Autorité de la concurrence

CMA
Competition & Markets Authority

The economics of open and closed systems

16 December 2014

Contents

1. Introduction

1.1 Competition authorities are accustomed to dealing with competition cases related to relatively 'basic' systems, combining a primary product with secondary products.[1] However, the digital economy developed large and complex systems, which often involve a vast number of firms and grow ever bigger, due, for instance, to network effects, both direct and indirect.[2] These systems are called 'ecosystems' in view of the significant number of products and services involved and of the symbiotic link between them. Furthermore, in addition to allowing products and services to work together, ecosystems may also act as intermediaries between various types of users, who engage in bilateral transactions enabled by the systems (eg applications developers who sell applications to the users of smartphones).

1.2 The digital economy exhibits fast-paced innovation and high rates of investment. At the same time, because of the importance of network effects,[3] a winner may end up capturing the entire market ('winner takes all'), particularly if strong network effects are present. Initial competition can thus be fierce to conquer a market share advantage over rivals. However, a competition authority may legitimately be concerned by the threat that all consumers could be locked into a single unavoidable system, monopolising many markets, with no more possibility of entry for competing systems or component makers; in this case, a competition authority could be willing to intervene early enough to avoid 'tipping'[4] or lock-in.

1.3 Likewise, as ecosystems can be relatively complex and are multisided, focusing too narrowly on only one part of the system and disregarding its other sides can lead to finding competition problems where they do not exist ('false positives') or, on the contrary, to observe fierce competition, while at the same time monopoly rents are extracted through a lock-in of consumers on another market ('false negatives').

1.4 In addition, the economic literature shows that it does not necessarily hold true that openness[5] is always good for competition and welfare, while being 'closed' is bad. Therefore, defining the appropriate scope of intervention of competition authorities is not an easy task. A competition authority or other

---

[1] These systems have been discussed in the literature widely. See, for example, OFT (2012a) and European cases such as Tetra Pak II (*Case C-333/94 P, Tetra Pak International SA v Commission [1996] ECR I-5951*).
[2] See paragraphs 2.11–2.18 below for more details. Broadly speaking, complex ecosystems differ from more basic systems in the importance of indirect network effects. Indeed, the greater the number of users on one side of the market, the more it attracts users on the other sides, and vice versa. Overall, the value of the ecosystem increases with the number of its users, which is less the case for simple aftermarkets.
[3] See OECD (2012).
[4] 'Tipping' is an alternative expression to describe the 'winner-takes-all' phenomenon.
[5] See Section 2 for a definition.

regulators have different tools to intervene, ranging from merger control to antitrust enforcement and market investigations to other 'softer' tools like advocacy. It may then be necessary to identify the right time of intervention and the right set of tools of intervention, which may be before a system is dominant and has locked in a large number of consumers (earlier intervention, using more traditional tools such as merger control – avoiding adverse effects on competition through remedies or even prohibition decisions)[6] or antitrust action at a later stage (regarding especially exclusivity practices, bundling and tying cases, or other exclusionary practices like predation) if the firm has acquired a dominant position. Standards can also be imposed by regulators or chosen by firms in order to create compatibility between systems.

1.5 Therefore, where an effects-based approach is appropriate, a case-specific assessment of the relevant potential effects should be carried out. This paper aims to provide a summary of the various effects that have been discussed in the economic literature and a source of information and references for practitioners faced with competition cases dealing with ecosystems. It should be noted that while these effects also frequently arise in competition cases dealing with simpler systems, they tend to be more important and complex in the case of ecosystems.

1.6 Before presenting the competitive assessment and efficiency gains of open vs closed systems in Sections 3 and 4, Section 2 defines and describes the notions that are at the core of the economic analysis of ecosystems: the systems themselves, network effects, switching costs and degrees of openness.

[6] See, for example, the commitments of the parties in the Intel/McAfee merger (M.5984), consisting of ensuring the interoperability of the merged entity's products with those of competitors, in order to alleviate the concern that rival IT security products could be excluded from the marketplace given Intel's strong presence in the world markets for computer chips and chipsets. By contrast, in Microsoft/Skype (M.6281), the European Commission found no conglomerate effects concerns, in so far as the new entity had no incentive to close, by degrading Skype's interoperability with competing services, because it is essential for the merged entity that Skype's services are available on as many platforms as possible in order to maintain and enhance the Skype brand. The reasoning was similar in Google/Motorola (M.6381).

2. Definition of the main notions

2.1 This section describes the notions that are at the core of the economic analysis of ecosystems: (1) the systems themselves, (2) the role of network effects and switching costs and (3) degrees of openness or closure.

Definition of an ecosystem

2.2 Ecosystems have been defined as ‘a number of firms – competitors and complementors – that work together to create a new market and produce goods and services of value to customers’.[7]

2.3 Ecosystems are fundamentally about complementarities. At their core they combine a platform and the multiple sides of the market that it intermediates between such as consumers, component producers, developers, etc.

2.4 Systems, in contrast, have been defined in the literature as ‘collections of two or more components together with an interface that allows the components to work together’.[8] Systems, as understood in this paper, are simpler in their structure and may, for example, consist of a primary product and a secondary product or service (for instance, a printer and ink cartridges). They are also built upon complementarities, but lack the complex intermediary role between multiple sides of a market involving various economic agents.

2.5 The various components of an ecosystem can, for example, include:

- the interface enabling the various components of a system to be compatible, such as an operating system
- the hardware: hardware is generally a durable good, such as computers or electronic devices or connected goods, for instance a smartphone, tablet or a multimedia console
- the software: for instance, applications, bought or downloaded in application stores or preinstalled on the hardware
- contents: music, newspapers, e-books, etc that can be listened to or read on the hardware or software of the system and bought or accessed on electronic stores that can belong to the system owner

[7] Hazlett et al (2011).
[8] Katz & Shapiro (1994).

2.6 These multiple components need to work together for a consumer to draw utility from usage of an ecosystem. For example, purchased software needs an operating system and hardware to run on. At the core of a complex ecosystem is therefore, similarly to a system, complementarity.[9]

2.7 An ecosystem does not necessarily need all the components described above. For example, platforms such as advertising-supporting content platforms (which attract viewers through content and sell access to their viewers to advertisers, like social networks, online gaming, online newspapers, etc) or marketplaces can also be considered as ecosystems. Several social networks offer applications or the possibility to develop them, but also contents, payment systems and even virtual currencies. Marketplaces act as intermediaries between sellers and buyers, and supply related services (advertisement, payment systems, etc). Even if there is no hardware (purchase) involved for the consumer in such ecosystems, and thus no need to buy another device when switching system, users can still be locked in, for example because of network effects or learning costs.

2.8 Whereas previously ecosystems, such as Intel's business model for microprocessors or Microsoft's operating system, allowed system owners to earn revenues from the direct sale of components to users of the system, owners of ecosystems now increasingly act as intermediaries between the demand and the supply for goods or services that may or may not be used on the system.[10] Ecosystems therefore compete in order to be the bottleneck between multiple sides of the market. The optimal payment and fees schedule would then typically take characteristics of all platform sides (such as price elasticities) as well as the direction and strength of network effects into account.[11]

2.9 This intermediary function may be more or less developed, as illustrated by the following examples (see also paragraph 2.28):

- For instance, a firm may focus on selling many components directly to the users of its systems, especially own devices (mobile devices, computers, etc), and has its own exclusive application store. This rather closed business model is more focused on the sale of electronic devices than on monetising an intermediary position.

---

[9] In some cases, the complementarity between the products composing the system may be asymmetric, in the sense that the demand for the primary product is not strongly affected by the characteristics of the secondary product. This may depend on switching costs between primary products for the end-consumer and on the switching cost to another primary product for the producer of the secondary product.
[10] For example, the applications are typically used on the system, but not the transactions enabled through the applications (for instance, the selling of train tickets).
[11] See Armstrong (2006) for the case of a monopoly platform.

- Alternatively, a firm may develop a different, more open business model, where the focus is on acting more as an intermediary between Internet users of its services and sellers of other products and services. In this business model, the role of advertising and the aim to attract as many users as possible to own services may be more pronounced.

2.10 Hence, the shape and focus of an ecosystem, including the degree of its openness, reflects different economic interests and different industry backgrounds.

Network effects and switching costs

Network effects

2.11 Ecosystems feature a significant degree of both direct and indirect network effects, ie the benefit of a user of being part of the ecosystem depends on the number and types of other agents being part of the system (for example, consumers, application developers, content producers, console sellers, etc). Network effects in an ecosystem need not be bidirectional and can flow in various directions between multiple agents: some types of users benefit from the number and the presence of other users, whilst it may cause disutility to others. For instance, consumers typically prefer a system with fewer advertisements, whereas a great number of consumers attract advertisers on the system.

2.12 Systems, defined as a primary and a secondary product, are also exhibiting network effects though these are less complex than in an ecosystem (for example, additional users of a specific printer model are likely to increase cartridge availability or lower prices of cartridges, which in turn attracts consumers for the specific printer model: this is an indirect network effect).

2.13 Networks effects can be viewed as positive consumption externalities that increase the utility that a consumer derives from a good when the number of users who are in the same 'network' increases.[12] If ecosystems are not compatible, benefits of network effects are limited to the users of the respective system only.

2.14 Network effects can be direct, due to the improved possibilities to interact (for example, the number of people who can be called increases the benefit from having a telephone), or indirect, when the increased number of users of one group (for instance, end-consumers of the system) attracts users of another

[12] Katz & Shapiro (1994).

group (for instance, developers of applications), generating a positive feed-back effect on the users of the first group (for example, the arrival of a new developer has the direct effect of decreasing the value of the system for the competing developers, but an indirect positive effect, as it increases the variety or quality of applications available, thus attracting new end-consumers).

2.15 When systems are multisided, network effects are reinforced by the existence of so-called ‘marginal network effects’. They are defined by Farrell and Klemperer (2007) as the fact that ‘one agent’s adoption of a good increases others’ incentives to adopt it’, by comparison with ‘total network effects’, where ‘one agent’s adoption of a good benefits other adopters of the good’. For example, competing sellers may be forced to join an ecosystem even if belonging to the system reduces their revenues, for instance when the system owner charges licence fees. Indeed, as the ecosystem becomes an important or even the main access to consumers, not joining the system while their competitors join the system makes sellers lose customers compared with the situation without ecosystem. As a result, even if an ecosystem does not bring any additional revenues to the sellers, network effects can force more and more sellers to join the system, which can then levy rents on the sellers for this access.

2.16 The size of a network might also be important for its quality, which may reinforce network effects. In ‘digital economy’ markets, for example, the number of users may directly influence the quality of the product or service as consumers produce valuable usage data for firms.[13]

2.17 In the presence of (particularly direct) network effects, especially when combined with high switching costs, a single firm may dominate the market, a situation that has been termed as ‘winner takes all’[14] or ‘tipping’. Indeed, in the presence of network effects, the size of a system is an important factor of success and so-called ‘snowball effects’ can be observed, where large systems attract more and more users. Network effects thus constitute a barrier to entry, as attracting consumers from another successful network can be very costly, as all users would need to switch at the same time if they want to keep benefiting from the positive externalities of the network, unless they can and are willing to use several systems at the same time (‘multihoming’).

---

[13] For instance, algorithms can learn from user data and update or improve the product or service. For a similar argument relating to service networks, see Katz & Shapiro (1985).
[14] For an empirical treatise, see Hand (2001), who finds that the US Internet sector is characterised by such a situation. A ‘winner-takes-all’ situation may also arise from first mover monopolists because of high fixed costs or increasing returns of adoption.

2.18 Finally, network effects also require system owners to coordinate different groups of users: indeed, when users choose whether or not to adopt a system, they do not take into account the positive externality generated on the other users of the system. Absent coordination and cross-subsidies between the various groups of users, there is a risk of under-adoption of the system or even of failure of the system.[15]

Switching costs

2.19 Switching costs can be defined as the real or perceived costs incurred when changing supplier but which are not incurred by remaining with the current supplier.[16] Switching costs are relevant both for systems and for more complex ecosystems.

2.20 Switching costs take various forms and can stem from various causes, including:

- The price of the primary product (the 'hardware', like the mobile devices, the computer, etc) that needs to be bought when switching systems.
- The absence of portability of data or content (like music, e-books, applications, data saved in the cloud,[17] or even phone number or email address), which have to be repurchased or changed when switching. Transferring content from one system to another may be impossible or costly, depending on the compatibility between systems (and hence their degree of closure). Sometimes, the available contents are not identical on competing systems (for example, television contents can depend on the Internet access provider chosen), which can raise switching costs heavily for a consumer accustomed and attached to some contents and even partition consumers among systems based on their content preferences.
- Network effects themselves can engender switching costs (costs of losing access to one's network due to coordination problems between users when switching, for instance in cases where there exists a means of communication only between the users of the system, where the ecosystem is built around a social network).

---

[15] Katz & Shapiro (1994).
[16] See OFT (2003). In this context, consumer behavioural biases might also be relevant – see OFT (2011).
[17] For instance, for some systems cloud storage or additional software and contents on a usage basis ('software as a service', music streaming) are offered. In practice, this implies that users are less likely to consider switching to a different ecosystem.

- Contractual costs, like long-term contracts between the users of the system and the system host.

- Learning costs: some knowledge investment is incurred when switching to a different system: specific tools, a programming language, a habit to use a specific environment (for example, Apple's iOS environment, Microsoft's Windows environment, etc).

2.21 Such costs tend to be higher when systems are (technically) incompatible,[18] as components need to be repurchased and contents are non-transferable. The strong synergies between the components inside a system also reinforce switching costs as switching one component may imply switching all the other complementary components in order to keep benefiting from the synergies.

2.22 A system host can try to raise switching costs artificially in order to discourage switching, making the system de facto more closed. Switching costs imply a certain degree of lock-in to a system as leaving the system for a competing one would imply costs for a user. This can reduce competition between systems once consumers are locked in, but engender a fierce competition for the acquisition of an installed base of consumers. Consumer switching costs also increase barriers to entry as consumers are less likely to opt for a new ecosystem if the switching costs are high, even if the new system is of a higher quality.

2.23 When switching costs and network effects are sufficiently high, consumers choose their systems on their expectations about the future success of a system, as their choices to adopt one system rather than another locks them into this system for a certain period of time. This can lead the system owner to act on the expectations of consumers and coordinate them in order to achieve the success of the system by, for example, subsidising the primary product.

2.24 Importantly, in a multisided context, switching costs imply that some users on one or several sides of the platform 'single home' (ie belong to one system only) and may then be locked in to a single system. Thus, the platform would become a bottleneck for the users on the other sides wanting to access these users. These various implications of switching costs in the assessment of closed vs open systems are developed further in Sections 3 and 4.

[18] As explained in paragraphs 2.31 and 3.9 below, incompatibility between systems can also result from closure within systems, as it implies that the components available on competing systems will not be the same and will have to be bought again.

Open and closed ecosystems

2.25 'Openness' of an ecosystem and of its components is an important characteristic for competition purposes because it can impact on consumers, competition between firms, and the level of innovation in an industry. When we refer to 'open', we generally refer to a system that is equipped with an interface that is accessible to component makers or system developers other than the system owner itself and thus can work with a relatively wide variety of other components available on the market; in contrast, in a 'closed' system, each component can work only with selected other components. As a consequence, an open system will allow a significantly larger number of component variations to be used by consumers and lead to competition between these.

2.26 The more combinations of components are possible and the more those components are available outside the ecosystem, the more open is an ecosystem. So an ecosystem may be considered more open than another ecosystem whenever:

- there are more possible combinations of components within the ecosystem
- more of those components are not supplied by the system owner

2.27 In practice, there is a continuum of possibilities between totally closed systems and totally open systems. Indeed, most systems are 'hybrids', with some of their components being open and some others being closed.[19] Systems therefore exhibit a spectrum of degrees of 'openness',[20] often reflecting the extent of vertical integration and of control of the system components by the system owner, and the compatibility between systems. For the purpose of this paper, the terms 'closed' and 'open' will be used to describe systems that are relatively closed or relatively open.

2.28 The different degrees of openness of ecosystems are not only reflected in the main characteristics of these systems but may also arise from different business models and the system design.

2.29 A more closed ecosystem may focus on selling hardware with a proprietary operating system which is only licensed for use on specific hardware and certain functions of the device may only be accessed by proprietary

[19] See Kaiser (2011) for a discussion. 'A fully open system is an oxymoron because systems are, by definition, different from their environment and must therefore be closed in some respects. … Similarly, it is hard to come up with an example of a fully closed system, because even the most locked-down, tethered appliance must at least connect with the power grid.'
[20] Mehra (2011).

software.[21] The system may nevertheless be open to third parties' content contributions: through programming interfaces[22] developers may still create 'applications' which they can then sell and distribute only through the system owner's application store.

2.30 An alternative approach which does not necessarily exclude the sale of hardware may be more focused on online advertising services to which the system owner's products and services route consumers. One of these products may be an operating system. This may also be installed and customised by device manufacturers, in some cases even without paying a licence fee. On the other hand, such an ecosystem may be partly open (eg having an application store and allowing access for programmers through APIs), and partly closed at the same time (eg the system or parts of it may not satisfy the definition of 'open source'). Other products such as applications or services may, however, be available on different operating systems and devices. It may also allow competing application stores to run on the system and on the same device. With such a business model, a firm may therefore benefit from relatively more open components in its system in order to attract as many users as possible to generate advertising revenue on other sides of the platform.

2.31 Depending on the characteristics of the industry, closing a system within (ie by preventing or limiting competition between components within a system) may be implemented through various means. It may first result from technological incompatibility between the system and competing components that could otherwise have been used with the system. For instance, producers of the primary product may protect their aftermarket through patents and refusals to license, which may prevent competitors from exploiting the interface through their own secondary products. The system host may also regularly introduce new versions of the interface which may not be compatible with old versions of secondary products. Finally, closing a system may also result from contractual arrangements, such as long-term exclusivity contracts for the supply of the aftermarket products (eg mobile phone – subscription for mobile phone services, photocopier and maintenance) or bundling or tying between the various products of the system (such as the tying of Internet Explorer to Microsoft Windows).

2.32 Secondly, a closed system can also result from technological incompatibility between systems. The absence of interoperability between systems prevents users of competing systems from interacting with other systems, leading to a

[21] See Baskin (2013).
[22] For example, Application Programming Interface (API).

situation where network effects are restricted to within a system (eg a proprietary instant messenger which can only be used on one ecosystem). Incompatibility can also prevent the use of components or content bought on one system when switching to a competing system. ‘Incompatibility’, in this sense, means ‘absence of portability’. Possibly incompatibility between systems prevents some components from being sold on several competing systems, unless they are adapted to each system or adapters exist. Incompatibility between systems is not necessarily decided by systems’ hosts but may be due to technical reasons, when there is no standardisation process.

3. Competitive assessment

3.1 This section summarises important potential effects of system openness on competition as discussed in the literature. There are four features of note. First, while openness can encourage competition within the system (1), a closed system can generate fierce competition between systems. Second, in some cases, such inter-ecosystem competition may offset the negative effects of closure (2). Third, market shares and the chosen degree of openness can change quickly in some systems markets so that a long-run assessment of their effect on competition will sometimes be necessary (3). Fourth, in the case of low degrees of inter-ecosystem competition, a reduction of intra-ecosystem competition may not systematically further reduce competition and welfare. Indeed, the 'one monopoly profit theory' states that, in many cases, the decision to opt for a more closed or a more open system essentially hinges on the anticipated efficiency gains, as the decision to close a system might be due to efficiency considerations. However, this is not always the case and needs to be carefully examined as the 'post-Chicago school' has emphasised situations where the decision to close a system is based on anticompetitive reasons (4).

The potential competition gains from open ecosystems

3.2 Open ecosystems can potentially generate many positive effects for competition compared with closed systems. This section outlines some of these effects with further aspects being discussed in later parts of this paper.

3.3 Greater compatibility between ecosystems reduces switching costs[23] and increases competition between them, as ecosystem users can easily move from one system to another at any point in time (inter-ecosystem competition). The effects of this enhanced ability to switch are compounded by a greater willingness to switch, through the reduction of the reluctance of users to switch to a competing system for fear of being locked in.

3.4 Compatible ecosystems yield the full benefits of direct and indirect network effects:[24] users of an ecosystem can interact with the users of other compatible ecosystems[25] and benefit from a larger number of other agents in the system (app developers, etc).

[23] The level of the switching costs can be influenced by other factors that are independent from the degree of closure (see paragraphs 2.19–2.24 above).
[24] Farrell & Klemperer (2007).
[25] Consider the customers of a mobile phone operator that are able to call subscribers of other networks. This would be impossible in the absence of call termination between mobile telephony networks.

3.5 Economies of scale are maximised for component makers, who do not have to develop as many components as there are existing ecosystems. A component maker will be able to sell the same component to all consumers, irrespective of the system they have chosen. In this regard, openness in the sense of compatibility between systems encourages innovation.

3.6 Furthermore, an open system also allows for more competition between various substitutable components of the system (intra-ecosystem competition), increasing variety, and reducing prices. Consumers are then able to 'mix and match' to obtain their preferred varieties, especially if ecosystems are also compatible.[26]

3.7 Finally, openness encourages entry on the components market because the entrant can make use of the infrastructure of the ecosystems already in place and simply produce its specialised complement.[27] Thus, openness enables competing firms to enter a market through component innovation; as various producers develop and experiment with different approaches and solutions, the markets for components can evolve relatively quickly. Eventually, all firms stand to benefit from the various technologies which are implemented by competitors when producing and creating the components of a system since there is a dissemination of best practice in the industry with firms learning from each other's trials and errors.[28] By contrast, closed systems increase entry costs by requiring that new entrants develop both the infrastructure (platform) and each of its components rather than just a single component in order to compete with the incumbent.

Competition between closed systems reduces and sometimes can offset or outweigh the negative effects of closure on competition

3.8 Although openness can have these positive effects on competition, that is not to say that closure of an ecosystem is automatically bad for competition. Closure of an ecosystem can also generate positive effects on competition.

3.9 The extent of inter-ecosystem competition first depends on whether consumers take the prices and the quality of complementary products into account when choosing between systems (ie on whether they are 'myopic' or not). Provided that the share of consumers still able to trade one system against the other (ie consumers that are not locked in to a system yet and are subject to choice, so-called 'marginal consumers') is sufficiently large and that

[26] See Matutes & Regibeau (1988).
[27] See Carlton & Waldman (2002) and Carlton & Gertner (2003).
[28] See Farrell & Weiser (2003) and Wu (2007).

competition between systems is strong enough, the ability of closed systems to profit from their locked-in consumer base is limited (as it would deter consumers from entering the system). However, the influence of 'marginal consumers' as a disciplining device in general is likely to depend on the scope for price discrimination between new and already locked-in customers, myopic and non-myopic consumers, etc. Similarly, if the system owner's reputation is likely to suffer due to the exploitation of its installed base, it may refrain from raising its prices on locked-in users, in order to keep attracting new users.[29]

3.10 Second, even if consumers are 'myopic' or if there is no reputation effect, the profitability of locked-in consumers can engender fierce competition 'for the market' between systems. Indeed, even if consumers are 'myopic', firms are generally able to estimate the profits they can achieve with each new consumer once they are locked in. Thus, competition between firms can make them decrease the price of the primary product (often the hardware component, which is a durable good) until the profits generated on other components markets are fully dissipated through lower prices and/or better quality of the primary product. This competition can be particularly fierce in the presence of significant network effects and switching costs: indeed, in that context, the related markets are prone to a situation of 'tipping', with one competitor winning over most of the market[30] and firms 'struggle for dominance'.[31]

3.11 The same compensation mechanism explains why competition between closed ecosystems may also be good for innovation and entry. Indeed, innovation and entry are partly driven by the expectation of future profits. The higher and more likely these future profits are, the more firms will invest and compete to innovate.[32]

3.12 According to Farrell & Klemperer (2007), however, there are several reasons why the compensation scenario in which low penetration prices exactly offset the profits generated by lock-in on secondary markets may not hold.

3.13 First, risk aversion, information asymmetry, and liquidity constraints limit firms' ability to propose introductory prices that exactly compensate for the ex-post rents.

3.14 Second, in some cases, multisided platforms will compete to attract the most valuable groups of users (defined as groups of users likely to attract other groups, ie creating most network effects) or subsidise the groups having the

---

[29] This assumes the firm values the future to a certain extent.
[30] In some cases, however, consumers are heterogeneous and several incompatible platforms can coexist, corresponding to each type of consumer.
[31] Farrell & Klemperer (2007).
[32] See Teece (2006) and Carlton & Gertner (2003).

highest sensitivity to price. This can result in platforms offering their services to consumers for free and can also lead to excess investment in potentially less efficient parameters, like costly advertising,[33] resulting potentially in higher prices or lower quality of products.

3.15 Third, fierce ex ante competition for the acquisition of a large installed base of locked-in users does not always take place, as the tipping of the market towards a given system can occur before competition between systems takes place. In that case, there even exists a risk of standardisation on a system that turns out to be inferior to another one[34] that arrived later on the market. Indeed, the presence of switching costs and network effects can make history and past market shares, rather than prices or quality, the crucial choice parameters of consumers. For example, the 'QWERTY' keyboard has not been abandoned for the arguably[35] superior 'DSK' keyboard.

Evolution of market structure

3.16 In general, the stronger the competition between systems, the more closure is likely to occur for efficiency reasons (see Section 4). This is because competition between systems puts pressure on system owners to be efficient and to offer competitive conditions to consumers. If closure occurs in these conditions of competition, it may be that closure generates efficiency gains compared with openness. Conversely, however, in the absence of sufficient competitive pressure between systems, a system owner may be tempted to foreclose entrants or small rivals by closing a system.

3.17 Because of the competitive effects of compatibility, incompatibility is often more profitable for a dominant system than compatibility: a dominant system has little incentive to be compatible with small competing platforms as it is no longer subject to the competitive pressure of these much smaller platforms and can already fully benefit from the network effects linked to its size, without the need to open to other competing networks.[36] Therefore, dominant systems are probably seeking incompatibility too often in order to relax competition. By contrast, a small competitor willing to grow generally seeks compatibility in order to allow users of the incumbent's system to switch more easily to its own system and not lose access to important network effects.

---

[33] There is an increasing body of economic research on advertising. Normative theories suggest that advertising can be both welfare-reducing and welfare-improving depending on the determinants of advertising (for instance, informative vs persuasive advertising, advertising as a signalling mechanism or advertising as endogenous sunk cost). For an overview of the literature, see Bagwell (2007).
[34] See Nahm (2004).
[35] See Noyes (1983) (in favour of 'DSK') and Liebowitz & Margolis (1990) (against 'DSK').
[36] See Katz & Shapiro (1985), Crémer et al (2000) and Farrell & Klemperer (2007).

3.18 Markets in which ecosystems compete may evolve over time towards three different market structures.

3.19 **No tipping.** If differentiation between systems is strong, or network effects weak, in the long run the market could evolve into an oligopoly equilibrium of closed systems, with few marginal consumers choosing between systems and dampened competition. Niche minority products can survive even if the systems stay closed, or if the market is segmented in groups who are localised in different incompatible systems.[37] This can be the case when consumers are heterogeneous and if network effects only act between groups of users.[38] In these cases, even if there is no dominant position, the systems could close in order to relax competition between them and to profit from their locked-in consumers.

3.20 **Instability.** Markets with network effects may be subject to significant instability. If a large share of users are initially not locked in, and systems are of comparable sizes, a small increase in the size of one network can induce a snowball effect and make it gain more and more market share. Moreover, ecosystems often involve multisided platforms and indirect network effects can make a system lose market share quickly if it loses market share on one side of the market. Consequently, even if firms can rapidly acquire a dominant or even a monopoly position as a result of network effects, as long as a sufficient share of users are not locked in yet, systems have to perform well in each of the markets that comprise the ecosystem. If the system loses market share on one side of the market, it can enter a vicious circle and lose market shares on the other sides of the market due to indirect network effects, and finally collapse. In order to cope with this risk, a closed ecosystem may choose to open to some extent when faced with a potential entrant[39] or with a competing rival, which is potentially open, especially if a sufficiently large share of the demand is not locked in yet on one or several sides of the market.

3.21 **Tipping.** As discussed above, in the presence of strong network effects and switching costs, and in the absence of compatibility between systems, markets are prone to 'tipping', with one competitor winning over most of the

[37] See Farrell & Klemperer (2007).
[38] For example, the total absence of or limited interoperability between mobile networks could generate such a phenomenon, because consumers would choose the system their closest correspondents use, leading to different tribes gathering on different networks which do not compete with one another, unless tribes manage to coordinate easily to switch to another system.
[39] See Nahm (2004).

market.[40] This is because, in the presence of network effects, users are better off joining the biggest network. If, in particular, direct network effects are significant, the size of the network can be more important in the choice of a system than other parameters, like quality, price or the adaptation to the consumers' preferences. Thus, even if systems are slightly differentiated, a situation of tipping can occur.

Incentives to close a system for a monopolist

3.22 As seen above, gains from competition can come from competition between closed ecosystems and competition within open ones. However, where an ecosystem is dominant, competition between closed ecosystems is unlikely to compensate for a loss of openness. Nevertheless, as regards monopoly ecosystems, in contrast to a case where there are multiple competing ecosystems with one dominant ecosystem, the incentive to close can be ambiguous because in the absence of efficiency gains, closure does not necessarily increase profits to the system owner compared with openness. This is discussed in the first section below. That said, there are several contexts where closure can be for anticompetitive reasons. These are discussed in the second section below.

Closure occurs when it generates efficiency gains

3.23 Even in those cases where the system owner is in a monopoly or dominant position, system closure does not necessarily reduce welfare compared with openness. Indeed, according to the 'one monopoly profit' theory,[41] there is only one monopoly profit to earn for the whole system; as soon as a platform holds a bottleneck, it is able to extract this monopoly rent while keeping several sides of the system open to competition. Indeed, as summarised by Farrell and Weiser (2003), monopolists will elicit the degree of openness that maximises the platform's value to consumers and internalise the complementary efficiencies created by the components through the price of the primary product. Hence, in an open system, the value generated by the development of new components is appropriated by the platform monopolist through an increase in the access price it charges on different sides. Alternatively, in a closed system, the platform monopolist will capture the value created by the system and its components by either raising the prices of

[40] Sometimes tipping can occur on at least one or several sides of the system even when systems are compatible. This is especially the case when network effects act like switching costs or when a technology strongly dominates others or is forfeited by its inventor. Consequently, in the long run, there is a risk of 'hold-up' in systems markets, where systems are declared to be open in a first step in order to attract many users and then choose to close, once tipping has occurred and there is no competing system any more. See Wu (2012).
[41] Posner (1976) and Bork (1978).

its components or by increasing the prices of the access licences transferred component suppliers.[42] Thus, in many cases, the platform monopolist will merely opt for the most efficient structure, ie competition on the components' markets, coexistence of an integrated system with independent complements, broad or restricted licensing, etc. This internalising of complementary efficiencies is analogous to the 'one monopoly profit' idea in the economic literature on vertical restraints.[43]

There are situations where closure occurs for anticompetitive reasons

3.24 Conversely, there are situations where the internalising of complementary efficiencies is not the driver of ecosystem closure, ie cases where the system owner will not implement the degree of openness that maximises efficiency and welfare and the decision to close a system is sought for anticompetitive reasons.[44]

3.25 A first reason can be the protection of the host markets (ie its core business) by the system owner. In particular, a dominant platform may seek to exclude rivals on the component markets because these competitors could threaten to enter the core business market. There are several mechanisms through which entry on the component markets can threaten the position of the system owner on the core business market. First, component markets may only be a first step of entry into the system: some component makers may become powerful enough to 'climb the ladder' and enter the core market by creating their own system, a risk that a monopolist on the core market could seek to diminish by closing its own system.[45] Second, if the component markets are already open, then there exist suppliers of components for a potential entrant on the host market, who would thus only have to enter on the core market. For instance, by foreclosing alternative component suppliers, a system monopolist can raise the cost of entry for potential competitors into the core

[42] As a simplified example, suppose that a printer producer has to choose between opening the cartridge market to independent developers and restricting this market to its own cartridges. If competition on the cartridge market increases the surplus of consumers, this will increase their willingness to pay for the printer. Opening the cartridge market could therefore in theory be profitable since it will allow the firm to increase the price of the printer. It is not in the interest of the printer producer to exclude rival cartridge makers since it can receive the benefits of a competitive cartridge market (such as diversity, innovation and lower prices) through an increase in the price of the printer. Conversely, if the consumer does not value competition on the cartridge market, the printer maker may as well close the cartridge market and reduce the price of its printer in order to reach the desired level of sales.
[43] OFT (2013).
[44] Systems may also be open for strategic reasons. For instance, the existence of network effects in relation to a platform induces strong competition between closed systems. In the analysis of Katz & Shapiro (1986), competing firms then choose to open their systems in the early stages of market evolution in order to reduce competition among themselves.
[45] See Carlton & Waldman (2002).

market, by forcing them to enter all the markets served by the system at the same time.[46]

3.26 A second reason is specific to multisided ecosystems, where direct and indirect network effects are important. In this context, a system owner who holds a monopoly on one or several sides of the market may manage to foreclose the other sides by closing the sides on which it holds a monopoly. Foreclosure effects can be particularly important in the context of multisided platforms. 'A successful platform needs to get both sides on board and it needs to get enough of both sides on board to create sufficient value for everyone'.[47] For instance, buyers are generally crucial for sellers who generate profits for the platform. Thus, the platform can try to subsidise the buyers' side and close or raise switching costs on this side,[48] so that buyers single home on its platform (ie do not use competing platforms). The platform can then recoup the costs of subsidy with profits on the sellers' side.[49] Thus, a platform that is able to subsidise the users of one side in order to increase participation by using profits on the other side is a strong competitor for firms that cannot, or have fewer options to, cross-subsidise. More broadly, a platform that is covering many markets is a powerful competitor for platforms which cover fewer markets, because the latter have fewer possibilities to cross-subsidise between markets. For example, a two-sided platform may struggle to compete with a three-sided platform subsidising the two markets on which its competitor is present with its profits on the third market. Thus, platforms can seek to cover more markets than their competitors (a strategy known as 'envelopment'[50]) and foreclose access to those sides that are crucial for competitiveness.

3.27 Third, another scenario in which the system owner may close its system in order to reduce competition is when the components of the system can be used alone, without the host platform. In that case, the benefits associated with competition in the markets for components do not fully translate into higher demand for the primary product because some consumers choose to

---

[46] See Carlton & Gertner (2003). More broadly, in the presence of many markets on the system, if there is no competing open system in the industry, a new entrant would need to pursue a strategy of multicomponent innovation to enter the market, making entry less likely to occur. As successful component innovators create external benefits for innovators in other component markets, absent closure, there will be potentially many good component innovators available in the market and able to make components for an alternative system; thus, closure can help an incumbent to preserve its position in the primary market by making complementary applications unavailable.
[47] Evans (2008).
[48] As explained in the introduction, switching costs can be linked to network effects only. Thus, a platform, if big enough, does not necessarily need to close its market, the network effects within its platform being sometimes sufficient to avoid switching to a competing platform.
[49] See, for example, Evans et al (2006). We often observe multi-homing on this side, as sellers need to have access to various networks of buyers who single-home.
[50] ibid. Also see Eisenmann et al (2006).

buy the competitors' components without acquiring it. Hence, for the system owner, the lost benefits on the component markets are not totally compensated by higher benefits on the host market. The system owner may then seek to close the system in order to reduce the demand for independent component makers serving the autonomous demand, with the possible effect of excluding them from the market.[51] This requires economies of scale in the component market and a sufficiently small share of autonomous demand, so that the system owner will be able to foreclose rival component suppliers in the autonomous market.

3.28 Fourth, in some sectors, the price on the platform may be subject to regulation while the components markets are not. If the regulated price cap is below the profit-maximising price that the host would like to set, the hosts may find it profitable to integrate into the components markets and generate additional profits there. This may affect consumer welfare as it will raise components prices for end-users in comparison with the case where there is competition on the components markets.[52]

3.29 Fifth, competition on the component market may prevent or limit the exercise of market power by the system owner.[53] A system owner may not be able to extract monopoly profits (eg through a fixed licence fee) from the suppliers competing on a component market because of a commitment problem: if the system owner cannot credibly commit to always charge a high licence fee, it will, after having negotiated a high licence fee with one supplier of the component, be tempted to increase its revenues by granting another licence at a lower price to other competing suppliers of the component, etc. These suppliers will be able to lower the price of the component, which will be harmful to the first supplier who has paid a high licence fee. Anticipating this, the first supplier will be reluctant to pay a high (monopoly) licence fee and will only accept payment of the licence fee at the competitive price. Thus, the system owner will not be able to extract the monopoly profit from the component market, unless it closes the system and thereby credibly commits not to lower the licence fees to components' suppliers (by, for instance, contracting an exclusivity with one supplier of the component or supplying it himself and refusing to grant a licence to competing suppliers).

3.30 Finally, control over component markets may also allow the platform host to price discriminate. Suppose that consumers value differently the platform, depending on their usage of the platform. A firm can price the platform at a low price (through low prices of hardware, eg mobile devices) in order to

[51] Whinston (1990).
[52] Farrell & Weiser (2003).
[53] See Hart & Tirole (1990).

attract both occasional users and frequent users, who have a high value for the platform.[54] The firm will then be able to extract the surplus of the high-value consumers through the sales of high-price components. Closure of the system is necessary to this price discrimination since competition would drive price toward cost on the market for the component, making it impossible to extract the surplus of high-value consumers. Price discrimination may or may not be harmful to consumers: on the one hand, it can increase demand and consumer surplus by reducing the price of the host product; on the other hand, it can reduce consumer surplus in comparison with a situation without price discrimination, because of higher prices paid by high-value users and lower levels of innovation in components.[55]

[54] For instance, a printer manufacturer can set low prices for printers in order to attract both occasional users of printers, having a low willingness to pay for the printers and high users, who have a high willingness to pay for the printers. By setting high prices for printer cartridges (consumables), it is possible to set high prices for high users, while selling also the product to occasional users.
[55] Chen & Ross (1993) and Farrell & Weiser (2003).

4. Potential efficiency gains

4.1 The previous section focused on the potential effects of closure on competition in various market settings. However, closure can affect many dimensions other than the intensity of competition and it can be difficult to disentangle the various effects. Below, various efficiency gains that may be brought about by the decision to open or close an ecosystem in terms of cost reduction, quality, price coordination, and innovation are summarised.

4.2 In the following, we will in particular focus on the efficiency gains of openness and secondly on the efficiency gains of closure.

Efficiency effects associated with open ecosystems

4.3 The efficiency effects of open ecosystems include: they maximise network effects, they maximise scale economies, they solve ‘hold-up’ problems. These will be discussed in turn.

4.4 A large open ecosystem is maximising the potential of direct and indirect network effects as it does not restrict the size of the user base through measures to close the system and exclude certain users.

4.5 Similarly, an open ecosystem allows for greater scale economies and lower production costs as component makers will be able to sell the same component to all consumers. As explained in Section 3 above, this encourages innovation in so far as component makers do not have to develop as many components as for multiple closed systems, achieve scale economies, and can compete with and improve the innovations made by other component makers. In this sense, openness can be viewed as an ‘innovation catalyst’.[56]

4.6 In contrast to open systems, a market characterised by competing closed ecosystems can discourage innovation.[57] This is related to a risk of ‘hold-up’ in the negotiation process between the system host and the component makers. Indeed, component makers are exposed to the risk that, once specific investments in the system are incurred, the system owner can renegotiate the access fees to the system upwards. Foreseeing this ‘hold-up’ risk by the system owner, the components’ markers can renounce investing in a technology that is specific to the system. The openness of the system,

[56] Wu (2012).
[57] See Farrell & Weiser (2003).

through, for instance, compatibility with other systems, can make the investments not specific to the system and encourage them.[58]

4.7 Openness also allows the system owner to commit not to 'expropriate' users of their investment in the system. In the presence of switching costs, owners of ecosystems face a 'double commitment' problem.[59] In order to achieve a critical mass of users, platform hosts may need to give away their technology for zero or even for negative prices to early adopters. The fact that the host makes initial losses can serve as a signal of its confidence that its platform will be successful, allowing the recoupment of these initial losses later on.[60] Simultaneously, however, the host must also convince users that they will be left with a net gain once that critical scale has been achieved: indeed, once consumers are locked into an ecosystem because of switching costs, the platform host enjoys some market power that may allow it to 'expropriate' users' investments. In this sense, the openness of a system can serve as a commitment no to exploit users in the future, which can encourage users joining the system.

4.8 By releasing their technology into the public domain or giving it to a non-profit organisation, the host can credibly solve this double commitment problem. Development costs can be recouped either from technologies that have not been forfeited, by payments from user groups that it has not forfeited to, or from sales in complementary markets. Thus, a trade-off exists between forfeiting technologies in order to encourage adoption and recovering costs through some degree of system closure. However, by releasing technology into the public domain, a market characterised initially by a number of closed ecosystems can become more open, ie systems might be more likely to become compatible over time.

4.9 Firms' voluntary forfeiture of a valuable technology is common practice. For example, Bell Labs made its technology behind transistors publicly available and even offered seminars to rivals for them to gain understanding of their functionality. Similarly, Microsoft released its APIs into the public domain, also offering technical assistance.[61]

---

[58] However, other means than openness exist to solve 'hold-up' problems, and for instance long run contracts.
[59] See Barnett (2011).
[60] A successful example of such a strategy is JVC's wide licensing of its VHS technology in the 1970s, leading to the demise of Sony's competing Betamax. On the other hand, Nokia's opening of its Symbian operating system did not prevent its drastic loss of market share, highlighting the need to view the opening of platforms within context; Mehra (2011) likens the Symbian example to 'leaving unwanted but useable furniture at the curbside for others to repurpose', as Symbian was already on a clear downward trajectory when it was made available under an open source licence.
[61] See Barnett (2011).

4.10 Instead of simply revealing its secrets or indiscriminately licensing at a low price, a host may forfeit its technology to a non-profit organisation which by law may not distribute earnings to controlling external parties. The host may thus retain some control over the technology[62] while credibly committing against expropriation.

Efficiency effects associated with closed ecosystems

4.11 The efficiency effects of closed ecosystems include: they ensure compatibility between the components of the systems, they avoid free-riding, they allow user coordination and avoid the drawbacks of standardisation. These will be discussed in turn.

4.12 By allowing a stronger integration between the various components and markets it is composed of, a closed system might be able to generate a better 'quality' of the system and user experience (for example, by ensuring better compatibility between components as well as coherent technological advances across multiple components).[63] As systems are collections of complementary components that work together, systems markets are subject to free-riding and shared liability problems. Thus, system owners need to exert a degree of control over their system and the firms cooperating in it and closure can help address these problems. This might be especially relevant in markets in which the quality of the components associated with a given system cannot be easily assessed beforehand. The selling of low-quality components could reduce the consumer willingness to buy even high-quality products for fear that they are of low quality.[64] In addition, some component makers could behave opportunistically and be tempted to decrease the quality of their component while blaming sellers of the other components for the resulting malfunction.[65]

4.13 In addition, a closed system may be in a better position to overcome information asymmetries and free-riding problems. The owner of a closed system has no incentive to sell low-quality components as this would directly reduce its customer base for all its other components and for the primary product itself. Finally, when information about quality of the system is imperfect, the owner of a closed system may be willing to sell its primary product at a low price and make profits on the component market as a means

[62] For example, avoid a forked development path such as happened in the case of UNIX.
[63] Boudreau (2007).
[64] For example, Atari allegedly lost its dominant position in the video game industry by indiscriminately licensing low-quality third-party games. Nintendo succeeded by following a more closed approach and ensuring the quality of its games. See Lunney (1989).
[65] OFT (2012a).

to convince consumers that the system is of high quality. This strategy signals that the firm knows that the consumer will be satisfied by the primary product and will therefore purchase many complementary components that will enable the firm to recoup its losses on the primary product.[66] Such a strategy would not be possible in an open system with a competitive market for components because the system owner could not recoup the losses made on the primary product on this competitive market. However, the strategy generates efficiency gains, because absent closure, the price of the primary product might be higher, the number of users of the system lower, and consequently, the price of the components higher or the value of the system as a whole lower, which can result in higher prices for all the products of the system or lower utility for users of the system.

4.14 Some of these efficiency gains may also be obtained without completely closing the system. For instance, a system owner could open its system to qualified competitors on the components market, subject to the condition that they respect some quality criteria defined by the system owner. A system owner may also charge licensing fees in exchange for the access to the system from competitors on the components market. This has the effect of increasing the components prices, but also preserves diversity of the components available on the system and competition compared with a situation of a complete closure of a system. Finally, compatibility and coherent technological advances may be ensured by a system owner defining standards and making partnerships with component suppliers to ensure coherent development of the system. However, this coordination activity is likely to be costly for the system owner in the sorts of complex ecosystems that are our focus here; in this case, it may be better for an ecosystem to be closed and to have integrated components, which limits transaction costs in comparison with an open ecosystem.[67]

4.15 Closure could also facilitate the coordination of users of a system. Likewise, as the components of a system are often complementary, the firms selling the various components exert externalities on the other firms of the system and do not take these externalities into account in their pricing policies. Closing a system can help solve these coordination problems. There are two types of efficiency from this: innovation efficiencies and pricing efficiencies.

4.16 Innovation can be either ‘systemic’ or ‘autonomous’.[68] Whereas autonomous innovation can occur in any environment, systemic innovation, or the ‘(co-)

---

[66] Schwartz & Werden (1996) and Rey et al (2001).
[67] See Arora & Bokhari (2007).
[68] See Hazlett et al (2011).

creation of markets',[69] requires deep coordination.[70] A market characterised by closed systems can potentially facilitate more systemic innovation because of reduced transaction costs within each system (ie between the various component producers).[71] However, this may be a stronger argument in favour of vertical integration (diversification of the system owner into the market for components) than in favour of closure (exclusion of competitors from the market for components).

4.17 As to pricing, coordinating the prices of the various complementary components of a system can lead to lower prices of the components overall. This coordination will be easier to implement in a closed system. Indeed, the owner of a closed system completely internalises the increase in component sales which results from selling access to the host platform or from selling complementary components at a lower price. Conversely, when the various parts of an ecosystem are sold by different companies, a price reduction for one component also increases the sales of the companies producing the other (complementary) components, but the component maker reducing prices does not see this benefit, meaning its incentive to reduce prices is lower. Conversely, when a firm raises the prices of its components, the resulting decrease in demand can negatively affect complementary products sold by other firms, without being compensated for this damage by the firm who raised prices. This phenomenon, according to which in the presence of complements, coordination between pricing policies of each of the complements leads to lower prices and higher demand than the absence of coordination is called 'Cournot effect'.[72]

4.18 Such pricing coordination will also be particularly important in the presence of network effects because the system users do not take into account the positive externality generated on the other users of the system. Absent coordination and cross-subsidies between the various groups of users, there is a risk of under-adoption of the system or even of failure of the system.[73] The more sides the ecosystem has, the greater this risk, because platforms need to make cross-subsidies between many sides of the platform in order to raise the total number of users of the platform.[74] Such a subsidy may only be feasible in closed ecosystems.

---

[69] See Pitelis & Teece (2010).
[70] Hazlett et al (2011).
[71] As modelled by Arora & Bokhari (2007). In line with this, Farrell & Weiser (2003) point out that open systems can disadvantage certain more substantial innovations requiring, for example, a change in the platform or application interface, as this might require the time-consuming approval of many parties.
[72] For an explanation of the Cournot Effect, see, for example, Motta (2004).
[73] Katz & Shapiro (1994).
[74] For example, credit cards are more likely to be used by consumers (cards holders) if they are more widely accepted by retailers, while retailers will accept credit cards that are more widely used by consumers. The credit

4.19 The efficiency gains brought about by better pricing coordination between the various components of the system also relate to price discrimination between users with a high willingness to pay and those with a low willingness to pay (see paragraph 3.30). If the system is closed – so that a single firm provides both the host and complementary products – the host product can be sold at a low price to attract both high- and low-value users and the surplus from high-value consumers will be extracted through the sales of component products. Opening the system would prevent this kind of discriminatory pricing since prices on a competitive market for components would be aligned with costs and there could be no possibility of cross-subsidy from high- to low-value users. As a result, low-value users could renounce using the system, leading to a lower volume of demand. The effect of discrimination on welfare is in general indeterminate, but in the case of ecosystems it is possible that discrimination increases total welfare.[75]

4.20 Finally, the standardisation implied by openness is not always the best social outcome. Compatibility can be achieved through standardisation or through 'adapters', both of which can imply substantial costs. Standardisation can also reduce welfare inducing variety under consumer heterogeneity. It may also prevent the emergence of a promising but unique and incompatible new technology.[76] Similarly, compatibility may make it more difficult to introduce innovations.

card scheme may thus offer credit cards very cheaply on one side of the market (the consumers) and cross-subsidise with the other side of the market (retailers). See Armstrong (2006).
[75] Chen & Ross (1993) and Carlton (2001).
[76] Katz and Shapiro (1994).

5. Conclusion

5.1 Ecosystems are fundamentally built around complementarities between goods and services. They typically combine a platform and the multiple sides of the market that it intermediates between such as consumers, component producers, developers etc. Ecosystems are more complex than simple systems (such as printer and cartridges) involving direct and indirect network effects that can flow in various directions between economic agents. Switching costs between competing systems can also exist in various forms. The size of the switching costs, either natural or resulting from system owners' practices, has an impact on the economic analysis of ecosystems.

5.2 We referred to systems that are accessible to component makers and developers and can work with a variety of components as being 'open'. In reality, there is a large spectrum of degrees of openness and closure, and both can have effects on consumers, competition, and innovation.

5.3 Five ways in which ecosystem openness is good for competition have been discussed. Greater compatibility reduces switching costs. Openness achieves full benefits of network effects and economies of scale for component makers, increased intra-ecosystem competition and market entry through component innovation is more easily feasible. However, two ways have been discussed which show that closure can be good for competition: closed systems increase inter-system competition (which can lead to fierce competition 'for the market') and they can lead to an increased incentive to innovate and to entry due to future profit expectations.

5.4 Open systems generate efficiencies in four ways: they maximise network effects, they maximise scale economies, they enable the system owner to commit not to renegotiate ex post the access fees with the component developers, once the specific investments in the system have been incurred and they enable the system owner to commit not to exploit the users who have joined the system, which increases incentives to join the system. However, there are also four ways in which closed systems generate efficiencies: they ensure compatibility between components, they avoid free-riding, they allow user coordination, and avoid the drawbacks of standardisation.

6. Bibliography

Armstrong, M (2006). Competition in two-sided markets. *RAND Journal of Economics, 37* (3), 668–691.

Arora, A and Bokhari, F A (2007). Open versus Closed Firms and the Dynamics of Industry Evolution. *The Journal of Industrial Economics, 55* (3), 499–527.

Bagwell, K (2007). The economic analysis of advertising. *Handbook of industrial organization*, *33*, 1701–1844.

Barnett, J M (2011). The Host's Dilemma: Strategic Forfeiture in Platform Markets for Informational Goods. *Harvard Law Review, 124*, 1861–1938.

Baskin, J (2013). Comparative Regulation of Mobile software Systems: Promoting Innovation Through Reform of Antitrust and Patent Laws. *Hastings Law Journal, 64* (6), 1727–1758.

Baumol, W J (1982). Contestable Markets: An Uprising in the Theory of Industry Structure. *The American Economic Review, 72* (1), 1–15.

Benkler, Y (2006). *The Wealth of Networks: How Social Production Transforms Markets and Freedom.* New Haven, London: Yale University Press.

Besen, S M and Farrell, J (1994). Choosing How to Compete: Strategies and Tactics in Standardization. *The Journal of Economic Perspectives , 8* (2), 117–131.

Bessen, J (2002). What good is free software? In Hahn, R (ed), *Is Open Source the Future of Software?* Washington DC: AEI-Brookings Joint Centre for Regulatory Studies.

Bessen, J and Maskin, E (2009). Sequential Innovation, Patents, and Imitation. *RAND Journal of Economics, 40* (4), 611–635.

Bork, R H (1978). *The Antitrust Paradox.* New York: Free Press.

Boudreau, K (2007). Does opening a platform stimulate innovation? The effect on systemic and modular innovations. *MIT Sloan Research Paper, 4611–06*.

Brousseau, E, and Pénard, T (2007). The Economics of Digital Business Models: A Framework for Analyzing the Economics of Platforms. *Review of Network Economics, 6* (2), 81–114.

Carlton, D W and Gertner, R H (2003). Intellectual Property, Antitrust and Strategic Behavior. In Jaffe, A, Lerner, J and Stern, S (eds), *Innovation Policy and the Economy, 3*, 29–60; Cambridge: MIT Press.

Carlton, D W and Waldman, M (2002). The Strategic Use of Tying to Preserve and Create Market Power in Evolving Industries. *RAND Journal of Economics, 33* (2), 194–220.

Casadesus-Masanell, R and Ghemawat, P (2006). Dynamic mixed duopoly: A model motivated by Linux vs. Windows. *Management Science, 52* (7), 1072–1084.

Chen, Z and Ross, T (1993). Refusals to deal, price discrimination, and independent service organizations. *Journal of Economics & Management Strategy*, *2* (4), 593–614.

Choi, J P and Stefanadis, C (2001). Tying, Investment, and the Dynamic Leverage Theory. *RAND Journal of Economics, 32* (1), 52–71.

Church, J, Gandal, N and Krause, D (2008). Indirect Network Effects and Adoption Externalities. *Review of Network Economics, 7* (3), 337–358.

Clements, M T and Ohashi, H (2005). Indirect Network Effects and the Product Cycle: Video Games in the U.S., 1994–2002. *Journal of Industrial Economics, 53* (4), 515–542.

Corts, K S and Lederman, M (2009). Software Exclusivity and the Scope of Indirect Network Effects in the U.S. Home Video Game Market. *International Journal of Industrial Organization, 27* (2), 121–136.

Crémer, J, Rey, P and Tirole, J (2000). Connectivity in the Commercial Internet. *Journal of Industrial Economics*, Wiley Blackwell, *48* (4), 433–472.

Darmon, É, Le Texier, T and Torre, D (2011). Proprietary or Open Source software: winner takes all competition, partial adoption and efficiency. *Revue d'Economie Industrielle, 136* 4.

David, P A and Bunn, J A (1988). The economics of gateway technologies and network evolution: Lessons from electricity supply history. *Information Economics and Policy, 3* (2), 165–202.

Devlin, A J and Jacobs, M S (2010). Antitrust Error. *William and Mary Law Review, 52* (1), 75–132.

Economides, N (1989). Desirability of Compatibility in the Absence of Network Externalities. *The American Economic Review, 79* (5), 1165–1181.

Eisenmann, T, Parker, G and Van Alstyne, M (2006). Strategies for two-sided markets. *Harvard Business Review*, *84* (10), 92–101.

Evans, D (2008). Competition and Regulatory Policy for Multi-Sided Platforms with Applications to the Web Economy. *Concurrences,* 2, 57–62.

Evans, D S, Hagiu, A, and Schmalensee, R (2006). *Invisible Engines – How Software Platforms Drive Innovation and Transform Industries.* Cambridge: MIT Press.

Evans, D and Hylton, K (2008). The Lawful Acquisition and Exercise of Monopoly Power and Its Implications for the Objectives of Antitrust. *Competition Policy International, 4* (2), 203.

Farrell, J and Klemperer, P (2007). Coordination and Lock-In: Competition with Switching Costs and Network Effects. In Armstrong, M and Porter R (eds), *Handbook of Industrial Organization,* 1967–2072. Amsterdam: Elsevier.

Farrell, J and Saloner, G (1992). Converters, Compatibility, and the control of Interfaces. *The Journal of Industrial Economics, 40* (1), 9–35.

Farrell, J and Saloner, G (1985). Standardization, Compatibility, and Innovation. *RAND Journal of Economics, 16* (1), 70–83.

Farrell, J and Weiser, P (2003). Modularity, Vertical Integration, and Open Access Policies: Towards a Convergence of Antitrust and Regulation in the Internet Age. *Harvard Journal of Law and Technology, 17* (1), 85–134.

Gandal, N, Kende, M and Rob, R (2000). The Dynamics of Technological Adoption in Hardware/Software Systems: The Case of Compact Disc Players. *RAND Journal of Economics, 31* (1), 43–61.

Gawer, A and Cusumano, M A (2014). Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management, 31* (3), 417–433.

Hand, J R (2001). Evidence on the Winner-takes-all Business Model: The Profitability Returns-to-scale of Expenditures on Intangibles Made by U.S. Internet Firms, 1995–2001, *Working Paper Series*.

Hart, O and Tirole, J (1990). Vertical Integration and Market Foreclosure, *Brookings Papers on Economic Activity (Microeconomics)*, 205–286.

Hazlett, T, Teece, D and Wavermann, L (2011). Walled Garden Rivalry: The Creation of Mobile Network Ecosystems. *George Mason University Law and Economics Research Paper Series, 11 (*50*).*

Heller, M A (1998). The Tragedy of the Anticommons: Property in the Transition from Marx to Markets. *Harvard Law Review, 111* (3), 621–688.

Hovenkamp, H J (2008). Schumpeterian Competition and Antitrust. *University of Iowa Legal Studies Research Paper, 8* (43).

Jarosch, J (2011). Novel Neutrality Claims against Internet Platforms: A Reasonable Framework for Initial Scrutiny. *Cleveland State Law Review, 59* (4), 537–588.

Johnson, J P (2006). Collaboration, peer review and open source software. *Information Economics and Policy, 18* (4), 477–497.

Jorde, T M and Teece, D J (1990). Innovation and Cooperation: Implications for Competition and Antitrust. *The Journal of Economic Perspectives, 4* (3), 75–96.

Kaiser, H F (2011). Are 'Closed Systems' an Antitrust Problem? *Competition Policy International, 7* (1), 91–113.

Katz, M L and Shapiro, C (1985). Network Externalities, Competition, and Compatibility. *The American Economic Review, 75* (3), 424–440.

Katz, M L and Shapiro, C (1986). Product Compatibility Choice in a Market with Technological Progress. *Oxford Economic Papers, New Series, 38*, 146–165.

Katz, M L and Shapiro, C (1994). Systems Competition and Network Effects. *The Journal of Economic Perspectives, 8* (2), 93–115.

Kuan, J (2002). Open Source Software as Lead User's Make or Buy Decision: A Study of Open and Closed Source Quality. *Stanford Institute for Economic Policy Research*.

Lerner, J and Tirole, J (2002). Simple Economics of Open Source. *The Journal of Industrial Economics, 50* (2), 197–234.

Lerner, J and Tirole, J (2005). The Economics of Technology Sharing: Open Source and Beyond. *Journal of Economic Perspectives, 19* (2), 99–120.

Liebowitz, S and Margolis, S (1990). The fable of the keys. *Journal of Law and Economics, 30* (1), 1–26.

Lunney Jr, G (1989). Atari games v. Nintendo: Does a closed system violate the antitrust laws. *Berkeley Technology Law Journal, 5* (1), 29–73.

Madureira, A, den Hartog, F, Bouwman, H and Baken, N (2013). Empirical validation of Metcalfe's law: How Internet usage patterns have changed over time. *Information Economics and Policy, 25* (4), 246–256.

Mantena, R, Sankaranarayanan, R and Viswanathan, S (2007). Exclusive Licensing in Complementary Network Industries. *NET Institute Working Paper, 07* (04).

Mariniello, M (2011). Fair, reasonable and non-discriminatory (FRAND) terms: a challenge for competition authorities. *Journal of Competition Law and Economics, 7* (3).

Matutes, C and Regibeau, P (1988). ‘Mix and match’: product compatibility without network externalities. *RAND Journal of Economics, 19* (2), 221–234.

Mehra, S K (2011). Paradise is a Walled Garden? Trust, Antitrust and User Dynamism. *George Mason Law Review, 18* (4), 889–952.

Motta, M (2004). *Competition Policy: Theory and Practice.* Cambridge: Cambridge University Press.

Nahm, J (2004). Open Architecture and R&D Incentives. *The Journal of Industrial Economics, 52* (4), 547–568.

Nair, H, Chintagunta, P and Dubé, J-P (2004). Empirical Analysis of Indirect Network Effects in the Market for Personal Digital Assistants. *Quantitative Marketing and Economics, 2* (1), 23–58.

Nalebuff, B and Majerus, D (2003). Bundling, Tying, and Portfolio Effects. *DTI Economics Paper* (1).

Noyes, J (1983). The QWERTY keyboard: A review. *International Journal of Man-Machine Studies*, *18* (3), 265–281.

OECD (2012). Digital Economy. *DAF/COMP/WD* (22).

OFT (2013). Anti-Competitive Effects of RPM (Resale Price Maintenance) Agreements in Fragmented Markets.

OFT (2012a). The Economics of Secondary Product Markets (OFT1471).

OFT (2012b). Price Relationship Agreements (OFT1438).

OFT (2011). Consumer Behavioural Biases in Competition, A Survey (OFT1324).

OFT (2010a). Online Targeting of Advertising and Prices (OFT1231).

OFT (2010b). Review of Barriers to Entry, Expansion and Exit in Retail Banking (OFT1282).

OFT (2003). Switching costs. Part one: Economic models and policy implications (OFT655).

Owen, B M (2011). Antitrust and Vertical Integration in ‘New Economy’ Industries. *Review of Industrial Organization, 38,* 363–386.

Pitelis, C N and Teece, D J (2010). Cross-border market co-creation, dynamic capabilities and the entrepreneurial theory of the multinational enterprise. *Industrial and Corporate Change, 19* (4), 1247–1270.

Posner, R A (1976). *Antitrust Law: An Economic Perspective.* Chicago: University of Chicago Press.

Prieger, J E and Hu, W-M (2006). An Empirical Analysis of Indirect Network Effects in the Home Video Game Market. *NET Institute Working Papers, 6* (25).

Rey, P, Seabright, P and Tirole, J (2002). The Activities of a Monopoly Firm in Adjacent Competitive Markets: Economic Consequences and Implications for Competition Policy. *IDEI Working Papers, 132*.

Rosch, J T (2011). The Intersection of Antitrust and Intellectual Property: The Quest for Certainty in an Uncertain World. Federal Trade Commission, 18 May.

Saint-Paul, G (2003). Growth Effects of nonproprietary Innovation. *Journal of the European Economic Association, 1* (2–3), 429–439.

Schmidt, K M and Schnitzer, M (2003). Public Subsidies for Open Source? Some Economic Policy Issues of the Software Market. *Harvard Journal of Law and Technology, 16* (2), 474–505.

Schwartz, M and Werden, G J (1996). A Quality-Signaling Rationale for Aftermarket Tying. *Antitrust Law Journal, 64* (2), 387–404.

Shapiro, C and Varian, H R (1999). *Information Rules: A Strategic Guide to the Network Economy.* Boston: Harvard Business School Press.

Teece, D J (2006). Reflection on 'Profiting from Innovation'. *Research Policy, Elsevier, 35* (8), 1131–1146.

Tirole, J (2005). The Analysis of Tying Cases: A Primer. *Competition Policy International, 1* (1), 1–25.

Von Hippel, E (2005). *Democratizing Innovation.* Cambridge, London: MIT Press.

Whinston, M D (1990). Tying, Foreclosure, and Exclusion. *The American Economic Review, 80* (4), 837–859.

Williamson, O E (1979). Transaction-Cost Economics: The Governance of Contractual Relations. *Journal of Law and Economics, 22* (2), 233–261.

Wu, T (2007). A Tale of Two Platforms. *Harvard Law Review, Forthcoming*.

Wu, T (2012). Hearing on Digital Economy: Oversight of Innovation Catalysts. *OECD DAF/COMP/WD* (2).

Zittrain, J (2008). *The Future of the Internet and How to Stop It.* New Haven, London: Yale University Press.