[2] A firm that wants to gain market share must thus offer a price that is low enough make individual consumers switch, regardless of what his peers do.

The utilities associated with the two choices consumers face can be seen from Table 2, both for the situation when *A* is able to win Bertrand competition (first column), and when *B* is. Using Table 2, substituting utility levels from Equations (2) and (3), and prices from Table 1 this criterion can be rephrased as

$$0 < P_{ACOMP} < (1-\beta)+(2\phi p-\phi) \tag{4}$$

for *A* to win, and

$$0 < P_{BCOMP} < (\beta-1)+(2\phi(1-p)-\phi) \tag{5}$$

for *B*. Let us call the firm for which such a price exists the dominant firm, and the other one the dominated firm. These are the respective Bertrand winner and loser. Because

$$(1-\beta)+(2\phi p-\phi) \;=\; -\left[(\beta-1)+(2\phi(1-p)-\phi)\right], \tag{6}$$

the two conditions show that the whole parameter space is divided into two areas with one dominant firm in each; there will always be exactly one dominating firm, and exactly one dominated one.

	firm *A* dominant	**firm *B* dominant**
individual chooses *A*	$T\cdot U_A - P_{ACOMP} - (T-1)P_{ACOL}$	$T\cdot U_A - 0 - (T-1)P_{ACOL}$
individual chooses *B*	$T\cdot U_B - 0 - (T-1)P_{BCOL}$	$T\cdot U_B - P_{BCOMP} - (T-1)P_{BCOL}$

Table 2: lifetime payoffs to individuals for both products under the assumption that other consumers do not switch.

When will the dominant firm try to compete? Maximizing profits for firm *A,* competition is profitable if

2 In reality, one does not have to look far to see such inertia. For example, both the QUERTY (computer) keyboard and the VHS video cassette are thought to be inferior to contemporary alternatives, yet both managed to become a de facto standard due to a larger installed base, and subsequent path dependency.

$$\lim_{T\uparrow\infty}\left[P_{ACOMP}+(T-1)P_{AMON}>T\cdot p\cdot P_{ACOL}\right]. \tag{7}$$

Since we assume *T* to be very large, we can disregard the profits in the first, switching period, and simplify this to

$$P_{AMON}>p\cdot P_{ACOL}. \tag{8}$$

Similarly, *B* competes if

$$P_{BMON}>(1-p)P_{BCOL}. \tag{9}$$

Taking Equations (8) and (9), and substituting prices from Table 1, we get

$$1-\beta+\phi>p(1+\phi p) \tag{10}$$

and

$$\beta-1+\phi>(1-p)(\beta+\phi(1-p)) \tag{11}$$

respectively. Rewriting Equation (10) as

$$1-\beta-p-\phi p^2+\phi>0, \tag{12}$$

and Equation (11) as

$$\beta-1-\beta(1-p)-\phi(1-p)^2+\phi>0, \tag{13}$$

and taking into account the constraints on the parameters, we can then see that the occurrence of the competition equilibria increases in the size of the externality ϕ and in the dominant firm's relative product quality, while it decreases in the dominant firm's initial market share. Given that a firm can win Bertrand competition, its incentive to do so is thus stronger when its product is better and when its market share under collusion is smaller, as well as when the externality is larger.

Graphically, we can take the union of the areas in Equations (4) and (8) to obtain the area where *A* both can and will compete (top row of Illustration 1, first column). The union of the areas (5) and (9) gives us the area where *B* can and will compete (top row, second column). This area is empty for the model's default setting of $\phi=0.5$, but qualitative outcomes are robust to other settings where this is not the case. In the remainder of of the parameter space, a preference for the collusion equilibrium prevails. From these preferences, the three actual equilibria arise. They can be seen seen from the third column.

4 The model extended: open source

Now suppose that both firms have an option to open source (OS) their software. This allows them to make an outside profit of $\pi_{OS} > 0$ by selling a complementary proprietary good or service. The good or service is thought not to affect the attractiveness of primary product. For consumers, open sourcing means that the firm will credibly commit to a zero price for all future periods (cf. Feller et al. 2005, p. 101). By committing to a zero price, firms also implicitly make any current or future collusion impossible. Note that in the benchmark case, it is not possible for firms to commit to low prices because they always have an incentive to raise them again when their user base grows, and consumers know this.

Changing Table 2 to allow for open sourcing by one or both firms, we obtain Table 3 and Table 4 respectively. Between Tables 2 and 3, only one thing changes: the dominated open sourcing firm commits to a zero price. However, it would be forced to set a zero price under Bertrand competition in any case, and thus the dominating product's relative attractiveness is unchanged. To prove this, we can resubstitute utilities into Table 3 and see that the area in which *A* is dominant is given by

$$0 < P_{ACOMP} < (1-\beta) + (2\phi p - \phi), \qquad (14)$$

which indeed equals equation (4). Hence, open source does not change the winner of Bertrand competition.

When the dominant firm open sources itself (Table 4), its zero price is strictly lower than under Bertrand competition. Therefore, winning Bertrand competition must always be feasible for an open sourcing firm if it is feasible when it does not open source. I omit the case where only the dominant firm open sources because it then always strictly profitable for the dominated firm to do so as well.

	firm *A* dominant	**firm *B* dominant**
individual chooses *A*	$T \cdot U_A - P_{ACOMP} - (T-1) P_{AMON}$	$T \cdot U_A - 0$
individual chooses *B*	$T \cdot U_B - 0$	$T \cdot U_B - P_{BCOMP} - (T-1) P_{BMON}$

Table 3: payoffs to individuals when the dominant firm competes, and the other responds by open sourcing.

	firm *A* dominant	**firm *B* dominant**
individual chooses *A*	$T\cdot U_A - 0$	$T\cdot U_A - 0$
individual chooses *B*	$T\cdot U_B - 0$	$T\cdot U_B - 0$

Table 4: payoffs to individuals when both firms open source.

Even if open source does not change the Bertrand winner, it may still alter firms' incentives to compete or collude. We write

$$T\cdot\pi_{COL} = T\cdot p(1+\phi\cdot p) < T\cdot\pi_{OS} \tag{15}$$

$$\pi_{COMP} + (T-1)\pi_{MON} = (1-\beta+2\phi p-\phi) + (T-1)(1-\beta+\phi) < T\cdot\pi_{OS} \tag{16}$$

to see when *A* prefers open sourcing over its alternatives, and

$$T\cdot\pi_{COL} = T\cdot(1-p)(\beta+\phi(1-p)) < T\cdot\pi_{OS} \tag{17}$$

$$\pi_{COMP} + (T-1)\pi_{MON} = (\beta-1+2\phi(1-p)-\phi) + (T-1)(\beta-1+\phi) < T\cdot\pi_{OS} \tag{18}$$

to see when *B* does. In the limit, we can rewrite these equations as

$$p(1+\phi\cdot p) < \pi_{OS} \tag{19}$$

$$1-\beta+\phi < \pi_{OS} \tag{20}$$

for *A*, and

$$(1-p)(\beta+\phi(1-p)) < \pi_{OS} \tag{21}$$

$$\beta-1+\phi < \pi_{OS} \tag{22}$$

for *B*.

From the above we can then see that open sourcing becomes more attractive relative to collusion for lower market shares and product qualities, and for lower values of the network externality. For a competing dominant firm, the attractiveness of open sourcing decreases in relative product quality and the size of the externality. A dominated firm that faces competition will always choose to open source, since its expected profits from competition are zero. Firms' resulting strategic choices can be seen from Illustration 1 for various settings of the open source profit.

The model is robust to parameter changes within its broader assumptions. It explicitly allows for the ratio of product qualities, the ratio of market shares, the outside open source profit π_{OS}, and the network externality ϕ to take any nonnegative value. Setting ϕ larger than the default value of 0.5 causes to B compete in some or all cases where it is dominant, but does not change the qualitative outcomes of the model.

5 Conclusions

I have asked whether open source can lead to inferior standards by giving Bertrand competition losers a second chance. I show that firms' incentives to open source decrease in product quality, and that competition losers always have an incentive to open source. However, for the competition winner, open sourcing by the other firm has the same implications as ordinary Bertrand competition, and it is still able to lower its prices enough to preempt any loss of market share. The inferior standard will not outcompete the superior one because of open source, and therefore the positive relationship between product quality and standard setting is not reduced or reversed. This outcome of this model is reminiscent of Casadesus-Masanell and Ghemawat (2006), where Microsoft (the incumbent) is forward-looking and lowers prices to preempt an all-too-large Linux market share. Also, section 2 shows that the outcome is in line with real instances of corporate open sourcing.

While the Bertrand winner is unaltered by open sourcing, open source does have an effect on markets by giving firms an incentive to give up collusion. Even if only one firm open sources, the other is forced either to compete fiercely, or to open source itself. Thus the existence of an outside profit from open sourcing increases competition.

We may also approach the matter from the other side, and ask under which circumstances the dominant product will be open source. Within the model, this can only happen when profits from open sourcing are very large so that the dominant player open sources. Outside of the model, there is another possibility. Subsequent development may be more effective for open source products, and product support may be better, so that the formerly dominated product achieves dominance on its own merits.

One could compare the model's product utilities in the different equilibria, but conclusions on consumer welfare or society's total surplus fall outside the scope of this paper. Open source not only has an effect on market outcomes, but also on investment decisions – it reduces incentives to invest in the development of new software because increased competition reduces profits. In terms of the model: one of the firms may choose not to enter the market in the first place (cf. Schmidt and Schnitzer 2003). At the same time, closed source development is known to lead to significant amounts of unnecessary duplication of effort because of the transaction costs of software licensing. The question which of these two market failures is greater, remains.

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Figures

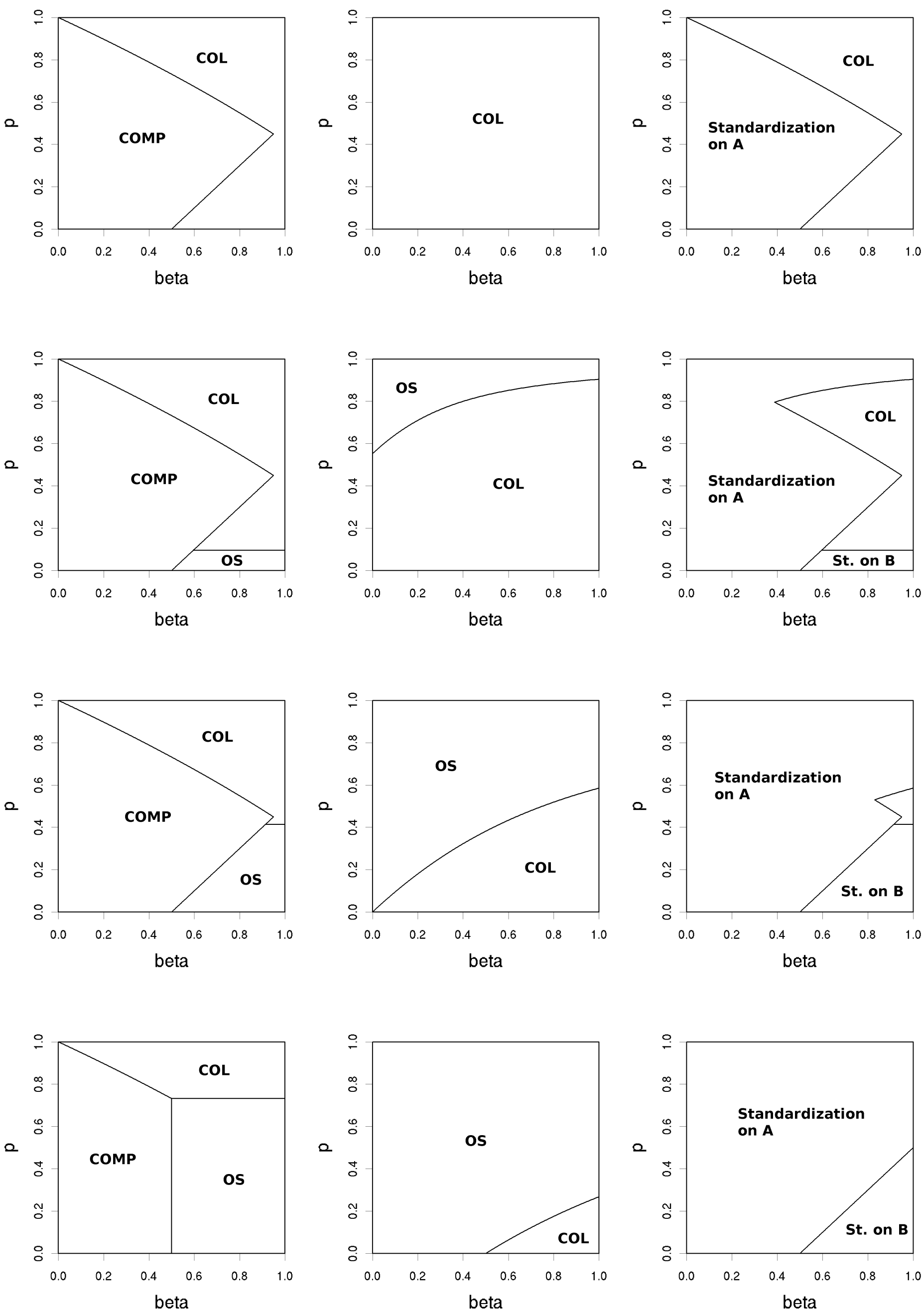

Illustration 1: Preferred strategies for A (first column) and B (second column), as well as equilibrium solutions (third column) under open sourcing for various values of $\phi=0.5$*. The rows give outcomes for values of* π_{OS} *equal to 0, 0.1, 0.5 and 1 respectively. Note that the outcome for* $\pi_{OS}=0$ *is identical to the benchmark case where open sourcing is not an option.*

Aboa Centre for Economics (ACE) was founded in 1998 by the departments of economics at the Turku School of Economics, Åbo Akademi University and University of Turku. The aim of the Centre is to coordinate research and education related to economics in the three universities.

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Aboa Centre for Economics (ACE) on Turun kolmen yliopiston vuonna 1998 perustama yhteistyöelin. Sen osapuolet ovat Turun kauppakorkeakoulun kansantaloustieteen oppiaine, Åbo Akademin nationalekonomi-oppiaine ja Turun yliopiston taloustieteen laitos. ACEn toiminta-ajatuksena on koordinoida kansantaloustieteen tutkimusta ja opetusta Turun kolmessa yliopistossa.

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