The Economics of Social Network Interoperability*

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Abstract

We unify notions of social network interoperability (SNI) proposed by international regulators. We then adapt classical models from information economics and industrial organization to derive testable predictions on the effect of SNI on cross-side subsidies, the amount of personal data shared, and entrant innovation, and illustrate the role of expectations. We present two questions from the discourse on SNI that feature previously unexplored economic tradeoffs.

1 Why an Economics of Interoperability

Antitrust laws in several jurisdictions (such as the Sherman, the Clayton, and the Federal Trade Commission Acts in the US and TFUE Art. 102 in the EU) provide an established framework on how to prevent consumer harm from anticompetitive behavior and have done so in many industries in the past. Nonetheless, evidence of rising markups and the economic power of a few superstar firms that sell related products, but do not compete directly, casts doubt on whether existing antitrust regulations suffice Berry et al., 2019; Shapiro, 2019.

Many of these companies earn money with consumer data. Markets for such data have several unique properties: First, they show strong economies of scale and multiple customer groups, some of which need not pay if they provide data. Users' hesitance to share personal data, even for free, brings additional (behavioral) complexity to this market. Also, data, compared to other goods that show strong economies of scale, is hard to standardize, as is the definition of anticompetitive behavior in

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data markets.[1] The combination of these properties of data markets makes the analysis of regulatory and antitrust interventions into data markets complex.

Despite this complexity, the number of distinct remedies for antitrust violations is small. Since the Microsoft case, antitrust authorities mostly ordered fines as remedies (the latest Google antitrust case in the EU led to a penalty of approximately $ 1.65 Billion to Google for anticompetitive use of its feature “Adsense”). Because of winner-takes-most dynamics in data markets, one might doubt the effectiveness of fines. These doubts lead to the study of alternative antitrust regulations and remedies.

Social Network Interoperability (SNI) is a candidate antitrust remedy for data platforms that might be better suited to enhance consumer welfare—if its effects are properly understood.[2]

In this article, we adopt a broad definition of a social network: Whenever an application allows users to both store personal (profiles) as well as relational (messages, emails, tweets) information, we call it a *social network*. We will, however, in some of our models below, assume the prevalent ad-based business model of many successful internet companies. We call a system (or, more specifically, a social network) *interoperable* if interacting with more than one system does not require duplication of efforts. An example of interoperability is the ability to easily contact persons with a different phone carrier or mail provider.

Several regulators' expert panels make a case for SNI as a means to increase competition among social networks and to increase incentives to innovate (Crémer et al., 2019; Furman et al., 2019), referring to positive effects of interoperability regulations in industries, such as regulation on phone interconnection. The notions of interoperability that are proposed, however, differ among the regulators and impact consumer welfare differently.

This article, first, in a unified form, introduces four different notions of SNI found in policy recommendations by several different regulators and experts. We hope that this concise language will help economists in discussing crucial channels of influence for various degrees of SNI.

Then, we introduce variants of two classical and two recently proposed models of information economics and industrial organization that highlight crucial economic tradeoffs arising in SNI. We study questions around the role of expectations, the presence of cross-side subsidies in markets with multi-homing on both sides, competition and information sharing, and the effect of interoperability on innovation. We accompany each of our models with a testable prediction and a discussion.

[1] A case of such purportedly anticompetitive conduct was Facebook's decision to cut data access for the “find a friend” feature of Vine Hamilton, 2018 with devastating consequences for this competitor.

[2] There are other areas of antitrust enforcement that we do not study in this article, such as anti-merger enforcement for horizontal mergers, antitrust interventions in cases of labor market monopsonies (Shapiro, 2019) and data openness (Crémer et al., 2019).

Finally, we highlight two controversies surrounding social network interoperability that feature significant economic tradeoffs and entail open challenges for empirical economics and microeconomic theory.

The plan of the rest of the article is as follows: In section 2, we unify notions of social network interoperability put forward in policy recommendations. We then introduce our predictions and microeconomic models in section 3. In section 4, we present potential questions for further research and conclude.

2 Notions of Interoperability

In this section, we contrast different notions of SNI put forward in policy recommendations.

We start with preliminary definitions and notations. Systems are *interoperable* if interacting with more than one system does not require duplication of efforts. For example, there is no need for several SIM cards for domestic calls due to interoperability regulation that ensures that calls are possible to any other provider (47 US Code §251). As social networks are much more heterogeneous and complex products than call services, policy recommendations discuss several concepts of social network interoperability. We follow the nomenclature laid out in the *EU Commission Report* Crémer et al., 2019 and contrast it with other definitions. For brevity, we will also denote in the following Furman et al., 2019 as the *UK Report* and Morton et al., 2019 as the *Stigler Report*.

Data Portability Data Portability (*Discrete Data Mobility* in the UK Report) is the ability for a user to export personal data in a machine-readable form. Data Portability is a right under the General Data Protection Regulation (Art. 20) and the California Consumer Privacy Act (1798.100 (d)). Data Portability, formally, is not an interoperability notion, as it is *static*. It does only facilitate the transport of data at one point in time. Data Portability hence simplifies *switching* between different networks but is of little use in the maintenance of content at several places. Therefore, it does not help users *multi-home*, i.e., to be present on several networks at the same time. The most prominent examples of data portability are exports of data on popular social networks (such as Google Takeout, Facebook Archive and Twitter Archive).

Protocol Interoperability Protocol Interoperability (*Open Standards* in the UK and Stigler reports) is the existence of common standards under which data can be shared. In addition to data portability, it requires that the machine-readable exports of data can be understood by recipient services. As data portability, Protocol Interoperability is a static concept and hence only reduces switching costs, but not the costs of multi-homing. Examples of Protocol Interoperability can be found in the industry already. The Data Interoperability Project (Data Transfer Project, 2018) aims to provide more accessible interfaces for switching between (cloud) services of established internet companies. The *Facebook Whitepaper on Data Portability* (Egan, 2019) likely assumes a concept of Protocol Interoperability in their discussion of "Data Portability". A specific example of Protocol Interoperability in the research community is the ability for users to export bibliography to a bibliography management system of their choice (using the widely accepted `.bib` format).

Data Interoperability A first notion of (continuous) interoperability is Data Interoperability (*Continuous Data Mobility* in the UK report). It asserts the existence of so-called *privileged APIs* (Application Programming Interfaces) for competitors. Privileged APIs allow a selected group of other networks access to (some of) a network's data that cannot be accessed via public APIs. Despite its privilege, a "privileged" API might have severe restrictions on the access to a network's data; for example, it might be restricted to only access public posts. An example of a privileged API is given by the Twitter and Facebook extensions to (cross-)post public updates on one network also on the other. In contrast to Data Interoperability *qua* regulation, these extensions could, however, be unilaterally deactivated by either Facebook or Twitter and are not open to market entrants.

Full Protocol Interoperability The most substantial notion of interoperability is Full Protocol Interoperability (the UK and the Stigler report use the same name for this notion, with less emphasis on the difference to Data Interoperability). It is the integration of all services of a network with others. Gans, 2018 likely assumes Full Protocol Interoperability when he proposes "Identity Portablity" and the term "Social Graph Portability" introduced in Zingales and Rolnik, 2017 operationally likely coincides with Full Protocol Interoperability. An example of Full Protocol Interoperability already in place are the internet protocols (HTTP) and, as regulated in the US, the interconnection of phone providers. Another example of Full Protocol Interoperability is the Open Banking the EU Digital Payments Regulation 2. Open Banking means that customers of a bank can grant third parties access to their account data and to use an API to make transactions from their account. Open Banking allows for a market of applications to manage payments.

In defining Full Protocol Interoperability, standardizing what is meant by "all" services of a network is an important task. The Stigler Report proposes to charge an implementational institution, the "Digital Authority", to maintain standards, the EU report cautions against Full Protocol Interoperability for the reason of high costs of standardization and potentially adverse effects on innovation. The UK report chooses a midground and proposes to charge a "digital markets unit" to define which aspects of social networks should be made interoperable, in the spirit of Data Interoperability.

3 Microeconomic Theory of Interoperability

This section discusses four predictions from microeconomic theory and highlights implications for the design of SNI regulation. In subsection 3.1, we illustrate the role of expectations. We then discuss how interoperability might affect cross-side subsidies in subsection 3.2. We conclude with effects on privacy (subsection 3.3) and innovation (subsection 3.4). We will present all results in a social networking context, even if the results in the original papers were formulated in a different language. In one-sided markets, we call the price-taking side *users* and the price-setting side *networks*. In two-sided markets, we call the charged side *advertisers*, the intermediaries *networks*, and the subsidized side *users*.

Several models will include payments from users. We highlight that these can be negative and need not be monetary, but could be offering free services or lower ad levels.

3.1 The Role of Expectations

A first prediction is:

> If interoperability changes users' expectations of market composition, they will have a strong effect on market structure.

We give a variation of the Bertrand-type model in Katz and Shapiro, 1985, which allows for multi-homing (see also Dybvig and Spatt, 1983 for a first study on the multiplicity of equilibria and Westenbroek et al., 2019 for a re-discovery in the Computer Science literature). There are two networks $i = 1, 2$ that, in a first stage, simultaneously offer (uniform) prices p_i to join their respective network. In a second stage, a continuum of users with types $\theta \in [0, 1]$ chooses a network i to join. Users derive a positive externality from two sources. From their own network i, a user derives a positive externality of $v(x_i)$. Here, v is a function describing the extent of the externality such that v is an increasing function with $v(1) > v(0) = 0$; x_i is the mass of users that choose network i in equilibrium. From the other network, they derive a fraction $\alpha \in [0, 1)$ of the externality $v(x_{-i})$ on the other network. The utilities are, hence,

$$u(i;v) = \theta - p_i + v(x_i) + \alpha v(x_{-i}).$$

Networks maximise their Cournot revenue $\pi_i = p_i x_i$. We study subgame-perfect equilibria of this game.

There are many such equilibria. As an example, a monopoly by any of the networks can be supported as a subgame-perfect equilibrium. Indeed, if in equilibrium all users join i, as $v(0) = 0$, i can offer users a surplus of $\theta + v(1)$. The other network can offer a surplus of $\theta + \alpha v(1)$. To make types indifferent, i can charge

$$p_i = v(1) - \alpha v(1),$$

making it a best-response for all agents to join network i. In the network's game, the other network is indifferent between charging any price, making this an equilibrium. Therefore, either network being a monopoly can be supported as an equilibrium, depending on the *expectations* of users.

Crucial Assumptions, Variants, and Criticism This model can be criticized as unrealistic in terms of its *ad hoc* treatment of expectations, its effectively single-homing nature, and because of its rationality assumptions that might not be satisfied.

First, the model does not give insight into how expectations are formed and allows for (potentially too) high flexibility in choosing off-path actions. In this model, users can react to any deviation (e.g., a higher price by one network) with a *coordinated* move to the other network. Such coordination might not be realistic. If price discrimination is possible, a network can prevent threats from these coordinated moves by choosing prices carefully using a strategy called "divide and conquer" Segal, 2003. Another literature restricts coordinated responses of users off-path. In Aoyagi, 2018, users choose the least favorable equilibrium for a network if the network deviates from its strategy and study prices supporting monopolization. Weyl, 2010 uses payments contingent on other users' participation to derive a unique equilibrium.

A second strong assumption is that in how multi-homing is introduced into the model. Users still patronize a single network and get a discounted value from a secondary network, which might not be a good approximation of strong notions of interoperability such as Full Protocol Interoperability.

Third, the model assumes that users form rational expectations and will react to changes immediately. Rationality is not an innocuous assumption given behavioral biases and slow adoption rates.[3]

3.2 (No) Cross-Side Subsidies

A second prediction is

> If multi-homing is cheap both for advertisers and users, and preferences are such that a positive proportion of both sides multi-home, then competing networks cannot subsidize users.

We give a simplified version of the Hotelling-type model in Bakos and Halaburda, 2018 (in a different model, Anderson et al., 2018 arrive at similar conclusions).[4] There is a continuum of users $x \in [0, 1]$ and advertisers $y \in [0, 1]$ and two networks $i = 0, 1$. First, networks decide on prices p_i to users and r_i to advertisers. Then, users and advertisers decide which of the networks to join or to join both. We denote by x_i and y_i the mass of users, respectively, advertisers that choose network i. Users and advertisers have a standalone value of u_i, respectively, v_i for each of the networks. Both users and advertisers experience a linear positive externality from the other side of the market, with a coefficient of α for users and β for advertisers. Network i is positioned at i and users and advertisers each have a "transportation cost" of 1. Then, the utilities for joining network i resp. joining both networks is

$$u(i; x) = u_i + \alpha y_i - p_i - |i - x| \qquad u(i; y) = v_i + \beta x_i - r_i - |i - x|$$

$$u(\text{both}; x) = u_0 + u_1 + \alpha - p_1 - p_2 - 1 - k \qquad u(\text{both}; y) = v_0 + v_1 + \beta - r_1 - r_2 - 1 - k.$$

Observe that the utility for multi-homing is derived by adding standalone values, prices and transportation costs, but assuming that users and advertisers do not derive any additional utility from advertisers resp. users on the other side of the market that they reach twice (there is no *value of second impressions*). In addition, there is a constant cost k of multi-homing. We assume that each user and each advertiser participates in at least one network.[5] We are interested in pricing of the networks in parameter settings such that some, but not all agents on both sides of the market multi-home.

[3] This is different from financial markets, in which one tweet by Kylie Jenner, an Instagram Influencer, brought severe losses to competitor Snap Inc., see Ungarino, 2019.

[4] We use that in Bakos and Halaburda, 2018, one can normalize the "transport cost" in each of the utility functions to one without changing the model. Indeed, the agents' utility functions are homogenous of degree 1 in the vector of all parameters.

[5] Which is realistic in a static market where completely new users are not strategically relevant for networks.

The main determinants of the price are the types that are indifferent between choosing, *in addition to* the other network $-i$ to also join network i, as these mark the right resp. left end of the interval of types that pay for network i. Denote these types by $\hat{x}_i$ resp. $\hat{y}_i$. Then, for these types, we have $u(-i; \hat{x}_i) = (\text{both}; \hat{x}_i)$ and $u(-i; \hat{y}_i) = (\text{both}; \hat{y}_i)$. Basic algebra yields that these types for network 0 are given by

$$\hat{x}_0 = u_i + \alpha(1 - y_1) - p_0 \qquad\qquad \hat{y}_0 - k = v_0 + \beta(1 - x_1) - r_0 - k$$

(Similar expressions hold for network 1.) The cutoffs, and hence also the revenue from one side of the market, do not depend on the mass of agents from the other side that are on this network, but only how many are on the other network. In particular, this implies that is is impossible to positively influence revenue by charging one side a lower price and expecting a higher bargaining power on the other side of the market.

This lack of cross-subsidies arises from the preference of marginal users, respectively, advertisers. Assume an advertiser is indifferent between joining network 0 or joining both networks. In her decision, the advertiser is interested only in users that are *exclusive* to network 1. A decrease of 0's price to users affects this advertiser directly, as this means that there are fewer exclusive users on network 1. A price change to users on 1, however, will not change the number of unique users of network 1, but invite users to multi-home on networks. This means that subsidies seize to be optimal in this setting.

Crucial Assumptions, Variants, and Criticism Our conclusion contradicts an established result on two-sided markets from Rochet and Tirole, 2003[6]: In two-sided markets, that is, markets with very different customer segments ("sides") that have positive externalities on each other, it can be optimal to subsidize one side of the market to extract more revenue from the other side. Our above model makes strong assumptions on the structure of cross-side externalities, the zero value of second impressions, and the structure of the cost of multi-homing. We comment on each of these potential criticisms.

A first criticism is on the structure of cross-side externalities. In the model, both users and advertisers get a positive network externality from the other side. Such an externality is a reasonable approximation of reality for advertisers. Despite standard in the literature on two-sided networks,

[6]See Armstrong, 2006 for a model of similar structure, but with different utility specification for users, Caillaud and Jullien, 2003 for a model of an intermediary incorporating search of agents. See Evans and Schmalensee, 2013 for a survey of the literature on two-sided markets

Rochet and Tirole, 2003, it may be questioned, however, whether users derive a positive externality from a higher number of advertisers. One can argue that there will be at least a small positive externality as more advertisers allow for more personalized and, hence, less distracting ads. This shortcoming of the theory should be investigated in further research extending Bakos and Halaburda, 2018.

Also, in the model, second impressions have a zero value, i.e., advertisers and users only derive an externality from exclusive agents on the other side. If one relaxes this assumption, then cross-subsidies re-appear, see the independent discoveries Anderson et al., 2018 and Bakos and Halaburda, 2018, Section 6. The crucial role of the value of second impressions points towards potential policy implications. If cross-subsidies in the market are desired, networks should have sufficient freedom in their treatment of advertisements to allow for a non-zero value of second impressions. For a further discussion of an extension of this model, see section 4.

Finally, in the model, there are only constant costs associated with multi-homing. If there is any discounting of the externality from the other network, then, as is not hard to show, cross-subsidies re-appear. Such a discounting can be seen as an interpolation of different strengths of interoperability. Our model hence illustrates a tradeoff between interoperability, the value of second impressions, and the size of cross-subsidies.

3.3 Privacy and Interoperable Social Networks

The third prediction is

> If all bargaining power is with the networks, excessive data sharing persists, even if networks compete.

We give a simplified model of social network competition of Bergemann, Bonatti, and Gan, 2019, Section 8.[7] There are I users $i = 1, 2, \dots, I$, a monopolistic advertisers, and J competing data intermediaries $j = 1, 2, \dots, J$. In the following, all random variables are independent, standard normally distributed unless defined otherwise. The users have correlated types $w_i = \theta + \theta_i$, where θ_i is deterministic. Users maximize a utility function given a (personalized) quantity-price offer by the advertiser,

$$w_i q_i - p_i q_i - \frac{1}{2} q_i^2.$$

[7]Compare the complementary study Acemoglu et al., 2019 where users experience disutility if networks (can) estimate their type more accurately and there is no price-discriminating advertiser, and Choi et al., 2019 which assumes an exogenous privacy concern. Both papers arrive at similar conclusions on the effect of competition as we do here.

Users only observe a noisy observation $r_i = w_i + \zeta_i$ of their type. Network j decides at the outset on data offers (κ_j^i, m_j^i) to agents before any random variables are realized. Here, κ_j^i is a precision with which the data intermediary wants to learn a user's type, m_j^i is a transfer from the users. There is a lower bound $\underline{\kappa}$ on the precision with which an intermediary can learn a user's type.[8] The users simultaneously accept or reject a subset of the offers (κ_j^i, m_j^i) by different networks. If user i accepts network j's offer, then j learns

$$s_i = r_i + \kappa_{ij}\varepsilon_{ij}$$

The networks then offer prices m_j to the advertiser for offering all observations s_i. The advertiser accepts or rejects a subset of the offers and finally offers (personalized) prices p_i and quantities q_i to the users to maximize revenue $\sum_{i=1}^{I} p_i q_i$. The equilibrium concept is symmetric subgame-perfect equilibrium where indifferent users accept offers. Networks would like to maximise total remunerations $m_j + \sum_{i=1}^{I} m_j^i$.

Bergemann, Bonatti, and Gan, 2019 predict for our restricted model:

Proposition (Bergemann, Bonatti, and Gan, 2019, Proposition 19)**.** *In every equilibrium, the networks will choose the maximum level of accuracy,*

$$\kappa_j^i = \underline{\kappa}$$

and users will be indifferent between accepting none of the offers and all of them.

Arriving at this result requires several steps. First, a single user's incentives to deviate by not accepting offers is of a limited effect, as the network already learns an important part of the data from the other users' shared information. Other contributions identified this *data externality* independently Acemoglu et al., 2019; Choi et al., 2019. Furthermore, a deviation by one network to collect less data is not profitable. Such a deviation could increase a network's remuneration if this implies that more users reject other networks' offers, as then the network would have a better when facing the advertiser. The deviating network, however, also loses, as it has less valuable information to sell to the advertiser. It can be proved that the latter effect outweighs the further, compare Bergemann, Bonatti, and Gan, 2019, Proof of Proposition 19.

Crucial Assumptions, Variants, and Criticism One might challenge our prediction due to its potentially unrealistic distribution of bargaining power, its static nature, and the assumption of a

[8] This is to prevent multiplicity of equilibria, as is the specification of user choice in case of indifference, compare subsection 3.1.

particular business model. In the following, we extend each of these criticisms.

First, in this model, the social network has all bargaining power—it makes take-it-or-leave-it offers to both users and the advertiser. This distribution of bargaining power might be realistic in today's social networking market, one hope for SNI is, however, to redistribute this bargaining power. Even the introduction of Protocol Interoperability would considerably strengthen (groups of) users' bargaining power. Allowing for coordinated deviations would introduce a multiplicity of equilibria into the above model, as users would need to coordinate on to which network to switch and hence complicate the analysis.

Also, the model is inherently static, which might not be a realistic model of social networks. In particular, the model assumes that networks know the complete structure of the users' types. If instead, networks acquired information dynamically in repeated interaction with users, we expect that the networks' bargaining power facing users is even stronger, giving individual networks an even stronger incentive in competition to extract more data.

Finally, the model prescribes an ad-based business model for networks. If users are in a weak bargaining position, one could argue, then any network that does not sell data to the other side of the market might miss out on some revenue. If users, however, have a preference for not sharing their data and cooperate (as mentioned in the first criticism of this model), other results might be obtained, which is the hope of interoperability regulation Bergemann and Bonatti, 2019.

3.4 Competition, Interoperability, and Innovation

The last prediction is

> If only the dominant network is required to be interoperability, the incentives for innovation by entrants might be lower than without a regulation.

This surprising result comes from the tradeoff that a forward-looking entrant must also take into account policies for incumbents, thinking about scenarios where it will be successful. We present a variant of the model of Segal and Whinston, 2007, Section 3.B to illustrate this tradeoff.

Two networks interact in a discrete, infinite-horizon game with discounting $\delta > 0$. In each round, a unit mass of two overlapping generations of users are present—an *old* and a *young* generation. In each round, only the young users coordinatedly join one of the networks, the old generation stays on the network it joined last round. The network that was chosen by last round's young generation is called the *incumbent*, the other network the *entrant*. At the beginning of a period, the entrant chooses $\phi \in [0, 1]$, an amount of R&D activity. With probability ϕ, the entrant successfully innovates, and users choosing this network derive an additional utility of Δ from choosing it compared to the other network for both periods of their lifetime. If the entrant is unsuccessful, they derive an additional utility of Δ from choosing the incumbent network. We call the network that gets this additional utility the *technological leader*. After nature determines the technological leader, both networks choose a *compatibility* $b \in [0, 1]$, which determines how much users joining the network of the next technological leader will profit from this network's externality. The value of the network externality to a user is linear and given by $1 + b$, where 1 is the mass of users in one's generation, and b is the discounted effect of users on the last technological leader via compatibility. We assume that there is an interoperability regulation that requires the technological leader has to choose a level of compatibility of at least $\varepsilon > 0$. The networks also choose a price for users to join the network. Finally, the young user generation chooses which network to join, taking into account Δ, the network externality, and the prices of the networks. We call the network that the young generation chooses in the current period *successful*, the other network *unsuccessful*. We study stationary Markov-perfect equilibria of this game.

We limit our discussion to on-path observations thanks to the following Proposition.

Proposition (Segal and Whinston, 2007, Section III.B)**.** *If $\Delta > 1$, there is an equilibrium such that*

1. *the technological leader is successful,*
2. *the technological leader offers a price that makes the young generation indifferent between joining it and the unsuccessful network when the rest of the play is on-path,*
3. *on path, an unsuccessful network chooses the least costly compatibility level, $b = 0$.*

This on-path characterization is intuitive, as, if the indifferences would not hold, either of the networks could profitably deviate by offering lower resp. higher prices.

Observe that all unsuccessful networks derive zero value from this round's young generation. The only two types of networks that derive positive revenue from the young generation are entrant and incumbent technological leaders.

Consider first the value to an incumbent technological leader. That there is an incumbent technological leader implies that the R&D efforts of the entrant were unsuccessful. Fixing all other play, the entrant offers a (lifetime) surplus of $1 + \delta$ (As in case the users chose this network, this network cannot innovate, and hence, the next young generation will choose the other network, the technological leader). Note that this uses that unsuccessful networks will choose $b = 0$ by item 3 of the Proposition. The incumbent network can offer users a surplus of $2 + \delta G(\phi) + (1 + \Delta)\Delta - b^*(\alpha)$, where

$$G(\phi) = (1 - \phi) \cdot 2 + \phi \cdot 1,$$

is the nextwork externality from the incumbent network that the young generation expects in the next round, and $b^*(\alpha)$ is the optimal compatibility level given the lower bound α for the technological leader. By item 2 of the Proposition, the revenue (which equals the payment) from the young generation is equal to the surplus difference,

$$(2 + \delta G(\phi) + \Delta - b^*(\alpha)) - (1 + \delta) = 1 + \delta(G(\phi) - 1) + \Delta - b^*(\alpha).$$

Consider now an entrant technological leader. If the recent incumbent were chosen, this would generate a surplus of $2 + \delta$, where we again used item 3 of the Proposition. The entrant can give the users a surplus of $1 + b^*(\alpha) + \Delta + \delta(G(\phi) + \Delta) - b^*(\alpha)$. Again, by item 2 of the Proposition, the revenue from the young generation is

$$-1 + \Delta + \delta(G(\phi) + \Delta - 1)$$

Note that under this specification, the expected profit from the young generation of an entrant technological leader is *independent* of the value of α, but the continuing incumbent's revenue is strictly decreasing. As a forward-looking entrant will use the information on the future earnings in making an innovation decision, raising α can even decrease the innovation choice ϕ.[9]

Crucial Assumptions, Variants, and Criticism This model is effectively one-sided and makes strong assumptions on incumbent behavior and consumer choice. We comment on criticisms arising from this in the following.

First, the model does not capture the two-sided nature of platform businesses. An analysis including another side of the market is possible, but will likely not influence the main result: If a regulation reduces the expected future benefits of an incumbent, this might lower incentives to innovate also for an entrant.

Second, in this model, only the young consumers decide which network to join. This multi-generation assumption might be realistic in today's social network economy, but might be limiting in strong forms of interoperability, where usage patterns might be more complex.

Finally, this model studies only *forward interoperability*, i.e., inter-operability with networks that

[9] Formally, this requires a proof that $b^*(\alpha)$ is indeed increasing in α, or, stronger, that the lower bound on compatibility always binds. We refer the reader to Segal and Whinston, 2007 for a further discussion.

are increments of the existing networks. This assumption might be unrealistic in that (in particular Full Protocol) interoperability might require *backward* compatibility, i.e. that new innovations are required to allow users on older networks to interoperate. Backward compatibility might pose other challenges to innovation (as it limits what kinds of innovations are possible) but might change the conclusion of the above model. In particular, it requires different modeling choices, as the overlapping generations model presented above cannot easily accommodate such a change. We leave the study of backward compatibility for further work.

4 Two Questions on Social Network Interoperability

This section introduces previously unexplored economic tradeoffs surrounding SNI, and concludes.

The role of second-order connections The Facebook Whitepaper on Data Portability argues that even Protocol Interoperability introduces a severe tradeoff between privacy and market entrants' expectation of success (Egan, 2019, p.15). The paper contrasts two scenarios on the role of indirect relationships in interoperable social networks. In the first scenario, when users that have a common friend on another network join a new network, this network and the users learn that they have a common friend elsewhere. Egan, 2019 illustrates that, in this scenario, the new network can infer information about the common friend of the users, even if this person is not on the network. In a second scenario, no such information is passed on to a new network. For this scenario Egan, 2019 raises the question of whether the limited information would effectively help market entrants. Gans, 2018 proposes an opt-out solution to this problem: Information on common friends is shared unless users explicitly opt-out.

The tradeoff between privacy and revenue for entrants is amenable for economic analysis. A first challenge is an empirical one: How much (ad) revenue is derived from the information of indirect links (this can be seen as a variant of the *strength of weak ties* Granovetter, 1973). An approach for comparative statics in an economic model might be to interpolate between the first and second scenarios: A fraction α of users allows sharing information to identify his or her friends on new networks, the rest does not.

Non-existence of multi-homing equilibria A second question arises from our observations in subsection 3.2 on the non-existence of cross-subsidies in two-sided markets with partial multi-homing. We assumed zero utility from "second impressions", which depressed the value of multi-homers for the networks. Bakos and Halaburda, 2018 show that, in our model from subsection 3.2, there are parameters such that, in equilibrium, a positive mass of agents multi-home. We propose the study of an additional disincentive to multi-homing with within-side externalities: If second impressions are not valuable, this does not mean that users are not concerned about their privacy when interacting on several networks. Specifically, if a multi-homing user connects with another multi-homing user, the fact that both multi-home does not give them additional utility, but an additional privacy concern, as several networks know about the users' connection. Incorporating such a privacy concern could preclude any equilibria with a positive mass multi-homing on both sides. If non-existence results were obtained, cross-subsidies might re-appear, but interoperability has missed its intent (as no-one multi-homes).

Conclusion In this article, we reviewed and structured policy recommendations for SNI. We adapted classical and recently introduced models of industrial organization and information economics to illustrate economic tradeoffs arising from social network interoperability. Finally, we introduced two open questions for further study in an Economics of Social Network Interoperability.

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