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Appendix A: Detailed Overview of Innovation and Competition Policies

While decisions with regard to regulations and especially policy can severely impact the economic growth, the ratio of what is known to unknown with respect to the relationship among competition, innovation, and policy is low. This section aims to provide an in-depth discussion on whether the best form of competition policy is a strong innovation policy.

9.1 Introduction

Wrong policies and the anti-competitive behavior of companies can influence the effectiveness of competition even though the markets work fair most of the time. Being one of the essential forces affecting markets, competition refers to the rivalry among companies that aim to acquire sales and earn profits (Buccirossi et al., 2013).

Although different definitions might exist for competition policy, the following definition for competition policy as defined by Buccirossi et al. (2013) will be used throughout this section: a collectivity of restrictions and requirements that constitute the essential rules of competition (or antitrust) law along with the existing set of tools of competition authorities for controlling and punishing any violation of the same rules.

9.2 Taxonomies of Innovations

There can be different determining factors for different kinds of innovations. For example, the determinants for organizational process innovations might differ from technological or product innovations. So, in order to specify these determinants, it might be useful to conduct a disaggregation based on a micro- and a meso-level of analysis of different types of innovations and establish different taxonomies for them.

As the category of innovation can be complex, it is important to understand *what* is produced by firms and *how*. As stated below, innovation can entail both process and product innovations:

- In terms of *what* is produced, product innovations can take the form of goods or services.
- In terms of *how* goods and services are produced, process innovations can be organizational or technological. Although product and process innovations may be closely interrelated, it is still crucial to make a distinction among these categories. There can be transformations among these two categories as well. To give a specific example, products that have been bought for the purpose of investment rather than immediate consumption belong to this category. While a piece of industrial equipment such as a construction machine counts as a product when it is produced it becomes a process during its use in the production process.

Table A9.1 provides a more detailed taxonomy based on these two general categories (Scott, 1980).

Table A9.1 Modes of innovation and possible policy responses based on type of market failure (Scott, 1980)

Main Mode of Innovation	Main Sources of Market Failure	Typical Sectors	Policy Instrument
Development of inputs for using industries	Financial market transactions costs facing SMEs; risk associated with standards for new technology	Software, equipment, instruments	Support for venture capital markets; bridging institutions to facilitate standards adoption
Application of inputs developed in supplying industries	Small firm size, large external benefits; limited appropriability	Agriculture, light industry	Low-tech bridging institutions (extension services)
Development of complex systems	High cost, risk (particularly for infrastructure technology)	Aerospace, electrical technology, semi-conductors	R&D cooperation. subsidies; bridging institutions to facilitate development of infrastructure technology
Applications of high-science content technology	Public nature of knowledge base	Biotechnology, chemistry, materials science, pharmaceuticals	High-tech bridging institutions

Still, some other complementary taxonomies have been used by several other scholars such as indicated by Edquist and Riddell (2000):

(1) Small ongoing incremental changes,
(2) Discontinuous extreme and major changes,
(3) Massive changes in some ubiquitous technology designed for general purpose (GPT), also referred to as "techno-economic paradigms." (Edquist and Riddell, 2000).

Although product innovations are the major driver underpinning the structure of production process innovations should also be taken into account as they are crucial for the competitiveness of firms regardless of their country or sector.

9.3 Literature Review

This section provides the theoretical background with regard to both competition and innovation policies before putting forth the theoretical results.

9.3.1 Theories Underpinning Competition Policy

From Adam Smith onward, most economists established a consensus on the workings of competition for the general interest, yet no such agreement exists with regard to the social benefit of competition policy. Some scholars, starting with the Austrian School (e.g., Von Mises, 1940), assert that any government intervention including competition policy which interferes with free markets will be for the disadvantage of the society.

Economists such as Crandall and Winston (2003) assert that the inefficiency of the antitrust law in the United States is caused by both the difficulty of making a distinction between genuine, healthy competition and anti-competitive behaviors and the underestimated market power to restrain anti-competitive abuses. They see the application of anti-trust law necessary for only blatant price-fixing and mergers to monopoly.

In disagreement with this point of view, Baker (2003) and Werden (1998) claim that competition policy has a positive net effect on social welfare. According to these scholars, social welfare is enhanced by competition policy by causing companies to give up anti-competitive conduct without any competition authority's intervention. With regard to this ongoing debate, Whinston (2006) stated that there is a gap in empirical evidence in terms of the effects of the practices prohibited by antitrust law (e.g., competitors

communication on prices) and of active enforcement of antitrust law on social welfare.

The existing body of literature referred to a positive relationship among competition and productivity. By analyzing firm-level data, Aghion et al. (1997, 2001) show that productivity is spurred by product market competition. Furthermore, a theoretical framework has been provided by Aghion and Howitt (1992) to claim that productivity may be enhanced by competition-enhancing policies.

9.3.2 Theories Underpinning Innovation Policy

The analytical framework of private innovation in a market economy was specified by Schumpeter (1994), who held throughout different stages of his career two opposing ideas with regard to the interrelatedness of technological performance and market structure.

In the earlier stages of his career, Schumpeter (1994) asserted that technological advancement occurs within the research laboratories of large companies that possessed market power. Also referred to as a theory of technological contestability in modern terminology, this theory asserts that economic profits of such firms would be used to invest in large-scale and risky R&D activities that could also contribute to the society's well-being at the same time, and hence enable firms to dominate the product-market.

According to this second perspective, the level of technological progress will be greater if only a few large companies dominate the markets. Innovation investment could be undertaken better by such firms as they could take advantage of such large and perhaps diversified economies of scale, and, they would also be in a better position to apply the new technological developments in a commercially viable way. Furthermore, Schumpeter (1994) also asserted that risk is an inherent feature of commercialization and research and development; and market power provided an "insurance" against such risk.

While the debate in terms of the implications of these two positions is still ongoing, one of the recognized views was that from a social point of view, the rate of investment in R&D (research and development) is likely to be too low, regardless of the structure of the market being simple, a highly concentrated oligopoly, or in between.

In a similar vein, according to the existing body of literature of endogenous growth, technological progress is seen as a main driver of economic development. Although the accepted view that wants exceed means may hold true, the fair distribution of resources to enhancing society's means

can alleviate the problems along with the globalization, economic progress, and structural adjustment. One of the most effective ways with regard to the allocation of such resources would be to target the specific kinds of market failure that prevent innovation in various industries.

Within the context of modern economy, "innovation" entails not only the formal R&D happening in research laboratories, inputs (such as funding and engineering or scientific staff), and outputs (patents) that can be analyzed and reported to government authorities, but also incremental changes in product design and development processes that happen as a result of an amalgamation of tacit, uncodified knowledge within individual firms which cannot be conveyed to or appropriated by rivals without any costs (Reinganum, 1983).

Within this light of information, good reasons exist for policy makers to encourage private innovation, and various measures can be taken by them to do so. There will be differences in such measures based on their sector and policy design which does not consider these differences across industries in terms of the sources of market failure will not be very successful.

9.3.3 The Role of Competition Policy in the Innovation Process

Understanding where competition policy does interfere with the innovation process is crucial to discuss if the best form of competition policy is a strong innovation policy.

As most of basic research does not occur in the private sector, the role of competition policy in basic research is modest. Basic research undertaken by for-private companies, especially research conducted by a single firm, is in general not limited by competition policy. Constraints of the pure research activities due to competition policy might arise when two or more firms conduct joint research (D'aspremont et al, 2000). Competition authorities in general stated that they will not interfere with research done by research joint ventures (RJVs) and other forms of collaboration. To give a specific example, in the United States, legislation was passed expressly to ease antitrust limits on RJVs and there are virtually no examples of joint research activities that have been blocked because of antitrust regulations. In general, the concept that basic research entails aspects of a public good, and hence is very appropriate for RJVs, is a commonly accepted idea in antitrust circles (D'aspremont et al, 2000). Specifically, collaboration is accepted as the most relevant means to undertake so-called "pre-competitive" research, i.e., research that can effectively be used and shared by several industry

participants, so that firms can later compete by developing their own unique products (D'aspremont et al, 2000).

Competition policy does also not play a very active role in the invention process. Although in the United States, there is a mention of "innovation markets" in the Department of Justice (DOJ) Guidelines which is prepared by Federal Trade Commission (FTC) with regard to licensing of Intellectual Property ("IP Guidelines"), this type of analysis relates to traditional issues of potential competition.

Whether or not competition policy has an important influence on the *incentives* for private firms in order for them to incur the costs necessary to produce inventions is another question, yet these impacts occur due to the rules putting a limit onto the subsequent behavior and returns throughout the commercialization, diffusion, and extensions phases of the innovation process (D'aspremont et al, 2000).

9.3.4 Competition in the Market or for the Market?

Within the context of innovative industries, competition can be thought of as a number of races for the development of new technologies (D'aspremont et al, 2000). Once a leadership position is attained, victory is achieved in a single product market or more. Yet, this should not be interpreted as if the winner can then have a rest to enjoy the victory. In order to maintain leadership, another new race should be entered immediately (D'aspremont et al, 2000).

Due to the winner-takes-most or all outcomes and the technological opportunity, the competition form that matters most from a welfare perspective is the competition *for* the product market rather than the competition *in* a product market such as the case of advanced industries. An example for the prior one is a race for being the first deliverer of a new product to market or the first producer by use of a new technology. Contrary to advanced industries in which new entrants receive the market share on a gradual basis, the dominant incumbent is rapidly replaced as a result of successful entry in such innovative industries (D'aspremont et al, 2000).

Due to the substantial R&D cost in these sectors that are mostly not dependent on volumes of production, the total cost becomes less on average with output. Therefore, companies cannot continue to exist by offering an amount close to the marginal cost of production (D'aspremont et al, 2000).

Moreover, effects of both network and positive feedback should be taken into account in knowledge-based sectors. Network effects occur due to the increase in value attributed to a particular product by each user as the total

user number increases (D'aspremont et al, 2000). Positive feedback exists when goods complement each other and widened use of that particular product enhances the value of other products more (D'aspremont et al, 2000). To give a specific example, a larger user base for an installed operating system increases the value of a spreadsheet software running on that system. Similarly, due to the widened use of that software, the operating system's value also increases. Both of these positive feedback and network effects lead to increasing returns to scale on an inter-temporal basis (D'aspremont et al, 2000). Markets in which these effects are strong experience "tipping" (D'aspremont et al, 2000), in other words, as time passes a single product can dominate due to the fact that there might be an unstable existence of various incompatible products. As a result of tipping, a *de facto* standard will be adopted (D'aspremont et al, 2000).

Within the innovative industries, competition policy can affect welfare through the following channels (D'aspremont et al, 2000):

- The race's intensity to make an innovation.
- Competition within the context of the product market, with a high probability to influence variables such as price and service quality.
- Competition within the context of the licensing market.

Behavior which reduces competition in one field may increase it in another. As a consequence, competition policy is exposed to two interrelated yet conceptually different issues (D'aspremont et al, 2000):

i) How to evaluate the impacts on competition in each of the previously mentioned three fields;
ii) How to calibrate for the trade-off between opposite impacts of competition in different fields; specially, how to weigh both static and dynamic factors of competition.

Within the context of innovative industries, these characteristics of competition relate to the question of how one evaluates the success of competition policy. If the consideration is that competition policy be inclined toward the aspects of competition *in* the product market, then its success depends on whether dynamic efficiency is increased by the product market's competition at a more intense level (D'aspremont et al, 2000). So, if there are crucial races to reduce costs or to deliver new products to market, and if winners are expected to acquire most or all of the market share, then competition policy should be evaluated on the ground of whether it enhances the incentives to make an innovation (D'aspremont et al, 2000).

9.4 Theoretical Results

Throughout the literature, several factors such as market failure, limited appropriability, and external benefits to knowledge production imply that pure reliance on a market system will lead to an underinvestment in the field of innovation, in comparison to its socially desirable level, so a strong innovation policy may not always be the best form of competition policy. First, theoretical results are put forth and then both empirical and case-study evidence is provided before making recommendations on policy formulation.

9.4.1 Competition versus Monopoly

In order to analyze the issues raised by Schumpeter (1994), Arrow (1962) developed a simple framework to make a comparison between the monopolist and a single entity (operating in similar markets except for their supply structures) in terms of their profitability of a cost-saving innovation in R&D and production.

The uncertainty or imperfect appropriability of the profit produced by the successful innovation was not taken into account by Arrow (1962). Apart from crucial aspects of the R&D process, time and strategic interactions in R&D among rival suppliers were also left aside as only the extreme cases of a single entity (such as monopoly) and several small companies were considered. As a simple comparison between the monopolist and the individual rival company in terms of the benefit of a cost-saving innovation, the cost aspect of the R&D process or the financing of R&D was also not considered while keeping the demand side of the market the same in both cases.

Within the context of his model, Arrow (1962) asserted that the profit of the competitive firm from successful innovation would exceed the monopolist's profit. From the point of view of the monopolist, the incentive to make an innovation occurs due to the incremental financial gain from a production at lower unit cost instead of higher unit cost. Part of the financial gain made after innovation by the monopolist just replaces the financial gain made before innovation. According to Arrow's model, an entity in a perfect competitive sector will gain more from a successful innovation in comparison to an entity in an otherwise similar monopolized sector (Arrow, 1962).

9.4.2 Racing Models

Some models within the literature such as those developed by Lee and Wilde (1980) consider the development time as a random variable. A company can

decrease the *expected* discovery time by making more effort for R&D or increasing its R&D budget, but the actual time for discovery is dependent on luck.

The early stream of work in the racing literature considered the income occurring due to the successful innovation to be exogenous, and investigated how the expected discovery time might alter as the total amount of independent R&D projects gets bigger. Results depend on details of how the cost function of R&D was specified, yet in general it was argued that the expected discovery time decreases as the amount of entities conducting R&D projects increases.

Considering of R&D as a random process weakens the argument that it is inefficient for various companies to follow the same research goal (Nelson, 1961). As several R&D projects with the aim of developing a new product or process might pursue different strategies, it is not possible to know in advance which of these strategies will prove to be more successful. Due to the existence of several R&D projects with the same goal the probability of success of at least one project is increased. As the successful project cannot be known in advance, it will not be useful to make a retrospection after innovation and label the unsuccessful projects as being wasteful.

The later part of the literature with regard to racing (Gilbert and Newbery, 1982; Reinganum, 1983, 1984) investigates if a potential entrant or an incumbent company could make an innovation earlier, in the sense of an expected value. These frameworks provide a generalization of Arrow's model and they don't make any separation between R&D cooperation and the product-market cooperation.

The path-dependence literature suggests that there can be more preference for the next or later versions of an innovation, yet these may be precluded from successful implementation due to time constraints. This argument is against the very early emphasis on a specific line of development.

Although details of model development shape the specific results, the results suggest that in comparison to large incumbents, smaller companies and potential entrants are likely to invest more in innovation. This view is also in line with the innovation perspective of "creative destruction" rather than the perspective of product market innovation.

9.4.3 R&D Cooperation Policy

Local antitrust or competition policy, generally, favors competition as entities make their own independent decisions and follow their self-interest in

contrast to the international "competition" policies such as promotion of national champions.

According to this presumption, two assumptions underpinning R&D process are:

- Private investment in innovation on its own will not reach the socially desirable level.
- Adopting a permissive competition policy attitude toward R&D cooperation will enhance technological performance.

Viewed from a theoretical perspective, although R&D cooperation may enhance the performance of the market, this may not necessarily happen due to increased levels of innovative effort or output. On the contrary, although innovative effort may get reduced in such models, the market performance in general increases. Due to a joint R&D, various firms will be able to access the new products or technology in the post-innovation market. From a consumer perspective, this is good as greater product-market competition is ensured after discovery rather than a single company controlling the innovation. It is exactly this enhanced competition that decreases the incentive for a cooperative project to make an R&D invest investment. So, although there is a delay in innovation (in terms of an expected value), users are much better off after the discovery happens.

9.4.4 R&D Subsidies

Contrary to the R&D cooperation that deals with knowledge spillovers in a direct way, by enabling the coordination of R&D activities for companies that gain from spillovers, subsidies' way of dealing with spillovers is indirect: while spillovers decrease the marginal benefit of a successful innovation, subsidies can cause the marginal cost of innovation investment to be decreased, if well designed. As the basis for companies to make their decisions is their own profitability, the additional gain to users of additional R&D is not taken into consideration. The government can influence through the means of subsidies the companies' decisions in such a way that this external benefit to consumers requires. Yet, subsidies on their own might not be enough to eliminate underinvestment in R&D and the market failure (Scott, 1980).

The government can also influence through the means of subsidies the structure of R&D cooperation. Due to the existence of a subsidy, a cooperative R&D can also occur whereas companies, if left to their own devices, would prefer to conduct R&D independently. Subsidy may lead to a joint

venture, which is one of the crucial forces for growth and innovation in the early years within a particular industry.

9.4.5 Patents

Despite the general understanding that patents may lessen the incentives for companies' R&D investment, patents increase the probability for a product-market competition among patent-holders over other products or processes which can be substituted (Steinmueller, 1987). Obtaining a patent increases the incentives for the patent-holder to provide a license for the patent use in order to avoid cases of "inventing around" the patent. In this way, the diffusion of the patented innovation can also be facilitated (Steinmueller, 1987).

The patent's breadth and length are interrelated. Although patents decrease the incentive for R&D investment, this can be mitigated by increasing the patent coverage's length. Matutes et al. (1996) assert that a narrow patent regime may cause delays in patenting, as innovators might privately develop business applications before the disclosure of the innovation's traits to their rivals. The rate of technological progress is reduced due to this delay of disclosure. Although the scope of patent protection should be broad enough to foster initial R&D investment, it should not be so broad as to hinder the search for other improvements.

Levin et al.'s (1984, 1987) claim that as appropriability mechanisms, in most R&D intensive sectors, lead time, secrecy, learning-curve effects, and efforts for sales and service received a higher ranking than patents. According to Vonortas (1994), the underlying reason is the significant "learning-by-doing" investment necessary to use information. Technological knowledge entails a combination of both incomplete and poorly defined know-how and a highly codified information set which is hard to obtain (Vonortas, 1994). So there will be some degree of appropriability of the income occurring because of the innovation, regardless of the nature of the patent system (Vonortas, 1994).

Depending on the sector, the role of patents may also differ. Mowery (1995) states that throughout the history of the US semiconductor industry, patents acted as bargaining chips that allow a firm the trade of licenses to access technology protected by other patent-holders. In these cases, patents lead to the diffusion of technology. One example is the Semiconductor Chip Protection Act of 1984, which facilitated patent protection for computer chip designs and hence increased the possibility for patent infringement suits (Mowery and Rosenberg, 1993).

Although technological progress can be fostered by the patent system by increasing post-innovation appropriability, this will not always happen given the presence of extensive knowledge externalities. To give a specific example, based on a 1956 antitrust consent decree, AT&T required licenses for a patent-controlled technology at suitable rates and it required cross-licenses of patents from companies to which licenses were granted. This pattern of cross-licenses enabled the fast entry into and development of the US semiconductor chip industry (Steinmueller, 1987). The knowledge diffusion in this industry was also facilitated by staff's free movement among rival companies, including startups financed in venture capital markets.

9.5 Empirical Evidence

There is substantial evidence based on case studies that despite the fact that technological frontiers may be pushed out by joint R&D, the main advantage of such an R&D occurs due to the information diffusion among stakeholders and product-market competition following the diffusion. Due to the product market rivalry, the incumbents try to adopt state-of-the-art developments on time, and as a result technological performance is promoted.

In case of an extremely high R&D cost, subsidies for single or cooperative R&D may be effective. When granting direct public subsidies, an agreement should be made by recipients that the research results will be openly licensed at reasonable rates.

According to the rent-seeking literature (Fudenberg et al., 1983; Fudenberg and Tirole, 1987; Anderson et al., 1997), overinvestment in innovation is also possible as rivals that strive to gain a post-innovation competitive advantage may have from the perspective of the society a higher spending in total. This is referred to as "the overbidding problem" by Baldwin and Scott (1987) in contrast to the "appropriability problem" that causes underinvestment.

9.5.1 The Rate of Return to Investment in R&D

As the existing body of literature suggests, the social rate of return to investment in R&D can be estimated by means of measurement of some R&D input or output as a variable of an explanatory equation that relates to the increase in total factor productivity (Jones and Williams, 1997). The approximate R&D coefficient shows how much productivity growth would be increased if R&D activity were increased.

According to Jones and Williams (1997), the social rate of return to R&D is made of various components that demonstrate the value of additional ideas *per se*, the value of the additional output enhanced by increased knowledge, and the value of increased spillovers.

Still some other studies include evidence about factors that have an effect on the rate of return to investment in R&D. In some studies such as Link's research (1987) publicly funded R&D is taken into account as a separate constituent of productivity; so the impact of public funds with regard to the R&D's rate of return can be estimated. According to Link (1987,1997),

(1) In his sample of manufacturing companies, the productivity growth for government support of basic research exceeded the one for government support of applied R&D;
(2) In general, the availability of government funding reduces the approximated private rate of return on R&D.

One commonly accepted view is that public funding provides support for private companies to do projects that are socially advantageous but less privately advantageous than the average projects in portfolios of the private firms' R&D (Link (1987, 1997).

9.5.2 Cross-sectional Evidence

Another line of research investigated the question of whether or not government funding removes private spending which has been asked by Irwin and Klenow (1996) by making use of cross-sectional evidence. One conclusion reached by Scott (1980) and Mansfield (1985) was that public funding does not dislocate private R&D spending; instead the private spending grows to some extent from what it would have happened without the public funds. In a large cross section including more than 400 firms with over 3,000 observations on their activities in several industries as done by Scott (1980), it was observed that for each federal research dollar earned by the average company, the company spent an additional eight one-hundredths of a dollar of its own money on R&D, other things being held equal, including a total set of industrial effects.

In order to interpret these different findings with regard to the dislocation of private spending by public spending, one question that might be asked is whether it can be specified which cooperative and/or public R&D acts as either a substitute for or a complement to private and independent R&D.

In alignment with the empirical literature on public funding of R&D investment, one answer is that public R&D generally complements private R&D undertaken by small firms (Acs et al., 1994a,b; Lerner, 1995; 1996).

Moreover, Lichtenberg's (1987) focus on the relationship between public and private R&D and private sales versus sales to the government could offer an explanation with regard to the complementarities found for the larger firms, rather than concluding that the gain of smaller firms from the government funding to contribute to individually performed R&D investments would probably be higher.

In light of this information, private spending is not dislocated by public funding of R&D *in general* except in a few specific cases.

9.6 Suggestions

To make use of the insights suggested by modern industrial economics, which is a collection of unique game-theoretic models for specific markets that entail detailed assumptions about order of moves, strategic variables, data sets, and solution concepts, policy advice on innovation should be tailored. This section takes as its starting point the general agreement within the existing body of literature that from a social perspective, relying purely on market processes may result in an underinvestment in R&D related to innovation. So R&D and innovation policy should take as its basis specific sources of market failure in order to be designed effectively for competition rather than focusing on problems that do not affect a particular industry.

If an open economy and innovation includes the competition policy as one of its parts, both domestic investment and FDI can be fostered by means of this policy, as it contributes to the investor confidence by offering a consistent framework within the related sector. Not only does an effective competition policy encourage innovative new entrants to take a crucial role in the development process, but it also contributes to development while reducing opportunities for corruption and rent seeking.

When designing an appropriate national competition policy both the local realities including the governance capabilities and political realities including the presence of small and frequently vulnerable domestic markets should be taken into account in order to enable a strong innovation policy. A culture of competition should be created among government, firms, and consumers by gaining an increased understanding of the objectives of innovation policy. Civil society and an open media specifically can act as a constructive and valuable means for building a culture of competition. Above all, politicians

must be committed to having a detailed understanding of their official duties toward markets and to supporting the building of the technical capacity required for this task.

9.7 Conclusion

Fair competition plays a crucial role both for reducing poverty and economic development. Eliminating unnecessary distortions to competition can facilitate significant reforms within innovation policy. A detailed understanding is essential at innovation policy levels by not only government or the business sector, but also consumers, in terms of the positive impact of both effective competition and competition policy on an economy.