Firm Competitiveness, Growth and Digitalisation—A Special Review on Network Economics

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Abstract

From a perspective of network economics, we look into the dynamics of competition, innovation and growth. This view relates theories, models and policy implications in a framework to approach the impacts of innovation and market dynamics on scale and scope of network industries, therefore, to foster breadth and depth of economic growth. Innovation has a major network inducing effect, so has competition. Competition always carries dynamic features and is intrinsically linked to interactive models in games of strategy. A review focuses on both the interaction of competition and innovation and sets out to outline the empirical tasks ahead through industry cases and econometric coverage within modern traditions of Schumpeterian economics.

Keywords

Innovation, Competition, Network Industry, Dynamic Markets, Schumpeterian Economics

1. Introduction: Statement of the Problem

Ever since Schumpeter (1942) was suggesting that large firms would count for the majority of product/process innovations in a dynamic (Schumpeterian) economy discussion continues across industries, market structures and competitive scale whether and to which extent large companies as compared to small and mid-sized firms (SMFs) will continuously generate a larger bulk of innovations (in terms of market shares, revenues or profits) and therefore contribute to industrial and economic growth.

An economic investigation would need to clarify how to capture and measure innovation in specific industries and how to identify success in the market context and for sustainable growth in the longer run. Further what are the underlying diverse explanatory factors (variables) that incentivise firms to engage in serial innovations that result in structural growth of the company. Thus it carries a standardised operational measurement, an incentive and performance problem within an organisation.

Five interlinked hypotheses center on industrial economics:

(1) Innovations increase more than proportionately with firm size but at some tipping point with a decreasing rate;

(2) Innovations may increase with market concentration;

(3) Competition vs. Innovation;

(4) Intensity of Competition and Level of Competitiveness;

(5) Competition and Industrial Growth.

Depending on the industry (1) suggests that in multi-activity firms up to a point in conglomeration there is an equal increase of innovation activity which might lag in other areas when they exceed "core competencies". In (2) and (3) one needs to explore which major incentive drive or slow innovation, either in the form of more innovation to escape competition or of less innovation due to a "rent dissipation" effect of competition. As in hi-tech industries, we observe that intensity of competition in some industries spills over to a beneficial effect on an international level of competitiveness (4). As in (5) competitive structues of leading national industries promote sectoral, regional and national growth through trade and investment.

From this we follow the stream of thematic issues:

1) Derive levels of competitiveness from technological/innovation racing within technology driven industries in relation to international competitiveness as compared to other industrial areas outside the EU.

2) Identify innovation processes (in products, operations) jointly with dynamic competition in respective industries.

3) How does digitalisation with industry-wide use of general purpose technologies (GPTs) foster, accelerate and spread industrial competition through increasing returns, new markets, and organisational forms of digital delivery.

This all will take place under the framework of a modern network economy of supply and demand side integration (Gottinger & Goosen, 2012; Gottinger, 2017a, 2017b).

With regard to measurement there are varies measures of growth generating innovation that clearly allow definable interindustry or even interfirm comparison except for certain kinds of product innovations that are technically identifiable such as performance in, say, semiconductors or new chemical entities in pharmaceuticals, and sometimes left for econosmic proxies such as welfare or quality changes (Gottinger et al., 2010).

For process innovations, changes as in factor productivity of the respective organisation could be an appropriate measure. Further, patent data (counts) have been used frequently as approximations of innovative activity of firms in some industries, though more relevant in some (pharmaceuticals) than in others (software) with particular cases in semiconductors restraining competition when firms build patent fences through patent clusters through patent clusters (Qualcomm, Texas Instruments). The economic value of patent counts is highly heterogeneous (Jaffe & Lerner, 2004).

The diversity of organisations across industries, make it challenging to specify econometric tools in which the major explanatory variables could reasonably explain the level of innovative activity of the organisation as a dependent variable. For example, some variables expected to influence process innovation may have no impact on product innovation and vice versa. Also the importance of these variables may vary on innovative activities across types of industries.

For firms and industries being of key interest is the relationship of firm size and market structure. Schumpeter was impressed by the qualitative difference between innovative activities of SMEs and large modern corporations with established R & D laboratories. It has been suggested in industrial economics since then, as a hypothesis, that there is a positive effect of firm size on innovative activity.

Through studies of innovation in industrial organisations we learn that roughly two-thirds of innovations are of the product improvement type while one-third is of the process innovation type (cost reducing or productivity enhancing).

Another issue of firm level innovation drive more recently is the focus of products and services for sustainable economic growth.

2. Competition, Market Structure and Innovation

A long-standing question in the economics of technological change has been the nature of the relationships between market structure, competition, innovation and growth (Gottinger, 2002, 2006, 2018).

The relationship between concentration of an industry and its rate of technological innovation is complex. Market structure may have an impact on the rate of innovation, but innovation is also an important factor that shapes market structure. In fact, it is necessary to recognise that the relationship between concentration and innovation is not a causal one: both are the endogenous outcomes of the operation of market forces and exogenous factors such as the nature of demand, technological opportunity, the conditions governing use, and some chance.

The classical point of departure in the economic analysis of the relationship between static market structure (i.e. concentration) and innovation is the seminal work by Arrow (1962). Arrow considers the case where a cost-reducing innovation is exogenously available and investigates firms' willingness to pay for the innovation under different market structures. For a drastic innovation, Arrow's analysis shows that a firm that is already a monopolist would have lower incentives to innovate than a firm that is currently in a perfectly competitive environment, essentially because it would have the lower profit incentive. On the other hand, innovation is certainly an important factor that affects market structure: innovation is a means by which a firm tries to escape the constraints imposed by competition. Innovation may truly not happen depending on whether an "escapism effect" dominates according to which a firm innovates, i.e., to escape a leveling of rents due to intense competition, or comversely, that tough competition discourages innovation reducing the expected rents from innovation or a "rent dissipation effect" (Aghion & Griffith, 2005).

Studies in the Schumpeterian tradition have emphasized the importance of ex-post market power for firms' incentives to innovate. Some degree of market power is necessary for a firm to cover its R & D outlays: dynamic and static efficiency are somehow conflicting. These are themes elonging to the microfoundations of growth that have been well developed in the recent literature on endogenous economic growth (Scherer, 1992; Scherer, 1999, Gottinger, 2016).

The industrial organisation literature has studied the relationship between concentration and innovation in firms' rivalry positions. If there are exogenous entry barriers, an increase in the number of firms causes each firm to spend less on R & D in equilibrium, however total R & D expenditure increases with the number of firms. When entry is considered to be endogenous, one would observe more innovation in those industries that are characterised by a higher degree of monopoly power, although no causality should be imputed to this relationship.

Some models consider the relationship between product market structure (i.e. concentration) and innovation. In the context of models where firms race to innovate another interesting question concerns the relationship between the number of firms that are part of the race and the pace of technological advance.

These are racing models of innovation where R & D expenditures are committed upfront (that is, the probability of success depends on the scale of the R & D activity) and show that increasing the number of firms reduces the expected date of invention.

One class of models considers a setting where firms can vary the research intensity but does not assume that the rate of expenditure is constant over time. Instead, firms may adjust R & D intensity in response to elapsed time and rival progress. Then in this setting, when imitation is not possible, an increase in the number of firms increases the equilibrium rate of investment for each firm and decreases the expected time of innovation. When there is no full patent protection, the relationship is ambiguous and depends on the relative payoffs to the innovator and the imitators.

2.1. Dominance

In many advanced industries characterised by long-term market dynamics competition may take the form of competition "for the market" rather than competition "in the market". In these markets the issue is not whether more or less concentration is associated with faster technological progress but whether market dynamics would be characterised by persistent dominance of the incumbent leader or by action-reaction whereby incumbents are overtaken by some rivals whose incumbency is itself of short duration. The dynamic evolution of market structure depends on both abilities and incentives of the incumbent and the rivals to innovate. Game theoretical models in industrial organisation are well suited to analyse the incentives underlying R & D investments and the resulting evolution of market structure. If we focus on economic incentives, and set aside differences in R & D abilities, persistence of monopoly or action-reaction can be related to the different profit incentive and competitive threat faced by the leader and the follower(s).

The profit of a successful incumbent who innovates is that of a monopolist firm, whereas if it were the entrant to innovate each firm would get the profit of a duopolist. Hence, the competitive threat of the incumbent can be measured as the difference between the profit of a monopolist firm and the profit of a duopolist firm. The incumbent's competitive threat, instead, is simply equal to the profit of a duopolist. This implies that the incumbent would have more incentives to innovate (i.e. the larger competitive threat) if, as it is normally the case, the profit of a monopolist is greater than the combined profits of two duopolists.

For minor innovations, the industry leader will typically be the innovator, whether or not imitation and licensing are feasible. For markets where patent protection is strong, it is likely that the major innovations will be made by industry leaders. But if imitation is easy, industry followers or entrants will make the major discoveries. Racing models show that when the first innovator captures a sufficiently high share of the post innovation market, then the incumbent firm invests less on a given project than does the potential entrant. This is because the incumbent has less incentive than the challenger to shorten the period of its incumbency.

Market dynamics have also been investigated in models that consider a sequence of innovations. They consider a sequence of drastic innovations and show that market dynamics are characterised by a process that resembles Schumpeter's process of "creative destruction": the incumbent invests less than each challenger in each stage. In comparing market dynamics under Bertrand and Cournot competition one finds that when the product market is very competitive then there is increasing dominance, but when it is not very competitive there is action-reaction. When innovation is drastic, then market dynamics are characterised by increasing dominance. The differences in the results obtained in industry models can be ascribed to the different roles that the profit incentive and the competitive threat play in innovation racing on rivalry. In a deterministic model the incentive to pre-empt (larger for the incumbent) dominates the firms' decision. When success is stochastic, however, the threat from the rival innovating is less acute. In the case of drastic innovations, the competitive threat is the same for both firms and it is the profit incentive (which is larger for challengers), next to diverse non-monetary incentives, that determines the level of R

& D investments. The relevance of the profit incentive extends to the case for some non-drastic innovation. Also even for large private enterprises the availability of venture capital, externally or internally, could provide an added incentive for facilitating continuous innovation (Lerner, 2012).

2.2. Competition Intensity and Innovation

Market structure is often associated with the concept of competitiveness: usually, a high level of concentration in an industry is interpreted as weak competition. This view is based on a symmetric Cournot model, where price-cost margins are higher as the number of firms increases. However, it is preferable to disentangle the notions of market structure and toughness of price competition as, among others, in Sutton (2001).

In a simple world with homogeneous firms, toughness of price competition can be considered as being related to the level of price-cost margins given any level of concentration. Hence, a differentiated Bertrand market would be considered to be more competitive than a differentiated Cournot market because price-cost margins would be lower in the former, for any level of concentration. As a result, more competitive markets may allow fewer firms to profitably survive.

When intensity of competition is low it is the follower that would be the next innovator, whereas when intensity of competition is large, it is the current technological leader that is likely to innovate. When it is the follower that innovates, tougher competition implies lower profits and hence lower incentives to innovate. However, when it is the current leader to innovate, an increase of toughness of price competition would further increase the profits related to his technological leadership and hence would increase the value of innovation for the firm. Hence, the relationship between toughness of price competition and innovation would be inversely-shaped (Aghion & Griffith, 2005).

3. Firm and Market Behaviour

In a competitive environment of industrial economics between leader and follower, or incumbent and entrant, we observe two contradistinctional behavioural rules. The incumbent's behaviour is influenced by what the literature identifies as the "replacement effect" (Tirole, 1988: Chap. 10). The conventional replacement effect says that in an effort to maximise the discounted value of its existing profit stream an incumbent monopolist invests less in R & D than an entrant, and thus expects to be replaced by the entrant (for example, when the innovation is drastic enough that the firm with the older technology would not find it profitable to compete with the newer technology). This replacement effect could cause the incumbent to be replaced only temporarily, subsequently she regains a dominant position in the market since she has a superior version of the new technology. The analog event may happen on the macro scale, eventually somewhat more slowly, when one country passes another in innovation induced growth performance. This would be a natural thing consistent with convergence hypotheses in neoclassical growth models (Barro & Sala-i-Martin, 1995: Chaps. 1, 8). On the other hand, in the micro industrial economics literature it has been shown that the monopoly term is increasingly important to a firm as it gets ahead of its rival, and that the duopoly term is increasingly important to a firm that falls behind.

One question of interest is whether chance leads to a greater likelihood of increasing the lead, or in more catch-up behaviour. The seminal work (Grossman & Shapiro, 1987; Harris & Vickers, 1987) have suggested that a firm that surges ahead of its rival increases its investment in R & D and speeds up while a lagging firm reduces its investment and slows down. Call this the Grove paradigm, after Intel CEO Andy Grove (1996). On a macro scale an Intel economy would be the prototype of an R & D driven endogeneous growth model when both industry leaders and follower firms invest in R & D in each industry (Segerstrom, 2005). This behavioural pattern would suggest that the lead continues to increase, and there will be divergence.

On a macro scale this racing paradigm would suggest that a large economy would mobilise all its technology/science/entrepreneurial resources to increase or keep its distance to other emerging economies. With science/technology being an evolutionary cumulative enterprise, for a dominating country with a portfolio of major increasing returns industries, the odds of leapfrogging oneself are higher than being leapfrogged by close followers, thus this asymmetry could play a distinctive role. Abramovitz' (1986) advantage of backwardness may hold on up to a certain limit but with decreasing returns.

In an interesting study, under some seemingly reasonable assumptions on linear technology investment and dynamic equilibrium path of capital accumulation in a neoclassical type development model Lau and Wan (1993), also Wan (2004), obtain the following results which they argue are fully consistent with empirical growth economics: These are:

"(a) Not all economies converge in growth with each other. (b) Economies with an initial technical capability will converge in growth with the advanced economies. The difference in per capita output grows exponentially, if the developing economy engages only in imitation (and not innovation). (c) With an initial technical capability there is a 'high growth' period, preceded (followed) by a phase of 'trend acceleration' ("trend deceleration"). (d) With an initial technical capability the technology gap widens forever."

The previous analysis indicates that the possibilities opened through competitive industrial racing are far richer and more surprising than they would emerge from the macro-scale models.

4. Network Economy

The Network Economy is formed through an ever-emerging and interacting set of increasing returns industries; it is about high-intensity, technology driven-racing, dynamic entrepreneurship, and focussed risk-taking through (open) venture capital markets endogenised by societal and institutional support. As we observe a significant shift toward movements in this direction, many large industrial areas will see the full benefits of the Network Economy within a Global Economy.

Racing behaviour on technological positions among firms in high-technology industries, as exemplified by the globally operating telcom industries, produce spillover benefits in terms of increasing returns and widespread productivity gains. Due to relentless competition among technological leaders the network effects result in significant advantages in the value added to this industry contributing to faster growth of GDP, and through a flexible labour market, also to employment growth. This constitutes a new paradigm in economic thinking through network economies and is a major gauge to compare the wealth-creating power of the US economy over the past against European and advanced Asian economies. It is interesting to speculate on the implications of the way companies in major high-technology markets, such as telcoms, split clearly into the two major technology races, with one group of firms clearly lagging the other.

The trajectories of technological evolution certainly seem to suggest that firms from one frontier cannot simply jump to another trajectory. Witness, in this regard, the gradual process necessary for a firm in the catch-up race to approach those in the frontier race. There appears to be a frontier "lock-in" in that once a company is part of a race, the group of rivals within that same race are the ones whose actions influence that company's strategy the most. Advancing technological capability is a cumulative process. The ability to advance to a given level of technical capability appears to be a function of existing technical capability.Given this path dependence, the question remains: why do some firms apparently choose a path of technological evolution that is less rapid than others? Two sets of possible explanations could be derived from our case analysis, which need not be mutually exclusive. The first explanation lingers primarily on the expensive nature of R & D in industries like telcoms which rely on novel discovery for their advancement. Firms choosing the catch-up race will gain access to a particular technical level later than those choosing the frontier, but will do so at a lower cost.

5. Technological Frontiers, Markets and Metrics

The evolution of a cross section of high technology industries as drivers of "entrepreneurial/managerial capitalism" (Chandler, 1990) reflects repetitive strategic interactions between companies in a continuous quest to dominate the industry or at least to improve its competitive position through company and industry level technological evolution. We can observe several racing patterns across industries, each of which is the result of a subset of firms jockeying for a position either as a race leader or for a position near the leader constituting a leadership club. The identification and interpretation of the races relies on the fact that different firms take very different technological paths to target a superior performance level with the reward of increasing market shares, maintaining higher productivity and profitability. In a Schumpeterian framework such races cannot be interpreted in a free-riding situation where one firm expands resources in advancing the state of technology and the others follow closely behind. Such spillover interpretations are suspect when products are in the domain of high complexity, of high risk in succeeding, and different firms typically adopt different procedural and architectural approaches.

The logic underlying this evolution holds in any industry in which two broad sets of conditions are satisfied. First, it pays for a firm to have a technological lead over its rival; it also boosts its market image and enhances its reputational capital. Second, for various levels of technological complexity among the products introduced by various firms, technological complexity can be represented by a multi-criteria performance measure, that is, by a vector-valued distance measure. The collection of performance indicators, parameters, being connected with each other for individual companies form an envelope that shapes a "technological frontier". The technological frontier is in fact a reasonable indicator of the evolving state of knowledge (technical expertise) in the industry. At any point in time the industry technology frontier (ITF) indicates the degree of technical sophistication of the most advanced products carried by companies in that industry in view of comparable performance standards. Firm level technology frontiers (FTF) are constructed analogously and indicate, at any point in time, the extent of technical sophistication achieved by the firm until that point in time. The evolution of company and industry level frontiers is highly interactive. Groups of company frontiers are seen to co-evolve in a manner that suggests that the respective firms are racing to catch up with, and get ahead of each other.

We suggest a selective investigation in a given set of products (systems) by major European, American and Asian enterprises in those industries for a sufficiently representative period of market evolution. In principle, we can identify at least two races in progress: frontier race in each of those industries, the other, for example, the European frontier race which technically would constitute a subfrontier to the worldwide race. The aggregate technology frontier of the firms in a particular race (that is, ITF) is constructed in a manner similar to the individual FTFs. Essentially, the maximal envelope of the FTFs in a particular race constitutes the ITF for that race. The ITF indicates, as a function of calendar time, the best achievable performance by any firm in the race at a given date for laggards and imitators.

Technological frontiers at the firm and industry race levels offer a powerful tool through which to view evolving technologies within an industry. By providing benchmarking roadmaps that show where an individual firm is relative to other firms in the industry, they highlight the importance of strategic interactions in the firm's technology decisions.

Let TF(C) be each racing company's technological knowledge frontier (its firm technology frontier or FTF) while TF(I) would be the respective industry's frontier (the industry technology frontier or ITF) represented by the most advanced companies as a benchmark. All firms engage in pushing their frontier forward which determines the extent to which movements in the individual TF(C) of the racing firms translate into movements of the TF(I). While a variety of situations may emerge, the extremal cases involve: either one firm may push the frontier at all times, with the others following closely behind or all firms share more or less equally in the task of advancing the TF(I). The first situation corresponds to the existence of a unique technological leader for a particular race, and a number of quick followers. The other situation corresponds to the existence of multiple technological leaders. In some industries firms share the task for pushing the frontier forward more equally than in other industries. This is usually the case the more highly paced and dynamic the race is in an industry.

In any race, "closeness" is an important but relative attribute. The races are more or less close by construction; however, some might be closer than others. As a closeness measure (metric) of a race at any particular time we may define:

$$\mathrm{C}(t) = \sum_0^N \left[\mathrm{TF}(\mathrm{C}_i) - \mathrm{TF}(\mathrm{I})\right]^2 \Big/ N(t) \quad (1)$$

where $N(t)$ is the number of active firms in that industry at time t. The measure thus constructed has a lowest value of 0 which corresponds to a "perfectly close" race. Higher positive values in the unit interval correspond to races that are less close.

Unlike other characteristics such as the domination period length during a race, innovation when ahead versus when behind, and leapfrogging versus frontier-sticking which describe the behaviour of a particular feature of the race and of a particular firm in relation to the frontier, the closeness measure is more of an aggregate statistic of how close the various racing parties are at a point in time. The closeness measure is simply an indication of the distance to approach a benchmark; it does not say anything about the evolution of the technological frontier. To see this, note that if none of the frontiers were evolving, the closeness measure would be 0, as it would be if all the frontiers were advancing in perfect lock-step with one another.

From the point of view of technology or innovation races between countries we look at clusters of advanced and developing economies with diverse value generating industries who's ITFs remain close enough through a given lengthy period. We could then identify at least two different kinds of races for a given time duration. One comprises the world frontier race in each of these industries, the other a subfrontier race (say, North America, Europe, South/East Asia) which technically would constitute a subfrontier to the world, also allowing in extreme cases for the subfrontier to be very close or identical to the frontier.

The technology frontiers of the firms in any race (that is generating the ITF) is constucted in a manner similar to the individual FTFs. Essentially, the maximal envelope of the FTFs in a particular race form the ITF for that race. So the ITF indicates, as a function of calendar time, the best achievable performance by any firm in that race. This begs the question how to assign industry value to multi-national companies in particular industries. They would be assigned to any national/regional industry where they have their headquarters and where most of their major R & D activities take place.

A statistical profiling of technological evolution and innovation relates to competitive racing among rival companies. Among the (non-exclusive) performance criteria to be assessed are 1) frequency of frontier pushing, 2) technological domination period, 3) innovations vs. imitations in the race, 4) innovation frequency when behind or ahead, 5) nature of jumps, leapfrogging or frontier-sticking, 6) inter-jump times and jump sizes, 7) race closeness measures, 8) inter-frontier distance, 9) market leading through "market making" innovations and 10) leadership in "innovation markets". These performance indicators could characterise the microfoundations of economic growth.

A race may or may not have different firms in the leadership position at different times. It may be a tighter race at some times than at others, and in general, may exhibit a variety of forms of interesting behaviour. While analysis of racing behaviour is left to various interpretations, it is appropriate to ask why the firms are motivated to keep on racing at all. As access to superior technology expands the scope of opportunities available to the firms, the technology can be applied in a range of markets. However, leading edge technology is acquired at a cost. It seems unlikely that all the companies would find it profitable to compete to be at the leading edge all the time. Also not every firm has access to equal capabilities in leveraging a given level of technological resources. Firms may, for example, be expected to differ in their access to complementary assets that allow them to appropriately reap the benefits from their innovation. It is reasonable to assume that whatever the level of competence of a company in exploiting its resources it will be better off the more advanced the technology. Based on this procedure an analysis will show how dynamic competition evolved in the past.

Unlike other (statistical) indicators (such as patent statistics) referring to the degree of competitiveness among industries, regions and countries concerned, the proposed measures cover behavioral dynamic movements in respective industries, and therefore are able to lend intrinsic predictive value to crucial economic variables relating to economic growth and wealth creation. The results are likely to provide strategic support for industrial and technology policy in a regional or national context and will enable policy makers to identify strengths and weaknesses of relevant players and their environments in those markets. While this process looks like a micro representation of dynamic technological evolution driving companies and industries into leadership positions, we may construe an analogous process that drives a region or a nation into advancement on a macro scale in order to achieve a higher level pecking order among its peers. This may allow using the micro foundations of racing as a basis for identifying clubs of nations or regions among them to achieve higher levels and rates of growth.

6. Increasing Returns Mechanism

An increasing returns economy (IRE) is a natural extension of a network economy induced by technological changes applied to newly emerging industries. Though not making explicit recourse to the network economy more recent work on IRE shows the extension of economies of scale, marginal cost pricing and efficiency to the main body of economic theory (Quinzii, 1992).

Most built-up sectors of highly industrialised economies are not perfectly competitive. They are usually formed by a small number of big firms with non-negligible market share; besides being prevalent in the economy, big firms cluster around concentrated industrial structures which exhibit a skewed distribution of firm size and market share (Gottinger, 2003, 2006). This situation may be brought about by the intrinsic potential of dynamic technological competition to end up in (temporary) technological monopoly, so in those cases industrial competition may start out symmetric but end up asymmetric. The competitive process proliferates in increasing returns industries (IRIs) where the total of all unit activities linked together yield a higher return than the sum of the individual unit activities operating separately. For this to happen it is necessary to show that a variety of increasing returns mechanisms, sometimes facilitated through open source technologies to combine and enable the effect of an escalating income industry (Foray, 2006; Gottinger, 2017a).

We consider an integrated framework to provide tools and insights for explaining competition among skewed industrial structures. However, it is only a tentative step toward attempting to explain the path-dependent, indeterminate, suboptimal, locking-in nature of technological competition under increasing returns. Due to this we need to cover the literature on the dynamics of technological fusion, substitution, and competition. The purpose is to show that a person cannot accurately understand industrial competition without taking into account the self-reinforcing nature of commercial success in most emerging markets. The increasing returns mechanism is enriched by incorporating a set of stronger, yet neglected increasing returns mechanisms, reputation effects, infrastructure effects and positive network externalities, into a preliminary framework model. The resulting theoretical structure captures the interdependent and cumulative character of three aspects of industrial competition: the number and size of firms, skewed industrial structures, and the nature of technological competition.

The increasing returns discussion in economics through its historical roots (J.S. Mill, A. Marshall in the nineteenth century) has provided important insights into the characteristics and dynamics of modern industrial economies. However, the discussion on policy applications had some misleading features in the past to conclude that a completely *new economy* is emerging and that it obeys a set of rules, which are totally different from those that apply to traditional sectors of the economy. While it is undeniable that the increasing returns paradigm remains fairly new and revolutionary and while there is no doubt that this paradigm is key to our understanding of new industrial sectors, and their sustaining role in productivity growth, we must clarify its proper role in industrial structure and growth of the economy.

At this stage we are most concerned about the catalytic role of technological competition in increasing returns industries. IRIs are nowadays most likely to be identified with high technology industries, in particular with information, communication and health care related industries. It is further enhanced by (foreign) trade related industries. As an example, in a corporate context, how to unlock increasing returns in its global operations; consider a typical firm (such as German Siemens AG and previously U.S. General Electric (GE)). It seeks to redefine the market more broadly to include adjacent products or services; this continual questing lies behind successful moves from manufacturing to services that has allowed it to keep growing in complementing given industrial markets. This even remains true, as nowadays, in financial distress situations where complementing growth activities could accelerate a downward cycle. In growth processes we observe the quest for market dominance, expansion through mergers and acquisitions, diversification and integration, investment constraints and "barriers to entry": all of those traits fostering or hindering the growth of firms which also prevail in the competitiveness between nations (Penrose, 1995).

For those industries Shapiro and Varian (1999) have suggested a combination of supply-side scale economies and demand-side scale economies to explain the intrinsic aspects of technological competition. It appears however that this way of seeing technological competition is too simple to capture the variety and complexity of real-world businesses. Thus we suggest a general framework to describe technological competition in the *increasing returns economy.*

7. Network Platforms

Network platforms are a major ingredient of network economies, in fact, they are one of their distinctive features. They provide a wide-ranging applicability and use in multi-sided businesses from financial services (credit cards), healthcare to video games. In particular, they have an increasingly important proliferation in media industries or social networks. Companies such as Google, Ebay or Amazon or Alibaba could not operate as such, or much less efficiently, if it were not for software platforms. The financial service industry (fintech) used software platforms to leverage (subprime) loans and commercial papers with world-wide exposure – allowing multi-sided business (buyers/sellers). From a consumer's viewpoint software platforms are the virtual reality (VR) equivalent of physical shopping malls. YouTube, Facebook, Twitter are social platforms while digital business evolves through market-place platforms like Amazon and eBay. In terms of product provision, platforms vs. pipelines function through 'plug and play'. They benefit from superior marginal economics of scaling supply plus various network effects. As in the Internet of Things (IoTs) use various data platforms, technical platform designs are essential features for optimizing IoT generated industrial systems. The much heralded blockchain revolution would be a platform on a trusted network. From an aggregate or macro perspective platform economics helps to organize an emerging "sharing economy" which could become the constitutional part of a network economy (Gottinger, 2017b).

The network platform business utilizes direct or indirect network effects to attract customers and facilitate network economies. How to switch from a "pipeline model" (product line model) to a "platform model"? Some business and social network platforms (eBay, Facebook) have been able to harness network effects to fuel truly continuous growth. On the other hand, platform businesses, even without fixed costs or economies of scale, need to acquire critical mass when they are launched even to survive (Evans & Schmalensee, 2010), and we may observe "tipping point" effects or failure of "critical mass" generated through "chicken and egg" problems in platform building processes. They show that in the case of direct network effects the basic problem is that the level of participation on the platform affects the quality of the products offered to participants, and if the quality is too low, participation falls, which might reduce quality further, to a downward spiraling effect. In the case of indirect network effects participation by each customer group affects the quality of the product experienced by the other group and the dynamics may set off a similar upward or downward spiral.

What is the rationale to design Internet platforms? A platform typically provides a set of capabilities through built-in application interfaces (APIs), modules, tools, etc., which make it easier for developers to innovate new applications and services of interest/value to consumers. This, however, comes at a cost to the platform, and this cost grows with the number of features offered. The question for the platform provider is then to determine the number of features that make profits. The issue is here how to activate positive direct, indirect and cross-externalities such as "bandwagon effects" on platform building (Parker & van Alstyne, 2016). With platform design capabilities limited applications tend to be more complex, therefore, limit the number of application developed for the platform. This makes the platform less attractive to consumers and lowers revenues. On the other hand, a scalable and diversifiable platform is expensive to build, but the cost may be offset by facilitating the development of more applications, therefore attracting more consumers.

This trade-off arises in many environments and properly assessing it can have far-reaching consequences for sustainable business success or failure. For example, many attribute the Internet initial success to its simple and transparent design principles. However, as it matures and transforms from a "physical" network platform to a broader ecosystem of software and web services, the question is how new scalable features can be successfully integrated (Choudary, 2015).

From an architectural perspective, the creation of the worldwide web as a network hub turned into an interactive system as a two-sided market place facilitates the transformation of the Internet from a physical network to an ecosystem of software. The network is the platform and seeks to "connect" users to services. The present day Internet offers examples of network and operating system platforms whose success largely comes from their ability to connect users and service/application developers.

Services are offered by developers and asked for by consumers that rely on the platform and its features. A feature-rich platform facilitates service development, which yields more services. This in turn attracts more users and benefits the platform (Evans, Schmalensee, & Hagiu, 2006).

A platform provider attracts developers and consumers by creating value that entices them to join the platform. This "value" depends on a number of factors, such as the subscription fees to join it, the cost of developing applications for it, and externalities that affect the value that either developers or customers derive from joining the platform.

In a two-sided market, both sides of the market derive cross-externality benefits from the presence of the other, i.e., consumers benefit from more applications offered by developers, and conversely developers benefit from being able to target their applications to more consumers.

This fits many software products and services, where platform and applications share a common technology.

In general, the construction proceeds on a model's applicability to platforms that are software ecosystems, e.g., cloud computing, web services, operation systems, etc. In the order of real applications we observe PC platforms, video game platforms, personal digital assistant (PDA) platforms, smartphone (mobile) platforms and digital media platforms.

In principle, such a network platform design would proceed and could be solved using a sequential decision process for the platform to select the level of functionality to offer. Thus we consider platform launch as a decision process rather than an event only as it was considered in the emerging literature (Gottinger, 2017b).

In a first stage, the platform provider chooses the number of features to build into the platform. Given this choice for a number of features, participation prices (fees) for the two market sides are chosen in a second stage. Compatible capacity levels of consumers and developers are simultaneously realized in a third stage. This sequential decision process is then solved in the reverse order, like a dynamic programming (DP) framework. Capacity levels for users and developers are first computed for a given choice of participation prices and number of built-in features. Next, given a choice for the number of built-in features, "optimal" participation prices are computed based on the scale levels of the previous step. The results characterise the platform's profit for any given number of built-in features. This is then used to find the "optimal" number of features that maximise the platform's profit.

8. Conclusion

Our framework attempts to address the interrelatedness of innovation, competition with industrial and economic growth under the umbrella of network economics. The basic economic principles, tools remain intact but a digital economy is only a modern economy driven by large scale technology innovations in its operations, realisations and outcomes. And it is necessarily a network economy idealised in its architecture by the Internet Economy (Gottinger, 2017b).

Some organisation models, in the review of studies of network industries, suggest that competitive interaction in innovative activities may take different forms according to the structure of payoffs of innovative activities to "winner" and "losers". In the first case, competition in innovation may be the essential, or at the limit of the only dimension of the competitive process, i.e., the winner-takes-all (WTA) markets. Persistence of monopoly may be observed in a WTA market, but provided that competition in innovation is effective, this does not necessarily imply that competitive forces are muted. On the other hand, in these markets, competition in innovation is the area where the current dominant firm may be more likely to abuse its dominance (since, by definition, such markets are not conducive to product market competition). These considerations suggest that it is useful to distinguish between different economic environments, according to the relative importance of competition in innovation and competition at the product market level that can be expected in the market. The literature on network industries is particularly useful in explaining why a market may exhibit WTA properties.

By focusing on competition in defined product markets, be these current or future, analysis may miss the effect of competition in innovation. In some instances, this will not hinder successful examination of competition case, either because competition in innovation is subordinate to competition in the product market, or because analysis of the effects on competition in the product market may act as a "proxy" for analysis of the effects on competition in innovation. However, where innovation is clearly an important part of the competitive process, the effect of a merger or anticompetitive conduct on competition in innovation may be significantly different for its effect on competition on the product market. For example, if a market seems to exhibit WTA properties, such that it can only sustain one firm at a point in time, an abuse of dominance may need to explicitly consider whether conduct by the dominant firm affects competition in innovation rather than product market competition. As such, competition in innovation may need to be considered in its own right investigation.

The structural core of this investigation focuses on the dynamic economics of technological races in key network industries among major competitive areas North America, European Union, East Asia (PRC, Japan, ROK). It helps to identify technological frontiers and to classify intensity of competition and level of competitiveness among those high-tech industries with a dominant ingredient of general purpose technologies (GPTs), that is, digital content in products, processes and operations.

9. Focus: Comparative Economic Research

We outline here a few skeleton steps toward ranking global industries in industrial economic context.

1) First identify three major industries product or service centered in which technological racing takes place in core EU economies and compare them with likewise technological firms in North America, China/Japan/Korea.

2) Look into the most notable value-added internationally exposed industries on high innovation levels, among them computer/communications, advanced manufacturing, machine tools, biotechnology & pharmaceuticals which are prone to increasing returns mechanisms.

3) Show how dynamic innovation into digitalisation and applied artificial intelligence (AAI) leads to expanded replacement of pipeline by platform companies and their evolutionary impact on industrial and endogeneous growth (Lee, 2018).

In experimental statistical design an innovation index as a dependent variable in the regression could be taken as R & D intensity, i.e. the ratio of R & D to revenues or sales. The explanatory variables could be qualitative therefore discrete in regression equations (Maddala, 2002).

For the econometric design the task setup is threefold:

i) estimating the effects of the composition of an industry's or firm's innovation (R & D) expenditures on its rate of productivity increase (when its total real R & D expenditures are held constant),

ii) explore the relationship between the composition of a firm's R & D expenditures and its innovative output, as measured by the number of major innovations introduced,

iii) determine what factors are associated with the composition of a firm's R & D expenditures with particular attention being directed at firm size and industrial concentration.

The prescription and description of industrial racing patterns can be viewed as identifying objectives for performance evaluation of firms, industries, regions and national economies.

a) A key objective is to explore and explain which type of racing behaviour is prevalent in global high technology industries as exemplified by information technology industries (semiconductors, computers, telecommunications). The pattern evolving from such behaviour would be benchmarked against the frontier racing type of the global technological leaders.

b) Another objective is to draw policy inferences on market structure, entrepreneurship, innovation activity, industrial policy and regulatory frameworks in promoting and hindering industry frontier races in a global industrial context.

c) Given the statistical profile of technological evolution and innovation for respective global industries, how does it relate to competitive racing and rivalry among the leading firms? Among the performance criteria to be assessed are frequency of frontier pushing, technological domination period, innovations vs. imitations in the race innovation frequency when behind or ahead, nature of jumps, leapfrogging or frontier sticking, inter-jump times, jump sizes and race closeness measures.

d) An empirical proliferation of racing in these global industries need to be explored, comprising of datasets identifying relationships between technological positions (ranks) of firms in successive years (10 - 25 yrs. period).

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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