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(SELF-)REGULATION OF A NATURAL MONOPOLY VIA COMPLEMENTARY GOODS – THE CASE OF F/OSS BUSINESS MODELS

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Abstract: The paper investigates the optimal regulation of a (software) firm which acts as a natural monopolist, who also offers a complementary good (IT services) on a competitive market. It is shown that a first-best-regulation accompanied with an optimal taxation schedule in order to compensate the losses is equivalent to a cross-subsidisation of the software by the complementary good. This is the same result as in business models with Free/Open Source Software (F/OSS). Even if a price of zero for F/OSS does not reflect the use of resources for software development, the price system in F/OSS related markets leads to a welfare improving allocation. F/OSS license models can be seen as institutional arrangements which mimic a social planner.

Keywords: natural monopoly, regulation, Ramsey pricing, welfare, complementary good, Open Source Software.

JEL-Classification: L51, H21

1 Introduction

Software is a special good: The development of software leads to high first-copy-costs while the reproduction and distribution of software licenses is characterized by very low marginal costs close to zero. This reflects that software, as a digital good, implies nonrivalry in consumption. The economics of software including the analysis of its market-based allocation are extensively discussed in the literature which, however, addresses predominantly specific issues of software and software markets (cf. Church and Gandal (1992), Quah (2003), Gröhn (1999)). This paper focusses on the subadditive cost function for software licenses. Due to this cost structure, the efficient production and distribution of commercial software requires a natural monopoly. Such a monopolistic market may be contestable, preventing the supplier from using his market power by charging the monopoly price. This argument is often claimed in defense of large powerful software firms when they are drawn into juristical conflicts regarding violations of competition law. However, software is also characterized by network externalities and other switching costs on the demand side. Such switching costs are the higher the more the software is based on proprietary standards. This theoretical objection to full contestability is also proven by empirical studies (cf. Gandal (1995), Gröhn (1999)).

Hence, software markets are characterized by imperfect competition, and the market power of some software firms calls attention of competition policy (cf. Gilbert and Katz (2001), Hall and Hall (2000)).

The usage of software requires additional complementary goods. Such complementary goods are, e.g., hardware, consulting, IT services like customization, administration, and support. Not only professional users like firms have a need for such services, but also private households do. With exception of hardware, which is often a matter of a separate decision, most of these services are self-produced by the households. But it has to be pointed out, that also a purchase of proprietary software in a store is always a purchase of a *bundle* of goods, containing software and complementary goods like a physical CD/DVD, a handbook, and even the packing. Especially professional customers do not have a willingness to pay for software only, but for a complete software “solution”, including many of the goods and services mentioned above. It can then be stated that markets for software (licenses) and markets for complementary goods are closely related. But while the former is characterized by natural monopolistic power (moderated by contestability of some degree), the latter can be considered to be close to competitive markets.

In the last decades, an alternative model of software production has been evolved and becomes more important: Open Source Software (OSS) or Free Software (FS) – in the following combined to F/OSS – is characterized by giving the customer the freedom to use the software for any purposes, to investigate and change the code, and to redistribute it almost without limitations (cf. www.opensource.org and www.fsf.org). This implies that most of F/OSS, even if the basic idea of free software is not anti-commercial, can be obtained free of charge via the internet. The free access to the code and therefore the possibility of code improvements by other people is a core feature of the production philosophy which is, among others, responsible for its success. While in the first decade(s) F/OSS was primarily developed by decentralized groups of volunteers without explicit contracts, recent studies show that more than 40% of actual F/OSS is developed by professionals within IT firms (cf. Boston Consulting Group and Open Source Technology Group (2002)). Also F/OSS is regulated by legal institutions, i.e. by license models like the GNU General Public License (GPL) or the BSD license (cf. www.gnu.org/licenses). Proprietary licenses are designed to give as much power to the owner of the “intellectual property” (the software code) as possible, and

to give only some rights to the customer as it is necessary to skim his willingness to pay. Contrary, F/OSS licenses give most of the rights to the user, and, as a consequence, F/OSS code becomes in most cases a quasi-public good with free access and non-rivalry in usage. Contributions to F/OSS projects, regardless whether they are done by volunteers or by firms, are then contributions to quasi-public goods. Therefore, F/OSS business models must be based on supplying *bundles* of goods, containing software and complementary goods (e.g. consulting, support, pre-configuring and pre-compiling the software, more intensive debugging). Since most professional customers have a willingness to pay for the complete bundle, they do not care about which amount of the price reflects the efforts in contributing to a F/OSS project. This may inspire the interpretation that these customers “cross-subsidize” the development of F/OSS, and customers who do not demand complementary goods benefit from this business model because of their free access to the software. Kooths et al. (2003) raise the argument that F/OSS partially suspends the price system and hence the regulatory power of competitive markets. The possibility of free access to most of F/OSS would not reflect the use of resources for software development, and create severe distortions in relative prices. Hence, the allocation of resources is also distorted and software markets fail to be efficient. In particular, F/OSS business models which are based on cross-subsidisation would create false relative prices and would be a source of inefficiency.

The paper investigates this argument whether a price close to zero for F/OSS is a source of inefficiency and loss of welfare. It is shown in chapter 2 that under certain conditions an optimal regulation of a monopolistic commercial software supplier, accompanied by an optimal taxation to compensate the supplier’s losses, yields the same result as F/OSS business models. In chapter 3, the result is briefly interpreted: F/OSS license models are legal institutions, created by the markets themselves, which have a similar function like a regulator or social planner. These institutions help to reduce market power and to enforce competition, and they create further positive spillover effects by giving free access to the knowledge stock and by establishing open standards.

2 The model

Consider a good q_1 (“software”), which is produced by a natural monopolist. The cost function is characterized by very low constant marginal costs $c_1 \geq 0$ and high fix costs F (“first-copy-costs”) which implies a subadditive cost function. In addition to q_1 there is a complementary good q_2 (“IT services”), so that the demand depends on both prices: $q_i(p_i, p_j)$, $i, j = 1, 2$, $j \neq i$. For complementary goods $\partial q_i / \partial p_i < 0$, $\partial q_i / \partial p_j < 0$, $i, j = 1, 2$, $j \neq i$ holds true. In the following, strict complementary is assumed so that both goods will be consumed in a fixed ratio. By normalization of quantity measures it is assumed without loss of generality that $q_1 = q_2$ holds true for all optimal consumed quantities. Thus it follows

$$\frac{\partial q_i}{\partial p_i} = \frac{\partial q_j}{\partial p_i}, \quad i = 1, 2, j \neq i. \quad (1)$$

The complementary good is produced with constant marginal costs $c_2 > 0$ and it is traded in a more or less competitive market. The supplier may be able to charge a price with a markup on marginal costs: $p_2 = (1 + \beta)c_2$, $\beta \geq 0$. Without loss of generality we assume for simplicity that $\beta = 0$ holds true.

The normalization of the quantities ($q_1 = q_2$) does not rule out the possibility that a part of customers does only demand good 1 and not the complementary good. In case of software markets some customers have no need for IT services or they produce these goods by themselves. This motivates the following assumption that demand q_1 is more sensitive to variations of price p_1 than to variations of the complementary good price p_2 :

$$\left| \frac{\partial q_1}{\partial p_1}(p_1, p_2) \right| > \left| \frac{\partial q_1}{\partial p_2}(p_1, p_2) \right| \quad \Rightarrow \quad \frac{\partial q_1}{\partial p_1}(p_1, p_2) < \frac{\partial q_1}{\partial p_2}(p_1, p_2) < 0 \quad (2)$$

Because the supplier of good 1 is a natural monopolist he will choose a monopolistic price $p_1^M \gg c_1$ according to the Amoroso-Robinson condition. It is assumed that this price covers the fix costs because otherwise there will be no market supply (see figure 1, left side).

Regulation of a monopoly aims at a welfare maximizing supply (cf. Braeutigam (1989)).

Welfare is defined as the social surplus, containing consumer and producer surplus:

$$W_1 = \int_{p_1}^{\infty} q_1(s, p_2) ds + (p_1 - c_1)q_1(p_1, p_2) = \int_0^{q_1} (p_1(s, p_2) - c_1) ds$$

with $p_1(q_1, p_2)$ as the inverse demand function. A first-best regulation with $\max_{p_1} W_1$ leads to the solution $p_1^* = c_1$ which is not only welfare-maximizing with respect to market 1, but

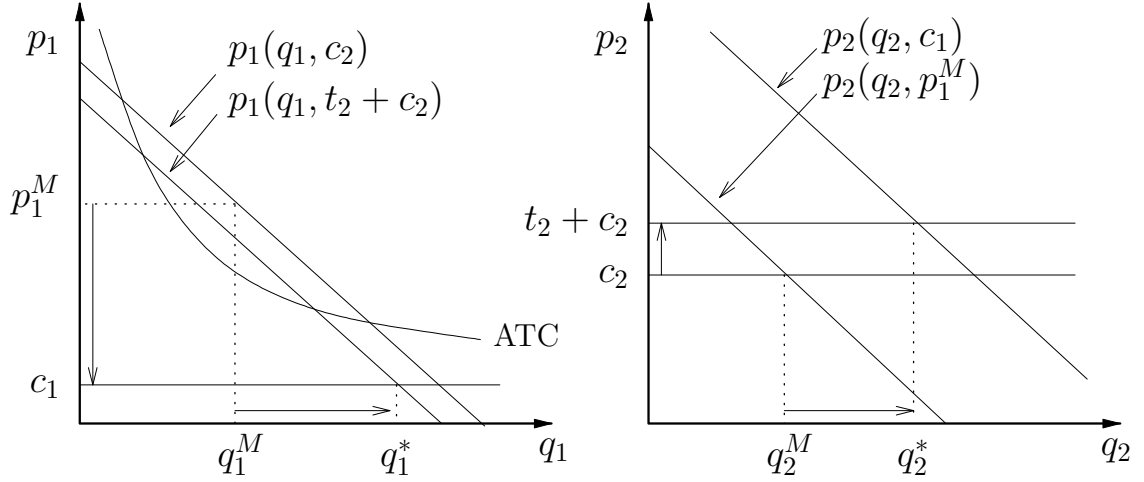


Figure 1: Regulation via the complementary good

also provides large positive spillover effects to the complementary market 2. Due to price regulation the demand curve for good 2 shifts outwards (see figure 1, right side). However, the first-best regulation induces a loss F . In order to ensure a market supply of good 1 the loss has to be compensated. This can be done either by a second-best regulation where the price equals total average cost, or the loss has to be compensated by a tax.

Usually, a poll tax is recommended because it induces no substitution effects and hence minimizes the dead weight loss. In this case, however, a poll tax is not appropriate. First, the optimality of a poll tax requires an efficient allocation before taxation. But by assumption, the monopolistic pricing in market 1, including negative spillovers in market 2, is not efficient and is the reason for regulation. Second, with a poll tax also people finance the fix cost F who have no demand for good 1 or good 2 and hence do not benefit from the regulation. An optimal taxation would require a revelation of the individual willingness to pay for a first-best regulation. The regulation $p_1 = c_1$ can be interpreted as a public good which will be financed by the customers of good 1. The willingness to pay t_1 is obviously given by $t_1(q_1) = p_1(q_1, p_2) - c_1$. Unfortunately, the preferences are not observable, and a revelation mechanism is often very (possibly prohibitively) expensive, especially in large markets, or it may fail to exist (cf. d'Aspremont et al. (1990)).

Instead, we assume a commodity tax on the quantities of good 1 and/or good 2. The market prices are then calculated by adding the tax rate t_i to the marginal costs: $p_i = t_i + c_i$, $i =$

1, 2. Since the taxation should compensate the supplier for his losses in case of a first-best regulation we have:

$$t_1 q_1 + t_2 q_2 = F \quad \Rightarrow \quad t_2 = \frac{F - t_1 q_1}{q_2} \equiv f(t_1) \quad (3)$$

A second-best regulation where price equals total average costs is then a special case of a taxation schedule with $t_2 = 0, t_1 = F/q_1$. A quasi-optimal taxation follows the famous *Ramsey rule* (cf. Braeutigam (1989)). The optimality of a Ramsey commodity taxation is based on welfare maximization. In case of independent demand functions the Ramsey rule can easily be derived. With dependent demand schedules like in the case of complementary goods the analysis is much more complicated. But with the assumptions given above the calculus leads to a simple boundary solution.

Result: Under the given assumptions, the quasi-optimal taxation schedule is given by $t_1 = 0, t_2 = F/q_2$.

Proof: Total welfare for both markets can be expressed by

$$W = \underbrace{\int_{p_1}^{\infty} q_1(s, p_2) ds + (p_1 - c_1)q_1(p_1, p_2)}_{W_1} + \underbrace{\int_0^{q_2} (p_2(s, p_1) - c_2) ds}_{W_2}$$

with $p_2(\cdot, \cdot)$ as the inverse demand function for good 2. A change of the tax rate t_i and hence of the price p_i affects directly the traded quantity of good i and the surplus on market i , and also the demand function of good $j \neq i$ and hence the surplus on market j . Since $p_i = t_i + c_i$ and hence $\partial p_i / \partial t_i = 1$ we have

$$\frac{\partial W}{\partial t_i} = \frac{\partial W_i}{\partial p_i} + \frac{\partial W_j}{\partial q_j} \frac{\partial q_j}{\partial p_i}, \quad i = 1, 2, j \neq i$$

The derivatives yield

$$\frac{\partial W_i}{\partial p_i} = (p_i - c_i) \frac{\partial q_i}{\partial p_i}, \quad \frac{\partial W_j}{\partial q_j} \frac{\partial q_j}{\partial p_i} = (p_j - c_j) \frac{\partial q_j}{\partial p_i}$$

Using the complementary property (1) it follows

$$\begin{aligned} \frac{\partial W}{\partial t_1} &= (p_1 - c_1) \frac{\partial q_1}{\partial p_1} + (p_2 - c_2) \frac{\partial q_2}{\partial p_1} \\ &= [(p_1 - c_1) + (p_2 - c_2)] \frac{\partial q_1}{\partial p_1} \end{aligned} \quad (4)$$

$$\frac{\partial W}{\partial t_2} = [(p_1 - c_1) + (p_2 - c_2)] \frac{\partial q_1}{\partial p_2} \quad (5)$$

It is obvious from assumption (2) that the negative impact of an increase of t_1 on the welfare is stronger than an increase of t_2 :

$$\frac{\partial q_1}{\partial p_1} < \frac{\partial q_1}{\partial p_2} < 0 \quad \Rightarrow \quad \frac{\partial W}{\partial t_1} < \frac{\partial W}{\partial t_2} < 0$$

However, it has to be considered that welfare is maximized under the condition that the tax amount is F . Hence, an increase of t_1 due to (3) implies a decrease of t_2 according to the demand elasticities and vice versa. Inserting the restriction (3) into the function $W = W(t_1, t_2)$, welfare then depends only on t_1 : $\tilde{W}(t_1)$. Maximizing welfare under the non-negativity constraint $t_1 \geq 0$ leads to

$$\max_{t_1} \tilde{W}(t_1) \quad \text{s.t.} \quad t_1 \geq 0.$$

The first-order conditions are given by:

$$\begin{aligned} \frac{\partial \tilde{W}}{\partial t_1} &= \frac{\partial W}{\partial t_1} + \frac{\partial W}{\partial t_2} \frac{\partial f}{\partial t_1} \leq 0, \\ \frac{\partial W}{\partial t_1} \cdot t_1 &= 0 \end{aligned}$$

For proving the result it is sufficient to demonstrate that the restriction is binding, i.e. that the first condition holds true with the strict inequality sign. Using (4), (5) and $q_1 = q_2$ we have

$$\begin{aligned} \frac{\partial \tilde{W}}{\partial t_1} &= [(p_1 - c_1) + (p_2 - c_2)] \frac{\partial q_1}{\partial p_1} + \\ & [(p_1 - c_1) + (p_2 - c_2)] \frac{\partial q_1}{\partial p_2} \left[-\frac{q_1^2 + F(\partial q_1/\partial p_1)}{q_1^2} \right] \leq 0 \end{aligned}$$

Factoring out $((p_1 - c_1) + (p_2 - c_2))$ and dividing by this (positive) expression it follows

$$\begin{aligned} \frac{\partial q_1}{\partial p_1} - \frac{\partial q_1}{\partial p_2} \left[\frac{q_1^2 + F(\partial q_1/\partial p_1)}{q_1^2} \right] &\leq 0 \\ \Rightarrow q_1^2 \left(\frac{\partial q_1}{\partial p_1} - \frac{\partial q_1}{\partial p_2} \right) - \underbrace{F \frac{\partial q_1}{\partial p_2} \frac{\partial q_1}{\partial p_1}}_{>0} &\leq 0 \end{aligned} \quad (6)$$

and by assumption (2) the difference in brackets is also negative. Thus we have

$$\frac{\partial \tilde{W}}{\partial t_1} < 0 \quad (7)$$

and the non-negativity constraint is binding: $t_1 = 0$, implying $t_2 = F/q_2$.

The proof shows that assumption (2) is only sufficient, not necessary. Also a positive bracket term in (6) could be overcompensated by sufficiently high fix costs F . Furthermore, it can be stated that the normalization of the quantities, implying the proportionality $q_1 = q_2$, is not necessary. Other proportionalities $q_1 = \alpha \cdot q_2$ are also possible but make the analysis more complicated.

3 Discussion

A taxation of good 2 increases p_2 and decreases welfare on market 2. However, this enables a first-best price regulation on market 1 implying a maximum of positive spillover effects to the complementary goods market. This positive effect overcompensates the losses induced by the increase of p_2 . The customers of good 2 have anyway a demand (a willingness to pay) for a bundle of (q_1, q_2) . How the total price is allocated to both goods is not relevant for them. Consumers who demand good 1 only, benefit more from first-best regulation because they do not carry the weight of taxation. Therefore the positive welfare effects are accompanied by some distributional effects between different groups of consumers. But it has to be pointed out that also the consumers of the bundle (q_1, q_2) benefit from this type of regulation. As the calculus shows, they benefit more than in case of a second-best regulation $p_1 = c_1 + F/q_1$. The presented mechanism exploits the necessity of consuming a complementary good. The willingness to pay for good 2 under the first-best regulation of good 1 is then a proxy for an individual revelation of preferences for first-best-regulation. Hence, a complicated and expensive revelation mechanism is not required. But, of course, welfare cannot be as high as in case of an individual revelation of preferences.

If good 1 is interpreted as software and good 2 as IT services like support or customization, then the discussed business strategies which are based on F/OSS can be seen as an implementation of the derived welfare maximizing regulation mechanism. Customers who rely on complementary services are then forced to (partially) reveal their willingness-to-pay also for the software component of the bundle. They will charge a price for F/OSS even if “software only” can be downloaded for free from the internet.

If the business strategy is based on F/OSS then the supplier is restricted in deciding on an appropriate license model for the software component. Since he contributes to a F/OSS

project he is more or less committed to the legal institutions of F/OSS licenses like the GNU General Public License (GPL) or BSD license. These institutions cause the effect that “software only” can be obtained by its marginal cost close to zero. The user has far reaching rights of using and distributing the software. This implies non-disclosure of utilization and it is an important issue of the F/OSS production process. Therefore, F/OSS license models are an economically interesting institutional arrangement since they enforce a kind of *self-regulation* of software firms. These license types mimick the function of a social planner who regulates the natural monopoly of software supply.

We now turn back to the above mentioned argument that F/OSS and F/OSS related business strategies distort the system of relative prices and reduce the efficiency of allocation (Kooths et al. (2003)). This argument is based on the assumption of independent demand functions and competitive software markets. Since these are fairly inappropriate assumptions the argument fails to be valid. In contrast, the analysis has shown that the opposite is true: this kind of “cross-subsidiation” is a welfare-improving self-regulation mechanism. Moreover, it can be questioned whether cross-subsidiation is an appropriate interpretation because consumers of the bundle (q_1, q_2) fully finance the production of both goods while other consumers benefit from free access to good 1.

Futhermore, F/OSS business models have far reaching positive externalities. Since the software code is a quasi-public good, firms contribute to a public capital stock of knowledge. Such knowledge stocks play an important role in growth theory (cf. Meijers and Hollanders (2003)). The access to this knowledge stock can accelerate the process of software development and innovation. In addition, free software implies open standards which are not protected by restrictive intellectual property rights. This leads to lower barriers of market entry and enforces competition in the markets. A more sophisticated calculus of welfare maximization should also take these externalities into account.

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