Information Intermediaries for Digital Platforms

Vasyl Gorbachuk, Serge Garvylenko, Gennadii Golotsukov, Myhailo Pustovoit[1]

[1]*V.M.Glushkov Institute of Cybernetics of the National Academy of Sciences of Ukraine, 40, Academician Glushkov Avenue, Kyiv, 03187, Ukraine*

Abstract

Network effects are determined by the influence of an additional user of a product or service on the value that other users attach to this product or service. Platforms are then defined as entities that connect economic agents, actively managing network effects among the digital copies (images) of those agents. Network effects are distinguished by their sources: such sources can be users of the only group or users of several groups. Because, on a digital platform, network effects are generated jointly by all users, regardless of the groups to which they belong, and interest in the platform increases when the volume of interaction this platform manages increases, it is difficult to distinguish between different sources of network effects. User participation in the platform and their application of platform features can be important because their active evaluation of products and services, together with information provided by user actions (for platforms that collect and apply big data), gives an understanding of those actions, allows providing better services by the platform or adding specific offers. When consumers search for a product, they face travel costs, price information costs, and product feature comparison costs. When suppliers are looking for a willing buyer, they incur travel costs and communication costs regarding their products. Intermediaries reduce transaction costs by centralizing the exchange. In the presence of a random-matching market, there are profitable opportunities for intermediaries to conduct centralized exchanges, since buyers and sellers are influenced by the type of their matching partner, and intermediation allows self-selecting for types of economic agents. Intermediated trade can partially or completely replace decentralized trade and lead to more socially efficient allocations.

Keywords

Network effects, intermediated trade, self-selection, decentralized pricing, matching, big data, consumer surplus

1. Introduction

To proactively manage the interaction of buyers and sellers, platforms can implement rating and recommendation systems based on big data technologies to produce network effects. For example, Amazon publishes product reviews and average ratings: the more active users Amazon has, the more informative these reviews and ratings are, thus allowing consumers to make better-informed decisions. Amazon also provides recommendations by matching product characteristics with consumer interests.

Similarly, the more consumers are active on the platform and the greater the volume of transactions they generate, the better data Amazon receives about consumer characteristics and the better pair connections (matchings) the company can generate (offer) [1]. Hence, the quality of recommendations increases as the number of consumers increases, generally increasing their expected net gains [2]. The aforementioned mechanisms indicate positive within-group network effects.

13th International Scientific and Practical Conference from Programming UkrPROGP'2022, October 11-12, 2022, Kyiv, Ukraine
EMAIL: GorbachukVasyl@netscape.net (A. 1); S.A.Gavrilenko@nas.gov.ua (A. 2); Golotsukov@nas.gov.ua (A. 3); Pustovoit@nas.gov.ua (A.4)
ORCID: 0000-0001-5619-6979 (A. 1); 0000-0002-4160-3276 (A. 2); 0000-0002-3366-3762 (A.3); 0000-0002-8039-8180 (A.4)

To understand the choice of an intermediary, let us focus on the organization of exchange of products (goods and services) between sellers and buyers through the two extreme forms of intermediary exchanges, ignoring the other roles that intermediaries often play [1]. In one form of intermediary exchange, the intermediary acts as a dealer (retailer) in a sense it buys products from sellers and resells them to buyers: pricing is centralized by the intermediary. In the second form of intermediary exchange, the intermediary does not take control of the seller's products, but simply offers access to a platform (or marketplace) where buyers and sellers can interact as they see fit: pricing is decentralized to market participants, and the platform taxes trade [2].

The first form corresponds to a business model in which the dealer sets the wholesale price for sellers and sets the retail price for buyers, and sellers and buyers are price-takers. The second form corresponds to a business model in which the platform operator collects a platform usage charge from each seller and collects a platform usage fee from each buyer, and sellers set retail prices for buyers.

Firms carry out transactions, servicing the payment system, inventory control, and record keeping, which are important for the functioning of markets [3]. In addition, firms provide a central place of exchange, thus reducing the search costs for buyers and sellers [4]. By comparing the costs of intermediation with the costs of non-intermediated exchange in the markets, matching buyers and sellers, or the costs of search, it can be shown that an intermediated exchange happens to be more beneficial [5]. Indirect network effects [6] on both sides of the market lead to the concept of so-called two-sided platforms. In such a platform, the primary role of intermediary is to control access to the platform that at least two groups of economic agents use to their interaction. A similar platform should be valued more by users of each group when the platform is used more by another group. Individual decisions to join a particular platform (including Platform as a Service (PaaS)) then generate indirect network effects on agents on the other side of platform.

However, in a multi-intermediary world, consumers and suppliers continue to incur search costs due to reacting to multiple intermediaries [7]. Consumers and suppliers discount future net gains due to monetization of search time costs [8, pp. 188−193]. Consumers have different levels of willingness to pay, suppliers have different opportunity costs, and intermediary firms have different transaction costs. These firms set both bid prices and ask prices. Consumers look for firms that offer a lower purchase price, and suppliers look for firms that offer a higher sale price.

Due to such heterogeneity and search costs, the market equilibrium is a distribution of sale prices and a distribution of purchase prices. This equilibrium depends on the discount rate of consumers and suppliers, for whom a higher discount rate stands for a decrease in activity (the number of active consumers and suppliers), while a higher discount rate means an increase in the activity of intermediary firms (the number of active firms): a higher discount rate increases the costs of time-consuming search for consumers and suppliers.

Intermediary firms then raise their purchase prices and lower their sale prices because consumers and suppliers are willing to pay a premium to avoid further search, thus increasing the returns to intermediation for firms and stimulating growth in the number of intermediary firms active at the market equilibrium [1]. Thus, the discount rate determines the search costs. When this rate falls to zero, the search costs are eliminated and the relationships between the size of the bid-ask spread and transaction costs are revealed. Then the Walras equilibrium will be the limiting case of the intermediated market when transaction costs fall, and the supply and demand model can be considered an ideal case compatible with the market under consideration at the presence of search costs and price-setting firms.

The cloud technologies are saving the general search costs. The two basic cases of providers for such technologies are monopoly and competition.

2. Monopoly and competition

Contrary to uncompatible products, compatible products have network externalities [9]. It is shown that under uniformity of consumer preferences the output of compatible or uncompatible products by a monopoly is socially optimal one. But under non-uniformity of such preferences market failures are possible. Consumer preferences are said to exhibit network externalities if the utility of each consumer increases as the total number of consumers buying the same or compatible brand increases. One approach to modeling consumers' preferences for the compatibility of the PCs they buy is to assume that their preferences exhibit network externalities.

This assumption approximates the consumer's desire for compatibility in the sense that the consumer's utility is expressed simply in terms of the number of consumers of the same or compatible brand, not in terms of the degree of compatibility between the machine (computer) this consumer buys and the machines other people use. Before starting the analysis, it is necessary to find out what are the main problems and questions that should be explained and what answers can be expected: how increasing the compatibility of brands affects the price and profit levels of brand-producing firms; how increasing brand compatibility affects consumer utility and social welfare; how variations in the market structure (increasing the number of firms producing brands, for example, the transition from a monopoly to a duopoly) affect the degree of compatibility of brands and/or the pricing of differentiated brands.

A monopoly pricing strategy in the presence of network externalities can be seen in a market with one computer manufacturer selling a single brand to identical users who value compatibility. In a single-brand computer market, all computers run the same OS and are therefore considered compatible, provided that the machines can be connected via cables attached to communication ports (directly or via the Internet) or by transferring such storage tools as floppy disks and portable hard drives. These cables and devices are generally called adapters. Thus, in the case of monopoly, compatibility is valued because installing an adapter will allow any two machines to communicate and work together. Since the installation of an adapter increases the cost of production, computer manufacturers often find it unprofitable to install such an adapter.

Proposition 1 [10]. A monopoly selling computers to identical consumers will install compatibility adapters if and only if it is socially optimal to do so: here monopoly does not lead to market failure.

Proposition 1 resembles the result that a monopoly manufacturer of electric lamps will have no incentive to reduce the duration of operation of electric lamps below the socially optimal level. A monopoly uses the price mechanism to extract additional rents, but at the same time acts as a social planner to solve the same problem of technology choice (cost of production). When consumers have different compatibility preferences and the monopoly cannot discriminate between different types of consumers, then statement 1 does not hold. Let's continue the analysis of the market with a single manufacturer selling a single computer brand to heterogeneous users who differ only in their compatibility preferences.

Proposition 2 [10]. If consumers are not identical, then a market failure can occur, where it is profitable for a monopoly to produce one type of machine, and it is socially optimal to produce another type of machine.

The entry of a new firm into the telecommunications industry increases the utility of already joined consumers and leaves the utility of newly joined consumers unchanged. A monopoly maximizes its profits by setting its price to join so that the number of users exceeds half of all available users. It leaves low-paying consumers out of the network [11].

The formulation of the problem consists in investigating the possibility of an endogenous and almost discontinuous path of diffusion (for a new network technology), based on the effect of the installed base (the available number of the technology users) [12]. Current research in the field of global cellular telephony suggests that technology exhibits installed base effects in (new technology) adoption and that cellular diffusion varies between countries and groups of countries due to technological, socioeconomic, and regulatory factors that influence the diffusion process [13].

As a rule, existing models cannot empirically distinguish periods of rapid diffusion, common in most industrialized countries, from a critical mass that does not rely on price reductions or exogenously changing technologies [14]. There are known attempts to exclude another potential cause of endogenous diffusion − epidemic effects, in which the level of penetration increases with a constant intensity of use. An unsolved question is the properties of the models that allow finding the critical mass of the technology expansion and proposing appropriate regulations [8]. The purpose of the work is to strictly justify regulation in the field of telecommunications.

The main results are derived from an economic model consisting of two equal groups of consumers who want to join a certain telecommunications service (say, receiving a telephone connection): consumers of the type H value joining this service higher, and consumers of the type L value joining this service lower.

After constructing the demand curve, let's define a concept that telecommunications firms find very useful when marketing their new service: for a given service subscription fee, the critical mass is the minimum number of users needed to guarantee that at least this number of users will have the non-negative utility from subscriptions. In order to organize a party or a weekend trip, the organizer must convince potential participants that a certain minimum number of people will definitely attend, which in effect means even more participants due to increasing network effects.

In telecommunications, the critical mass is always a function of market price: an increase in price will mean an increase in the critical mass, and a decrease in market price will decrease the critical mass, because at a lower price users will be satisfied by a smaller network size. Commanding such concepts, the former student of one of the authors developed the Djuice project, which earned Kyivstar more than two billion dollars in five years [15]. If in equilibrium only one type of consumer joins a given service, then this is the type H: consumers, who value the service highly, will be the first to purchase it.

Until the 1980-s, most countries had a monopoly market structure in the field of telecommunications. For example, in Ukraine such a monopoly firm was called Ukrtelecom, in Estonia − Estonia Telecom. In Israel, until the 1960-s, a similar firm also provided postal services.

During the 1980-s, governments began to realize that monopolistic market structures in the telecommunications industry, which were believed to be natural monopolies, were distorting industry markets. The main event that led to the introduction of competition in this field was the division of the US AT&T company into 7 regional telephone companies in 1982, as well as the creation of MCI and SPRINT companies as the main competitors in the long-distance and international markets.

In the 1980-s, regulators discussed three basic issues:

knowing that many users (of type H) are already connected to the existing monopoly provider of telecommunications services, can social welfare be improved by allowing the new operator to connect other users (of type L) to the network;

whether a new operator entering the market will make a profit;

when the entry of new providers is socially desirable, how can the existing monopoly be prevented from engaging in predatory pricing to attract more customers, thereby narrowing the potential market for a new firm entering the telecommunications industry.

In 1997, the market for international telephone calls in Israel was deregulated when two new firms entered the market at the same time. In order to prevent Bezeq Company's existing monopoly from engaging in unfair price-cutting practices, the Israeli Ministry of Telecommunications issued a restriction that prohibited price discounts by Bezeq Company when Bezeq Company's market share exceeded 70%. Therefore, we assume that the regulator orders the existing monopoly not to reduce its price (fee) for connection (to the network) when the market entry of a competing provider is not completed: the existing monopoly serves only consumers of type H, and the new firm can serve all consumers of type L, reducing its connection fee below the fees of the existing monopoly.

Proposition 3 [10]. Entry into the telecommunications industry increases the utility of already connected consumers and leaves the utility of newly joined consumers unchanged, increases the profit of the new firm and leaves the profit of the existing firm unchanged. When, in addition to the market for accessions, the market for the flow of services provided (telephone calls), after the addition of the type L consumers during the entry of a new firm, is taken into account, the existing firm will suffer a reduction in profits, but social welfare will increase due to a decrease in price.

Proposition 4 [10]. A monopoly telephone company maximizes its profits by setting its subscription price so that the number of users exceeds half of all existing users and there are unconnected customers.

Proposition 5 [10]. When the total number of consumers increases, the monopoly price and utility of the connected users increase proportionally, and the monopoly profit increases quadratically.

Installed base effects may derive from other social diffusion effects, including social learning under uncertainty and social-normative pressures. With a strong decrease in the intensity of use, the epidemic effect is mostly absent or at least overshadowed by other factors, primarily consumer heterogeneity. It follows that the driving forces of diffusion are constantly falling prices and/or increasing quality.

The main conclusion is that the entry of a new firm into the telecommunications industry increases the utility of already joined consumers and leaves the utility of newly joined consumers unchanged. A monopoly maximizes its profit by setting its subscription price so that the number of users exceeds half of all available users and there are unconnected consumers. Questions that require further investigation: whether exogenous changes are responsible for all diffusion (without a critical mass); whether there is an element of endogenous diffusion.

3. Network effects dependent on product categories

Positive cross-group network effects can occur on bilateral platforms [7]. For example, a high-quality seller, planning to participate in e-commerce on eBay, Taobao, Amazon Marketplace, or another B2C platform, also plans on opportunities to build their reputation. The more buyers are active on the platform, the more accurate the information about the type of seller at a given point in time (assuming true consumer ratings): there is a positive cross-group network effect from buyers to high-quality sellers. Similarly, the more buyers on the platform, the better the match between buyers and sellers (in terms of horizontal characteristics), the lower the expected number of goods returned to sellers: there is a positive intergroup externality from buyers to sellers due to the recommendation system. This effect is enhanced by more detailed data about each consumer and each seller, which improves the expected quality of the mentioned match [5].

Ratings are intended to help consumers make decisions based on quality or value-for-money dimension. Recommendations can also serve this purpose, with the potential to elucidate the heterogeneity of personalized shoppers. In the context of the rating system, some personalization is also feasible: several platforms offer the option of personalization, showing ratings and reviews only of buyers with certain profiles. Such a selection of ratings can provide better guidance because a high rating of a product for one group of buyers does not mean a high rating of this product for another group of buyers: for example, a business traveler may have needs and preferences that differ from those of the family on vacation. Then such a traveler can give preference only to the ratings and reviews of fellow travelers.

The big data economy relies on ratings, reviews and recommendations that have become mainstream on digital platforms. Rating and feedback systems provide platform users with information about goods or transaction counterparties. Of course, the informativeness of these systems is crucial, depending on the actions of users, as well as on the specific design chosen by the platforms.

Recommender systems, focused on reducing users' search costs by directing them to transactions that may better suit their tastes, deserve attention. In addition to the ability of such systems to generate network effects, such systems have the ability to influence the ratio of sales among mass-market products and so-called niche products [6]. Platforms may have incentives to reduce the informativeness of recommender systems.

In general, it is assumed that the decisions of platforms regarding rating and recommendation systems are guided by the intention to improve the user experience, but the incentives of platform monetization do not exclude potential conflicts [7]. The analysis of rating and recommendation systems can be supplemented by studying additional channels through which big data can generate network effects and other self-reinforcing processes on platforms [5]. Ratings and reviews prevail on digital platforms. Platforms that act as vertically integrated retailers (such as Amazon or JD) typically ask customers to rate products or services, often allowing customers to write reviews. Then there are product ratings and product reviews.

For platforms that host buyers and sellers (such as Amazon Marketplace or Taobao Marketplace), users on the supply and demand side are often asked to rate and comment on a transaction counterparty. Then there are ratings and reviews from the supply and demand side.

An economic analysis of these two types of rating and feedback systems requires an understanding of their role for digital platforms. It can be shown that in conditions of asymmetric information [16], ratings and reviews become an important source of network effects, as well as tools in the efforts of platforms to obtain market shares. It is also worth investigating the informativeness of ratings and reviews for platform users.

In economics and marketing, the SEC (Search, Experience, Credence) classification by archetypes is used for the entire range of goods and services, based on the level of consumers' ability to obtain information about a product or service and make a decision.

Search goods have attributes that can be evaluated prior to their purchase or consumption: consumers rely on prior experience, direct product inspection, or other actions to search for information useful in the evaluation process. The category of search goods includes most products (for example, clothing, office supplies, home furniture).

Experience goods can only be accurately evaluated after the product has been purchased and tested. The experience product category includes many personal services (for instance, restaurant, hair salon, theme park, travel, leisure). Credence (post-experience) goods are difficult or impossible to evaluate despite their consumption experience: the consumer may lack the knowledge or technical expertise to realistically evaluate the product, and the costs of information-seeking activities (about the product) may exceed the value of information available.

Many professional services (for example, accounting, legal, health care diagnostic, medical, and cosmetic services) fall under the category of trust products.

In contrast to an experience product, a search product is a product (service), the functions and characteristics of which are easy to evaluate before its purchase [17]. Substitution and price competition are more applicable to search products because it is easy for consumers to check their prices and their alternatives at other outlets to compare such products. Branding and more detailed product specifications help it move from an experience product category to a search product category.

An experience product is a product (service), the characteristics (price, quality) of which are not easy to evaluate before its (her) purchase, but can be determined after consumption of this product. Experience products present challenges for consumers in making the right decisions. In some service industries (for instance, healthcare), experience products promote the reputation of the service provider and create an inertia. Experience products tend to have lower price elasticities than search products because consumers may associate lower prices with unobserved problems or unknown quality issues.

A trust product is a product (service), the effect of which utility is difficult or impossible for the consumer to determine. Unlike experience products, the increase or decrease in utility of trust products is difficult to measure despite their consumption. Since the sellers of such products know value of the change in utility when consuming the products, a situation of asymmetric information is emerged. Examples of trust products: vitamin supplements; education; car repair; many forms of medical treatment; plumbing and electrical services for house maintenance; transactional legal services. Trust products may reflect a direct (rather than inverse) relationship between price and demand, similar to Veblen products, for which price is the only possible indicator of quality.

Veblen's product is a type of luxury good, the demand for which increases with the increase in price, which clearly contradicts the law of demand (but not always contradicts the facts). From a psychological point of view, higher prices for Veblen products may increase the demand for them as a status symbol in the practices of conspicuous consumption and ostentatious leisure. In sociology and economics, ostentatious consumption describes and explains the consumer practice of buying and using products of higher quality and price, as well as the volume of production, which is greater than practically necessary. Showy or visible leisure is spent in order to demonstrate and achieve social status [18].

In the process of trading goods and services, intermediaries play the role of a dealer and the role of a platform operator. The most basic role of a dealer is to buy and resell products without adding any services to the transaction. However, this simple activity of buying and reselling can add value for some decentralized market participants during the interaction of buyers and sellers: intermediation allows for valuable self-selection of types, when the buyer's (seller's) decision depends on the type of partner in the buying and selling transaction (by matching). Therefore, intermediaries can find profitable opportunities for the operation of centralized exchanges.

Centralized exchanges (intermediaries) can offer the proposal of buying and reselling goods (acting as a dealer) and offer the possibility of meeting buyers and sellers (acting as a platform operator). Since decentralized pricing leads to positive and negative effects for the intermediary, one of the offers is not always more profitable for him (her) than the other. Intermediaries, that provide

matching services between buyers and sellers, can add value through the internalization of two types of externalities, which will require an appropriate environment.

Agents in one group may value the intermediary's matching services because the more participants in the other group, the more chances of these agents finding their matches: an indirect network externality may occur. In addition, users of matching services can pay attention not only to the number of promising combinations, but also to the identity of combinations: there is an external effect of sorting. Knowing this, the mediator can control the composition of different groups and thus internalize this effect.

Amazon.com started its business as a dealer or retailer, buying books from publishers and reselling them to consumers. Such a business was similar to the business of traditional bookstores. Amazon.com's specialty was online shopping instead of traditional shopping in physical stores. This raises the question of why publishers and readers use such intermediaries instead of trading directly with each other. For trade in physical goods, logistics, storage, inventory are important, and for trade in digital goods, the connection between reader and publisher is important, which can be improved by an intermediary.

4. The roles of intermediaries

Most goods and services are not sold directly from the producer to the final consumer, but pass through market intermediaries who provide their services. The main roles for mediators are:

dealer – an intermediary who buys goods or services from suppliers and resells them to buyers;

platform operator – an intermediary that provides a platform where buyers and sellers (generally different groups of agents with complementary types of business) are able to interact;

information intermediary or infomediary – an intermediary that acts as an information gatekeeper, allowing consumers to access information about the price or cost of products when matching buyers and sellers (match value), and effectively processes such information;

trusted third-party – an intermediary acting as a certification agent by ascertaining information about the reliability or quality of a product or seller.

Although the intermediary actually chooses the role of dealer or platform operator, hybrid business models are also feasible, as exemplified by the well-known electronic intermediary Amazon. Because the roles of information broker and trusted third party are complementary and often important to the functioning of markets, Amazon assumes these roles as well. At the beginning of its activity in 1995, the intermediary Amazon.com was a pure online retailer, starting with the sale of books, then music CDs, video cassettes, DVDs, software, and later many other categories of goods (consumer electronics, toys, games, kitchen utensils, items for the garden and orchard, etc.).

Amazon's main competitive advantage as a dealer was its ability to offer a much wider range of product titles than traditional dealers or mail-order companies. In addition, Amazon's advantage was the ability to quickly adjust its product portfolio, using global best practices, including that of eBay Inc. eBay is an American multinational e-commerce company that facilitates C2C (consumer-to-consumer) and B2C (business-to-consumer) sales through its website.

Obviously, there are many cases when trade takes place or matches (of buyers and sellers) are established in the absence of intermediaries, say, in cases of visits to department stores or shopping malls. Although some producers sell directly to consumers, and people often establish personal relationships in the absence of intermediaries, there are shops and dating clubs when there are economic agents who benefit from the use of intermediaries. We may begin with the analysis of a decentralized market in which buyers and sellers interact in the absence of an intermediary, and then proceed to the analysis of changes in the distribution of profits and rents in the market, where an intermediary has entered.

Assume that the market is free, that is, buyers and sellers are not charged for joining it. Let's also assume that buyers and sellers (in general, trading partners from two groups) match randomly. Then the market maker can profitably enter the market to buy and sell the product at the price difference to enable a profit, despite the opportunity for consumers to participate in the random matching market for free. Intermediaries must compete with the decentralized exchange option, in which consumers and suppliers seek each other out and negotiate prices directly [19−21]. Sometimes such competition is at close quarters: for example, an organized used car market served by car dealers coexists with a decentralized market where buyers and sellers meet informally, often using advertisements. In the

matching market, consumers have different levels of willingness to pay, and suppliers have different opportunity costs.

Before entering the matching market, the consumer and the supplier do not know the type of their trading partner. We will assume that after the consumer and the supplier have decided to trade (have agreed to trade), they learn each other's type. At this point, the trade takes place if and only if they have gains from the trade.

If consumers and suppliers match randomly (in a decentralized manner), the terms of exchange become uncertain, increasing the risks that the parties will not reach an agreement. When consumers and suppliers trade directly, the buyer has an incentive to understate his (her) willingness to pay and the seller has an incentive to overstate his (her) opportunity costs. Asymmetric information about willingness to pay and opportunity costs leads to inefficient trading volumes, including zero volume (trading breakdown). An intermediary can eliminate this uncertainty by publishing bid prices and ask prices, thus offering an advantage over a decentralized matching market.

When buyers and sellers can choose between using intermediaries to trade at a known price and the risky option of a decentralized market, intermediation can be profitable for the trading parties [20]. Then the market demand function is represented by the distribution of the buyer's willingness to pay levels, and the market supply function is represented by the distribution of the supplier's alternative value levels.

5. The market size dependent on intermediaries

The intermediary chooses the spread – the difference between the best buying and selling prices at the same moment in time for this product in order to maximize his (her) profit, taking into account the value of the matching-market option for buyers and sellers: at market equilibrium, consumers willingly paying above the critical purchase level (more than the purchase price) will buy (the product) from the intermediary, and suppliers with opportunity costs below the critical selling level (below the selling price) will sell to the intermediary; consumers and suppliers whose willingness to pay or opportunity cost lies in the gap between these two critical levels enter the market of matches.

For simplicity, let all clients (users) be identical, and the demand is equal to 1. The net utility of the client of the platform is equal to $U-A$, where U − his (her) gross utility (utility), A − the price of his (her) access to the platform. Positive network effects involve the growth of the function $U(N)$, where N is the number of clients. Constant marginal costs c of production under conditions of competition mean equality $A=c$. Then the net utility of the (representative) customer is equal to $U-A=U(N)-c$.

At the same time, economies of scale of production imply a decline in the function $c(N)$. Then the client's net utility will be $U(N)-c(N)$. In the real world, network effects and economies of scale can exist simultaneously: for example, when Amazon (as a retailer) ships more products, it benefits from economies of scale in the logistics network (hence the decreasing function $c(N)$), while Amazon's customers can benefit from faster delivery (when demand becomes more predictable, Amazon's inventory decisions better reflect consumer tastes).

An increasing function $U(N)$ and a decreasing function $c(N)$ mean that an increase in the number N of customers leads to an increase in the net utility of the customer $U(N)-c(N)$. Then the question arises about the socially optimal size N of the client base. The condition of optimality is the equality of marginal social gain and marginal costs. The total gross social gain, taking into account network effects, is $N\times U(N)$, and the marginal social gain is equal to the derivative $U(N)+N\times U'(N)$. Hence, the optimal size N^* of the client base satisfies the equality $c=U(N^*)+N^*\times U'(N=N^*)$, where $U'(N=N^*)$ is the value of the derivative $U'(N)$ at $N=N^*$. There is also the question of whether marginal cost pricing corresponds to a socially optimal outcome: if a platform as a private firm sets a price equal to marginal costs, it does not incur losses and does not exit the market in the absence of fixed costs. The client base will increase at $0\le U(N)-A=c-N\times U'(N)-A$. When buyers and sellers can choose between using

intermediaries to trade at a known price and the risky option of a decentralized market, then intermediation can be profitable for the trading parties.

Marketers, including retailers, wholesalers, used car dealers, energy dealers, buy and resell goods. Brokers, in particular travel agents, real estate agents, insurance agents, stock brokers provide coordination services without buying and selling goods. Real estate brokers set home prices, fix commissions, and invest in finding home buyers and sellers.

The model [21] explains the value of such shared listings as the Multiple Listings Service (MLS) − an organization with a suite of services that real estate brokers use to establish cooperation and compensation offers (among brokers), as well as to accumulate and disseminate information to enable real estate appraisals. The MLS database and software are used by real estate brokers (or aircraft brokers) who represent sellers under a listing contract to widely share information about properties with other brokers who may represent potential buyers or who wish to work with the seller's broker to find buyer to the property or asset. The listing data stored in the MLS database is the proprietary information of the broker who obtained the listing agreement with the seller of the property.

Such intermediaries improve the welfare of consumers and suppliers by reducing or eliminating the uncertainty associated with establishing a satisfactory match [22]. Intermediaries also increase the number of potential trading partners, thereby increasing the probability of meeting a trading partner and reducing search costs [23].

In many markets, an intermediary can not only buy and sell products (being a dealer), but also control the price of a transaction or simply charge a fee for access to the trading platform and for transactions (being a platform operator). For example, a department store can set prices on both sides of the market (assuming that the department store has pricing power on both sides of the market) or simply rent its shelf space, as some retailers do in part, for example, Walmart (WMT in the stock exchange listing NYSE).

In the basic model of the platform operator, it does not matter which side of the market has to pay for using the platform: let's limit ourselves to the case where sellers have to pay for using the platform. If sellers have the authority of the price setter on the platforms, then in procurement problems, such authority is generally held by the buyers: the analysis of the procurement processes is similar to the analysis of the intermediary exchange through the platforms.

Using a simple model, we will show that buyer-seller relations in the two specified forms of intermediary exchange are markedly different and have ambiguous consequences for the intermediary's profit and the volume of trade. Therefore, the success of the two respective business models depends on additional factors.

Practical examples show that dealers, platform operators and mixed (hybrid) forms of intermediation are present in different parts of the digital economy [24]. The two specified forms of mediation can be considered two extreme points of the whole spectrum. Internet intermediaries can occupy different positions in this spectrum [25]. For example, the abovementioned company eBay may resemble a platform because its main role is to establish contacts between buyers and sellers, as well as to tax trade on the platform. Another extreme point was Apple's iTunes Music Store.

Let each consumer buy at most one unit of the product and each supplier sell at most one unit of the product. Suppose there is a large number of heterogeneous buyers and sellers: buyers have a high valuation type v_H or a low valuation type v_L (regarding to a product unit), and sellers have a low cost type c_L or a high cost type c_H; there are no other types of buyers and sellers. Let both types of buyers and sellers be equally likely [1, 5].

Proposition 6 [26]. When $c_H > v_L$ different agents have the following expected net surpluses (ENSs):

a buyer of the type v_H has $ENS(v_H) = 0,5(v_H - c)$, where $c = 0,5c_H + 0,5c_L$;

a buyer of the type v_L has $ENS(v_L) = 0,25(v_L - c_L)$;

the type c_L seller has $ENS(c_L) = 0,5(v - c_L)$, where $v = 0,5v_H + 0,5v_L$;

the type c_H seller has $ENS(c_H) = 0,25(v_H - c_H)$.

Proposition 7 [26]. When $v_L > c_H$, different agents have the following expected net surpluses:

the type v_H buyer has $ENS(v_H) = 0,5(v_H - c)$ (as with $c_H > v_L$);

the type v_L buyer has $ENS(v_L) = 0,5(v_L - c)$;

the type c_L seller has $ENS(c_L) = 0,5(v - c_L)$ (as with $c_H > v_L$);

the type c_H seller has $ENS(c_H) = 0,5(v - c_H)$.

The propositions 6 and 7 validate the participation constraints which are keys for operating markets, communities, digital platforms, and societies.

6. Conclusions

Market intermediaries coordinate the actions of buyers and sellers. Due to the centralized operation of the platform, the intermediary can add value and capture rents by facilitating the internalization of the externalities related with network effects. The characteristics of intermediaries must meet certain expectations of market participants.

7. References

[1] D.F. Spulber, *Market Microstructure. Intermediaries and the Theory of the Firm*, Cambridge University Press, Cambridge, UK, 1999.

[2] B. Krogfoss, L. Sofman, M. Weldon, Internet architecture evolution and the complex economies of content peering, *Bell Labs Technical Journal* 17 (1) (2012) 163–184. doi.org/10.1002/bltj.21529

[3] P. Maille, B. Tuffin, *Telecommunication Network Economics: From Theory to Applications*. Cambridge University Press, New York, NY, 2014.

[4] O. Shy, *The Economics of Network Industries*, Cambridge University Press, Cambridge, UK, 2001.

[5] P. Belleflamme, M. Peitz Inside the engine room of platforms: reviews, ratings, and recommendations, in: *Economic Analysis of the Digital Revolution. FUNCAS Social and Economic Studies*, vol. 5., J.-J.Ganuza, G.Llobet (eds.), FUNCAS, Madrid, Spain, 2018, pp. 75−114. blog.funcas.es/wp-content/uploads/2018/11/Economic-Analysis-of-the-Digital-Revolution.pdf

[6] J. Rohlfs, A Theory of interdependent demand for a communications service, *Bell Journal of Economics* 5 (1) (1974) 16–37. doi.org/10.2307/3003090

[7] D.F. Spulber, Market making by price setting firms, *Review of Economic Studies* 63 (4) 1996 559–80.

[8] V. Gorbachuk, *Methods of Industrial Organization. Cases and Exercises. Economy and Organization of Production. Economic Cybernetics. Economics of Enterprise*, A.S.K., Kyiv, Ukraine, 2010. (In Ukrainian).

[9] P. David, Clio and the economics of QWERTY, *American Economic Review* 75 (1985) 332–337. www.jstor.org/stable/1805621

[10] V.M. Gorbachuk, The ways of coping with market imperfections in the telecommunication industry, *Odesa National University Herald. Economy* V. 18 3(1) 84−87 (2013). (In Ukrainian).

[11] E. Altman, A. Legout, Y. Xu Network non-neutrality debate: an economic analysis, in: *International Conference on Research in Networking* (May 9–13, 2011, Valencia, Spain), part II, J. Domingo-Pascual, P. Manzoni, S. Palazzo, A. Pont, C. Scoglio (eds.), Lecture Notes in Computer Science (LNCS), 6641, Springer, Heidelberg, 2011, pp. 68–81. doi.org/10.1007/978-3-642-20798-3_6

[12] V.M. Gorbachuk, M.S. Dunaievskyi, A.A. Syrku, S.-B. Suleimanov, Substantiating the diffusion model of innovation implementation and its application to vaccine propagation, *Cybernetics and Systems Analysis* 58 (1) (2022) 84−94. doi.org/10.1007/s10559-022-00438-1

[13] J. Krämer, L. Wiewiorra, C. Weinhardt, Net neutrality: a progress report, *Telecommunication Policy* 37 (9) (2013) 794–813 doi:10.1016/j.telpol.2012.08.005

[14] V. Gorbachuk, T. Bardadym, S. Bespalov Economic mechanisms and cases to close Internet coverage gaps, in: *Transformation of Economy, Finance and Management in Modern Conditions*, A.Pawlik, K.Shaposhnykov (eds.), Baltija Publishing, State University of Jan Kochanowski, Riga, Latvia, Kielce, Poland, 2022, pp. 436−450. (In Ukrainian).

[15] Antonina Radzikhovska, in: *Ukrainian participants in U.S. Exchange Programs. Building a new country: my story*, The Alumni Resource Center in Kyiv, Kyiv, Ukraine, 2012, p. 14.
[16] V.M. Gorbachuk, An asymmetric Cournot–Nash equilibrium under uncertainty as a generalized Cournot–Stackelberg–Nash equilibrium, *Cybernetics and Systems Analysis* 43 (4) 2007 471–477.
[17] P. Nelson, Information and consumer behavior, *Journal of Political Economy* 78 (2) (1970) 311−329. www.jstor.org/stable/1830691
[18] F. Hirsch, *Social Limits to Growth*, Harvard University Press Cambridge, MA, 1976, reprint 2014.
[19] S. Bhattacharya, K. Hagerty Dealerships, trading externalities, and general equilibrium, in: *Contractual Arrangements for Intertemporal Trade.* E.C.Prescott, N.Wallace (eds.), University of Minnesota Press, Minneapolis, MN, 1987, pp. 81–104.
[20] T. Gehrig, Intermediation in search markets, *Journal of Economics and Management Strategy* 2 (1) 1993 97–120.
[21] J. Yinger, A search model of real estate broker behavior. *American Economic Review* 71 (4) 1981 591–605.
[22] V. Gorbachuk, M. Dunaievskyi, S.-B. Suleimanov, Modeling of agency problems in complex decentralized systems under information asymmetry, in: *IEEE Conference on Advanced Trends in Information Theory* (December 18–20, 2019, Kyiv, Ukraine), Taras Shevchenko National University of Kyiv, Kyiv, Ukraine, pp. 449–454. doi:10.1109/ATIT49449.2019.9030498
[23] V. Gorbachuk, S. Gavrilenko, G. Golotsukov, D. Nikolenko, To digital technologies of patent processing for development of critical products, in: *Information and Digital Technologies 2021* (June 22−24, 2021, Zilina, Slovakia), University of Zilina, Zilina, Slovakia, pp. 137−147.
[24] A. Hagiu, Merchant or two-sided platform?, *Review of Network Economics* 6 (2) 2007 115–133.
[25] V. Gorbachuk, S. Gavrilenko, The impact of cloud services pricing on provider profit, consumer surplus, and social welfare, in: *UkrPROG 2020*. (September 15−16, 2020, Kyiv, Ukraine). I.Sergienko, P.Andon (eds.), National Academy of Sciences of Ukraine, Kyiv, Ukraine, http://ceur-ws.org/Vol-2866/ceur_237-245gorbachuk23.pdf
[26] V. Gorbachuk, S. Gavrilenko, G. Golotsukov, M. Lupei, D. Nikolenko, M. Pustovoit, L. Batih, Asymmetric information, intermediation, coordination, rational self-selection, and social welfare, *Problems of Control and Informatics* 3 2022 151−160.