



Ca' Foscari  
University  
of Venice

Master's Degree  
in Global Development and  
Entrepreneurship

Final Thesis

**Navigating the Ambivalence of Innovation:  
Knowledge Diffusion and IPP in High-Tech  
Industrial Clusters.**

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**Academic Year**

2023 / 2024

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*“The premise that innovation prospers when ideas can freely connect and recombine with other ideas may seem like an obvious truth, but the fact is that the economics of innovation of the past two centuries has pursued the exact opposite argument, building walls between ideas thus limiting the creative potential of innovation. Paradoxically, those walls called IPP have been erected with the explicit aim of encouraging innovation. (...) The problem with these closed environments is that they reduce the innovation capacity of the economic system. Protecting ideas means protecting them from other ideas that might improve them, might develop them in new paths or radical innovations.” – Johnson (2010).*

## **Abstract**

The research highlights the ambivalence of innovation, discussing its inherent tendency to diffuse while simultaneously creating a demand for Intellectual Property Protection (IPP). The case of high-technology industrial clusters, particularly Silicon Valley’s success, demonstrates how favouring the spread of knowledge over appropriability mechanisms can enhance innovation in the economy. The paper challenges the vertical orientation of a ‘firm-based’ ecosystem, which tends to keep the innovation’s results within the company’s boundaries. In contrast, it supports the horizontal and external orientation of a ‘network-based’ system that relies on technological spillovers, cooperation, imitation and competition among firms. Regarding IPP, the study introduces two different appropriability instruments: patents and trade secrets (with the related non-compete clauses). The scope of the analysis and the existing relationship between trade secrets and patents ultimately lead to a focus on patents, which is the main topic of the first part. To support its position, the research: a) analyses several papers and articles that explore the dual nature of innovation, the complexities of IPP (especially the patent system), and the role of industrial clusters in fostering technological advancement; b) demonstrates the critical aspects of the patent system in promoting innovation and providing a true solution to secrecy; c) uses game theory to illustrate the individual incentive to patent innovations in a one-time game, as well as the potential for cooperative equilibrium in the repeated interactions within industrial clusters; d) defends the idea of a competitive market for innovation that freely diffuse ideas and promote cooperation; and e) concludes with policy recommendations aimed at prioritising knowledge sharing over stringent IPP, underscoring Silicon Valley’s unique ability to create a network of competitive and collaborative relationships. The thesis represents a pure economic theory analysis. As such, it can serve as a foundational basis for future research and empirical validation.

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# Introduction: The Ambivalence of Innovation

## Introducing the Cluster Dilemma

The idea of writing this thesis stems from the existence of the so-called “Cluster Dilemma”. The term refers to the paradox of measuring clusters’ innovative performance through the patent spatial concentration, even though patents and other Intellectual Property Protection (IPP) instruments may actually hinder the dissemination of knowledge<sup>1</sup> - a factor that is fundamental to the competitive advantage of industrial districts<sup>2</sup>. A good example of this paradox is provided by Stek (2020), who develops a methodology for identifying and evaluating technology clusters based on geographic patent density. While the construction of heat maps using readily available patent data may offer valuable insights into the spatial distribution of innovation activities, it underscores a critical issue: patents serve as legal mechanisms to protect intellectual property, whereas industrial districts thrive on the dynamic exchange and interplay of ideas between firms. Though patents could be indicative of a system’s innovative capacity, insisting on them as a proxy of cluster’s performance might lead policymakers to prioritise exclusivity and proprietary knowledge over the benefits of technological spillovers, collaboration initiatives, and free competition. This creates tension between protecting individual achievements and fostering the network-based ecosystem essential for sustained innovation.

The Cluster Dilemma not only distorts the understanding of the existing relation between industrial districts and IPP, but it also reflects a broader tendency to measure an economy’s innovation capacity by the number of patents registered. This widely adopted approach is based on the assumption that creative initiatives, to a large extent, would not occur without the incentives provided by the patent system. Nevertheless, there is a lack of consensus among scholars on the subject, with some rejecting the mainstream theories of patents. While patents can serve as a good proxy for innovative performance, they should not be misconstrued as an unquestionable prerequisite for technological advancement. A more cautious approach is recommended when considering the role of patents in innovation processes. This involves assessing the (temporary) monopolistic positions they create and examining their actual effects on the dissemination of knowledge and the development of future innovations. Moreover, it is important to determine whether the patent system acts a ‘producer of innovation’ or merely a

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<sup>1</sup> The last part of the first chapter analyses the effects of patents and trade secrets on knowledge diffusion.

<sup>2</sup> The third chapter focuses on business clusters, which Porter (1998) defines as ‘geographic concentrations of interconnected companies and institutions in a particular field’. The analysis will then examine the mechanisms that, by renewing the industry life cycle of high-technology districts, preserve the competitiveness of these clusters.

‘consequence of innovation’, as this distinction sheds light on the self-reinforcing nature<sup>3</sup> of patents.

### **The Ambivalence of Innovation**

How can we solve the Cluster Dilemma? The paradox gains meaning once the dual dimension of innovation is acknowledged: new ideas tend to naturally diffuse in the economic system while creating a demand for IPP to appropriate the value created. This is the ‘Ambivalence of Innovation’, an expression describing two opposing forces not in contradiction: the concepts of diffusion and exclusivity coexist in the economics of innovation. Yet, this dichotomy highlights the need for more balanced approaches in terms of innovation policies.

Facilitating access to new ideas and practices is crucial for spreading the results of innovation and promoting collective, multidimensional learning among economic actors - an important factor given the sequential, cumulative and complementary nature of the innovation process. Free dissemination of knowledge can also spur competition and collaboration initiatives, ultimately benefiting society in the long run. However, the unlimited diffusion of ideas would undermine the interests of original innovators by exposing them to imitation and unauthorised use, thus diminishing their economic incentive to innovate. How can we fairly compensate and reward individual innovators while still guaranteeing, to third parties, full access to the potential value of innovation? Achieving the optimal equilibrium requires a legislative framework that promotes openness and technological diffusion and, to the same extent, safeguards innovators’ investments. While providing adequate protection remains essential, there is a risk that overly strong intellectual property rights may ultimately choke the system's innovative capacity. These concerns are particularly relevant in the analysis of high-technology industrial districts, where rapid innovation and exchange of ideas are crucial for maintaining competitive advantage.

With respect to the legal environment, once its general importance for innovation is recognized, the scope of the following analysis leads to a focus on two specific IPP instruments: patents and trade secrets, including the particular case of non-compete clauses. Since, according to theory, the patent system aims to solve the issue of secrecy by disclosing inventions to the public<sup>4</sup>, the initial questions are: are patents truly effective in disseminating knowledge? What happens when the innovation system relies heavily on a network of cooperative and competitive relationships? And what are the consequences of patents when the fast pace of technological change quickly

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<sup>3</sup> Regarding this aspect, the second chapter demonstrates that ‘patents call for more patents’ through the lens of game theory.

<sup>4</sup> This idea will be challenged in the first chapter, in which the fragilities of the patents’ disclosure effects are revealed.

diminishes the value of innovations? Unlike the unclear and ambiguous effects of patents on innovation, trade secrets clearly hinder technological spillovers, thereby threatening the very foundation of high-tech industrial districts' competitiveness.

### **Thesis structure: chapters and their contents**

Building on the inconsistencies previously discussed, this thesis seeks to develop a novel perspective on patent theory, the economics of innovation, and the regional policies that best support the competitive levers of high-tech clusters. The dissertation is organised as follows:

The first chapter reviews mainstream patent theories and their inherent weaknesses. It begins by addressing the appropriability problem faced by innovators and the traditional trade-off associated with patents, presenting a static analysis of the effects of IPP on innovation. This assessment reveals how the protective function of patent law often overshadows its intended role in knowledge disclosure. The analysis then shifts to a dynamic setting in which IPP may diminish incentives for innovation in the long term, particularly given the cumulative nature of technological progress. The second part of the chapter critically examines the impacts of the patent system on knowledge diffusion, challenging the *contract theory of patents* and exploring the complexities of *licensing*. Despite these issues, patents remain preferable to pure secrecy, as they provide a structured mechanism for protecting and (to a limited extent) disclosing innovations. In this sense, patents can be viewed as a second-best solution.

The second chapter introduces the concept of a competitive market for ideas without patents, offering an interesting counterfactual perspective that advocates for the free diffusion of ideas within the economy. It explores the advantages of a more interconnected and dynamic innovation ecosystem, arguing that reducing (or even eliminating) control over new products and methods could increase the overall level of innovation while still guaranteeing sufficient profits for initial inventors. Even without the monopolistic rents granted by patents - which inevitably distort the market - innovators can still extract enough value from their discoveries to cover R&D costs and remunerate risk. The chapter emphasises the importance of promoting competition, imitation and open innovation initiatives to spur innovation. Drawing on empirical evidence by Boldrin and Levine (2014), it underscores the critical role of competition and imitation, especially in the early stages of an industry's development when innovative potential is highest. The demand for IPP typically emerges only as a sector matures and innovation rates plateau. Given this, the chapter poses an important question: how can we explain the growing reliance on patents<sup>5</sup> in an economy

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<sup>5</sup> A Statista (2024) graph shows a steady global increase in patent applications from 1990 to 2022. The consistent upward trend seems to describe an expanding role of patents in driving technological progress.

whose frequency of innovation has surged in the last decades? Game Theory demonstrates that, with the patent system in place, mutual patenting becomes the dominant strategy. In a non-cooperative framework, the individual incentive to protect inventions leads to a self-reinforcement cycle: ‘patents call for more patents’, functioning more as a negative consequence of innovation than a true economic incentive. The chapter concludes by recalling the need to cultivate an environment that facilitates interdependencies and collaborative initiatives, effectively countering the systematic individualism and inward-looking behaviour of firms.

The third chapter focuses on high-technology industrial clusters, emphasising the mechanisms that enhance the competitiveness of these important innovative ecosystems. Key factors such as knowledge spillovers, competition, imitation, and cooperation among firms are crucial for renewing the cluster’s life cycle and sustaining its innovative dynamism. Yet, geographic proximity fosters continuous interactions and mutual trust among firms, which suggests the presence of repeated games that can lead to a cooperative equilibrium in which every player is more inclined to share the results of innovation. These considerations explain why the protection provided by IPP can significantly limit the innovative potential of high-tech districts, particularly given the rapid pace of technological change that quickly erodes the competitive value of innovations. The adoption of weaker IPP becomes rational when the benefits of encouraging subsequent and complementary innovation - allowing to pursue multiple technological trajectories - outweigh the costs associated with reduced initial invention incentives. This is indeed the case of high-tech clusters. The second part of the chapter describes the contrasting experiences of Route 128 and Silicon Valley, illustrating how network-based industrial systems are more innovative and technologically dynamic compared to districts where the innovation process is isolated within individual firms. Silicon Valley continually reinvented itself as its specialised producers collectively learnt and adapted through evolving patterns of competition and collaboration. In contrast, the separate and self-sufficient organisational structures of Route 128 hindered adaptation by restricting technological change within corporate boundaries.

Silicon Valley’s competitive advantage relied more on openness and diffusion (the horizontal dimension of innovation) than from exclusivity and protection (the vertical dimension of innovation). This experience highlights the natural tendency of ideas to diffuse without friction, challenging the notion that innovation depends solely on individual incentives like patents. Once again, it is demonstrated that prioritising knowledge dissemination over strict intellectual property controls can increase the economy’s level of innovation.

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Complementary to this, a WIPO (2023) article reports a new record of patent filings in 2022, with significant contributions from China, the United States, and Japan.

Before starting, one key premise has to be made. In this analysis of the economics of innovation, innovation is not seen as the outcome of individuals with specific characteristics, such as high tolerance for risk or visionary thinking - often associated with the myth of the *Schumpeterian entrepreneur*. Instead, innovation has to be interpreted as a systematic, collective process involving multiple organisations, institutions and networks. It is the interplay between these actors that drives technological change. This is why policymakers should concentrate on shaping the institutional, cultural and regulatory environment to enhance the economy's innovation capacity.

## **Chapter I: The Traditional Patent Theories and their fragilities**

### **Knowledge as a Public Good and the Traditional Patent Theories**

Kenneth Arrow (1962) laid the basis for understanding the market failures that arise in the context of innovation. He argued that knowledge – taking the form of information – possesses the characteristics of a public good. Specifically, non-excludability and non-rivalry are the key features that differentiate knowledge from traditional private goods.

- *Non-excludability* refers to the difficulty of preventing or restricting others from accessing and using knowledge once it has been disclosed, largely due to the null or minimal costs of transmission.
- *Non-rivalry* (in consumption), on the other hand, means that the one firm's use of knowledge does not reduce its availability for others, allowing for its unrestricted diffusion and simultaneous usage without diminishing its utility.

These characteristics give rise to the low appropriability issue faced systematically by original inventors: despite bearing significant fixed costs associated with research and development (R&D), innovators can capture only a negligible part of the value their innovations generate. Because competitors can benefit from this value without incurring costs – leading to a free-riding problem - the economic incentives for investing in the production of new knowledge are weak. Another critical factor to consider is the high degree of uncertainty that characterised R&D activities. According to Schumpeter (1960), innovation is inherently risky as the outcomes of innovative efforts are often unpredictable; as a consequence, firms may be reluctant to invest in innovation without adequate protections or guarantees of return. All these aspects combined point to the existence of a market failure: given that innovation activity is costly (high costs of R&D) and risky (uncertainty of results and economic return), a market economy might devote insufficient resources to the production of new knowledge. An inefficient level of innovation will be reached whenever innovators are not fairly compensated.

By demonstrating the presence of a market failure, Arrow's analysis provides a compelling case for public intervention in the market of knowledge. Patents and other IPP instruments emerge as necessary remedies for guaranteeing optimal levels of innovation in the economy, in an attempt to align private incentives with social welfare and foster the continued production of valuable knowledge. This thesis concentrates the analysis on the economics of patents, exploring their relationship with trade secrets<sup>6</sup>.

The patent system grants inventors the right to exclude – for a limited period of time - others from the commercial use of the patented innovation. Patenting new knowledge means restricting others from using it without permission. The prospect of temporary monopolistic rents constitutes an incentive for innovations that would not otherwise occur given the public good nature of knowledge. Klein (2022) presents the traditional theories of patents, which consider patents as unquestionable tools (thus overlooking the potential negative effects they can have on innovation processes). In particular, two theories explain the rationale for patents:

- *The Reward Theory* views patents as an essential incentive mechanism, stressing their exclusivity function and the related profits they guarantee to innovators. The core idea - already mentioned - is that without the promise of such rewards, firms would be less likely to invest in costly and uncertain innovation efforts.
- *The Contract Theory*, on the other hand, considers patents as a contract between the inventor and society. Under this framework, the government grants a temporary monopoly to innovators in exchange for the full disclosure of their inventions. This disclosure effect allows, once the patent expires, others to assimilate the innovation thus promoting further inventive initiatives. The contract theory emphasises the role of patents in facilitating the diffusion of ideas. It suggests that patents are not merely rewards but are also critical to produce subsequent innovations, ensuring that new knowledge enters the public domain.

The contract theory interprets patent protection as a rational and effective alternative to *trade secrets*, which are particularly inimical to diffusion. The WIPO (2022)'s webinar guides us in understanding these two distinct forms of IPP. As previously noted, patents support innovative efforts by granting government-sanctioned and temporary competitive advantage to right holders in exchange for disclosing their inventions. Once a patent expires, the innovation enters the public

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<sup>6</sup> Patents, more so than other forms of intellectual property like copyrights, can create substantial barriers to competition and distortions in the market. By focusing on patents, also in their relationship with secrecy, the goal is to gain a deeper understanding of how IPPs impact the dissemination of knowledge and promote innovation – particularly within high-tech industrial clusters.

domain. In contrast, trade secret protection represents a right on confidential information known only to a select few, preventing the unauthorised use or theft of this information through unfair practices. Unlike patents, trade secrets can last indefinitely. Since patents' disclosure erode the innovator's competitive advantage in the long run, an inventor should prefer secrecy to patenting whenever possible<sup>7</sup>. As part of trade secret protection, *non-compete covenants* are frequently used. These agreements prevent former employees, after the employment termination, from competing with their previous employer - either by joining a competitor or starting a new business - for a designated period and within a defined geographic area.

Unlike patents, trade secrets are designed to completely prevent the dissemination of innovation's results across the economic system. In this respect, patents can be considered a more effective and widely accepted tool for safeguarding innovation while allowing the public - after the patent term - access to the new knowledge produced.

But the relationship between patents and trade secrets is more complex than that. These two protection mechanisms are not perfect substitutes: research by the EUIPO (2022) reveals that innovating firms often rely on both patents and trade secrets to protect their innovations. Furthermore, patents are not exempt from limitations. The following sections will critically evaluate the true effectiveness of the patent system in fostering innovation, both in a static and a dynamic setting, and its role in facilitating knowledge transfer between firms. Acknowledging the shortcomings of patents - while still recognizing their economic significance with respect to trade secrets - is crucial for designing an optimal environment for innovation, particularly within high-tech industrial clusters.

### **Static and Dynamic analysis of IPP's effects on Innovation**

In economics, the implications of IPP (in this section used essentially as a synonym for patents) have been analysed in both static and dynamic dimensions:

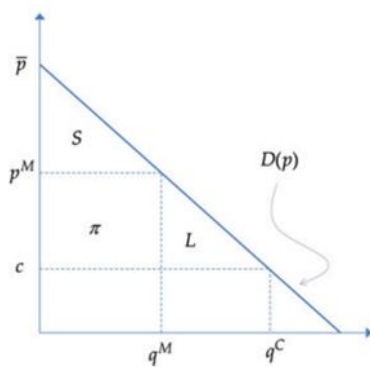
- The **static analysis** of IPP's effects on the production of new knowledge focuses on innovation occurring at a specific point in time. Even if the inter-temporal effects of IPP on inventive efforts are overlooked, this perspective of analysis is useful for understanding the immediate impact of IPP on the incentive to innovate. The consequences of IPP on innovation turns out to be contingent, depending on the balance between the negative effects of the monopoly power granted by patents and the positive effects arising from two primary sources: (a) the mitigation of the non-appropriability issue through a time-limited protection and (b)

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<sup>7</sup> This strategic choice is reasonable for process innovations which are not easily reverse-engineered.

the reduction of secrecy costs through the statutory disclosure of information when the patent is registered (Hall and Harhoff, 2012).

Regarding the negative effects of IPP, Clancy and Moschini (2013) discuss how patents can introduce inefficiencies in the market: by granting (limited) monopolistic power, patents enable right holders to set higher prices ( $p_M > c$ ) – thus earning the monopolistic profit  $\pi$  that constitute the incentive for R&D investments. Nevertheless, this also results in a production quantity that is inefficiently low ( $q_M < q_C$ ) with respect to a competitive market scenario. The exclusion of consumers whose willingness to pay exceeds the marginal production cost constitute a *deadweight loss* (L).



Clancy and Moschini (2013)

In this way: from an ex-ante perspective, patents remain essential for encouraging innovations that might not otherwise emerge; ex post, however, the limited monopoly leads to a suboptimal production level of the new product. As a consequence, the pareto equilibrium is not achieved. On top of that, patents create further inefficiencies. First, the reduction of competition - through the exclusion of potential imitators from the market - reduces incentives for inventors to increase productivity through incremental, welfare-improving innovations (thus keeping marginal costs too high). Second, patents encourage rent-seeking behaviour. With this expression, Boldrin and Levine (2014) describe the unproductive spending by innovators aimed at influencing political outcomes to reinforce patent-related market power. Such rent-seeking can be particularly detrimental to innovation, as it diverts resources from more productive uses such as R&D investments.

In respect of the arguments in favour of IPP, three more remarks must be done:

- a) According to Boldrin and Levine (2014) the claim that see patents as a remedy for secrecy does not hold because it is simply no logical. Rational innovators would opt for secrecy if they can keep their discoveries hidden for a period longer

than the patent's duration, while they would opt for patent protection if and only if the secret could be kept for a shorter period. Because of these considerations, patents do not provide a solid remedy to secrecy. In addition, the benefits of publication may be cancelled out by omitting essential know-how.

- b) Firms that are endowed with such IPP instruments may learn to use them in strategic ways that may not serve the intent of the primary legislation. This is indeed the case of “patent trolls” or non-practicing entities (NPEs) - companies that use patents as legal weapons by suing other firms for patent infringement, without developing or commercialising the underlying innovation. In this case, patents may be kept “sleeping” solely to disadvantage a competitor and to preserve a monopoly in a market segment. The emergence of these strategic practices demonstrates how the protective side of patent law can easily come to overshadow its disclosure functionality, exploiting the weaknesses in the patent system and diverting resources from more productive activities (like R&D).
- c) Finally, the Yale Survey (Levin, 1987) and the Carnegie Survey (Cohen et al., 2000) show how patents are not considered a good appropriability method by innovative companies, which in turn tend to indicate *first mover advantage*<sup>8</sup> and *secrecy* as much more effective instruments. Overall, both surveys recognize the importance of patents – especially in the pharmaceutical sector - but underscore the firms' preference for other innovation protection strategies.

- In a **dynamic analysis**, the trade-off between the positive and negative effects of IPP on innovation becomes more complicated. Innovation is now viewed as a sequential and complementary process: future advancements are built upon discoveries in the present, relying on the knowledge pool already developed, and each innovator takes a different research line. According to Bessen and Maskin (2009), IPP can enhance the incentives for today's innovation at the expense of increasing the costs for future innovation - thereby reducing the overall innovative capacity of the economic system (that is also less differentiated). In particular, each upstream patent holder can restrict access to useful knowledge, reducing the probability of follow-on innovations and slowing the pace of innovation. Strong IPP can be especially detrimental when downstream innovators

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<sup>8</sup> Being the first to introduce a new product or production method, the innovator (the market leader) can capture significant market share and secure a sustainable competitive advantage. This is achieved, for example, by establishing customer loyalty (reputational advantage), shaping the industry, and creating significant barriers to entry for potential competitors.

require access to multiple patented inputs (Heller and Eisenberg, 1998). From a dynamic perspective, society might ultimately be better off without protecting its intellectual assets<sup>9</sup>.

### **Effects of Patents on Knowledge Diffusion**

The last part of this chapter examines the effects of patents and trade secrets on technology transfer between firms. Economic theory suggests that secrecy largely reduces spillovers through non-disclosure, whereas the disclosure obligation for patents creates some knowledge spillovers. But to what extent? Does patent protection ultimately promote or inhibit the diffusion of knowledge?

One of the key justifications for the patent system is represented by the spillover benefit that derives from the disclosure requirement in the patent application phase. According to the contract theory of patents (previously illustrated), the full disclosure of the technical knowledge embedded in a patented invention is fundamental for revealing and diffusing innovation throughout the economy. By giving guidance on the current “state of the art” in a specific field, the publication of patents’ technical details can further research efforts in directions that avoid duplications of results. Additionally, when the inventor is not able to commercialise the innovation or when the invention has applications in other areas, patents can facilitate technology transfer through efficient contracting and licensing. As already mentioned, all these positive outcomes are best appreciated when compared to non-patent appropriability methods such as secrecy (also sanctioned by law).

Despite patents’ apparent advantage over secrecy, many economists and legal scholars remain sceptical about the effectiveness of the disclosure effect. Earlier in the chapter, we discussed how patents not only disseminate innovation-related information through its disclosure requirement. They also restrict to the public the use of patented technology for a limited time. This temporary exclusivity prevents potential competitors from copying the innovative idea, thus protecting the inventor’s ability to profit (here the role of patents as incentives for innovation). By restricting public access to valuable information, patents can weaken the positive externalities associated with innovation. It is ambiguous whether patents help or hinder the diffusion of knowledge (Song et al. 2022). A study by Schmidt (2010), which analysed data from 3’400 firms in the 4th

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<sup>9</sup> In the following chapters, the sequential and complementary nature of innovation will become increasingly important, particularly in the discussions of 1) how competition, imitation and cooperative efforts drive the production and dispersion of knowledge (Chapter II); and 2) High-technology industrial districts and the ideal conditions for supporting more efficient network-based innovation systems.

Community Innovation Survey for Germany, sought to find a definitive answer. The research revealed that secrecy as well as patents reduce knowledge spillovers within industries and consequently pose obstacles to innovation activities overall. Schmidt's regression analysis suggests that the patents' appropriability effect – their ability to restrict the use of the underlying innovations - outweighs the positive effects of disclosure. The same conclusion is valid when patent holders engage in strategic behaviours. As outlined in the previous section, anti-competitive practices like patent trolls amplify the protective side of the patent system, cancelling out any benefits to society.

Another area of investigation is whether licensing can mitigate the adverse effect of IPP on knowledge diffusion. In theory, licensing allows innovators to be compensated for their efforts while enabling the dissemination of technology across the economic system. In this way, licensing can strike a balance between the appropriability and diffusion functions of patents. Green and Scotchmer (1995) argue that a licence fee increases the incentives for innovators by providing them with a share of the profits from follow-on innovations. Nevertheless, with respect to their diffusion role, licensing contracts may still be suboptimal due to various market failures: 1) the presence of incomplete markets for licencing fees when identifying future innovators is difficult; 2) the fact that subsequent innovators should invest in their own innovations before negotiating a licensing agreement; 3) the likely asymmetry in information between licensors and the licensees, which can have diverging expectations about future profits; 4) the risk of having high transaction costs in licensing contracts, particularly for follow-on innovations that draws on multiple patents (Gallini, 2002). In general, licensing contracts become costly when dealing with complex innovations that rely on several patented technologies. These elevated costs can serve as a barrier to using upstream innovations as a foundation for future technological advancements.

One last point. The degree of technological diffusion is often measured by using patent citation analysis. Tracking the technological influence of innovations through patent citations accepts (again) the necessity of the patent system without questioning its actual impact on knowledge diffusion - this is similar to the biased approach seen in earlier discussions about the cluster dilemma. A good question to ask is the following: what would the economy look like in a counterfactual scenario without patents? While a) it remains unclear whether patents aid or inhibit knowledge diffusion, and b) measuring this diffusion is complex, we must acknowledge that technological transfer occurs primarily through three mechanisms: imitation, competition, and cooperation. All these mechanisms, explored in the following chapters, are constrained in the presence of a pervasive patent system. Patents tend to reinforce a vertical approach to innovation, where knowledge remains within the firm's boundaries. On the contrary, free competition,

imitation, and cooperative initiatives reflect a horizontal orientation of the innovation system that transcend the barriers created by patents.

## **Chapter II: The Competitive Market for Ideas: Cooperation, Competition and Imitation**

### **Exploring an Alternative Approach to Innovation: The Free Diffusion of Ideas**

The second chapter introduces the concept of a competitive market for new products and production methods, focusing on the advantages of a more interconnected and fluid innovation ecosystem that supports the free flow of ideas, as opposed to a traditional model based entirely on exclusive IPP. This alternative approach is based on the notion that IPP - particularly patents - may, in fact, hinder innovation. Some scholars argue that, rather than incentivizing creativity, patents lead only to market distortions and unnecessary barriers through to the monopolies they create. Therefore, they explore how an innovation ecosystem might function if the influence of IPP were weakened<sup>10</sup>, shifting the focus from the innovators' appropriability problem to the opportunities that arise from the free dissemination of knowledge without restrictions.

In particular, this more liberal model emphasises the cumulative and complementary nature of innovation - which is analysed in its dynamic dimension (Bessen and Meskin, 2009). Indeed, the second pillar of the competitive market for ideas is that the economy's innovative potential depends on how efficiently knowledge proliferates once shared, compared (whether competitively or cooperatively), and recombined without the vertical barriers that patents impose between firms. This is why some radical positions advocate for the gradual abolition of the patent system (Boldrin and Levine, 2014), envisioning an innovation model driven entirely by market mechanisms. In a patent-free world, fierce competition, rapid imitation, and cooperative initiatives becomes a catalyst for innovation, allowing for innovative complementarities and technological differentiation. This perspective supports the argument that innovation takes place regardless of patents and that a network-based, open innovation system offers stronger incentives for

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<sup>10</sup> The strength of a patent is determined by two key factors: length and breadth (or scope). *Length* refers to the duration of patent protection, and *breadth* defines the extensions of such protection. A longer and broader patent, by covering a wide range of the invention's functionalities for a longer period of time, provides robust protection against imitators. On the other hand, narrower and shorter patents facilitate subsequent innovations. Numerous studies have addressed the optimal design of patents, aiming at balancing these two dimensions. Key contributions are discussed in the conclusions of the thesis.

technological progress overall (Johnson, 2010). Even without the prospect of monopolistic profits, a competitive market for ideas can theoretically be a better producer of innovation.

Whether or not this alternative approach is valid and, more importantly, without rejecting the whole idea of IPP and patents, the discussion raises significant questions for the economics of innovation and policy-making. First, it challenges the prevailing belief that, without the artificial scarcity of intellectual property, innovation would grind to a halt. At the same time, it opens the door to alternative models that prioritise openness, collaboration, and the free exchange of knowledge among economic actors. An innovative environment should indeed support competition as well as cooperative interdependencies among its agents. It is thanks to these complex relationships that innovation ecosystems become adaptive and competitive over the long term. High-tech sectors, especially those within industrial district networks, are particularly responsive to these dynamics as demonstrated in the third chapter.

### **Innovation without patents, the importance of competition and imitation**

In the first chapter, we examined the negative impact of IPPs on innovation. Although offering clear advantages over secrecy, the (temporary) monopolistic power granted by patents introduces market inefficiencies and creates frictions and barriers between firms, without clearly benefiting knowledge diffusion. Furthermore, abusive practices that exploit the patent system's protection risks undermining the already delicate balance between private incentives and social welfare. Despite all these criticalities, challenging the common belief that views patents as fundamental incentive for ensuring optimal investments in innovation remains difficult. This is because a counterfactual scenario in absence of patents does not exist in practice and can only be hypothesised.

To address this analytical issue, Boldrin and Levine (2014) investigate innovation in highly innovative sectors where the use of patents was either absent or limited. In particular, their historical analysis describes how non-patentable industries like software<sup>11</sup>, computers and semiconductors – in which securing exclusive rights on innovative products was not always possible or desired – experienced radical technological advancements thanks to intense competition and imitation. Drawing on empirical evidence, they demonstrate the critical role of these market mechanisms during the early stages of industry development, when innovative

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<sup>11</sup> The *Diamond v. Diehr* (1981) Supreme Court case was pivotal in setting a precedent for software patentability in the U.S. It established that computer-implemented processes – mathematical formulae that are not patentable themselves - are patent-eligible if they contribute to a transformative industrial activity. This decision paved the way for software patents.

potential is at its peak. The pattern is the following: 1) dynamic and high-tech sectors initially attract numerous entrepreneurs due to the potential for substantial profits; 2) these entrepreneurs, by imitating and competing with one another, generate the high levels of innovation that defines the industry's technological development; 3) the demand for IPP typically arises and become prominent only as the sector matures and innovation slows, with firms seeking to use patent protection to preserve market dominance<sup>12</sup>.

Bessen and Maskin (2009) delve into the specifics of the matter, explaining why high-technology industries (and society as a whole) could benefit from weakened IPP. As discussed in the first chapter, free competition and imitation can be socially desirable when each innovation builds on the preceding one (sequentiality) and takes a different research trajectory (complementarity). In such cases, instead of wasting resources to secure monopolistic patent protection, innovative firms should continue to invest in R&D while embracing the possibility of being imitated. Without the barriers imposed by patents, imitators can easily develop subsequent innovations and, since they may possess ideas not available to the original inventor, more and diverse knowledge is produced. In a sequential setting, the original innovator as well could be better off if others imitate and compete against him: even if immediate benefits from his/her present innovation can be reduced, the probability of follow-on discoveries and future gains increases (Bessen and Maskin, 2009). That is, imitators do not produce direct “knock offs,” but rather permit technological complementarities and improve the likelihood of further innovations.

But how would original innovators be rewarded without the monopolistic rents provided by patents? Can a competitive market for ideas produce a sufficient level of innovation? Three factors must be considered in the analysis of innovation economics:

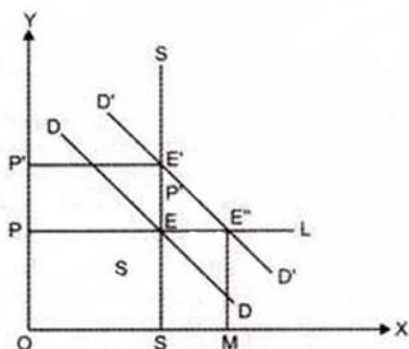
1) If intangible ideas are public goods with zero costs of transmission and replication, the product or production method that contains the idea - the one that have a value in the market - requires a minimum level of investments<sup>13</sup>. This implies the presence of temporary *Quasi-rents* or *Marshallian Rents* (Ogilvie, 1930). In the short term, physical constraints and limited production capacity allow original innovators to earn profits even without patent protection. When supply cannot immediately meet the exceptional demand for an innovative product, consumers are willing to pay prices above marginal costs. This creates “less than normal profits”, “something of the nature of a rent” under competitive conditions. The following graph illustrates this dynamic: the inelastic supply curve (SS) curve cannot adapt quickly to

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<sup>12</sup> This confirms that the patent system is subject to rent-seeking, as mentioned in the first chapter.

<sup>13</sup> In the case of high technology industries like computer and software, this includes investments in specialised capital and skilled labour.

the increased demand for the innovative product (which shifts from  $DD$  to  $D'D'$ ), leading to a price differential ( $P' > P$ ) that generates profits ( $OP' - OP$ ). Over the long term, as the supply adjusts itself to demand, the scarcity-related rents disappear.



2) Even if set-up costs do not dissuade imitators from entering the market, entry does not occur instantly. In this sense, original innovators enjoy a first-mover advantage: being the first in the market, they capture substantial market share (and profits) against would-be imitators. Since innovation is inherently risky, imitators also face uncertainties and generally invest in replication only after the original idea has shown success – meaning that the market has already (at least in part) embraced and assimilated the innovation. While the imitators develop their production capabilities, original innovators can leverage learning curves, build reputational capital, and reinvest in R&D in order to consolidate their competitive advantage.

3) Firms are incentivized to invest in innovation even without patents, thanks to the *two faces of R&D*. According to Cohen and Levinthal (1989), R&D serves not only to generate innovation but also enhances the skills and capabilities needed to absorb external knowledge. This includes knowledge spillovers from other firms and/or other institutions that operate under non-commercial incentives – such as the scientific community, universities, and military R&D. Aligned with this perspective, Rosenberg (1990) adds that firms conducting similar research activities are better equipped to understand and internalise external knowledge. Firms should naturally invest in innovation, as stronger internal competencies improve their ability to leverage technological spillovers (and imitate).

In summary, even in the absence of patent protection, innovators would continue to invest in R&D while still extracting enough value from their discoveries.

In agreement with this model of innovation, Johnson (2010) emphasises the importance of open-ended environments for the creation, diffusion and adoption of good ideas. By exploring the development of breakthrough innovations throughout history, the backbone of its multidisciplinary work is that the economy would be better served by connecting ideas than by

protecting them. New ideas tend naturally to connect with other ideas, recombine, reinvent themselves by crossing conceptual borders and competing. A good environment for innovation is a liquid, open-ended network, free from the barriers imposed by patents and that facilitate the formal and informal connections between the elements of the system. On the other hand, environments that isolate the knowledge produced tend to be less innovative in the long run.

### **The self-reinforcement nature of the patent system and the need for cooperation**

These reflections raise two important questions: if innovation can indeed occur without the support of IPP, and if imitation and competition are critical drivers of technological advancement in the most innovative sectors, how can we explain the economy's increasing reliance on patents? Do patents stimulate innovation, or are they merely a byproduct of it?

A simple Game Theory analysis provides a compelling answer. The two-player model outlined below suggests that, with a patent system in place, the dominant strategy for firms is mutual patenting of innovations (with the Nash equilibrium located in the first quadrant). In a non-cooperative game – where no cultural consensus, external regulation, or binding agreements enforce virtuous cooperation between players – both firms rationally choose to patent their innovations. The result is a pervasive patent system that grants original innovators the full economic benefits of their inventions but falls short in promoting overall social welfare. By patenting their discoveries, rational firms prevent other companies from freely utilising their knowledge, thereby hindering the development of subsequent innovations through imitation and competition. Moreover, the possibility to patent inventions promotes an innovation system that prioritises individual firm's interests. This isolates elements within the system and discourages important collaboration initiatives such as cross licensing, open-source collaboration, and open innovation agreements. Although these initiatives are not explored in detail in this thesis<sup>14</sup>, they highlight firms' growing awareness of IPP's negative effects on innovation. Conversely, they demonstrate the benefits of sharing (material and intellectual) resources for technological advancement.

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<sup>14</sup> The next chapter, which introduces high-tech industrial clusters, delves deeper into Innovation Ecosystems and Knowledge Sharing Networks. These models of innovation are based on informal and formal interdependencies of cooperation and competition, wherein firms exchange expertise and knowledge to solve shared challenges.

Firm A \ Firm B	<b>Patent</b>	<b>No Patent</b>
<b>Patent</b>	<i>Pervasive patent system</i> 1,1	A has free access to firm B's knowledge and then firm A patents its innovation. 5,0
<b>No Patent</b>	B has free access to firm A's knowledge and then firm B patents its innovation. 0,5	<i>No-patent economy</i> 3,3

The individual incentive to protect inventions explains the self-reinforcing nature of the patent system: ‘patents call for more patents’. This creates a negative feedback loop where patents serve as a consequence of innovation rather than a genuine incentive for it; the patent system becomes socially harmful, benefiting individual firms seeking monopolistic rents. This observation demonstrates that the software industry and the other examples discussed by Boldrin and Levine (2014) are not an isolated case but rather the rule. The demand for IPP emerges in a second instance, when a sector’s technology matures, and innovation slows.

Although mainstream theories of patents often overlook this fundamental truth, technology transfer between firms primarily occurs through competitive and collaborative relationships. When these processes are allowed to operate freely, they bypass the costs and market inefficiencies associated with licensing and avoid delays in assimilating knowledge after patent expiration. By adopting less stringent controls over new products and methods, the overall level of innovation can therefore increase, particularly when: a) the benefits of encouraging subsequent innovation outweigh the costs associated with reduced incentives for initial invention, and b) technology can be traded outside the market, with free know-how sharing that supports “collective inventions” (Arora and Gambardella, 2010). This dynamic is evident in high-tech industrial clusters (next chapter), where the rapid pace of technological change can quickly erode the competitive value of innovations. It is thanks to complex relationships of competition and cooperation that the most innovative districts achieve extraordinary adaptability and competitiveness over the long term (Saxenian, 1994).

In conclusion, fostering a more open innovation environment that facilitates the free exchange of ideas among economic actors is essential. Innovations policies should prioritize competition, imitation and open innovation initiatives, while still providing limited protection to initial inventors. IPP and patents, along with license agreements, remain critical in certain industries for safeguarding investments and facilitating structured technological transfer. A well-designed patent system - one that protects original innovators while promoting the diffusion of knowledge

- is particularly valuable in contexts where the cost of transferring and assimilating innovation-related information is indeed close to zero.

### **Chapter III: High-Tech Industrial Clusters and the Horizontal dimension of Innovation**

#### **The cyclical development model of high-tech industrial clusters**

An industrial district<sup>15</sup> refers to a geographically proximate group of interconnected companies and related institutions linked by commonalities (Porter, 1908). The spatial concentration of diverse actors operating in a particular field<sup>16</sup> promotes dynamic exchange processes, the creation of synergies and the development of complementarities within these regional innovation systems. The relationships between companies refer both to traded and untraded interdependencies such as market transactions, labour market mobility, imitation and competition, face-to-face interactions and informal linkages, as well as collaboration initiatives, most of which require a high level of mutual trust. Industrial clusters serve as hubs for knowledge inputs derived from established networks connecting competitors, firms in related industries, suppliers, customers, and institutions such as universities. The knowledge flows between different economic actors form a robust and dynamic technological infrastructure, underpinning the cluster's capacity for continuous innovations.

But why do economic activities tend to concentrate geographically? The benefits of clustering can be categorised into demand- and supply-side factors. Given our interest in high-tech districts, we emphasise Paul Krugman (1991)'s third supply-side externality - the one concerning knowledge spillovers. A key driver of clustering is the tacit nature of knowledge. As long as certain aspects of technology remain uncodified, proximity is essential for effective knowledge transmission thus creating the conditions for agglomeration economies. Marshall (1920) evocatively captured the essence and the importance of knowledge diffusion within industrial clusters, stating: "The mysteries of the trade become no mysteries; but are as it were in the air... if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus, it becomes the source of further new ideas." This observation aligns with Bessen and Maskin (2009)'s interpretation of innovation as a sequential and complementary process. It also

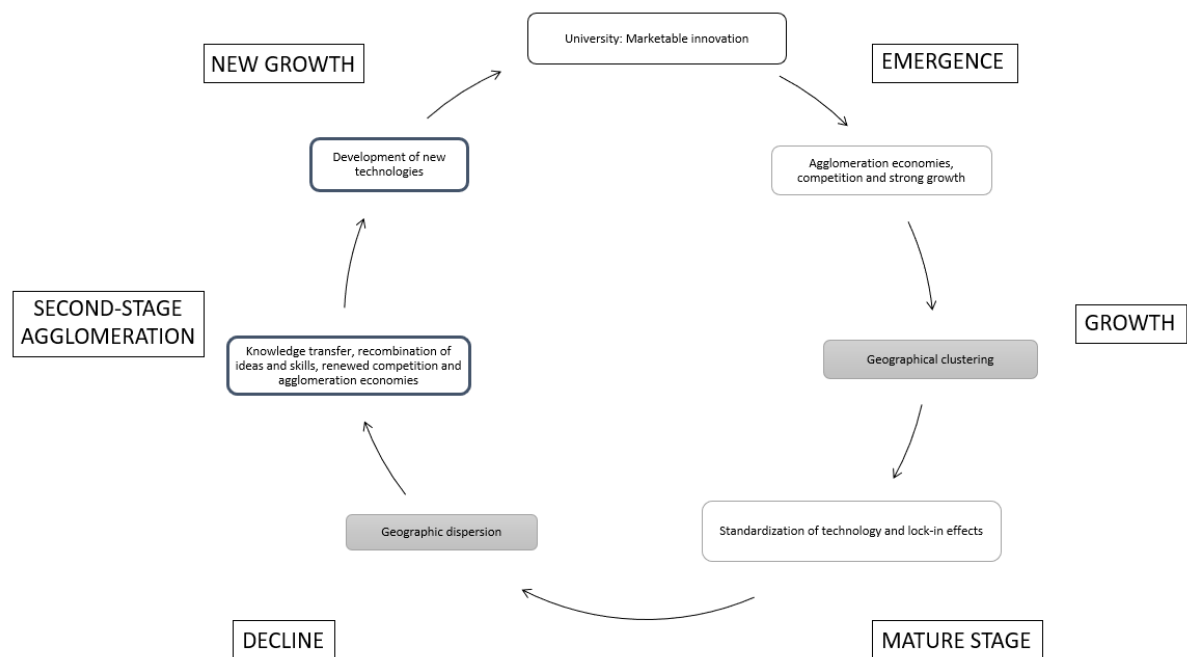
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<sup>15</sup> The concept originates from Alfred Marshall (1920), who first recognized the benefits associated with the concentration of firms in a specific geographical area.

<sup>16</sup> The economic actors belonging to the same cluster typically exhibit a) technological proximity, b) production in a common product category, or c) participation in different stages of the same value chain.

supports the idea of a competitive market for innovation, with weaker IPP that encourage follow-on innovations and technological diversification.

High-technology districts are of particular interest in modern, knowledge-based economies. A tech cluster is defined as a settlement that (i) accommodates knowledge-intensive firms operating at the technological frontier and (ii) encourages these firms to invest in R&D, leveraging intra-district knowledge transmission (Kerr and Robert-Nicoud, 2020). In addition to a highly specialized labour pool, these clusters thrive on knowledge diffusion, which directly contributes to their success. By examining the cyclical development model of high-tech industrial districts (Gilson, 1990), represented in the following figure, we can better appreciate the importance of facilitating knowledge diffusion.



The stages of a high technology cluster's life cycle are the following<sup>17</sup>:

- 1) Emergence. Krugman (1991) attributes cluster emergence to “historical accidents”, but persuasive empirical evidence<sup>18</sup> that points to the significant role of major university complexes exists - such as Stanford for Silicon Valley and MIT for Route 128. In brief, basic academic research fosters scientific innovation with commercial potential, laying the groundwork for a high-technology industrial district.

<sup>17</sup> This model represents a general pattern that helps shedding light on some significant aspects of high-tech industrial districts. Not all clusters follow this cycle from emergence to decline.

<sup>18</sup> For example, Saxenian (1994) and Pique (2020)

- 2) Growth. During the growth phase, tacit knowledge - particularly relevant when technologies are complex and rapidly evolving – amplifies the benefits of agglomeration economies. As a consequence, the clusterization process takes place (Gilson, 1990). In accordance with Boldrin and Levine (2014)’s empirical analysis, intense competition among firms, followed by market rationalization due to shakeout effects, generates high innovation rates and ultimately steers the cluster toward a defined technological trajectory.
- 3) Mature Stage and Decline. With product’s maturity, most technical aspects of production become standardized: the more an industry’s knowledge base is simple and well codified, the less important is the geographic concentration of firms and institutions. The diminished power of agglomeration economies, together with congestion effects (Gilson, 1999) - the lower wage and land costs available outside the area because of the impact of clustering – erodes the district’s innovation activity<sup>19</sup>. These factors often lead to the dispersion of production closer to consumer markets. In this way, the former technological specialization may become a disadvantage as companies are locked into a trajectory that can no longer keep pace with contemporary developments. This self-disruptive lock-in effect is also driven by the formation of closed networks that prevent the cluster from renewing its life cycle (Menzel and Fornahl, 2010). As a result, a cluster tends to lose its diversity, adaptability, and potential for independent renewal.
- 4) Second-Stage Agglomeration and New Growth. At this stage, the cluster can either decline or renew itself by entering a new phase of growth. This renewal depends on its ability to disseminate and recombine knowledge, unlocking new technological opportunities<sup>20</sup>. In particular, the district’s openness and trust-based network play a pivotal role in enabling both formal and informal mechanisms of technology transfer between firms. Formal spillovers occur through initiatives like joint ventures and cooperative relationships that facilitate the mutual exchange of technology. Informal spillovers, on the other hand, arise from competition, imitation, and worker mobility

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<sup>19</sup> Audretsch and Feldman (1996) analyse 210 industries, discovering that geographically concentrated companies show excessive innovation rate during the industry’s growing phase. Rather, companies outside cluster’s systems are more innovative during later stages. They explain how “the positive agglomeration effects during the early stages of the industry life cycle are replaced by congestion effects during the later stages of the industry life cycle”.

<sup>20</sup> In agreement with Johnson (2010), the transfer and recombination of ideas are essential to sustaining high levels of innovation.

- with employees bringing tacit knowledge embedded in their human capital from one firm to another. By leveraging these mechanisms, clusters can avoid stagnation and achieve a "second-stage agglomeration". The latter consists in a phase characterized by renewed agglomeration economies and competitive pressures that foster ongoing innovation.

Through openness, trust, and the creative recombination of ideas, high-tech clusters can repeatedly restart their life cycles. The case of high-technology industrial clusters demonstrates how favouring the spread of knowledge over appropriability mechanisms can enhance innovation while creating the conditions for technological dynamism and long-term competitiveness.

### **Cooperative Equilibrium and Collective Innovation in High-Tech Clusters**

The geographical concentration of firms inherently facilitates inter-company and intra-district knowledge exchanges, accelerating the continuous recombination of technologies and skills essential for the cluster's own survival. Beyond the well-known advantages concerning knowledge spillovers, geographic proximity fosters constant interactions within the cluster, thereby building mutual trust among the actors involved<sup>21</sup>. This dynamic suggests the presence of repeated games in high-technology clusters that can lead to a cooperative equilibrium, where participants are more inclined to share the results of innovation.

The non-cooperative equilibrium of the Prisoner's Dilemma, illustrated in the previous chapter, constitutes a suboptimal solution in the context of static games - one-shot situations with simultaneous decision-making by players. In contrast, a repeated game is a particular static game repeated a given number of times (finite or infinite), in which players account for past actions in their strategic choices. With the presence of long-term and persistent interactions, it is reasonable to expect players to opt for cooperation: if we cooperate today, I will cooperate tomorrow, with the threat of betraying (i.e., patenting their own innovation) acting as a deterrent. One strategy model that exemplifies this dynamic is the *grim trigger strategy*, also known as the *unforgiving trigger strategy*. The idea is the following: players implicitly agree on a cooperative action and a potential punishment action; the free sharing of ideas continues as long as no player has deviated from the agreed-upon cooperative actions in all previous periods. If a single deviation is observed - meaning that one firm decides to protect its own discovery - all players respond by permanently switching to the punishment action, in this case, patenting innovations in turn. *Cooperation*

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<sup>21</sup> In many cases, a sense of identity in industrial clusters creates "common goals" among its members. As we will see in the next section, this occurred in Silicon Valley's network of innovation.

persists if everyone has cooperated in all previous periods; however, a single defection triggers permanent non-cooperation (*pervasive patent system*).

To determine whether this postulate can be sustained as an equilibrium, it is necessary to compute the payoffs players achieve under the proposed strategy and compare them with the benefits of deviation. If players consistently find it more advantageous to adhere to the postulated strategy (cooperation) rather than deviate (patenting) at any period, the existence of a *Nash equilibrium in infinitely repeated games* can be demonstrated (Bartholomae and Wiens, 2024). From this perspective:

- Regional policies for innovation could establish institutions and legal frameworks that discourage deviations - i.e., the unilateral appropriation of innovation outcomes by individual firms – particularly when the mere threat of defection is insufficient to sustain the cooperative equilibrium.
- It is also critical to examine whether the payoffs of cooperation are sufficient. In other words, are collective actions for innovation effective and beneficial for society?

Theoretically, openness and collaboration initiatives can a) avoid duplication in R&D investments, b) reduce the sunk costs of introducing innovations to the market and the risk inherent in the innovation process, ultimately accelerating the pace of innovation cycles. The history of innovation provides compelling evidence that cooperation and free information sharing can indeed drive technological progress in industrial clusters, as reported by Allen (1983)<sup>22</sup>, Nuvolari (2004)<sup>23</sup>, Schwerin (2004)<sup>24</sup>, Von Hippel (1987)<sup>25</sup>.

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<sup>22</sup> Allen (1983) describes how engineers and firms in the Cleveland district (Britain) during the second half of the 19<sup>th</sup> century shared details of furnace designs, operational techniques, and improvements.

<sup>23</sup> Nuvolari (2004) examines the open-sharing model adopted by steam engineers and mine operators in Cornwall during the British Industrial Revolution. Following the lapse of the Watt-Bolton patents (described by Boldrin and Levine, 2014), collective efforts and the free dissemination of innovations led to rapid improvements in fuel efficiency and engine reliability. Nuvolari also highlights the role of a performance measurement system - known as "duty" - which quantified engine efficiency and facilitated comparative evaluations of designs, thus stimulating constructive competition among engineers.

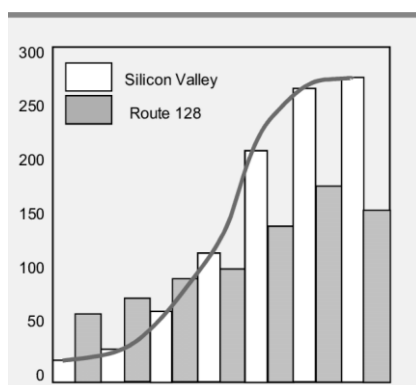
<sup>24</sup> Schwerin (2004) study explores how the Clyde region (Scotland) emerged as a global leader in shipbuilding during the late 19<sup>th</sup> century, creating an innovation network characterized by collaboration and knowledge-sharing among firms.

<sup>25</sup> Von Hippel (1987) documents instances of informal know-how trading networks among competitors in the US steel minimal industry in the late 20<sup>th</sup> century. These forms of cooperation for collective

These case studies underline the advantages of a collective approach to innovation as opposed to a patent-driven system - thereby prioritising knowledge diffusion over the appropriation of innovation outcomes. Foray (2006) delves into the ethical foundation underpinning these regional collaborative practices, describing a "collective belief" in the positive-sum game of knowledge sharing: inventors recognize that the prosperity of their local innovation ecosystem directly impacts their individual success. This shared understanding motivates firms to exchange expertise through both formal and informal (but continuous) interactions, particularly when the resulting productivity gains remain localized and shielded from external competitors (Allen, 1983). The next chapter will explore the most iconic and successful example of collective innovation in high-tech clusters, presenting its defining features: Silicon Valley.

### **Silicon Valley VS Route 128: the horizontal dimension of innovation**

During the 1970s, Silicon Valley (Northern California) and Route 128 (Boston) emerged as leading global centres of innovation in electronics. Both regions were celebrated for their technological vitality, entrepreneurship, and economic growth. They shared common origins in university-based research - Stanford for Silicon Valley and MIT for Route 128 – and exhibited technological similarities. However, their trajectories diverged in the 1980s when faced with shifting market trends and international competition<sup>26</sup>. While Silicon Valley successfully adapted and became the global benchmark for regional innovation, Route 128 lost its momentum. By the end of the decade, Silicon Valley had surpassed Route 128 in terms of employment growth, establishing itself as the national leader in computer systems innovation.



Saxenian (1996)

technological advancements were tolerated by managers because sharing innovation results led to reciprocal benefits, including faster problem-solving, and reduced costs of experimentation.

<sup>26</sup> During the early 1980s, both regions experienced significant challenges that tested their resilience. The difficulties of the Route 128 economy are typically attributed to maturation of the minicomputer's technology, as customers began shifting their preferences toward workstations and personal computers. Meanwhile, Silicon Valley faced intense competition from Japanese semiconductor manufacturers offering cheaper, high-quality products.

According to Saxenian (1994), this divergence stemmed from fundamentally distinct innovation paradigms the two clusters evolved.

Silicon Valley embraced a network-based innovation system that continually reinvented itself as its specialized producers learned collectively and adjusted to each other through shifting patterns of competition and collaboration. Its entrepreneurial ecosystem was defined by a culture of mobility and nonlinear career paths: employees frequently transitioned between firms, founded start-ups, or carried knowledge to competitors, thus fostering widespread knowledge transfers. In this way, the region's open, network-based structure institutionalized these spillovers, enabling the continuous recombination of technologies and the resetting of the innovation life cycle. Collaborative practices—such as cross-licensing of patents<sup>27</sup>, technology exchange agreements, joint ventures, and informal idea-sharing—reinforced trust and interconnectedness among firms. The ecosystem thrived also on intense competition, which incentivized rapid innovation and adaptation. By fostering diverse technological trajectories and embracing open innovation initiatives that transcends firm boundaries, Silicon Valley avoided industrial maturity and adapted rapidly to shifting market conditions and external shocks. This horizontal approach to innovation, together with the incentives derived from intense competition, recognised the central role of knowledge diffusion.

In contrast, Route 128 adhered to a firm-based innovation system characterized by secrecy, self-reliance, and vertical integration. with firms replicating the vertically integrated structure of large-mass production companies. Knowledge transfer was confined within firm boundaries, as long-term employment practices limited mobility and restricted the diffusion of ideas. Bringing about an inward-looking logic, innovation remained a company-specific endeavour in Boston, with minimal cooperation between firms. This rigid organizational structure hindered opportunities for collective problem-solving, slowed the pace of technological advancement, and left the region vulnerable to market shifts and technological disruptions. The cluster lacked the capacity to renew the cluster's life cycle consistently. By focusing on proprietary control and limiting the dissemination of knowledge, Route 128's performance declined over years.

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<sup>27</sup> Semiconductor firms in Silicon Valley, following the model set by AT&T's Bell Labs with the transistor, liberally cross-licensed their patents to competitors during the district's first three decades. This pooling of inventions and devices ensured that technical advances diffused quickly, allowing the cluster as a whole to progress regardless of the fate of any individual firms. As Robert Noyce, founder of Intel and nicknamed "the mayor of Silicon Valley" remarked, "Without cross-licensing patents, no firm could be using the latest technology in all areas" (Tilton, 1971).

Gilson (1999) highlights how the legal framework – particularly the rules governing the enforceability of *post-employment covenants not to compete* - played a critical role in shaping the trajectories of the two regions:

- Under Massachusetts law, post-employment covenants not to compete are enforceable. By seriously restricting employee mobility and the related knowledge spillovers, the legal infrastructure generated a self-enforcing equilibrium that failed at the second phase of the life cycle.
- On the contrary, California legislation made it extremely unlikely that post employment covenants not to compete would be enforced. Avoiding such restraints, that legal infrastructure creates the condition for a dynamic and successful cluster based on continuous exchanges of knowledge and expertise.

The contrasting experiences of Route 128 and Silicon Valley highlight the superior innovation capacity and technological dynamism of network-based industrial systems —making them more competitive and resilient to shocks—compared to high-tech districts where the innovation process is isolated within individual firms. Silicon Valley’s success illustrates how innovation thrives in an environment where ideas circulate freely and compete, collaboration transcends firm boundaries, and technological advancement becomes a collective priority. The region’s commitment to horizontal innovation—supported by trusted collaboration, intense competition, and openness to knowledge diffusion between firms—demonstrates that sustained innovation is not merely the product of individual efforts or proprietary incentives. Instead, it emerges from a cumulative, collaborative process that leverages the collective expertise and creativity of the ecosystem.

## **Conclusions and Policy recommendations**

This thesis has explored the ambivalence of innovation: drawing on theoretical models and empirical case studies, it emphasized the inherent tension between knowledge diffusion and IPP. The particular focus on high-tech industrial clusters, with the presentation of the successful example of Silicon Valley, has allowed for the exploration of the advantages of open and horizontal innovation processes that prioritize knowledge sharing, collective inventions, and the natural incentives of competition over exclusivity and the appropriation of results.

The first part critically assessed traditional theories of innovation and the incentives provided by the patent system. While patents offer advantages over secrecy, they often introduce market inefficiencies, create barriers between firms, and fail to significantly foster knowledge diffusion. This disrupts the delicate equilibrium between private incentives and social welfare, raising

critical questions about the optimal design of innovation policies. Acknowledging the importance of patents—especially in sectors with high imitation risks and low appropriability—this thesis advocates for a refined patent system that supports both diffusion and (partial) exclusivity. Influential works by Gilbert and Shapiro (1990), Nordhaus (1969), Scotchmer (1991), and Jaffe and Lerner (2004) underscore the necessity of calibrating patent length and scope to encourage present innovation without compromising long-term dynamism.

The second part introduced an alternative model of innovation, shifting the focus from the appropriability problem to the opportunities emerging from free knowledge dissemination. A competitive market for ideas relies on the efficient spread of knowledge, freed by the frictions imposed by strict IPP. In such an environment, fierce competition, rapid imitation, and cooperative initiatives become catalysts for innovation. Weaker IPP becomes particularly important when the benefits of encouraging subsequent and complementary innovation outweigh the costs of reduced incentives for initial inventions.

This model finds its most effective application in high-tech industrial clusters, where geographic proximity fosters continuous interaction and trust-based knowledge exchanges. The comparison between Silicon Valley and Route 128 provides empirical evidence of the advantages of a network-based innovation system. While Route 128 followed a closed, firm-centric approach that restricted knowledge flows, Silicon Valley flourished through its network-based system that balanced competition and innovation. This dynamic enabled sustained technological renewal through informal spillovers, worker mobility, and collaborative agreements.

## **Policy Recommendations**

In light of these findings, this thesis supports the implementation of regional policies that actively incentivize knowledge sharing and collective inventions while discouraging excessive knowledge appropriation. Drawing on the benchmark of Silicon Valley and the repeated game framework explored in the third chapter, policymakers in high-technology districts should:

1. *Promote Legal Frameworks for Open Innovation*: Implement legal reforms that support open innovation environments, including limiting the enforceability of non-compete clauses. This would enhance worker mobility, fostering knowledge spillovers and dynamic talent exchanges, as evidenced by California's legal framework that underpins Silicon Valley's success.
2. *Reward Cooperative Innovation*: Design policies that create both incentives for cooperation and penalties for behaviors that excessively restrict knowledge sharing. For

- example, public procurement preferences could be granted to firms demonstrating active participation in open innovation initiatives and knowledge-sharing networks.
3. *Encourage Cross-Industry Collaboration*: Provide targeted financial incentives, such as tax credits and research grants, to firms engaged in collaborative R&D projects, technology-sharing agreements, and cross-licensing practices. These initiatives can lower the costs of innovation and facilitate the spread of technological advancements within high-tech clusters, enhancing their competitiveness in global markets.
  4. *Strengthen Innovation Ecosystems by promoting Trust-Based Institutions*: Support the development of regional innovation hubs and networks that facilitate formal and informal knowledge exchanges. These ecosystems should serve as platforms for collaboration among firms, research institutions, and government entities, promoting trust-based relationships and collective problem-solving.
  5. *Foster a Culture of Knowledge Sharing*: Promote educational programs and public awareness campaigns that highlight the benefits of collaborative innovation. Encouraging a cultural shift towards openness can reinforce the systemic advantages of knowledge diffusion.
  6. *Optimise IPP Mechanisms*: Refine patent systems to achieve a balance between exclusivity and diffusion. This includes adjusting patent length and scope to prevent monopolistic stagnation while encouraging follow-on and complementary innovations. Flexible IPP frameworks can better accommodate fast-paced technological environments.

By fostering an environment where competition, imitation, and cooperation coexist, policymakers can cultivate an innovation ecosystem that enhances long-term economic growth and technological dynamism. Such an approach ensures that the benefits of innovation are broadly distributed, transcending firm boundaries and contributing to social welfare. Ultimately, this thesis advocates for a balanced innovation policy that improves, rather than rejects, IPP - recognising the complementary roles of exclusivity and diffusion, and prioritising the systemic, collective, and cumulative nature of technological progress.

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