Two-Sided Markets: An Overview*

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Abstract

The paper offers an introduction and a road map to the burgeoning literature on two-sided markets. In many industries, platforms court two (or more) sides that use the platform to interact with each other. The platforms' usage or variable charges impact the two sides' willingness to trade, and thereby their net surpluses from potential interactions; the platforms' membership or fixed charges in turn determine the end-users' presence on the platform. The platforms' fine design of the structure of variable and fixed charges is relevant only if the two sides do not negotiate away the corresponding usage and membership externalities.

The paper first focuses on usage charges and provides conditions for the allocation of the total usage charge (e.g., the price of a call or of a payment card transaction) between the two sides not to be neutral; the failure of the Coase theorem is necessary but not sufficient for two-sidedness.

Second, the paper builds a canonical model integrating usage and membership externalities. This model allows us to unify and compare the results obtained in the two hitherto disparate strands of the literature emphasizing either form of externality; and to place existing membership (or indirect) externalities models on a stronger footing by identifying environments in which these models can accommodate usage pricing. We also obtain general results on usage pricing of independent interest.

Finally, the paper reviews some key economic insights on platform price and non-price strategies.

Keywords: Two-sided markets, membership and usage externalities, Coase theorem.

JEL numbers: L13, L4, L5.

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1 Introduction

The paper offers an introduction and a road map to the burgeoning literature on two-sided markets. Two-sided (or more generally multi-sided[1]) markets are *roughly* defined as markets in which one or several platforms enable interactions between end-users, and try to get the two (or multiple) sides "on board" by appropriately charging each side. That is, platforms court each side while attempting to make, or at least not lose, money overall.

Examples of two-sided markets readily come to mind. Videogame platforms, such as Atari, Nintendo, Sega, Sony Play Station, and Microsoft X-Box, need to attract gamers in order to convince game developers to design or port games to their platform, and need games in order to induce gamers to buy and use their videogame console. Software producers court both users and application developers, client and server sides, or readers and writers. Portals, TV networks and newspapers compete for advertisers as well as "eyeballs". And payment card systems need to attract both merchants and cardholders. There are many other two-sided markets of interest,[2] only a few of which will be mentioned in this overview.

But what is a two-sided market and why does two-sidedness matter? On the former question, the recent literature has been mostly industry specific and has had much of a "You know a two-sided market when you see it" flavor. "Getting the two sides on board" is a useful characterization, but it is not restrictive enough. Indeed, if the analysis just stopped there, pretty much any market would be two-sided, since buyers and sellers need

[1]We focus on two-sided markets for expositional simplicity. Many markets or platforms are multi-sided, though. Consider a standard-setting organization attempting to convince a group of patent owners to join forces in order to establish a standard. It must obtain enough commitments from these owners (reasonable royalties, exact implementation of the technology, treatment of future innovation, etc.) in order to convince various potential users (e.g., consumer electronics and software companies) to invest in the technology, while also making it attractive for each and every intellectual property owner to get on board. The insights obtained for two-sided platforms apply more generally to multi-sided ones.

[2]See, e.g., Armstrong (2004), Evans (2003) and Rochet-Tirole (2003).

to be brought together for markets to exist and gains from trade to be realized.

Conceptually, the theory of two-sided markets is related to the theories of network externalities and of (market or regulated) multi-product pricing. From the former, it borrows the notion that there are non-internalized externalities among end-users.[3] From the latter, it borrows the focus on the price structure and the idea that price structures are less likely to be distorted by market power than price levels. The multi-product pricing literature, however, does not allow for externalities in the consumption of different products: To use a celebrated example, the buyer of a razor internalizes in his purchase decision the net surplus that he will derive from buying razor blades. The starting point to the theory of two-sided markets by contrast is that an end-user does not internalize the welfare impact of his use of the platform on other end-users.

To refine the analysis, it is important to distinguish usage and membership fees: The platforms' usage or variable charges impact the two sides' willingness to trade, and thereby their net surpluses from potential interactions; the platforms' membership or fixed charges in turn condition the end-users' presence on the platform. The platforms' fine design of the structure of variable and fixed charges is relevant only if the two sides do not negotiate away the corresponding usage and membership externalities.

The paper first focuses on usage charges and provides conditions for the allocation of the total usage charge (e.g., the price of a call or of a payment card transaction) between the two sides not to be neutral; the failure of the Coase theorem is necessary but not sufficient for two-sidedness.

Second, the paper builds a canonical model integrating usage and membership externalities. This model allows us to unify and compare the results obtained in the two hitherto disparate strands of the literature emphasizing either form of externality; and

[3]The theory of network externalities has largely ignored price structure issues, as well as many of the themes of the two sided-market literature such as multi-homing (focusing on the design of converters by platforms rather), or the control of interactions among end-users.

to place existing membership (or indirect) externalities models on a stronger footing by identifying environments in which these models can accommodate usage pricing. We also obtain general results on usage pricing of independent interest.

Finally, the paper reviews some key economic insights on platform price and non-price strategies.

This paper is organized as follows: Section 2 introduces platforms, service providers and end-users as well as the general setting. Section 3 focuses on pure usage externalities, and, in this context, defines one- and two-sided markets and identifies sufficient conditions for two-sidedness. Section 4 analyzes pure membership externalities. Section 5, the central section of the paper, builds a canonical model of two-sided markets and applies it to pure-usage and pure-membership externalities. It then shows that in the presence of (price-setting or bargaining based) payments among end-users the pure-membership-externalities model (also called the indirect network effects model in the literature) applies under some conditions, and it derives general results for the setting of usage charges. Finally, the section discusses several relevant extensions of the canonical model. Section 6 lists some pricing principles for two-sided platforms. Section 7 argues that the platforms' balancing act in general involves more than the choice of a price structure, in that platforms also regulate commercial interactions (price, identity of participants, and competition intensity) as they are led to (at least partly) internalize externalities among end-users. It also shows that policies adopted by two-sided platforms are radically different from those that are optimal under the "vertical view" of markets, in which the platform supplies an input to sellers who then deal with buyers (so the platform interacts with only one side of the market). Section 8 summarizes our main conclusions.

2 Setting the stage: membership and usage externalities

Suppose that there are potential gains from trade in an "interaction" between two end-users, whom for convenience we will call the buyer (B) and the seller (S). A platform enables or facilitates the interaction between the two sides provided that they indeed want to interact.[4] The interaction can be pretty much anything, but must be identified clearly. In the case of videogames, an interaction occurs when a buyer (gamer) buys a game developed by a seller, and plays it using the console built by the platform. Similarly, for an operating system (OS), an interaction occurs when the buyer (user) buys an application built by the seller (developer) on the platform. In the case of payment cards, an interaction occurs when a buyer (cardholder) uses his card to settle a transaction with a seller (merchant).[5] The interaction between a "viewer" and an advertiser mediated by a newspaper or a TV channel occurs when the viewer reads the ad. The interaction between a caller and a receiver in a telecom network is a phone conversation and that between a website and a web user on the Internet is a data transfer.

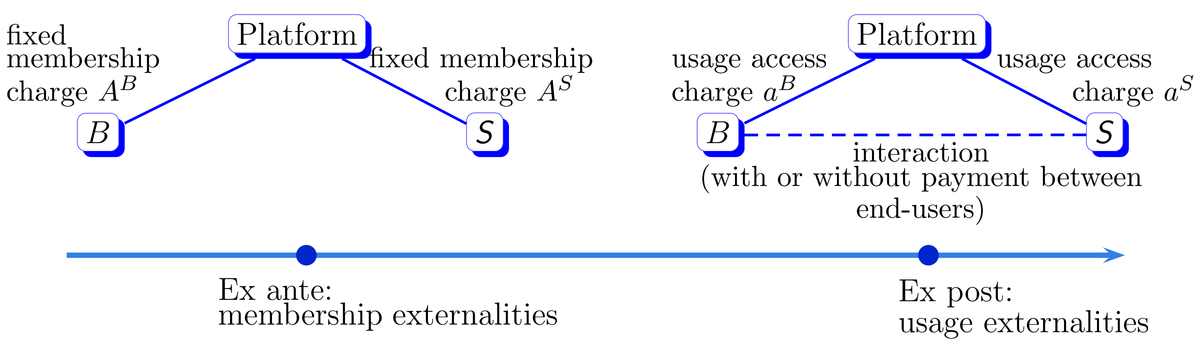

Figure 1

The paper makes a key *distinction between membership charges and usage charges,*

[4]The "interaction" in question is thus an interaction *through* the platform. This does not mean that the two sides cannot trade through an alternative platform (through mail instead of telephone, cash instead of credit card, city activities instead of dating club, etc.).

[5]The outside option for both users, which provides a benchmark for a surplus analysis, is to settle the transaction in cash or with a check.

and between membership externalities and usage externalities. Gains from trade between end-users almost always arise from usage:[6] The cardholder and the merchant derive convenience benefits when the former uses a card rather than cash; a caller and a callee benefit from their communication, not per se from having a phone; and so forth. Usage decisions depend on how much the platform charges for usage. As depicted in Figure 1, the platform charges a price or access charge a^S to the seller and a^B to the buyer for enabling the interaction. For example, American Express charges a merchant discount (say, 2% of the item's price for illustrative purposes) to the merchant, and so $a^S > 0$, while the buyer pays nothing for using the American Express card: $a^B = 0$.[7] Similarly, a caller is charged a per-minute calling charge and the receiver a per-minute reception charge. Usage externalities arise from usage decisions: If I strictly benefit from using my card rather than cash, then the merchant exerts a (positive) usage externality by taking the card. Similarly, if I benefit from being able to call a friend on his mobile phone, then this friend's willingness to give me his number and receive the call exerts a positive usage externality on me.

Ex ante, the platform may charge interaction-independent *fixed fees* A^S and A^B. For example, American Express charges yearly fees to cardholders ($A^B > 0$). In the case of videogames, platforms charge game developers fees for development kits ($A^S > 0$) on top of royalties per copy sold ($a^S > 0$); they charge gamers for the videogame console ($A^B > 0$). For Windows, Microsoft charges a usage-independent fee to consumers ($A^B > 0$) but no variable fee ($a^S = a^B = 0$). To the extent that an end-user on side i derives a strictly positive net surplus from interacting with additional end-users on side $j \neq i$, membership decisions generate membership externalities.

[6] An exception is the benefit that some people draw from being associated in membership with selected others within a club.

[7] $a^B < 0$ if the customer receives frequent flyer miles or cash-back bonuses.

In practice, Figure 1 is too simplistic in several respects:

- First, end-users may connect to the platform through intermediaries or "service providers", depicted by $\mathcal{B}$ and $\mathcal{S}$ in Figure 2. For example, Visa card or MasterCard holders and merchant affiliated to these two payment platforms are served by service providers called "issuers" and "acquirers", respectively. The merchant's bank, the acquirer, pays an interchange fee a^S to the cardholder's bank, the issuer, who receives a^B and so, for a not-for-profit platform and assuming away per-transaction costs, $a^S = -a^B > 0$.[8] Now the interaction costs perceived by the end-users, $\widehat{a}^B$ and $\widehat{a}^S$ in the figure, depend on the commercial conditions offered by the intermediaries, and coincide with a^B and a^S only under conditions of perfect competition among service providers.[9]

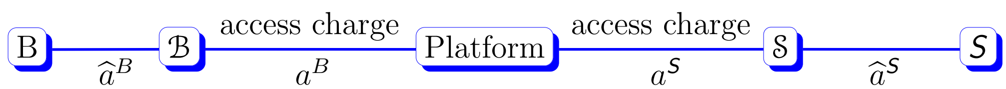

Figure 2: connection through service providers

Another illustration of indirect connection through service providers is the organization of the telecommunications and the Internet industries. There, $\mathcal{B}$ and $\mathcal{S}$ should be interpreted as telecommunications operators in the case of telecommunications and, say, backbones in the case of Internet.[10] The similarity with the payment card associations requires some elaboration. In the telecommunications and Internet applications, there is no natural "buyer" and "seller". There is a flow of communication between a caller and a callee, or from a website to a web user. The object to study is the particular communication between the two end-users. One of them (the caller, the website) is technically at the origin of the connection and can, purely by convention, be labeled S; the other (the receiver, the web user) is labeled B. To the extent that S and B are on two different but

[8] We here ignore "system fees", which are fees paid to the credit card associations in order to cover the associations' capital and operating costs.

[9] Assuming the latter incur no per-interaction cost. If they do, add these costs onto a^B and a^S to obtain $\widehat{a}_B$ and $\widehat{a}^S$ under perfect competition.

[10] In fact, there are often multiple layers of intermediaries, for example an ISP between the end-user and the backbone.

interconnected networks $\mathcal{S}$ and $\mathcal{B}$, the latter have an agreement for terminating the connection initiated on the former. This agreement specifies a (per minute or per megabyte) termination charge $a^S = -a^B > 0$ to be paid by network $\mathcal{S}$ to network $\mathcal{B}$. The networks $\mathcal{B}$ and $\mathcal{S}$ then pass through this termination charge or revenue to the end-users in the form of per minute calling and receiving charges or outgoing and incoming traffic fees. Note that the "platform" in this case is entirely virtual, or else can be viewed as the mechanism recording off net traffic and operating settlements.

• Second, and to the extent that end-users use service providers, these service providers (e.g., $\mathcal{P}_2$ in Figure 3) may in some instances connect two end-users (S and B_2), without needing to interact with other service providers (such as $\mathcal{P}_1$). Such interactions are called "on us" interactions in the case of payment cards and then correspond to the case in which the same bank is both the customer's issuer and the merchant's acquirer. Similarly, a telephone operator may serve both the caller and the callee, and the backbone serve the website and the web user; the traffic is then said to be "on net".

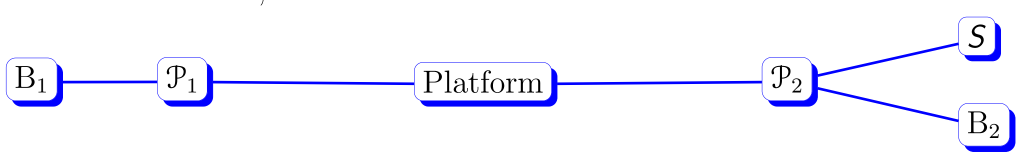

Figure 3: "on us" or "on net" interactions

A similar situation arises when the seller of a house sells through a real estate agency (the platform), but keeps the right to sell the house independently. There is then a chance that the interaction between the buyer and the seller does not occur through the platform.

• Third, there may be multiple non-interconnected platforms. For example, in the absence of common listing, the seller of a house may want to enter non-exclusive arrangements with multiple real-estate agencies in order to reach a wide range of potential buyers; alternatively the buyers may deal with multiple real estate agencies. Videogame developers may port their game to several game platforms. More generally, software developers often multi-home to competing but incompatible software platforms. Or, because different payment card systems are not interconnected (a Visa cardholder cannot use her card at a merchant that accepts American Express or MasterCard, but not Visa), merchants often accept and consumers often hold multiple cards. More generally, multi-homing by at least one side of the market is necessary for gains from trade to be reaped when platforms are incompatible or not interconnected.

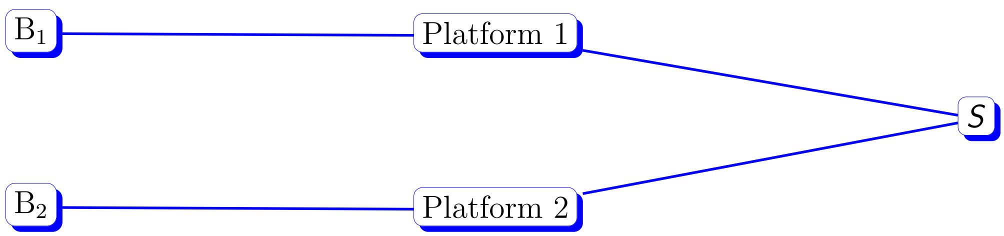

Figure 4: multi-homing

3 Pure usage externalities

Let us first focus on the elementary situation in which there are no membership externalities. The interesting question is then whether end-users intensively use the platform rather than whether they join it. While restrictive, this situation already encompasses a number of industries of interest, for example a mature telecommunications market in which everyone has a phone, or a mature payment system in which no substantial fixed cost or charge stands in the way of membership. Furthermore, and as Section 5.1 will show, the pure-usage-externalities paradigm is even relevant for some industries with incomplete memberships.

In this context, we introduce a distinction between the *price level*, defined as the total price charged by the platform to the two sides, and the *price structure*, referring to the decomposition or allocation of the total price between the buyer and the seller. Underlying the recent surge of academic interest in two-sided markets is the widespread belief among economists and public and private decision makers that the price structure affects profits and economic efficiency as well. Managers devote considerable time and resources to figure out which side should bear the pricing burden, and commonly end up making little money on one side (or ever using this side as a loss-leader) and recouping their costs on the other side. Policymakers also seem to strongly believe in the importance of the price structure. The monitoring of termination charges in telecommunications (and soon the Internet) and antitrust involvement in the computation of interchange fees in payment systems reflect this belief: That the locus of intervention is the price structure proceeds from the premise that economic efficiency can be improved by charging more to one side and less to the other relative to what the market delivers.

Private and public decision makers on the other hand would be wasting their time if the price structure were neutral, that is, if a price reallocation between the two sides had no impact on economic outcomes. Non-neutrality, though, is not a foregone conclusion. Econ 101 students learn that for a given level of VAT, it does not matter who, of the merchant and the consumer, is charged for it: The transaction price between the two parties adjusts accordingly.

A necessary condition for a market to be two-sided is that the Coase theorem does not apply to the relation between the two sides of the markets: The gain from trade between the two parties generated by the interaction depends only on the total charge levied by the platform, and so in a Coase (1960) world the price structure is neutral. As we will see, the failure of the Coase theorem to apply is not sufficient for the price structure to matter, though. We accordingly identify the conditions that do make a market two-sided.

3.1 A definition of two-sidedness

Definition 1 *Consider a platform charging per-interaction charges a^B and a^S to the buyer and seller sides. The market for interactions between the two sides is one-sided* *if the volume V of transactions realized on the platform depends only on the aggregate price level*

$$a = a^B + a^S,$$

i.e., is insensitive to reallocations of this total price a between the buyer and the seller. If by contrast V varies with a^B while a is kept constant, the market is said to be two-sided.

3.2 Examples of one-sided markets

It is easy to see that not all markets in which a platform stands in between the two interacting sides are two-sided. This subsection provides a few illustrations.

a) *VAT.* A government levying a value-added or excise tax on a transaction between a merchant and a consumer can be viewed as a platform (with the specificity that the use by end-users of the platform is not motivated by the platform's enabling or facilitating their trade, but results from the State's coercive power). It is well known that the allocation of the tax between the seller and the buyer (think for example about taxes on real estate transactions) is economically irrelevant. If the government increases the tax on the seller side and reduces that paid by the buyer by an equal amount, the price charged by the seller increases by this amount, whether or not the market is perfectly competitive.

b) *Neutrality in payment systems.* The choice of an interchange fee paid by the merchant's bank, the acquirer, to the cardholder's bank, the issuer, is irrelevant if the following conditions are jointly satisfied: First, issuers and acquirers pass through the corresponding charge (or benefit) to the cardholder and the merchant.[11] Second, the merchant can charge two different prices for goods or services depending on whether the consumer pays by cash or by card; in other words, the payment system does not impose a no-surcharge-rule as a condition for the merchant to be affiliated with the system. Third, the merchant and

[11] This is also true if the issuer and the acquirer charge two-part tariffs to their customers, as long as the variable price reflects their per-interaction cost one-for-one.

the consumer incur no transaction cost associated with a system of double prices for each item.[12]

c) *Bilateral electricity trading with injection and withdrawal charges.* Consider an electricity market run by bilateral contracts between generators and customers (large industrial customers and load-serving entities), and in which generators pay a variable (per MWh) fee for injecting their power in the transmission system and customers pay a variable (per MWh) fee for withdrawing electricity from the system. Such fees are used to cover the fixed cost of running the transmission system. This description is a rough approximation of the current electricity market in Europe.[13] As in the case of the VAT, a buyer and a seller, when bargaining for a bilateral energy trade, should then take into account only the total fee paid to the transmission system.

d) *Telecom charges when caller and receiver side-contract.* A caller and a receiver who could operate side transfers among themselves would choose the length of their communication solely as a function of the total per minute charge levied on them by their service providers. If the two end-users are connected to two different platforms or more generally if they face different per minute charges (say, because they have selected different plans), they must further be able to bargain on who will call, so as to minimize the total variable charge. By contrast, if say the communication between a fixed link and a mobile phone is mainly paid by the mobile customer, and no side transfer is possible, then the latter will be reluctant to disclose his number[14] and will keep conversations short.

Last, we address the subtle question of whether firms are two-sided platforms. Firms can be viewed as bringing together input suppliers and output consumers. Consider a competitive widget industry, in which one unit of labor is required to produce one widget.

[12]An early result along these lines is in Rochet-Tirole (2002). The broad generality of the proposition has been demonstrated by Gans and King (2003).

[13]End-users also often pay fixed (volume-insensitive) connection charges, though.

[14]Except to family and close acquaintances, with whom such side transfers (usually non-monetary ones) do exist.

A firm then chooses a^S, the "workers' access fee" to the platform, that is minus the wage of the workers, and a^B, the per-unit price of its widgets. According to our definition 1, the firm is indeed a two-sided platform: If it lowers its wage and reduces its widget price by the same amount, its customers will not be able to redeem their cost saving and compensate the workers[15] (the end users do not meet, let alone bargain!). We would argue, though, that, at least in competitive environments, firms are often *de facto* one-sided platforms, in that there is little "wriggle room" for them to manipulate the price structure: If they lower the wage, workers will leave, and if they raise their price, consumers will go to other suppliers.[16]

3.3 Usage externalities, the Coase theorem and conditions for two-sidedness

The Coase theorem states that if property rights are clearly established and tradeable, and if there are no transaction costs nor asymmetric information, the outcome of the negotiation between two (or several) parties will be Pareto efficient, even in the presence of externalities. Coase (1960)'s view is that if outcomes are inefficient and nothing hinders bargaining, people will get together and negotiate their way to efficiency. Because in the context of buyer-seller interaction mediated by a platform, the gains from trade between the two end-users depend on the price level, but not its allocation, the latter has no impact on the volume of transactions, the platform's profit, and on social welfare in a Coasian world. *The business and public policy attention to price structure issues is then misguided.*

The Coase theorem is a useful benchmark. In practice, though, various factors make it unlikely that the two parties will reach an efficient agreement from their perspective

[15]Similarly, a university must decide on how to allocate its budget between hiring prestigious, but expensive faculty and focusing more on student-related expenditures; the outcome of this cost allocation is unlikely to be neutral.

[16]If w and p are the market wage and price, then the constraints $|a^S| \geq w$ and $a^B \leq p = w$, together with the non-negative-profit condition $a^S + a^B \geq 0$ do not allow the firm to manipulate the price structure.

(so efficiency refers to their joint surplus, and not to social surplus: In the applications at hand, it does not include platform profit or externalities on other end users, say). As Section 3.3.1 shows, the following two statements are not equivalent:

(1) The end-users cannot reach an efficient outcome through bargaining.

(2) The platform's price structure choice is non-neutral.

That is, (1) is necessary, but not sufficient for (2).

3.3.1 Asymmetric information: the Coase theorem fails to apply, yet the price structure is neutral

One standard reason for why the negotiation between two parties may break down despite the existence of gains from trade is that parties have different views as to the size of these gains from trade. Parties to a negotiation try to get the best for themselves, and under imperfect information about what the other side can bear, may prove too greedy.[17]

Asymmetric information often implies a suboptimal volume of trade.[18] Yet it per se does not imply that the market is two-sided. Actually, unless at least one of the other assumptions underlying the Coase theorem is relaxed, the platform's price structure is still neutral. When the seller's access charge is increased by Δa and the buyer's access charge is reduced by the same amount, the bargaining strategies of the two parties remain the same, except that they are "shifted by the constant Δa". When making offers the seller demands an amount equal to what he was demanding earlier in similar circumstances (an amount that depends on the seller's actual cost of selling to the buyer and on the history

[17]This is the same reason why monopoly pricing in general imposes a deadweight loss. Under imperfect information about consumers' individual preferences, the monopoly trades off efficiency (a high volume of trade) and rent appropriation (through a high mark-up).

[18]See the literature on bargaining under asymmetric information as well as Myerson-Satterthwaite (1983). Farrell (1987) discusses institutional implications of a failure of the Coase theorem due to informational asymmetries.

of the bargaining process), augmented by Δa. Similarly, the buyer shades his price offers systematically by Δa.[19] Bargaining is inefficient, but the market is one-sided nonetheless.

3.3.2 Factors of non-neutrality

• *Transaction costs*: For an increase in the share allocated to the seller, say, to matter, it must be the case that the seller cannot pass the increase in his cost of interacting with the buyer through to the buyer. This is obviously the case for standard telecom networks, where there is no monetary transaction between the caller and the receiver. In other cases monetary transactions are technically possible but transaction costs may hinder this pass-through. Consider for example an arrangement in which websites pay for their (mainly) outgoing traffic.[20] As the variable charge for outgoing traffic increases, websites would like to pass this cost increase through to the users who request content downloads. A problem with this is that downloads are requested by thousands or millions of users, and that the corresponding payment by the end user would be very small, for example not sufficient to vindicate the costs for the website to set up a credit-card-payment system and especially for the user to give the credit card number and necessary information and to experience anxiety about potentially fraudulous use of the card by unknown people. Such concerns

[19]Technically, consider a general sequential bargaining game between the buyer and the seller, in which the two parties make offers to each other and respond to these offers in a specified order, and in which the transaction occurs only when one party has accepted the other party's offer. Then, the set of perfect Bayesian equilibria in the game indexed by access charges $\left(a^S + \Delta a\,,\, a^B - \Delta a\right)$ is isomorphic to the set of perfect Bayesian equilibria of the game with access charges $\left(a^S\,,\, a^B\right)$ in that an equilibrium in the former game and the associated equilibrium in the latter game yield the same economic allocation (including expected payoffs and expected discounted volume of trade): (history- and type-contingent) offers are translated upward by Δa for the seller and downward by Δa for the buyer and the (history- and type-contingent) acceptance / rejection decisions are unchanged provided that new types are defined (so a seller of cost c in the latter game has fictitious type $c + \Delta a$ in the former game, and similarly for the buyer).

A more limited result along similar lines can for example be found in Tirole (1986), in which a seller bargains with a buyer under the constraint that the seller will have to pay a cancellation fee to the buyer in case of non-delivery.

[20]They currently do, but the charge is for the moment limited by the fact that the backbones have for the most part not charged each other for terminating traffic. Such "bill-and-keep" agreements (in the notation of Figure 2, $a^B = a^S = 0$) reallocate the cost of Internet traffic somewhat from those who request downloads to those whose content is downloaded.

of course do not arise if most of the download is already part of commercial transactions, as in the case of the licensing of a music file. By contrast, an increase in their cost of Internet traffic could induce websites that post content for the convenience of other users or that are cash-strapped, to not produce or else reduce the amount of content posted on the web, as they are unable to pass the cost increase onto the other side.

Another illustration of the impact of transaction costs is provided by countries in which merchants are not prohibited by credit card systems from charging different prices for cash and card payments (for example, US merchants can offer "cash discounts", although they cannot impose "card surcharges"!). In practice, very few differentiate their prices despite their repeated complaints (and lawsuits such as the recent Walmart case) that interchange fees are excessive.

• *Prohibition or constraint put by the platform on the pricing of transactions between end users*: Another situation in which end users fail to haggle or set a price for their transaction arises when the platform prohibits them from doing so. A prominent case in point is a non-discrimination rule imposed by a payment system (the merchant's price must be the same whether the customer uses cash or a card).

In fact, this rule is just an illustration of the many ways in which platforms regulate the interactions between end-users. We postpone to Section 7 the discussion of the associated issues.

4 Membership externalities

4.1 Transaction-insensitive end-user costs and non-neutrality

While the recent literatures on the telecommunications, Internet and credit card industries as well as the regulatory attention to termination charges and interchange fees, have focused on pure usage externalities, both the early literature on indirect network externalities[21] and a number of recent papers have analyzed the polar case of pure membership externalities.

The focus on membership is associated with the existence of transaction-insensitive end-user costs. These include fixed fees levied by the platform as well as technological fixed costs on the user side. For example, a software developer incurs both a fixed payment for the development kit and attendance at trade shows and a fixed cost of developing the software. The dividing line between the two transaction-insensitive costs is sometimes a bit unclear: A software platform may try to attract software developers by charging a low price for the development kit (a fixed fee) and/or by giving away software development support or designing developer-friendly APIs. On the other hand, only the total transaction-insensitive cost matters for the end-user, and so we need not be concerned by our making this artificial distinction between fixed fees and fixed technological costs.

Thus under transaction-insensitive costs, the allocation of fixed fees between buyers and sellers matters unless small changes in fixed fees leave memberships (the set of end-users who decide to incur the transaction-insentive costs) invariant on both sides, a rather unlikely situation. An increase in the buyers' fixed fee A^B, say, is usually not passed through to the sellers. To be certain, one can find examples in which the membership decisions are coordinated. For example, divisions of a firm buying client and server software, or a family joining a tennis club to play with each other will take a concerted membership decision; the package offered to the firm or the family as a whole is the only relevant aspect of pricing, not the way in which the total price decomposes among divisions or members of the family. But such instances of "ex ante Coasian bargaining" are rather rare.

When the two sides transact ex post, fixed costs are sunk and therefore irrelevant. This implies for example that an increase in A^B compensated by a decrease in A^S computed so

[21]E.g., Katz-Shapiro (1985, 1986) and Farrell-Saloner (1985, 1986).

as to keep the platform's profit constant in general changes the volume of trade and social welfare. Fewer buyers will find the platform attractive, although this effect is somewhat alleviated by the prospect of being able to transact with more sellers; and conversely for the sellers. The non-neutrality of fixed fees is most dramatically illustrated by the following extreme but telling example, due to Wright (2003): Suppose that consumers all derive the same per transaction surplus b^B from the convenience of paying merchants by card rather than by cash; and that merchants are discouraged neither by transaction costs nor by a card system's non-discrimination rule from charging different prices for card and cash payments. Consider a merchant (a monopolist, to simplify the exposition) selling a merchandise with value v (when purchased by cash) to consumers. It is optimal for this merchant to charge v for cash payments and v + b^B for card payments. Thus a cardholder obtains no transaction-specific surplus from holding a card. If she must pay a yearly fee or incurs a transaction cost from applying for a card, she does not want to hold a card in the first place; the corresponding "investment" is then "held up" ex post by the merchants' surcharge (to use Williamson (1975)'s terminology).[22]

4.2 Platforms' motivations for charging membership fees

In practice, platforms have several motivations to recoup their costs (and perhaps make a profit) by levying membership fees.

a) *Not taxing the interaction is a response to an agency cost on the platform's side*

The platform may shy away from proportional pricing if the latter gives it perverse incentives. Real estate agencies usually charge a percentage of the sale price. Apparently, such pricing seems to fit in the variable-pricing, transaction-specific category. Except that

[22] By contrast, the allocation of the variable fees a^B and a^S keeping the total variable fee $a = a^B + a^S$ constant is still neutral, provided that there are no transaction costs that install grains of sand in the pass-through mechanism. First, the volume of ex post transactions is insensitive to the variable-fees allocation for given membership levels. Second, the split of the total end-user surplus between the two sides can be shown to be unaffected by the allocation of the total variable fee; membership on either side is therefore unchanged.

the "interaction" does not correspond to the actual service provided by the real estate agency: The latter's mission is to find potential matches for the buyer (and possibly the seller who may care about the identity of the buyer for solvency, environmental, or other reasons), and to show and provide information about these matches. Charging an overall fixed fee cum a per-visit charge would therefore seem to make more sense, since the service provided by the real-estate agent is not the sale per se. On the other hand, such a pricing structure would create moral hazard (or adverse selection) concerns for the end-users. Under a fixed fee, the real estate agency might put too little effort into finding good matches. Under a "per visit fee", the real estate agency would probably show houses that are of low interest to the buyer. Charging the buyer and the seller on the basis of a proxy of quality rather than the service itself is an attempt to alleviate the end-users'concern.[23]

b) *The platform is unable to tax the interaction properly*

The interaction between the end-users may not be perfectly observed, as illustrated by the case of a dating club. More generally, even if a transaction is observed, it may not be the entire transaction. Buyers and suppliers may find each other and trade once on a B2B exchange, and then bypass the exchange altogether for future trade. Or they may underreport the trading price and operate side transfers. The platform's ability to tax transactions depends on how much anonymity it can impose on trades. Another case in point is advertising. The actual "transaction"-namely whether the reader carefully reads the ad, thereby generating potential sales- is not observed.[24] The media's purchase price and the advertizing fees can be viewed as fixed costs relative to such individual

[23]See Schwartz-Werden (1996) for another illustration of how an agency problem on the manufacturer side can affect pricing strategies. In that paper, the manufacturer of a durable good charges for usage rather than the purchase of the initial equipment, solely to signal to its customers that they will like the product and therefore use it much.

[24]To be sure, there have always been attempts at measuring these. For example, the seller may ask the buyer to refer to the newspaper or magazine where the buyer learnt about the product. On the web, there have been some attempts at measuring the "eyeball"'s path of clicks ; and referral payments are now common.

transactions.

c) *Fixed fees may be an efficient way of taxing end-users*

As is well-known from the price discrimination and Ramsey pricing literatures, it is often efficient (both privately and socially) to recoup the platform's fixed cost (say, the cost of writing the platform's software) through charges on both the variable use of the platform and on general access to the platform.

d) *Fixed fees may enable the platform to capture end-user surplus*

Suppose that a software platform is concerned with independent developers' exercising market power over platform users (Hagiu 2004). The platform can reduce the price of applications through a proportional subsidy on applications. This policy, while encouraging efficient trade, is costly to the platform and may leave large surpluses to both application developers and consumers. Fixed fees levied on both sides are ways of capturing the end-user surpluses and of enabling subsidization.

5 Integrating usage and membership externalities in a canonical model

5.1 No payment between end-users

This section develops a formal model that integrates usage and membership externalities for a platform. Most existing models of two-sided markets, as well as earlier models of indirect network externalities, are subcases of this model. In particular, we obtain a pricing formula that encompasses the formulas obtained in the pure-usage-externality model of Rochet-Tirole (2003) and the pure-membership-externality model of Armstrong (2004); we also extend these two papers by rewriting the pricing formulas in ways that are amenable to a straightforward interpretation and comparison (see (10) and (12) below).

There are two sides of the market: $i \in \{B, S\}$, and a monopoly platform.[25] The

[25] The model can be extended to platform competition. Several of the papers analyzing platform com-

platform incurs fixed cost C^i per member on side i and marginal cost c per interaction between two members of opposite sides. On each side i, members are heterogenous over both their average benefit b^i per transaction and their fixed benefit B^i (often a fixed cost, and therefore negative) of joining the platform.[26] End-users on side i pay to the platform A^i for membership, and usage fee a^i per transaction.

Much of the literature assumes that the number of transactions is the product $N^B N^S$ of the numbers of members on both sides. This "non-rivalry" condition is not crucial, but will be made here for convenience as well.

More importantly, we assume in this section that the transaction between end-users involves no payment. This is a fine assumption for advertising or payment systems (to the extent that the merchant does not surcharge the cardholder for the use of the card). But, as Section 5.2 will show, under some conditions the model considered here is still valid when the buyer pays a price to the seller for the transaction.

The net utility of a buyer with usage benefit b^i and membership benefit B^i is thus

$$U^i = \left(b^i - a^i\right) N^j + B^i - A^i, \tag{1}$$

where N^j denotes the number of members on the other side connected with the platform. The number of side-i end users who decide to join the platform is thus

$$N^i = \Pr(U^i \geq 0). \tag{2}$$

Note that N^i depends only on the number of members N^j on the other side and on

petition follow the literature on two-way interconnection in telecommunications (Laffont-Tirole 1998a,b, Armstrong 1998, and subsequent papers) by adding an Hotelling model in which platforms are differentiated along the fixed component only. See Armstrong (2004) for a discussion of the implicit commitment assumptions involved in the choice of pricing rules in a duopoly situation.

[26]Benefits and costs can be negative. For example in the case of a newspaper mediating interactions between readers (the buyers) and advertisers (the sellers), B^B is the utility of reading the newspaper and b^B is the utility of reading an advertisement (which can be positive or negative). Papers with negative benefits from interaction include Anderson-Coate (2003), Gabszewicz et al (2003), Kind et al (2004), and Reisinger (2004).

the "per-interaction price", defined as:

$$p^i \equiv a^i + \frac{A^i - C^i}{N^j}. \tag{3}$$

Indeed, adding and substracting C^i in (1) and dividing U^i by N^j defines demand functions:

$$N^i = \Pr\left(b^i + \frac{B^i - C^i}{N^j} \geq p^i\right) \equiv D^i\left(p^i, N^j\right),\ i \in \{B, S\}. \tag{4}$$

Under regularity conditions, the system (4) has a unique solution characterizing memberships N^B and N^S as functions of (p^B, p^S):

$$\begin{cases} N^B & = n^B(p^B, p^S) \\ N^S & = n^S(p^B, p^S). \end{cases}$$

The derivatives of n^B and n^S with respect to p^B and p^S can be easily deduced from those of D^B and D^S by total differentiation of equations (4):

$$\frac{\partial n^B}{\partial p^B} = \frac{\frac{\partial D^B}{\partial p^B}}{1 - \frac{\partial D^B}{\partial N^S}\frac{\partial D^S}{\partial N^B}},\ \frac{\partial n^S}{\partial p^B} = \frac{\frac{\partial D^B}{\partial p^B} \cdot \frac{\partial D^S}{\partial N^B}}{1 - \frac{\partial D^B}{\partial N^S} \cdot \frac{\partial D^S}{\partial N^B}}, \tag{5}$$

with symmetric formulas for $\frac{\partial n^S}{\partial p^S}$ and $\frac{\partial n^B}{\partial p^S}$.

The platform's profit is equal to

$$\pi = (A^B - C^B)N^B + (A^S - C^S)N^S + (a^B + a^S - c)N^B N^S,$$

will can be transformed into:

$$\pi = (p^B + p^S - c)n^B(p^B, p^S)n^S(p^B, p^S).$$

For a given total price ($p^B + p^S = p$) the optimal price structure is obtained by maximizing volume of usage:

$$V(p) = \max\left\{n^B(p^B, p^S)n^S(p^B, p^S) \text{ under the constraint } p^B + p^S = p\right\}.$$

Then total price is determined by a standard Lerner formula:

$$\frac{p-c}{p} = \frac{1}{\eta}, \tag{6}$$

where η is the elasticity of volume with respect to total price: $\eta \equiv -p\dot{V}(p)/V(p)$, where dots represent derivatives. The optimal price structure is obtained when the derivatives of volume with respect to both prices are equal. This is equivalent to the equality of semi-elasticities, taking into account both direct and indirect effects:

$$\frac{1}{p-c} = \frac{\frac{\partial n^B}{\partial p^B}}{n^B} + \frac{\frac{\partial n^S}{\partial p^B}}{n^S} = \frac{\frac{\partial n^S}{\partial p^S}}{n^S} + \frac{\frac{\partial n^B}{\partial p^S}}{n^B}. \tag{7}$$

Note that semi-elasticities, rather than elasticities, are the relevant concept here since we are concerned by the price structure, the total price being given.[27]

Using formulas (5), we obtain an equivalent condition for an optimal price structure, this time based directly on the derivatives of D^B and D^S:

$$\frac{\frac{\partial D^B}{\partial p^B}}{D^B} + \frac{\frac{\partial D^B}{\partial p^B}\frac{\partial D^S}{\partial N^B}}{D^S} = \frac{\frac{\partial D^S}{\partial p^S}}{D^S} + \frac{\frac{\partial D^S}{\partial p^S}\frac{\partial D^B}{\partial N^S}}{D^B}. \tag{8}$$

Note that there is (in general) some redundancy in the pricing policy, since only per-transaction mark-ups p^B and p^S matter, whereas the platform has a priori four degrees of freedom: (a^B, A^B) on the buyers' side and (a^S, A^S) on the sellers' side. However there are particular cases in which some of these instruments are not available.

Pure-usage pricing: Consider a situation in which end-users on side i differ only in their per-transaction benefit b^i, but not in their fixed benefit or cost B^i. In this case, usage pricing is sufficient.[28]

Condition (8) then specializes to:

[27] However comparative statics properties are consistent with standard intuitions: if for example the demand from buyers becomes less elastic (say because of the presence of captive buyers), the price paid by buyers increase and the price paid by sellers decrease: See Section 6.

[28] With loss of generality, the platform can charge $A^i = B^i$. The end-user then uses the platform if and only if $b^i \geq a^i$.

$$\frac{\frac{\partial D^B}{\partial p^B}}{D^B} = \frac{\frac{\partial D^S}{\partial p^S}}{D^S},$$

or letting $\sigma^i \equiv -\left[\partial D^i/\partial p^i\right]/D^i$ denote the *semi-elasticities*,

$$p - c = \frac{1}{\sigma^B} = \frac{1}{\sigma^S}, \tag{9}$$

a formula obtained in Rochet-Tirole (2003). This formula can be rewritten as a standard Lerner formula:

$$\frac{p^i - (c - p^j)}{p^i} = \frac{1}{\eta^i} \tag{10}$$

where $\eta^i \equiv p^i \sigma^i$ is the elasticity.

Pure-membership pricing: Consider now Section 2 of Armstrong (2004), where on each side end-users differ only with respect to their membership benefit B^i, but obtain identical benefit per interaction b^i. Furthermore, the platform charges only membership fees, and incurs no cost per transaction between end-users. In this case we have:

$$N^i = D^i\left(\left(b^i - p^i\right) N^j\right).$$

Thus the derivatives of demand functions with respect to price and membership are given by:

$$\frac{\partial D^i}{\partial p^i} = -D^j \dot{D}^i, \text{ while } \frac{\partial D^i}{\partial N^j} = \left(b^i - p^i\right)\dot{D}^i.$$

Using formula (8), we obtain the condition characterizing the optimal price structure in Armstrong's model:

$$-\frac{D^S \dot{D}^B}{D^B} - \frac{D^S \dot{D}^B (b^S - p^S)\dot{D}^S}{D^S} = -\frac{D^B \dot{D}^S}{D^S} - \frac{D^B \dot{D}^S (b^B - p^B)\dot{D}^B}{D^B},$$

which gives after simplifying and dividing by $\dot{D}^S \dot{D}^B$:

$$p^B + b^S + \frac{1}{\sigma^B} = p^S + b^B + \frac{1}{\sigma^S}. \tag{11}$$

Last, Armstrong's formula (11) can also be rewritten (using formula (6) for the total price) as a standard Lerner formula:

$$\frac{p^i - (-b^j)}{p^i} = \frac{1}{\eta^i}\,. \tag{12}$$

We are now in a position to point at the similarities between the two polar cases of pure usage pricing (formula (10)) and pure membership pricing (formula (12)). Both formulas reflect the balancing act that the platform performs in its choice of price structure.

Under pure usage pricing, the loss of a transaction on side i due to an increase in the per-transaction price p^i has an opportunity cost $c - p^j$, since the platform cost c of the transaction has to be defrayed by the payment p^j levied on the other side. Except for the replacement of the per-transaction cost by the opportunity cost, formula (10) is the standard Lerner formula.[29]

Under pure membership pricing ($p^i = A^i/N^j$) the elasticity of demand with respect to the membership charge A^i is the same as the elasticity of demand, η^i, with respect to the per-transaction charge. Furthermore, a lost buyer, say, involves no per-transaction loss or benefit for the platform (recall: it incurs no per-transaction cost: $c = 0$, nor does it charge for transactions); but the platform loses membership fee p^B as well as the reduction b^S in the seller's (per buyer) membership fee required to keep membership constant on the seller side. This yields the Lerner formula (12).[30]

Proposition 1 *Consider the canonical model with utilities and profit:*

[29]Another way of obtaining formula (10) is to equalize the costs and benefits for the platform of raising p^i:

$$\left|\dot{D}^i\right| D^j(p-c) = D^i D^j.$$

[30]Another way of obtaining formula (12) is to equalize the cost and benefit for the platform of raising A^i, keeping membership on side j constant:

$$\left|\frac{\partial D^i}{\partial A^i}\right| \left[A^i + b^j N^j\right] = N^j.$$

$$
\begin{aligned}
U^i &= \left(b^i - a^i\right) N^j + B^i - A^i, \\
\pi &= \sum_{i=B,S} \left(A^i - C^i\right) N^i + \left(a^B + a^S - c\right) N^B N^S,
\end{aligned}
$$

and let

$$p_i \equiv a^i + \tfrac{A^i - C^i}{N^j}.$$

(i) The monopoly price per interaction, $p = p^B + p^S$*, is given by the Lerner formula* $(p-c)/p = 1/\eta$*, and the price structure is given by condition (7).*

(ii) Pure usage pricing arises when end-users on each side differ only in their per-transaction benefit b^i*. The price structure is then given by:*

$$\frac{p^i - (c - p^j)}{p^i} = \frac{1}{\eta^i}.$$

(iii) Pure membership pricing arises when end-users on each side differ only in their fixed membership benefit B^i *(i.e., on each side end-users have the same* b^i*) and interactions between end-users are not observed by the platform. The price structure is then given by*

$$\frac{p^i - (-b^j)}{p^i} = \frac{1}{\eta^i}.$$

5.2 Payment between end-users

Many models of membership or indirect network externalities are motivated by industries in which payments between end-users are fundamental. For example, in the software and videogames industries, the application or game developers sell their platform-compatible products to consumers. However, the canonical formulation above:

$$U^i = \left(b^i - a^i\right) N^j + B^i - A^i,$$

which encompasses many such models, as it stands, is inconsistent with the existence of payments between end-users: The number of actual transactions for a member of side i is then endogenous and need not be equal to the total number N^j of potential trading partners; relatedly, the per-transaction net surplus (here $b^i - a^i$) in general depends on the per-transaction charge a^j levied on the other side.

Let us assume that the per-transaction benefit b^i of a given member of side i is drawn from cumulative distribution $F^i(b^i)$ after the end-user has decided to become a member. The benefit can be the same across the N^j potential transactions or drawn for each of these; the key assumption is that the distribution F^i is the same for all B^i. Thus, end-users differ *ex ante* only in their fixed benefit B^i.[31] The hazard rates of the distributions, $f^i/(1-F^i)$ are, for expositional simplicity only, assumed to be increasing. There are still $N^B N^S$ potential transactions, but only an (endogenous) fraction $X \leq 1$ of these transactions will take place (thus, the total number of transactions is XN^BN^S).

When a buyer with ex post type b^B and a seller with ex post type b^S "meet", they bargain over the transaction price. A polar case of bargaining is price setting, in which the seller, say, makes a take-it-or-leave-it offer to the buyer. But haggling and more equal bargaining power are possible too. Let us therefore adopt a broad mechanism design approach.[32]

We know from Section 3 that whether bargaining occurs under symmetric or asymmetric information, the usage price structure is neutral. And so only $a = a^B + a^S$ matters. Let $b \equiv \left(b^B, b^S\right)$. Bargaining yields a (present discounted) probability of trade $x(b,a) \in [0,1]$ and balanced (present discounted) transfers $t^i(b,a)$ with:

$$\sum_{i=B,S} t^i(b,a) = 0.$$

So the *per-interaction expected net surplus* of a member on side i is:

$$\beta^i(a) \equiv E\left[\left(b^i - a^i\right)x(b,a) + t^i(b,a)\right], \qquad (13)$$

where expectations are taken with respect to the product distribution $F^B \times F^S$.

[31] A similar assumption is used in a number of papers on two-sided markets, notably Anderson-Coate (2003), Bakos-Katsamakos (2004), Caillaud-Jullien (2003), Hagiu (2004), and Guthrie-Wright (2004).

[32] As, for example, in Fudenberg-Tirole (1991, chapters 7 and 10).

The platform's profit is then

$$\pi = \sum_{i=B,S} \left(A^i - C^i\right) N^i + (a-c)\, X N^B N^S, \tag{14}$$

with

$$X \equiv E\left[x(b,a)\right].$$

Substituting and simplifying yields:

$$\pi \equiv \left[p^B + p^S + \mathrm{v}(a)\right] n^B n^S, \tag{15}$$

where[33]

$$p_i = \frac{A^i - C^i}{N^j} + a^i X - E\left[b^i x(b,a) + t^i(b,a)\right], \tag{16}$$

n^i is defined as in Section 5.1, and

$$\mathrm{v}(a) \equiv E\left[\left(b^B + b^S - c\right) x(b,a)\right] \tag{17}$$

is the average social surplus from potential interactions.

Formula (15) indicates that use can be made of the canonical model, setting platform per customer "cost" $(-\mathrm{v})$. The platform's optimization problem thus decomposes into the choice of prices $\left(p^B, p^S\right)$ (as in Section 5.1), and an ancillary problem of finding the per-transaction total access charge a that maximizes total transaction surplus. We now obtain some general results on the latter:

a) *Coasian bargaining* : Suppose that the seller and the buyer know each other's valuations when bargaining (under price setting: that the seller knows the buyer's willingness to pay and therefore can perfectly price discriminate). In this full information setting, trade occurs if and only if

$$b^B + b^S \geq a.$$

[33]Notice that the participation equation becomes

$$N^i = \Pr\left[E\left\{b^i x(b,a) + t^i(b,a)\right\} - a^i X + \frac{B^i - A^i}{N^j} \geq 0\right]$$

and that p^i is the same for all users on side $i = B, S$.

Thus, v is maximized if the end-users are confronted with the social cost of their transaction:

$$a = c.$$

b) *Asymmetric information bargaining and monopoly price setting*: Under asymmetric information, trade between end-users is quite generally sub-optimal if $a = c$.

Price setting. Consider the polar case of price-setting first. The seller chooses to charge the buyer price t $(= t^S = -t^B$ in our earlier notation) so as to maximize $\left[t - \left(a - b^S\right)\right]\left[1 - F^B(t)\right]$ (b^S is generally to be interpreted as minus the seller's cost of production), yielding a cut-off type for the buyer $\widehat{b}^B = t$ given by

$$\widehat{b}^B + b^S - a = \frac{1 - F\left(\widehat{b}^B\right)}{f\left(\widehat{b}^B\right)},$$

defining a function $\widehat{b}^B\left(a - b^S\right)$ increasing in a and decreasing in b^S. Total surplus from usage is then

$$\mathrm{v} = E_{b^S}\left[\int_{\widehat{b}^B\left(a - b^S\right)}^{\infty}\left(b^B + b^S - c\right) dF^B\left(b^B\right)\right]$$

and so, at the optimal per-transaction charge,

$$\frac{d\mathrm{v}}{da} = E_{b^S}\left[-f\left(\widehat{b}^B\left(a - b^S\right)\right)\frac{\partial \widehat{b}^B}{\partial a}\left[a - c + \frac{1 - F^B\left(\widehat{b}^B\left(a - b^S\right)\right)}{f^B\left(\widehat{b}^B\left(a - b^S\right)\right)}\right]\right] = 0.$$

We thus obtain two results:

(i) Subsidization: $a^* < c$.

(i) When the buyers' demand for usage is exponential (constant hazard rate), the monopoly distortion can be perfectly corrected, and the first-best level of transactions obtains.

Bargaining. Consider for example Chatterjee and Samuelson's 1983 double auction generalization of the Nash demand game: The seller and the buyer choose bids, and trade occurs at the average bid if the seller's demand is smaller than the buyer's stated willingness to pay. With uniform distributions on $[0,1]$, Chatterjee and Samuelson show that trade occurs if and only if

$$b^B + b^S - a \geq \frac{1}{4}.$$

Thus, setting $a^* = c - \frac{1}{4}$ delivers the first-best volume of trade.

Pursuing the analysis of familiar bargaining games with (generically) unique outcome,[34] we have checked that the subsidization result also holds for the random proposer game, in which each party makes a take-it-or-leave-it offer with some probability;[35] and for the standard finite- or infinite-horizon price discrimination game where a seller with known cost sequentially makes offers to a buyer with a discrete number of types or with a continuum of types strictly above than the seller's cost.[36]

Finally, we can consider efficient bargaining processes. We know from Myerson-Satterthwaite (1983) that constrained efficient outcomes of arbitrary bargaining processes yield trade if and only if

$$\sum_{i=B,S}\left[b^i - \alpha\frac{1-F^i\left(b^i\right)}{f^i\left(b^i\right)}\right] \geq a$$

for some weight $\alpha \in [0,1)$. This condition can be shown to imply that under a (weak)

[34]Bargaining games often have many perfect Bayesian equilibria. The analysis of the impact of a change in a requires an equilibrium selection, and is therefore left for future research.

[35]This result follows trivially from our analysis of the monopoly and monopsony cases.

[36]See Fudenberg et al. (1985) (the outcome is only generically unique). A reduction in the usage fee a "speeds up" the acceptance of offers by the buyer.

regularity condition[37]

$$a^* < c.$$

Proposition 2 *Suppose that trade between end-users is the outcome of bargaining (where bargaining includes, as a polar case, price setting); and that on each side i, the ex post transaction benefits (or costs) b^i are drawn from distribution $F^i(b^i)$ independently of the end-user's fixed membership benefit B^i.*

Then, the platform's optimization problem decomposes:

(i) The transaction charge a is set so as to maximize the average social surplus from potential interactions:

$$\mathrm{v}(a) = E\left[\left(b^B + b^S - c\right) x(b,a)\right].$$

Under symmetric information bargaining between end-users, the platform passes through

[37] An efficient bargaining process solves over the trade function $y(b,a) \in [0,1]$:

$$L(a) = \max_{\{y(\cdot,\cdot)\}} E\left[\left(\sum_i b^i - a\right) y(b,a)\right]$$

s.t.

$$E\left[\left[\sum\nolimits_i \left(b^i - \frac{1-F^i(b^i)}{f^i(b^i)}\right) - a\right] y(b,a)\right] \geq 0$$

(the latter condition coming from the budget balance after adding up the individual rationality constraints for the lowest types.) Note that

$$L'(a) < -Y(a) \text{ where } Y(a) \equiv E\left[y(b,a)\right]$$

since when the usage fee a decreases by a unit amount the same policy $y(\cdot,\cdot)$ satisfies the constraint with slack while the objective function increases by $Y(a)$.

The platform maximizes over a:

$$H(a) = E\left[\left(\sum_i b^i - c\right) y\right],$$

where y is determined by the optimization above. Because

$$H(a) = L(a) + (a-c)Y(a),$$

the first-order condition :

$$H'(a) = L'(a) + Y(a) + (a-c)Y'(a) = 0 < (a-c)Y'(a).$$

Make the (weak) regularity assumption that $Y' < 0$ (the volume of trade decreases with the usage fee, a property that is satisfied for example for uniform or exponential distributions); then $a^* < c$.

the per-transaction cost:

$$a^* = c.$$

Under asymmetric information bargaining, in a wide range of cases (including price setting), the platform optimally subsidizes transactions:

$$a^* < c\,;$$

(ii) The platform sets the price level and structure as in the pure membership version of the canonical model of Proposition 1, so as to maximize

$$\pi = \left[p^B + p^S + \mathrm{v}\,(a^*)\right] n^B n^S,$$

and utilities are

$$U^i = \beta^i\,(a^*)\,N^j + B^i - A^i.$$

5.3 Beyond the canonical model

The canonical model is a useful workhorse for analyzing two-sided markets. But one must be aware of its limits and know how to enrich it, as a few recent contributions do, when needed. To see what extensions might be relevant, let us return to the previous modeling of utility:

$$u^i = \mathcal{B}^i\left(b^i, N^j\right) + B^i - A^i,$$

where $\mathcal{B}^i = (b^i - a^i)\,N^j$ in the absence of payments between end-users and $\mathcal{B}^i = \beta^i(a)N^j$ in their presence.

The first implicit assumption[38] is that side i cares, on the other side, only about the number of users N^j. This assumption is violated if the average *quality* of matches on the other side depends on platform pricing, as in Damiano-Li (2003). Consider for example clubs whose members are snobs or dating agencies whose clientele prefers to meet wealthy

[38] In the tradition of the two-way interconnection literature in telecommunications (Laffont et al 1998a,b, Armstrong 1998).

counterparts; an increase in N^j brought about by a reduction in p^j attracts less wealthy individuals and reduces the "quality" perceived by side i. It then makes sense to assume that $[\partial \mathcal{B}^i/\partial N^j] / [\mathcal{B}^i/N^j]$ is lower than one and perhaps even negative.

Second, the independence of $\mathcal{B}^i$ relative to N^i excludes *same-side externalities*. Consider for example a software platform with N^S application developers and N^B consumers. Then, assuming $a = 0$,[39]

$$\mathcal{B}^S = b^S \left(N^S\right) N^B$$

with $\dot{b}^S < 0$ if the applications are substitutes (rivalry effects) and $\dot{b}^S > 0$ if the applications are complements[40]

Third, the possibility that end-users ex ante have *private information about their future per-transaction benefit* b^i creates some complications once one departs from the assumptions made in Section 5.1. In particular, consider the case of payments between end-users. The per-potential-interaction benefit β^i then depends not only on a and on the end-user's ex ante signal about b^i, but also on the distribution of b^js on the other side. This introduces quality effects similar to those discussed above: A smaller membership on side j improves the distribution of the b^js, and thereby raises β^i.[41]

Fourth, the canonical model involves simultaneous courting of buyers and sellers. For some industries such as software, one side may be courted before the other, which raises interesting commitment issues (Hagiu 2004).

Last, to perform welfare analyses, it is important to note that platform choices may affect end-users reservation utilities (normalized to 0 in the canonical model). For example, a merchant who does not accept credit cards may be affected negatively if a rival

[39] A reasonable assumption for operating systems, but not for game platforms, which demand per-game royalties.

[40] Ambrus-Argenziano (2004), Belleflamme-Toulemonde (2004), and Ellison et al (2003) develop different models exhibiting rivalry effects.

[41] Another point worth making is that the choice of the total per-transaction charge a no longer serves an efficiency purpose as in Proposition 2. This charge is also used to extract end-user rents.

merchant does take them;[42] or a company that does not advertize may be hurt if its rivals do.

6 Pricing principles for two-sided platforms

This section briefly reviews a few factors that affect prices charged to end-users and stresses the departures from standard business strategies that result from the platform's internalization of the other side's welfare (the linkage between the two sides from the platform's viewpoint). This linkage is most apparent when the platform makes no or loses money on one side. For example, media platforms usually give away newspapers or free TV programs not to prey on rival platforms, but to be able to charge higher markups to advertizers.[43] The linkage also shows up in the form of a simple "topsy-turvy principle": A factor that is conducive to a high price on one side, to the extent that it raises the platform's margin on that side, tends also to call for a low price on the other side as attracting members on that other side becomes more profitable.

a) *Elasticities.* As the analysis in Section 5.1 makes clear, demand elasticities on both sides are essential determinants of the pricing of platforms. Anderson-Coate (2003), Armstrong (2004) and Rochet-Tirole (2003) for example obtain comparative statics results that confort standard intuition. For example, in Rochet-Tirole, a factor affecting elasticities on a given side is the size of the installed base of end-users on that side. When, say, the number of captive buyers increases, the buyer price naturally increases, and the seller price decreases as attracting sellers yields a higher collateral profit on the buyer's side.

b) *Relative market power of service providers*: If end-users are served through intermediaries (as in Figure 2), the platform may try to "undo" the intermediaries' market power by

[42] See the analyses in Rochet-Tirole (2002) and Guthrie-Wright (2003).

[43] The cause of asymmetry most studied in the literature is a differential in (semi-)elasticities. Several papers (Ambrus-Argenziano 2004, Bakos-Katsamakos 2004, Caillaud-Jullien 2003) have shown that pricing and other asymmetries may arise even when the two sides are symmetric.

charging lower access charges. So, for example, if service providers charge an important markup to buyers, the platform ought to reduce a^B so as to limit double marginalization on that side, and increase a^S (as offering surplus to buyers by enlisting sellers becomes relatively less attractive).

c) *Surplus created on the other side*: Attracting one side by lowering price is particularly profitable for the platform if this side creates substantial externalities on the other side. For example, "marquee buyers" are courted as they allow platforms to charge high prices to sellers.[44]

d) *Platform competition and multi-homing.* Platform competition may have ambiguous consequences on the price structure. Suppose for example that a fraction of buyers multi-home (connect to multiple platforms). On the one hand, the elasticity of buyers' demand for a given platform increases, due to their ability to switch to a competing platform. On the other hand, the elasticity of sellers' demand is corrected by what Rochet-Tirole (2003) calls the "single-homing index". Roughly speaking, buyers' multi-homing allows platforms to "steer" sellers, i.e., to induce them to opt out of the competing platforms.[45] The smaller the single-homing index of buyers, the higher the incentive for platforms to steer sellers. Platform competition thus creates downward pressure on prices on both sides of the market, and the impact on relative prices is ambiguous.[46] In particular, platform competition does not necessarily lead to an efficient price structure.[47]

e) *Bundling.* Platforms offering several types of interaction services may benefit from bundling them. For example, payment card associations Visa and MasterCard offer both

[44] See Rochet-Tirole (2003) for details.

[45] What matters here is membership multi-homing rather than usage multi-homing (Rysman 2004 presents some evidence that cardholders multi-home much more in membership than in actual usage).

[46] For linear demands, though, platform competition does not alter the price structure; so, for example, competition among not-for-profit associations (for which the break-even-constraint fixes the price level) does not alter prices under linear demands.

[47] See Anderson-Coate (2003), Armstrong (2004), Guthrie-Wright (2003), Hagiu (2004), and Rochet-Tirole (2004) for further analyses of multi-homing. Multi-homing on both sides also raises fascinating questions with respect to the decision of which platform to route on (Hermalin-Katz 2004).

debit and credit cards and, until recently, used to engage in a tie-in on the merchant side through the so-called honor-all-cards rule. The motivations for tying in two-sided markets are different from the usual ones in classical markets (e.g., price discrimination or entry deterrence).[48] In a two-sided market, tying may allow platforms to perform better the balancing act between buyers and sellers, and is not necessarily detrimental to social welfare.

7 The regulation of interactions between end-users

We have seen that payment card platforms often try to discourage merchants from charging cardholders for card usage; and that a platform may want to subsidize sales of applications built around the platform (see Section 5.2, and Hagiu 2004). This section documents how platforms more generally woe end-users not only through the tariffs $\{a_i, A_i\}_{i=1,2}$ they charge them,[49] but also by regulating interactions between these end-users. That is, platforms must perform a balancing act with respect to their price structure as well as other policy dimensions; quite generally, they encourage positive externalities and discourage negative ones and to do so usually constrain one side to the benefit of the other.

In reviewing platform regulation of interactions among end-users, it will prove useful to compare platform choices with those that would prevail under a more standard *vertical view*, in which the platform would interact with only one side (say, the seller side) and have no direct interaction with the other side (say, the buyer side): see Figure 5.

[48] Rochet-Tirole (2004).

[49] In matching markets, the platform can also alter the distribution of the surplus between end-users through the choice of auction design. On this, see Bulow-Levin (2003) and Damiano-Li (2003). Parker-van Alstyne (2004), in the context of software platforms, look at non-price dimensions of licensing contracts (openness of code/disclosure, length of license). Bakos-Katsamakos (2004) consider the impact of the platform's technological design on the end-users' per transaction benefits.

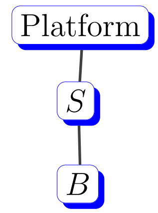

Figure 5: vertical view

7.1 The platform as a price regulator

While asymmetric information and the concomitant rent extraction concerns keep the platform's price structure neutral (Section 3.3), it is nonetheless a source of sub-optimal trade among end-users. Thus, if the seller side, say, has market power over the buyer side as in Wright (2003) and Hagiu (2004)'s papers, buyers derive too small a surplus from joining the platform. The platform then has an incentive to cap (Wright) or alter through a subsidy (Hagiu) the price charged to buyers so as to boost buyers' surplus and their willingness to join the platform. It then behaves pretty much like a public utility commission that addresses a market power problem by setting a price cap or by subsidizing some services through a fund levied from other services.

Two remarks are in order. First, the rationale for constraining the price charged by the seller to the buyer would vanish if the industry were organized according to the vertical view: Were the platform not to deal directly with buyers, the platform would want to provide sellers with the maximal profit in their relationship with buyers and therefore would grant them maximal commercial freedom.[50] It is only because the platform can extract surplus on the buyer side that it is willing to "displease" the seller side by

[50]The reader may here object that under the vertical view the platform may impose resale price maintenance (RPM) on the sellers so as to avoid double marginalization. But RPM is then (at least under symmetric information between platform and sellers) only a substitute for a missing non-linearity of the tariff charged to the sellers, and therefore is not an intrinsic feature of the relationship between platform and seller.

constraining it.

Second, given that interactions between end-users often exhibit monopoly or monopsony power, it is perhaps surprising that platforms do not always attempt to regulate transaction prices between end-users. There are, however, often good (and standard) reasons for laissez-faire as well: The platform may not be able to price discriminate as well as the price-setting end-user. Or, in situations in which an end-user, e.g., an application developer, sinks a substantial investment cost and in which the efficient transaction price varies substantially among applications and so price between end-users should not be fixed by the platform, a laissez-faire policy by the platform is a commitment not to hold up the application developer's investment through an expropriatory price cap on the sale of the application to platform users.

7.2 The platform as a licensing authority

End-users often care not only about the price (that they pay to the platform and to the other side), but also about the quality of the interaction. In some industries, the platform is therefore concerned about the identity of participants, as the latter creates externalities on the other side: Supermarkets do not auction off shelf space to the highest bidder, since the resulting outcome might not bring the desired diversity of brands to the average shopper.[51] Nightclubs, dating agencies, conferences and exchange markets try to avoid rowdy or undesirable types. Medias put at least minimum constraints on advertisers and advertisements so as not to offend their audience. In this respect, platforms resemble regulatory commissions (for example, in banking, finance, electricity or telecommunications) that impose minimum standards on operators in order to spare consumers negative externalities (as when the operator goes bankrupt).

Again, such non-price discrimination would be meaningless under the vertical view:

[51] Another issue in this case is that a seller's willingness to pay for shelf space depends on how much shelf space and prominent display is purchased by rival brands. So at the very least such auctions should be combinatorial.

A platform that would not internalize buyer welfare would have no incentive to be picky in the selection of sellers.[52]

7.3 The platform as a competition authority

When price regulation (Section 7.1) is complex or inefficient, the platform may still make itself attractive to one side of the market by encouraging competition on the other side. Competition on the other side brings prices closer to marginal cost, and the volume of interactions closer to the efficient volume; it also protects against the hold up of one's specific investments.

Accordingly, a two-sided platform benefits from allowing competition on a given side as it can at least partly recoup the associated benefits on the other side. Like a competition authority, it therefore cares about the benefits associated to competition (Belleflamme-Toulemonde 2004, Ellison et al 2003). Note, again, that it would not internalize these benefits if it contracted with only one side. In an illustration of the vertical view, a patent owner (the platform) in general grants licenses to one or a small number of licensees (sellers) who then market a final good to consumers (buyers).[53] Were the patent owner able to control access to the final goods and thereby charge consumers for their indirect use of the patent, she would grant licenses much more generously because she could recoup the consumer benefits of competition among licensees. One should therefore expect less foreclosure in a two-sided market than in a vertical environment. This example provides yet another demonstration that the application of standard economic institutions developed in vertical contexts to two-sided markets is misleading.

[52]At least in a static context. In a repeated purchase context, the platform might care about the impact of seller behavior on its reputation.

[53]See Rey-Tirole (2003) for an overview of foreclosure theory and practice.

8 Summary

Let us summarize the paper's main points:

a) Because all markets involve transactions between two (or more) parties and therefore could be two-sided markets, it is useful to circumscribe the scope of two-sided-markets theory. The first objective of the paper has been to propose such a definition in the pure-usage-externalities case: A market is two-sided if the platform can affect the volume of transactions by charging more to one side of the market and reducing the price paid by the other side by an equal amount; in other words, the price structure matters, and platforms must design it so as to bring both sides on board. A necessary (but insufficient) condition for a market to be two-sided is that the Coase theorem does not apply to the transaction between the two sides. That is, the relationship between end-users must be fraught with residual externalities. Factors conducive to two-sidedness include transaction costs among end-users and platform-imposed constraints on pricing between end-users. By contrast the usage price structure is neutral under monopoly price setting or bargaining under asymmetric information.

b) We built a new and canonical model of two-sided markets encompassing usage and membership externalities, and derived and interpreted the optimal pricing formulas. We extended this model to allow for payments between end-users. In this extension Coasian bargaining between end-users calls for a pass-through of platform variable costs to end-users. Price setting or bargaining under asymmetric information by contrast calls for a subsidization by the platform of transactions between end-users.

c) Because pricing to one side is designed with an eye on externalities on the other side, standard pricing principles often do not apply. We reviewed some key pricing principles.

d) Platforms must perform the balancing act between the two sides along various policy dimensions and not only with respect to the price structure. They therefore often regulate the terms of the transactions between end-users, screen members in non-price related ways and monitor intra-side competition. In all instances, they sacrifice profit by constraining one side to boost attractiveness for and recoup losses on the other side.

References

[1] Ambrus, A., and R. Argenziano (2004) "Network Markets and Consumers Coordination," mimeo, Harvard University, Yale University.

[2] Armstrong, M. (1998) "Network Interconnection," *Economic Journal*, 108: 545-564.

[3] —– (2004) "Competition in Two-Sided Markets," mimeo, University College, London.

[4] Bakos, Y, and E. Katsamakos (2004) "Design and Ownership of Two-Sided Networks," mimeo.

[5] Belleflamme P., and E. Toulemonde (2004) "Competing B2B Marketplaces," mimeo.

[6] Bulow J., and J. Levin (2003) "Matching and Price Competition," working paper, Stanford University.

[7] Caillaud, B., and B.Jullien, (2003) "Chicken & Egg: Competition Among Intermediation Service Providers," *Rand Journal of Economics*, 34(2): 309–328.

[8] Chatterjee, K. and W. Samuelson (1983) "Bargaining under Incomplete Information," *Operations Research*, 31: 835–851.

[9] Coase, R.(1960) "The Problem of Social Cost," *Journal of Law and Economics*, 3: 1–44.

[10] Coate, S., and S. Anderson (2003) "Market Provision of Public Goods: The Case of Broadcasting," forthcoming, *Review of Economic Studies*.

[11] Damiano E. and H. Li (2003) "Price Discrimination in Matching Markets," working paper, University of Toronto.

[12] Ellison G., D. Fudenberg, and M. Möbius (2003) "Competing Auctions," mimeo.

[13] Evans, D. (2003) "The Antitrust Economics of Multi-Sided Platform Markets," *Yale Journal on Regulation*, 20(2): 325–82.

[14] Farrell, J. (1987) "Information and the Coase Theorem," *Journal of Economic Perspectives*, 1: 113–129.

[15] Farrell, J., and G. Saloner (1985) "Standardization, Compatibility, and Innovation," *Rand Journal of Economics*, 16: 70–83.

[16] —– (1986) "Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation," *American Economic Review*, 76: 940–955.

[17] Fudenberg, D., and J. Tirole (1991) *Game Theory*, Cambridge: MIT Press.

[18] Fudenberg, D., Levine, D., and J. Tirole (1985) "Infinite Horizon Models of Bargaining with One Sided Incomplete Information," in A. Roth ed. *Game Theoretic Models of Bargaining*. Cambridge University Press.

[19] Gabszewicz,J.J., Ferrando,J,Laussel, D. and N. Sonnac (2003) "Two-Sided Network Effects and Competition : An Application to Media Industries," mimeo, December.

[20] Gans, J., and S. King (2003) "The Neutrality of Interchange Fees in Payment Systems," *Topics in Economic Analysis and Policy*, vol. 3(1).

[21] Hagiu A. (2004) "Optimal Platform Pricing in Two-Sided Markets," mimeo.

[22] Hermalin, B.E., and M. Katz (2004) "Your Network or Mine? The Economics of Routing Rules," mimeo, UC Berkeley.

[23] Jeon, D.S., Laffont, J.J., and J. Tirole (2004) "On the Receiver Pays Principle," *Rand Journal of Economics*.

[24] Katz, M., and C. Shapiro (1985) "Network Externalities, Competition, and Compatibility," *American Economic Review*, 75: 424–440.

[25] —–(1986) "Technology Adoption in the Presence of Network Externalities," *Journal of Political Economy*, 94: 822–841.

[26] Kind, H., Nilssen, T., and L. Sorgard (2004) "Advertising on TV: Under- or Overprovision?," mimeo, Norwegian School of Economics.

[27] Laffont, J.J., Rey, P., and J. Tirole (1998a) "Network Competition: I. Overview and Nondiscriminatory Pricing," *Rand Journal of Economics*, 29(1): 1–37.

[28] —– (1998b) "Network Competition: II. Price Discrimination," *Rand Journal of Economics*, 29(1): 38–56.

[29] Laffont, J.J., Marcus, S., Rey, P., and J. Tirole (2003) "Internet Interconnection and the Off-Net-Cost Pricing Principle," *Rand Journal of Economics*, 34(2): 370–390.

[30] Myerson, R. and M. Satterthwaite (1983) "Efficient Mechanisms for Bilateral Trading," *Journal of Economic Theory*, 28: 265–281.

[31] Parker,G., and M. Van Alstyne (2002) "Information Complements, Substitutes, and Strategic Product Design," mimeo, Tulane Univesity and University of Michigan.

[32] —– (2004) "Mechanism Design to Promote Free Market and Open Source Software Innovation," mimeo, Tulane University and University of Michigan Preliminary.

[33] Reisinger, M. (2004) "Two-Sided Markets with Negative Externalities," mimeo.

[34] Rey, P. and J. Tirole (2003) "A Primer on Foreclosure," forthcoming in M. Armstrong and R.H. Porter, eds., *Handbook of Industrial Organization.*

[35] Rochet, J.C. and J. Tirole (2002) "Cooperation Among Competitors: Some Economics of Payment Card Associations," *Rand Journal of Economics*, 33(4): 1–22.

[36] —– (2003)"Platform Competition in Two-Sided Markets," *Journal of the European Economic Association*, 1(4): 990–1029.

[37] —– (2004)"Tying in Two-Sided Markets and the Honor-all-Cards Rule," mimeo.

[38] Rysman, Marc (2004) "An Empirical Analysis of Payment Card Usage," mimeo, Boston University.

[39] Schwartz, M. and G. Werden (1996) "A Quality-Signaling Rationale for Aftermarket Tying," *Antitrust Law Journal*, 64: 387–404.

[40] Tirole, J.(1986) "Procurement and Renegotiation," *Journal of Political Economy*, 94: 235–259.

[41] Williamson O.(1975) *Markets and Hierarchies: Analysis of Antitrust Implications*. New York: Free Press.

[42] Wright, J. (2003) "Optimal Card Payment Systems", *European Economic Review*, 47, 587-612.