PRODUCTIVE PARADIGMS IN THE DIGITAL ERA

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ABSTRACT

While production has been traditionally explained as the result of a given combination of labour and capital the disruptive development of information technologies and the burgeoning information based production challenges this classic understanding. Specific characteristics of information technologies and information goods result in the presence of consumption externalities, failing to internalize them results in efficiency losses. Differently from network effects, consumption externalities directly affecting production (instead of other users´utility) cannot be internalized through two-sided market strategies. Internalization of these externalities results in considering use/consumption as a factor of production. As opposed to market-based production, peer-production is presented as a successful way to internalize such externalities. The size and type of consumption externalities is then used to explore relative advantages of different production modes.

Keywords: two-sided markets, network effects, peer-production, prosumption, antirivalry.

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INTRODUCTION

Peer-to-peer production, the growth of Wikipedia in comparison with the Encyclopedia Britannica, the growing importance of Linux in contrast to Windows, even the success of Google can be hardly explained within the classic economic paradigm. The classic economic paradigm was tailored for industrial economies. Production was explained as the result of a given combination of capital and labour. But, can this two productive factors explain the productive process of peer-to-peer, Wikipedia, Linux, Google? Certainly they can be used in explaining the productive behaviour of a car-factory, a textile-production or a small regular shop of any possible kind, but the explanatory power of that paradigm is much lower when facing the production processes present in many of the new productive entities that have appeared after the disruptive development of information technologies.

What is different? Highways vs. rural paths.
How highways are produced can be easily explained in terms of the two single productive factors capital and labour. But is this explanation useful in reasoning how a rural path is created? A rural path appears due to the repetitive use of a given route. This reiterated use of the route progressively eliminates vegetation establishing a marked track on the ground. If the path is not used enough, it just disappears. Obviously labour might have a role: a nearby village could reward a group of people to have some obstacles removed. Capital might also be relevant: a cliff could be avoided through the construction of a bridge. But the radical difference is that its production cannot be explained just through capital and labour. The production of a rural path could not possibly be explained without taking into account its mere use (consumption) as a productive factor.

Use as a factor of production.
Consumption externalities have been long ago recognized in the context of the so called information technologies(Rohlfs, 1974). Network-effects have usually been understood as the positive effect of extra users on the value of the product (Shapiro and Varian, 1998) not on the size of production. Consequently the internalization of network externalities does not imply that use becomes a factor of production, while in the rural path case, in the Wikipedia project, Linux, P2P platforms and even Google, presumably it is.

1. USE AS A FACTOR OF PRODUCTION

1.1. NETWORK EFFECTS AND TWO-SIDED MARKETS

Frequently positive effects of consumption are internalized by the same agent that produces them. A recurrent example is the buyer of a razor, who internalizes the net surplus derived from buying razor blades. Withal this is not always the case: in the rural path these positive effects accrue to any user of the path. A similar case is frequent in other communication networks: if only one individual has a fax machine the utility for this unique user is zero[1]. The utility of having a fax machine increases as more agents have access to such a device. These kind of externalities to consumption are known as network-effects. Network effects refer to the effect of extra users on the value of a given product to other users of that same product (Shapiro and Varian, 1998)[2]. In consequence, the demand of a good exhibiting network effects is a function of both its price and size, or expected size, of the network (Katz and Shapiro, 1994, p.96). In contrast to the well known supply side economies of scale, information technologies are frequently characterized by demand-side economies of scale (as well)[3]

The presence of network effects is troublesome for economics: in such a market there might be multiple equilibria or no equilibria at all, and fundamental theorems of welfare economics might not apply (Katz and Shapiro, 1994, p.94)[4].

The sources of this consumption externalities are related with the effect of the number of users on the quality and availability of the product/service, signalling effects of the size of the network or psychological, bandwagon effects (Katz and Shapiro, 1985, p.424). Complementarity of the elements composing the network underlies the existence of network effects (Economides, 1996).

With the development of the so called information technologies, information has become the centre of production, being both the basic input and output of production. The inherent properties of information, near zero marginal costs of production and non-rivalry has lead economist to consider information and knowledge by extension to be a a public good[5] (Stiglitz, 1999). Because information is frequently the input and the output of different production processes there is usually complementarity among

1 More formally, *"The utility of every consumer in a network of zero size is zero."* Economides (1996, p.9).

2 For a refining of these definition and some associated concepts see Liebowitz and Margolis (1994). They also argue that network effects are not necessarily positive.

3 See Varian, Farrel and Shapiro (2004, Ch.1.8).

4 The implications are far more complex, see for instance Liebowitz and Margolis (1995) on path dependence and lock in implications.

5 Information and knowledge are usually understood as public goods, but culture is not: *"(...) embodiments of culture (...) are no more rival than embodiments of any other form of information (...)."* (Benkler 2002, supranote 16).

markets, resulting in frequent consumption externalities (Katz and Shapiro, 1994). Non-rivalry and low marginal costs exacerbates its relevance.
The literature distinguishes between indirect and direct network effects. The former refers to symmetric complementarity, as in the fax machine example, when the number of users directly affects the demand of the product. The later is related to complementarity among different elements such as between an operative system and its applications, or between a hardware and a software, and it is "endemic" in information technologies[6].

Efficiency gains: Internalizing network-effects.
In presence of indirect network externalities utility is obtained from the matching of the elements of two different markets, thus each market is positively affected by the size of the complementary market. For instance an operative system will be more demanded the greater the number of compatible applications.
Platforms and the markets interrelated in such a manner form an imbricate composite. Because the size of one market affects the size of the other one, overall demand and platform profits depend not only on price levels, but on price structure. Systems behaving in such a manner are known in the literature as two-sided markets[7].
Coase (1960) theorem establishes that in absence of transaction costs and information asymmetry, as long as property rights are tradable and fully allocated the outcome will be Pareto efficient despite of the existence of externalities. While the presence of non-internalized externalities implies the failure of the Coase theorem, this is a necessary but insufficient condition for two-sidedness. Different reasons other than non price neutrality could cause the failure of the Coase Theorem: asymmetric information might result in a failure of the theorem and still price would be neutral (Rochet and Tirole, 2004 and 2006). Cross group externalities affect not only price level but price structure decisions. Non price neutrality is a necessary and sufficient condition for two-sidedness (Rochet and Tirole, 2004). Factors of non neutrality are those that limit the ability to impose fees or subsidies on the markets of the platform. These factors include transaction costs and direct constraints in the pricing of transactions between end users (Rochet and Tirole, 2006).

If there are cross group effects, *"(…) social marginal benefits exceed private marginal benefits"* and hence *"the equilibrium network size and the competitive equilibrium is not efficient"* (Katz and Shapiro, 1994, p.96). Since increasing interactions between these two distinct but complementary markets increases surplus and efficiency intermediaries or platforms are prone to appear.

6 See Varian, Farrel and Shapiro (2004, Ch.1.8) for more examples and literature.
7 Or more generally multi-sided markets, but for sake of simplicity only two-sided markets will be considered here.

In order to boost positive externalities, platforms tend to constraint one side of the market to the benefit of the other one. Depending on the relative size of cross-group externalities subsidizing one side of the market might trigger growth in the other, resulting in greater surplus for the platform. Thereby in such a situation one-sided pricing strategies would fail to internalize potential cross group externalities and thus *"a two-sided pricing strategy always increases the profits of the platform compared to the `one-sided´ pricing strategy profits (...)"* (Economides and Katsamakas, 2005, p.4).
The greater the cross group externalities and the lower the costs faced by the platform, the more likely that prices charged will be below the marginal cost. Parker and Alstyne (2009) reason that if relative cross-group externalities are big enough one side might offer its production for free: *"Free goods markets can therefore exist whenever the profit maximizing price of zero or less generates cross-market network externality benets greater than intramarket losses"* (Ibid, p.11).
In the other hand zero marginal costs are a defining characteristic of information related production[8], explaining hence the frequent policy of zero-priced goods. Platform operating costs and cross group externalities determines thus pricing strategies. Parker and Alstyne (2005) argue thereof that *"A product design strategy that discounts price to zero is aided by the unique properties of information. The key, however, relies less on nonrivalry than on low marginal costs. When these are negligible, a firm can subsidize an arbitrarily large market based solely on fixed initial costs." (Ibid, p.7).*

Two-sided markets characterize software industries, videogames, media, payment systems (see Rochet and Tirole, 2004) among many others[9]. This approach has also been used to study the competition between propietary and open source software (OSS). Two-sided market literature on OSS (Economides and Katsamakas, 2005, 2006; and Hagiu, 2006)[10] has recognized the presence of cross group effects but argued that OSS structure impedes applying two-sided pricing strategies and hence positives externalities are left uninternalized.

Both Economides and Katsamakas (2005) and Hagiu (2006) characterize open source by free-entry (prices equal to zero) in both user and developer side. Because prices are set to zero two-sided pricing would not be feasible. Accordingly, positive network effects would not be internalized, in contrast to proprietary platforms, where profit maximization provides incentives to do so.
Economides and Katsamakas (2006) extend their previous work by

8 For a further elaboration on this issue see for instance Varian, Farrel and Shapiro, 2004.
9 Rochet and Tirole (2003) provide a review on different two-sided markets.
10 As far as I am aware of.

conceptualizing users as developers in one side and developers of independent propietary, for profit, applications in the other. Users maximize their user surplus and their reputation as developers, while in the proprietary scheme platform providers and developers maximize their profit. Because for the open source platform zero prices are assumed no subsidies or fees can be imposed on the independent application developers. Therefore two-sided pricing strategies would not be implemented despite of the existence of cross-group externalities.

1.2. PROSUMPTION AND PEER-PRODUCTION.

Conceptualizing users as developers like in Economides and Katsamakas (2006) is common in the literature on open source and it entails crucial implications. Weber (2004) contends that open source production system with its centre in the user is a new way of organizing production that relies on *"(...) a set of organizational structures to coordinate behaviour around the problem of managing distributed innovation, which is different from division of labor."* (Ibid, p.224). Similarly Benkler (2002) argues that *"free [open[11]] software projects do not rely either on markets or on managerial hierarchies to organize production."*
The production model observed in OSS is also present in other communities working with information[12], such as Wikipedia or e-Bay (von Hippel, 2005). Benkler (2002) generalizes from the OSS phenomena to propose a different mode of production that does not rely neither on markets nor managerial hierarchy. Common-based peer production is defined as *"(...) a new modality of organizing production: radically decentralized, collaborative, and non-proprietary; based on sharing resources and outputs among widely distributed, loosely connected individuals who cooperate with each other without relying on either market signals or managerial commands" (*Benkler 2006, p.60)[13]. Peer-production would include open software, projects like Wikipedia or E-bay, P2P platforms or even Google searching engine whose page-rank software employs peer-production in ranking pages relevance (Benkler 2002, 192). Amazon also provides its costumers with the ability to rate the items they purchase, generating a peer-produced rating system by averaging the individual ratings (Benkler, 2006, p.75-76). Similarly Digg, Slashdot or Reddit voting systems result in a peer-produced ranking of relevance. Social media such as Twitter or Facebook also rely on user generated content. Information in

11 In Benkler (2002) the terms free and open software are used interchangeably (see supranote 2).
12 Von Hippel (2005, p.165) defines these communities as: *"communities or networks of individuals and/or organizations that rendezvous around an information commons, a collection of information that is open to all on equal terms".*
13 *"`peer production´ characterizes a subset of commons-based production practices. It refers to production systems that depend on individual action that is self-selected and decentralized, rather than hierarchically assigned."* Benkler (2006, p.62).

all these platforms is peer-ly produced by users.

The economic foundations of this phenomena are common to those of open source. The cornerstone of peer-production is users´ incentives and motivations[14] and the architecture that enables governance and organization/coordination (technical architecture plus norms and social rules). The incentives to contribute are of radical importance in a productive system where producers do not (directly) appropriate production.

While altruism might be present it is certainly not the driving source (Weber 2004, p.131). Even in the absence of altruism, since each user´s welfare is contingent upon the welfare of the other peers, even a selfish user has incentives to contribute to the welfare of the other peers[15]. Other motivations[16], as categorized by Benkler (2002, Ch.3), are rewards through indirect appropriation, hedonic gains and monetary rewards[17]. Mechanisms of indirect appropriation include mincerian earnings (i.e. positive effects of learning on future earnings)and reputational benefits resulting in signalling effects. Signalling effects, like learning effects, bring in increased future earnings (through contract obtention for service provision, such as consultancy, customization or maintenance, for example).

While indirect appropriation involves intertemporal utility gains, hedonic rewards can be associated with present consumption. Users obtain pleasure from the mere act of creation, physiological rewards and ego gratification through peer-recognition. In contrast to the typical microeconomics of labour where work yields negative utility which is compensated by monetary rewards (wage), in peer-production users self select themselves to engage in those productions that maximizes their utility. Peers obtain in return for their production rewards in terms of utility through consumption (hedonic rewards) and increased future earnings (through mincerian and signalling effects). There is thus an exchange production-for-consumption with no strict need of monetary means.

As Weber (2004, pp. 72–73) ascertains *"Open source software users are not consumers in the conventional sense (...). Users integrate into the production process itself in a profound way."* This is the confirmation of the early Toffler (1984, p.267)´s perception of the *"(...) blurring of the line that separates producer from*

14 See von Hippel (2006, table 1) for a useful literature review.
15 This is just a reformulation of Becker (1974)´s "Rotten-kid Theorem".
16 See Rossi and Bonaccorsi (2006) for a classification of literature on incentives. Incentives and motivations are also analyzed in Lerner and Tirole (2002 and 2004), Raymond (2001) and Weber (2004), among others.
17 As it is broadly known even though that gratis usually characterizes OSS, and more generally peer-production, it is not a necessary characteristic it is "free like in freedom" not like in "free beer" (http://www.gnu.org/philosophy/free-sw.html).

consumer". Users´ production entails consumption (hedonic rewards) and frequently consumption entails production as well. In peer-production users are indeed both consumers and producers, or prosumers as introduced by Toffler (1984) and later adopted by Tapscott and Williams (2008) in the context of peer-production.

The idea of prosumption is by no means new, as Senior already observed more than a century and a half ago *"Economists have in general opposed consumption to production"* (Senior, 1836, p.53)[18] although there are productive and unproductive consumptions. *"Productive consumption is that use of a commodity which occasions an ulterior product"* (Ibid., p.54): there is a positive externality to consumption. Differently from network effects, it is not just the utility of other users what is positively affected, it directly affects production. Like in the rural path case, extra users do not only entail network externalities, there is also an externality that affects positively the production of the rural path. A new user joining the path implies network effects: because the rural path net expands (to cover her location) increasing the utility of the rest of the users (as a result of the expansion of the net). Simultaneously the incorporation of this extra user entails a productive externality: the user contributes to the production of the path with the mere consumption he does by walking it. Differently from the network effect, this "prosumption effect" increases production rather than utility. A differentiation should be made between network effects and prosumption effects. While they might reinforce each other they are essentially different, not only because the former affects utility while the later affects production, but because for prosumption effects to take place a network is not necessary. Even if there is only one person in the world she can still give raise to prosumption effects when contributing with her walking to the creation of a rural path of which she is the only user. Conversely for a network effect the size of the network must be greater than one.

The novelty of peer-production relies on its capacity to internalize these consumption externalities, both network and prosumption effects. Effectively aggregating small and disperse contributions to production and hence incorporating use as a productive factor.

Efficiency gains: Internalizing "prosumption effects".

In *"The nature of the Firm"* Coase (1937) defines firms *"(...) as clusters of resources and agents that interact through managerial*

18 More recently and I reference to familiar/domestic economies Michael and Becker (1973) have also discussed the concepts of consumption and non-market production.

command systems rather than markets [the alternative system]" (Benkler, 2002, p.372) reasoning *"the emergence and limits of firms based on the differences in the transaction costs associated with organizing production through markets or through firms."* (Ibid.). Benkler (2002) expands Coase´s reasoning to include peer-production. The reasons why peer-production would be more efficient than either markets or firms is the absence of transaction costs and property rights. Transaction costs between end users associated with property and contract limit interactions making *"clusters of agents and resources sticky"* (Ibid, p.375). These transaction costs represent *"information opportunity costs"*, for firms and markets but not for peer-production. Given the low costs of information production and communication, peer-production holds a *"relative advantage"* due to the *"information-processing"* characteristics of the former and the existence of *"(...) increasing returns to scale for the size of the sets of agents and resources available to be applied (..)"* (Ibid.). Since users self-select for tasks (contributions to production) maximizing their utility scalability results in a pool of users where *"the diversity of motivations allows large-scale collaborations to convert the motivation problem into a collaboration problem"* (Ibid., p.434).

In comparison with the one-sided pricing strategy, two-sided pricing strategies resulted in efficiency gains. However prices still affect negatively two-sided markets in two different ways: first, given the presence of cross-group externalities transaction fees reduce the volume of interactions. And secondly, the presence of transaction costs associated with prices and property might deter scalability. Since demand in one group is dependant on the size of the other, limitations in scalability represents efficiency losses. The absence of these burdens in peer-production results in *"allocation gains"* (Ibid. p.415).
In contrast to both the one-sided and two-sided strategies, in peer-production users are prosumers, agents consume and produce with no need of monetary means eliminating thus price barriers and transaction costs, the mentioned factors of non-neutrality. By removing these burdens to interaction and scalability peer production might obtain efficiency gains in a networked environment with cross-group externalities.

Thereby peer-production platform boosts interactions among users and hence production, effectively bypassing two-sided strategies and internalizing not only cross group effects (indirect network effects) but also prosumption effects. Consumption externalities are fostered and internalized obtaining hence efficiency gains.
Similarly to the efficiency argument of one-sided versus two-sided strategies, it can be argued that in presence of prosumption-effects peer-production is more efficient than two-sided (and by

extension one-sided) pricing strategies. This inclusion of use as a factor of production results in a relative advantage over firms and markets.

2.2. ARCHITECTURAL LIMITATIONS

In OSS literature users are frequently conceptualized as developers, and more generally in peer-production as prosumers (Tapscott and Williams, 2008). While it is clear that production entails consumption, which is one of the fundamental motivations for contributing in a peer-production system, it is indeed arguable that every OSS user is a "real developer", or more generally that in peer-production all users actually contribute to production.
The famous Linus´law proposed by Raymond (2001, p.8), *"given enough eyeballs, all bugs are shallow"*, conveys that the aggregation of small contributions to production can become a relevant factor of production. A free-rider that poses a positive contribution to production is not a free-rider in the strict meaning of the term, reason why Raymond recast the term of free-riders into *"outriders"*.
Weber (2004, p.154) went further introducing the concept of *"anti-rival goods"*. Interestingly this implies that for any user, committed contributor or not, the mere use implies a contribution: *"The point is that open source software is not simply a nonrival good in the sense that it can tolerate free riding. It is actually antirival in the sense that the system as a whole positively benefits from free riders."* There are of course limits to this, *"this arguments hold only if there are a sufficient number of individuals who do not free ride (...)"* (Ibid). Thereby in as much as there is a sufficient number of contributors all users would positively affect production.

Peer-production architecture might force users to passively or involuntarily contribute as in file-sharing services such as Bit Torrent which *"(...) forces users to share the parts of files that they already own while they download the remaining bits"* (Strumpf and Oberholzer-Gee, 2010, p.10). Similarly searching in Google inevitably contributes to the production of the searching engine. In these cases use entails both consumption and production: production implies consumption and consumption implies production, or in Senior terms all consumptions are productive.

However even if all users are contributors there is a difference between committed contributors and passive or involuntary contributors. While the former´s contribution depends on utility gains (and indirectly in the architecture), for the later it only depends on the ability of the architecture to extract a

contribution from an agent that otherwise would be a free-rider. Examples of the first case are obvious and abundant, wikipedians, Linux developers, among many others, contribute because they decide to do so. Examples of platforms with passive/involuntary contributions are Google searching engine, Bit-Torrent protocol and most of the social media such as Facebook or Twitter. Similarly users of a rural path cannot avoid contributing to production.

The ability to obtain contributions not only from committed agents but from any user depends on the architecture of the productive entity. Nevertheless as important as the rate between contributors and free-riders or quasi free-riders (if there is antirivalry) is the relative contribution per user. In Google for instance the amount contributed by each user is really small, but all users contribute. Differently in Wikipedia the dispersion in the size of the contributions across users is much bigger and not all the users contribute.
The main characteristics of such an architecture determine the limits of antirivalry and the relative contribution per user. Because there are consumption externalities increasing the number of users renders greater production. Users decision to join and contribute depends on the incentives and the barriers of entry (such as learning required to be able to contribute) plus costs associated with participation such as privacy issues (like in Google or Facebook). Users contribute to production and obtain rewards in terms of consumption, (hedonic rewards) that are endogenous to the platform, and in terms of increased future earnings (indirect appropriation) which are exogenous.

In addition to the technical architecture there are social rules and norms, that combined with the former enables the coordination in the peer-production process. In order to foster the use of the platform and thus greater production, the architecture is characterized by (Benkler 2006, p.101) modularity (division of a project into smaller components -modules, that can be independently produced and posteriorly assembled) and granularity (related to the minimal size of the modules): *"The granularity of the modules therefore sets the smallest possible individual investment necessary to participate in a project. If this investment is sufficiently low, then `incentives´ for producing that component of a modular project can be of trivial magnitude."* (Ibid.). In the other hand this results in a bias towards small contributions that involve integration costs.

In a setting where antirivalry is present any user poses a positive contribution to production. Hence exclusion would have a negative role limiting access and reducing production. But in the other hand increasing the number of users of the platform

increases the stress of the architecture. Scalability aggravates maintenance costs by increasing communication and coordination costs and heightening the probability of undermining actions, either malicious, either through incompetence (Benkler, 2002, p.422). At the same time, the incentives necessary for a given level of contribution are at least partially produced by the platform (hedonic-consumption rewards are, but indirect appropriation rewards are exogenous). This relationship between necessary incentives for a given level of contributions, the integration costs and the costs associated with the maintenance and design of the architecture (rules, norms and technical layer) represent the main costs faced by the peer-production entity, and are *"(...) the equivalent for peer production of organization and decision costs in firms and of transaction costs in markets.* (Benkler, 2002, p.413).

Therefore there is a relationship between the quality of the design of the architecture and the production costs faced by the platform (Ibid). Depending on the capacity of the architecture to integrate consumption externalities, network effects might reverse its sign and exclusion will have to be introduced. This is the case of congestion either in a rural path or any network[19]. Up to the extent that integrating more contributions exceeds the gains antirivalry will be replaced by exclusion and barriers of entry increased rather than lowered. Depending on the size of the costs of the platform and the degree of rivalry platform´s efficiency will decrease (Ibid.)

In the Wikipedia there is not antirivalry, mere use does not necessarily involve production. At the same time exclusion even if present is low, and barriers of entry are also relatively low.
Suh et al. (2009) find that after reaching a peak in 2007-2008, the growth in the number of articles in Wikipedia is declining. "T*his result is consistent with a growth processes that hits a constraint (...)"* (Ibid.). They argue that this constrain is related to the *"(...) limited opportunities to make novel contributions." (Ibid.).* Indeed once an article has been written it might be improved, updated, rearranged, but it does not make much sense to write it again. As the article is improved there is less and less room for improvements. More individuals contributing to the same article result in decreasing marginal contributions and increasing overhead (integration) costs. However they find that in the other hand *"a greater proportion of the overall edits is being devoted to overhead activities such as coordination, policy setting, and governance"* (Ibid.). Therefore it can be argued that the slowdown is due to the decreasing opportunities to contribute for the given architecture of Wikipedia. The authors find *"evidence of growing resistance from the Wikipedia community*

19 See Liebowitz and Margolis (1994) and Reisinger (2004) on negative network effects.

to new content, especially when the edits come from occasional editors." (Ibid.) In a nutshell: because the costs of integrating more contributors exceeds the gains antirivalry is replaced with increasing levels of exclusion, greater barriers of entry and more contributions being devoted to the improvement of the architecture instead of the production of articles. While this investment in the design of the architecture might render future efficiency gains, in the short term resources are deterred from article creation and overall production decreases.

3. PRODUCTION MODELS: COMPETENCE AND SUSTAINABILITY ISSUES.

While in peer-production pricing is a priori possible, it would increase participation costs leading to a reduction in the number of users. In as much as antirivalry is present this results in a lower production and efficiency losses through non-internalized consumption externalities. This together with certain sets of beliefs common in many peer-production communities leads to a frequent zero pricing policy of the final good/service. Parker and Alstyne (2005, p.5)´s reason that it is rather the peculiarity of zero marginal costs of information production than non-rivalry what leads to zero pricing strategies. Conversely when prosumption externalities are present, the degree of rivalry becomes a fundamental factor.

Peer-production efficiency depends on the costs associated with the architecture design and maintenance. Improving the architecture entails costs affecting the efficiency of the platform. At the same time the sustainability of the platform and its relative advantage depends on its efficiency.

The costs associated with a certain level of efficiency can be assumed by the peer-process, like in Wikipedia, or can rely on hybrid forms like alliances between open software projects and firms, such as IBM. An extreme case is when a firm is propietary of the architecture where the peer-process takes place, like in Google or most of social media, such as Facebook or Twitter.

When the costs are assumed by the peer-production platform, like in Wikipedia it comes at the cost of an increasing rivalry and exclusion and a lower production (of articles in this case) leading to efficiency losses, at least in the sort term.

Frequently not all the costs of the peer-production platform can be peer-ly produced: infrastructure might need to be purchased and some labour employed. In this case the platform will need to

acquire them from firms or markets, outside of the peer-production environment. Since in the peer-process production and consumption takes place without need of monetary means, if money is actually needed, (part of the) production will have to be monetized. It is frequent to recur to donations and crowd-funding such as in the case of Wikipedia.

3.1. HYBRID MODELS

Other possible solutions are hybrid forms involving peer-production and firms. Complementarity between the firm and the peer-production platform and differences on efficiency in the provision of complementary goods or services is the basis of a symbiotic relationship (Lerner and Tirole, 2004). Increases in the incentives to contribute, improvements in the design of the architecture or funding of some monetary costs of the platform render efficiency gains and increased production in the peer-production process. Alliances between firms and peer-production platforms resulting in such a positive effects could be desirable from the peer-production point of view. Typical examples are Red Hat and IBM. For an OSS user/developer the probabilities of obtaining a contract with the firm involved in the open project increases (indirect appropriation incentives). In one hand participating in a project with the firm results in greater visibility (signalling effect), and in the other hand the technical skills and knowledge (human capital) are precisely those required by the firm. In such a symbiotic relationship the firm might benefit from increased peer-production and in order to encourage it the commercial firm might resort to subsidizing peer-production by allocating some workers to the peer-production platform (Lerner and Tirole, 2004). In this last case the commercial firm would benefit from human capital gains by the workers participating in the peer-production process. For instance an IBM engineer collaborating in the GNU/Linux invests in her human capital and both the worker and the firm enjoys the returns of this investment (Benkler, 2006).
Direct appropriation of production by the firm would be likely to reduce users motivations to contribute and probably lead to a desertion of the peer-production process (Benkler, 2002). Firms can instead benefit in segments of the market complementary to the peer-production (Lerner and Tirole, 2004) such as marketing or customer service (West, 2004). In the particular case of OSS and commercial firms collaborations, such as IBM, Lerner and Tirole (2004) point to increases in demand due to users gains through reduced risks of suffering lock in effects if the prices of the goods/services bought from the firm increases. Users also benefit from customization capabilities, being hence able to tailor their software. Another source of benefits for the firm is the

possibility to certify a standard by releasing code and possible gains in engineering efficiency (West, 2004).
The former reasons follow the logic of giving away the razor to sell more razor blades (the complementary product) (Lerner and Tirole, 2004).
In addition to the former reasons, commercial firms might be induced to collaborate with peer-production processes due to a certain combination of economical and technical circumstances that lead to unsustainability of fully propietary strategies. These conditions are related with the market share necessary to efficiently support propietary research and development and increasing buyer demands for open standards (West, 2004).

3.2. TWO-SIDED MARKETS REVISITED

Hybridity between peer-production and firms is a collaboration between two productive entities which provides a *"(...) constructive interface between market and nonmarket-motivated behaviour, through which actions (…) can reinforce, rather than undermine, each other"* (Benkler, 2006, p.102). Hybridity between peer-production and firms is based on the existence of complementaries and cross group externalities. Firms benefit from increased peer-production and peer-production platforms are able to attract more users if there is a successful collaboration with the for-profit organization. On the top of affecting positively users´ motivations to contribute, firms might subsidize peer-production. Subsidization is not necessarily through monetary means, like the IBM engineers collaborating in the GNU/Linux it does affect cost-relationships in the peer-production architecture, thereby a affecting efficiency and production.
This collaboration is indeed a two sided market. The necessary and sufficient condition for two-sidedness proposed by Rochet and Tirole (2004), non-price neutrality, is present in these hybrid production models. As it should be obvious prices are not necessarily monetary, and by reducing costs or barriers of entry (providing maintenance or service support for users or developing user-friendly interfaces) the for profit firm is able to subsidize peer-production. In the other hand the firm produces and offers in the market complementary services and goods whose price can control. Hence the for profit firm can benefit by subsidizing peer-production if that increases sales in the other, complementary market.
Within a peer-production platform two-sidedness is not relevant, the peer-production model internalizes consumption externalities more efficiently than a two-sided market and incorporates users as a factor of production (prosumption effect). However by eliminating price and property mechanism a barrier is created for interactions with firms and markets, where money mechanism is the

basis. Because there are cross group effects and prices are non-neutral there are benefits to be obtained for an intermediary applying two-sided strategies. Such an intermediation provides a link between non-monetary and monetary economies.

Hybrid production models monetize peer-production. By using outputs of the peer-produced processes as inputs of the goods or services offered in the market, the intermediary effectively internalizes consumption externalities in such a way that its production is the function of capital, labour and use. This explains the success of Google and propietary social media, in both examples information is peer-ly produced and consumed by the users: in Google, users create the searching engine and users use the searching engine; similarly, users post and users read the posts in social media. By exploiting this peer-ly generated information the platform is able to use it with for profit objectives, AdSense or AdWords and the increasing interest and presence of advertiser and sellers in Social media is good proof of this.
Google benefits from increasing number of advertisers and advertisers benefit from a greater audience. The scheme is similar for social media. In order to foster cross group externalities and prosumption effects these firms lower as much as possible the barriers of entry for new users and even subsidize them by providing services below their marginal costs, and usually for free. Increasing number of users attracts more sellers and advertisers and the increasing amount of data to be exploited increases the quality of the advertising service, reinforcing hence two-sidedness.

3.3. RELATIVE ADVANTAGES OF DIFFERENT PRODUCTION MODELS

From this reasoning a simple classification follows: market, non-market and hybrid production models. While market based production models might partly internalize consumption externalities (network effects), the factors of production are labour and capital: use affects utility, not production. Conversely peer-production represents a clear case of non-market production. Peer-production does effectively internalize consumption externalities, both network and prosumption effects, incorporating use as a factor of production. However since peer-production is not based in money signals it might face inefficiencies when interacting with the market to acquire labour and capital if these are needed.
Hybrid models implementing successful two-sided market strategies create a bridge between market and non-market production systems, monetizing (part of) the peer-production and incorporating thus market based factors of production (labour and capital) and use, the non-market productive factor.

The efficiency level of each model is dictated by the costs faced by the productive entity, the existing externalities and the capacity to internalize them. In presence of prosumption effects non-market and hybrid models will enjoy a relative advantage over market production systems, and due to this competence market production might become unsustainable. Conversely in absence of prosumption effects incentives to produce and efficiency gains for peer-production will be reduced and market based production might face a relative advantage given its greater ability to incorporate labour and capital to production.
Finally when prosumption effects are present and labour and capital requirements are sufficiently low peer-production will hold a relative advantage over both market and hybrid models.

4. CONCLUSIONS

Information technologies and information goods´ production are characterized by the presence of consumption externalities. While the literature has long ago identified the presence of network effects and proposed two-sided markets as a successful and more efficient way (as opposed to a one-sided strategy) of internalizing cross-group effects, other consumption externalities affecting directly production (instead of other users´utility) are present in productive entities such as Wikipedia, Open Software, different social media and even Google.
Internalization of the latter kind of consumption externalities, i.e. prosumption effects, implies reckoning use/consumption a factor of production together with labour and capital. Price and property rigidities result in efficiency losses when internalizing the prosumption effects through two-sided market strategies, peer-production is proposed instead as a more efficient solution.

The presence, kind and size of different consumption externalities leads to the existence of relative advantages. If there are network effects two-sided strategies will have a relative advantage over one-sided models. If there are prosumption effects peer-production will hold a relative advantage against market-based models (either one or two-sided).
Peer-production being a non-market based mode of production conveys limitations when interacting with markets. Costs associated with the building and maintenance of the architecture enabling peer-production might result in requirements of factors from the market (labour and capital). Complementarities between market and non-market based production lead to hybrid forms of production. Such hybrid forms of production implement two-sided strategies, with market-based production in one side and peer-

production in the other, internalizing thus both prosumption effects (through the non-market side) and cross-group effects (among non-market and market sides). When peer-production processes have high requirements of labour and/or capital hybrid forms of production will hold a relative advantage over all the other mentioned forms of production.

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