Industrial Economics

The economy of networks and positive externalities

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- Networks, physical as well as information and communication networks are all about positive externalities. The definition of an externality is "an effect on the welfare of someone without that this effect is taken into account in the decision-making process of the one who causes it".
- This implies a lack of feedback or of reciprocity. This is always due to transaction costs. The level of transaction costs determines the level of externalities (Coase). In the absence of transaction costs, no externalities exist (Coase according to Stigler).

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- Positive externalities can accrue on the production side (synergies, IRTS, physical networks) as well as on the consumption side ("my utility improves if you use the same product"). Relevant industries are:
  - Telecommunications
  - Computers (software, both user and programming)
  - Music, film, books, cultural products
  - Internet, social networks
  - Electricity, gas, water (especially in transport and distribution)
  - Physical networks (type SNFC)
  - Research and development (clusters of innovation)
  - Introduction and establishment of brands, advertising, name recognition ("viral marketing")
  - Technical standards (QWERTY, AC/DC, telephone networks)

Several remarks on positive externalities

- Positive externalities exist both on the consumer and producer side. Formally they can be expressed as follows:
  Consumption (utility):
  $Uai(2) + Uaj(2) > Uai(1) + Ubj(1) < Ubi(2) + Ubj(2)$.
  Production (cost): $C(a+b) < C(a) + C(b)$. This corresponds to the definition of subadditivity.
  Customarily, we speak of positive externalities especially in connection with phenomena on the consumer side.
- Positive externalities are often linked to phenomena in the areas of communication, information and shared knowledge or preferences.
- On the production side they are close to the notions of increasing synergy or increasing returns.

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- The value of a network (V) depends on the number of participants “n” and the value of each connection “vi“ between two participants, i.e., the value of the externality. This gives rise to Metcalfe’s Law: $V = v_i * [n * (n - 1)] = v_i * [n^2 - n]$.
- This is a quadratic function. Since it may be costly to build a basis with a sufficient number of initial participants, networks have production function that are characterised by very high fixed costs and low variable costs. One the critical mass of initial participants is built, networks imply a strong tendency towards monopolisation. Markets are of “winner-takes-all”-type. This raises the question of regulation.
- One must distinguish between static and dynamic effects. Frequently, network effects are spread through time and thus involve a change of parameters in addition to changes in the variables of price and quantity. This includes changes in skills, knowledge or preferences. Network effects and positive externalities are often related to learning.

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- If networks are static, the positive externalities in stable physical structures lead to natural monopolies or infrastructures that demand to be regulated. We will see in Lesson 9 that regulation consists partly in the separation of infrastructures with increasing returns such as transmission and distribution from production with more or less constant returns. One must, of course, take into account the size of the market with respect to the domain over which increasing returns unfold.
- If networks are exposed to dynamic change (computer programmes, social networks, fashion, music etc.), the question of regulation changes. Frequently, regulation is not necessary as one witnesses over time a rapid succession of monopolies (Atari - IBM - Microsoft - Apple - Google - Facebook - Instagram – ???) rather than one entrenched monopoly. In these cases, one talks about competition for the market rather than in the market.

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- If the monopoly is only temporary in a winner-takes-all market, the famous phrase by the economist John Hicks that "the best of all monopoly profits is a quiet night's sleep" no longer holds. It rather applies the phrase by Intel chairman Andy Grove that "only the paranoid survive".
- Competition for the market and the need to build critical mass leads to two additional phenomena:
  1. Very low initial sales prices, zero prices or selling at a loss (free samples, especially for "multipliers", free downloads, favourable terms etc.) in an initial phase. All web-based firms make (and are expected to make by their investors) considerable losses during their initial stage.
  2. Two-sided markets, where the forced monopolization of one market at great cost generates the user base for a second, profitable, market. The typical examples are free newspapers that bring in readers to which profitable advertising can be pitched. This is equivalent to a "loss-leader".

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- Both cases result again from a cost structure of the production function characterised by a very large initial investment costs and low, or zero, variable costs. This is equivalent to very strong increasing returns to scale, although they are deployed through time rather than through space.
- The fact that network markets require very low prices during an initial period generates some economic (not legal) ambiguity concerning the phenomenon of piracy (copying without payment). The loss of income due to pirating may be at least partially offset by increased demand and the establishment of a user base (Linux is delighted if you copy them legally, this is their business model). Piracy exists only in industries with very low variable costs (the costs of the copy). However, consumers in this case refuse to participate in financing the fixed costs, which, of course, constitutes a problem in the long run.
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- Positive externalities, network economies and static or dynamic monopolisation raise several questions regarding the industrial strategy of firms:
  1. The issue of standards and compatibility: is it more profitable to monopolise part of the market alone or to join others to earn a smaller share of profits from a larger or growing market? Consider the strategies of Microsoft vs. Apple or the strategy of Tesla. Any standard, especially if shared, can induce very strong customer lock-in (see below).
  2. Price discrimination and product differentiation (type 3 discrimination): price discrimination is the sign of a monopoly. Examples abound: standard and pro versions, collector editions, premium service etc. Shapiro and Dixit mention that parameters for web-based services can be differentiated by time, user interface, flexibility, image resolution, speed, size, performance, detail, completeness, harassment, technical support and so forth. There are certainly others. They also cite the following example by Kurzweil of product differentiation in the VoicePad voice recognition program.

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Product	Prices in Euros	Description
VoicePad Pro	79	Vocabulary 20 000 words
Staff	295	Vocabulary 30 000 words
Professional	595	Vocabulary 50 000 words
Office Talk	795	Business vocabulary
Law Talk	1195	Legal vocabulary
Voice Med	6000	Medical vocabulary
Ortho Voice	8000	Specialized medical vocabulary

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3. Piracy: how shall one deal with piracy and illegal copying, while ensuring the widest possible adoption to maximise positive externalities, value and demand?
4. Customer lock-in: since the size of the installed customer base is crucial, it is important not only to attract new customers but also to guard existing customers and stop them from leaving.
   Examples are loyalty programs over time, barriers to the termination of contracts. Foe the individual customer lock-in is negative, as it constitutes a loss of option value. For the firm it is positive, a strategy of survival. For society it is ambiguous there can be too much or too little inertia. The latter case may imply a lack of economies of scale.
   Firms will invest into customer lock-in up to the following point: Cost of lock-in (exit barrier) = Value of client i (Π_i) to the firm - advantage of change to the customer + cost of change to the firm.

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The objective is to establish, consolidate and operate a broad installed base that is attractive to new customers and whose value can be leverages (e.g., by selling access to the database to third parties). Again there exist multiple strategies:

Lock-in strategy	Cost of change
Contractual commitments	Termination fee, find the right person
Durable equipment	Replacing the installed equipment
Specific training	Learning costs
Data formats	Conversion or loss of data
Specialized suppliers	Recreation of contacts and trust
Opacity of information	Cost of research and information
Loyalty programs	Loss of accrued benefits

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- The game through time to attract the maximum number of clients, perhaps even while incurring temporary losses leads to extremely complex strategies concerning customer and investor expectations, reputation and sustainability of the business, the size of the installed base, the ability to innovation, intellectual property strategies (invite copiers or pursue them) etc. This remains a fascinating field of ongoing research.

The "band-wagon" model with positive externalities according to Saloner and Farrell (1985) (A leader-follower model with imitation)

- The model has two technologies that display positive externalities in use. Each technology is used by one or two users (two users correspond to a network use). There are three possible strategies and two periods.
- The two technologies, one established, the other new, are differentiated by the utility they generate:
- U indicates the utility of the old technology
- V indicates the utility of the new technology

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- For traditionalists it holds that $U(2) > V(2)$ and $U(2) > U(1)$. For extreme traditionalists it even holds that $U(1) > V(2)$.
- For innovators it holds that $V(2) > U(2)$ and $V(2) > V(1)$. For extreme innovators it even holds that $V(1) > U(2)$.
- The strength of the preferences U and V are measured along the segment [0,1] with $U(1,2) \in [0,1]$ and $V(1,2) \in [0,1]$. Preferences are homogenously distributed. This will allow probabilistic reasoning based on the strength of preferences (see below).

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- The model determines the switching points of users between different strategies according to the strength of their preferences. It also shows that there may too much inertia compared to the optimum as externalities in consumption are not internalised in the absence of coordination between users. There is not enough switching towards the new technology.
- The new technology can be adopted in period 1, in period 2 or not at all. During period 2, users can see what the other user has done in period 1.

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- The three possible strategies based on the preferences U and V are:
  1. Never change.
  2. Change in period 2, if the other user has changed in period 1.
  3. Change in period 1, hoping that the other user will do the same or follow in period 2.
- Graphically the three strategies are a function of certain segments of the preferences for the old and the new technology along the ray [0,1] which indicates the strength of preference for the old or the new technology.
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- Saloner and Farrell then seek to characterise analytically the levels of PREF* and PREF**, the level of preferences at which users switch, i.e. are indifferent between strategy 1 and 2 (PREF*) or between strategy 2 and 3 strategy (PREF**).

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- At point PREF* it holds that $U(1) = V(2)$
- A user, traditionalist, with a preference of PREF* is indifferent between strategy 1 (never change) and strategy 2 (change only if the other user has already changed in period 1). This is the point of indifference between staying alone with the old technology and following the "band-wagon".
- At point PREF** it holds that
  $V(2) * (1 - PREF^{**}) + U(2) * (PREF^{**}) =$
  $V(2)(1 - PREF^{*}) + V(1)(PREF^{*})$.

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- To decide between strategy 2 (switch only if the other user has switched) and strategy 3 (always switch, hoping the other will follow), an innovator must adopt a probabilistic reasoning based on the probable actions of the other user during period 1.
- The value of strategy 2 (switching only if the other user has changed during period 1) is the weighted sum of V(2) (in case that the other has already changed during period 1) and U(2) (in case that the other has not changed during period 1). The value of strategy 3 (switch in period 1) is the weighted sum of V(2) (multiplied by the now higher probability of $1 - PREF^*$, as strategy 3 may cause the other user to switch) and V(1) (if the other user, an inveterate traditionalist, does not switch).

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- In this model there is too much inertia. For instance for values above 0.5 but below PREF**, each user will wait for the other to make the first move. They will both stick to the old technology, although both agree that $V(2) > U(2)$. This result can be interpreted as excess inertia due to transaction costs between agents. Networks involve positive externalities. However due to transaction costs (frictions, absence of information etc.) they are not realised.
- Solutions may be communication (advertising), grants (prime the pump), loss on sale of the first units, advance announcements, forward contracts for future delivery, reversibility guarantees etc. or outright imposition of a new standard by a central authority.