IDEA FACTORIES

How Intellectual Property Sustains and Cultivates Technology Ecosystems

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EXECUTIVE SUMMARY

It is no coincidence that the single most prolific patent grantee of all time was also the founder of one of the world's first industrial research and development laboratories. Thomas Edison's famous lab in Menlo Park, New Jersey — nicknamed the "Idea Factory" — was the birthplace of groundbreaking inventions, including (among others) the phonograph, the incandescent light bulb, electrical distribution infrastructure, and improvements in telegraphy and telephony.[1] Edison constructed an intellectual property portfolio not only to protect the fruits of his team's labors against imitation but to seed and cultivate a knowledge ecosystem to distribute that technology broadly throughout the U.S. economy. Following in the footsteps of Edison and other legendary American inventors, today firms that specialize in innovation continue to rely on intellectual property to sustain a research pipeline that continuously disseminates new technologies through a complex network of implementers, producers, and distributors.

Specifically, this report shows how intellectual property rights (IPRs), and the contractual relationships and other transactional arrangements anchored in IPRs, enable the emergence of innovation specialists or "idea factories" that play a critical role in developing and diffusing new technologies in knowledge-based economies. Idea factories fuel a robust knowledge-based economy characterized by a continuous flow of new technologies. This category encompasses a broad range of entities — ranging from startups to licensing-based R&D specialists to academic research institutions — that specialize in innovation and partner with other entities on the steps necessary to embody innovation in technically and commercially viable products and services.

This report presents evidence for the following propositions concerning the function of IPRs in enabling innovation specialists and associated transactional mechanisms in tech ecosystems:

1. Robust IPRs promote innovation by enabling idea factories to monetize their R&D investments through contractual relationships with other entities that execute the rest of the commercialization process leading to market release.

2. Robust IPRs promote competition by enabling relationships between innovators on the one hand and producers and other implementers on the other hand. These relationships facilitate entry by upstream innovators who avoid production and distribution costs and downstream implementers who avoid R&D costs.

3. Robust IPRs promote disruptive innovation that is disproportionately undertaken by idea factories and other non-integrated firms that often rely on IPRs to compete against integrated firms that have inherent advantages in the financing, production, and distribution stages of the innovation cycle.

4. Robust IPRs promote participation by a broad range of firm types — ranging from innovation specialists to integrated producers — in standard-development organizations that support interoperability in tech ecosystems.

5. Robust IPRs promote the global competitiveness of the U.S. tech economy by providing a secure property-rights infrastructure that supports contractual transactions on which innovation specialists rely. Those transactions drive the U.S.'s large IP trade surplus and U.S. companies' leadership in standardization initiatives and global technology markets.

PART 1. HOW IPRS SUPPORT IDEA FACTORIES

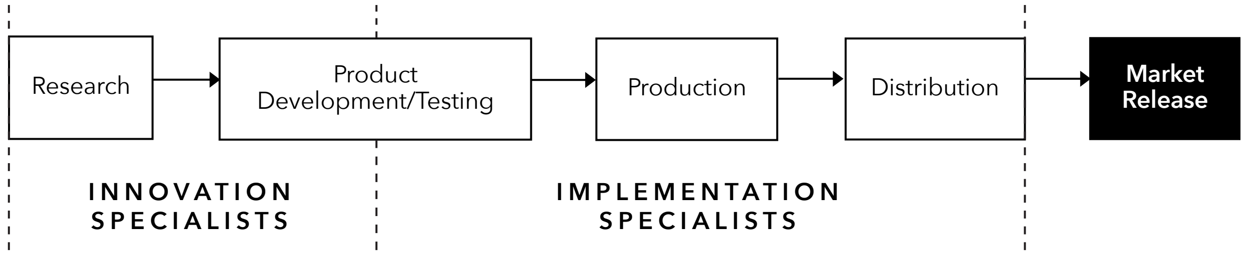
The extent to which different industries rely on IPRs to support innovation differs across industry and firm types.[2] Legal and business management scholars have argued that, across industries, firms that specialize in R&D, and do not invest substantially in production and distribution capacities, are most likely to rely on IPRs to capture returns on innovation.[3]

Empirical studies confirm this view, finding that R&D-intensive (and often smaller) firms often rely especially on patents and other forms of IPRs to monetize innovation. This empirical literature includes survey studies of smaller firms in the biopharmaceutical, medical device, and computing and communications hardware sectors[4], studies of U.S. technology history finding that the distribution of R&D expenditures shifts toward smaller firms when patents are reliably enforced[5], and qualitative studies of the business models used by R&D-intensive smaller entities in certain segments of the semiconductor and biotechnology industries.[6]

These findings reflect the fact that R&D-intensive firms often operate as upstream idea factories that specialize in innovation but do not develop production, distribution, and other downstream commercialization capacities. To monetize the underlying innovation and unlock its economic value, these firms must partner with other entities to embed their technology in products and services for the target market.

As illustrated below, the result is an efficient division of labor between firms that excel in innovation and firms that excel in the commercialization stages of the tech supply chain. This approximately tracks the "diseconomies of scale" that characterize innovation and product development — often a talent-intensive activity best executed in smaller environments — and the economies of scale that characterize production, testing, distribution, and other steps required to reach market release. It has been widely recognized that production and distribution functions require a standing physical infrastructure that is most efficiently maintained by larger firms, whereas "cutting-edge" innovation tends to thrive when executed by talented R&D teams in smaller environments free of bureaucratic frictions.[7]

Figure 1: Division of Labor in the Tech Supply Chain



IPRs facilitate this efficient division of labor by alleviating a fundamental transactional obstacle to information-sharing relationships between innovators and implementers.

The dilemma is known as the "information paradox," usually attributed to Nobel Prize-winning economist Kenneth Arrow.[8] Without IP rights, the upstream idea factory would be exposed to loss of its innovation any time it exchanged information with a sophisticated downstream business partner. Disclosing information concerning the idea factory's innovation is necessary to engage in negotiations and partnerships with downstream partners. While contractual and reputational mechanisms can mitigate the risk of knowledge leakage, IPRs, and the injunctive and damages remedies that stand behind them, can best facilitate the formation and implementation of contractual agreements by protecting and structuring information flows between innovators and implementers.

Following the common-sense principle of "good fences make good neighbors," robust IPRs enable innovators, investors, producers, and other entities to construct tailored relationships that exploit each entity's specialized capacities, minimizing the cost and speed of development, production, and time to market. Critically, these relationships support a virtuous cycle of repeat-play interactions among innovators and implementers. Under a secure IPR umbrella, innovators license new technologies to implementers who embody those technologies in new products, which in turn generate royalty streams that sustain innovators' development of the next technology generation. As shown in a recent empirical study of patent licensing transactions, licensors reinvest licensing revenues in increased R&D and patenting, enhancing innovation productivity, while licensees introduce more new products and services for consumers, saving on R&D costs and speeding up time to market.[9] This process of continuous innovation and product development supports the formation of technology markets populated by tens to hundreds of implementers and ultimately reaching millions to billions of end-users worldwide.

These positive feedback effects among IP rights, innovation, implementation, and market entry are depicted visually below.

Figure 2: Iterative Innovation and Monetization Cycle

To be clear, the transactional function of secure IP rights does not mean that these rights solely support “pure” innovation specialists that never elect to develop downstream capacities in production, distribution or other downstream functions. Firms may select from various degrees of vertical integration and dis-integration and may continuously adjust the level of integration at various levels of the supply chain in response to market conditions, technological capacities, and other factors. The critical point is that secure IP rights enable transactional choice in tech markets, rather than confining innovation within “walled garden” models that can only be constructed and maintained by the largest entities. Just as a market economy allocates resources efficiently by enabling competitive forces to select the prices of products and services, so too tech economies thrive by enabling innovators to select the transactional structures that can most efficiently transform innovations into technically and commercially viable products and services. For this purpose, secure enforcement of IPRs and IP-based agreements are often essential.

The following case studies, drawn broadly from the audio technology, biotechnology, wireless communications, and quantum computing industries, illustrate how IPRs and IP-based agreements have enabled four leading innovators — all firms founded by individual inventors — to construct and adjust business models in realizing the value embodied by each firm’s transformative technology.

Audio & Video Technology: Dolby Laboratories

Dolby Laboratories was founded by Ray Dolby in 1965 to commercialize a revolutionary noise-reduction technology for cassette-tape players and, as subsequently developed, for a wide variety of electronics devices. Throughout its history, Dolby has exemplified the idea factory model by focusing on R&D and principally monetizing its technology through IP licenses and related agreements with device producers and other implementers. This IP-driven business model enables Dolby to reinvest licensing revenues in developing new audio and video technologies that are widely used for streaming, playback, and broadcasting in desktops and laptops, mobile communications devices, television sets, and cinematic equipment.

These IP-driven transactions support an efficient division of labor in the audio tech value chain.

Firms such as Dolby specialize in developing and refining new technologies while original equipment manufacturers (OEMs) in the electronics and communications sectors — over one thousand licensed electronics manufacturers worldwide — specialize in embedding that technology in products for businesses and home users around the world. These favorable effects on technology access and market growth extend beyond the tech sector, reaching content producers in the motion picture, television, and music industries that produce creative works based on new audio and video technologies developed by Dolby. Remarkably, an interwoven network of technology and content markets — encompassing developers, distributors, consumers, and other stakeholders — can grow based on the next-generation technology developed through Dolby's R&D efforts.

For these "market multiplier" effects to be realized, a robust IP and contract-enforcement infrastructure is essential; that is, innovators must have a reasonable expectation that IPRs and contracts anchored in IPRs can be enforced against infringers at reasonable cost and undue delay. Without that expectation, innovators like Dolby would have difficulty safely sharing valuable technology with producers and other implementers that inherently pose knowledge leakage risks. Illustrating how IPRs can promote both innovation and access, these IP-driven contractual relationships among innovators and implementers both generate revenue streams that reflect the value of the innovator's technology to the ecosystem and make that technology widely available to users in a broad range of tech and creative markets.

Biopharmaceuticals: Genentech

Genentech was founded in 1976 by Herbert Boyer, one of the scientists who developed recombinant DNA technology, and Robert Swanson, a venture capitalist. Genentech had licensed the patented technology from Stanford University and developed a synthetic form of human insulin. However, the startup lacked the capital and infrastructure required to conduct clinical testing and, if successful, to manufacture and distribute the drug on a mass scale.[10]

To overcome these obstacles, Genentech contracted with Eli Lilly, a large pharmaceutical incumbent, which undertook these tasks. In 1982, this partnership resulted in the market release of Humulin, the first FDA-approved and biotechnologically engineered drug, delivering returns to Genentech's investors and improving the health of millions of diabetic patients.

Why were IPRs so crucial to this innovation success story?

First, IPRs protected the innovation against imitation following market release. Without a patent, any imitator would have underpriced the original drug since it had not incurred Genentech's R&D costs or Eli Lilly's clinical testing costs. Second, IPRs protected Genentech against loss of its crown-jewel asset during its interactions with Eli Lilly and other partners during the testing and manufacturing process. Without a robust IPR portfolio, Genentech would have been exposed to knowledge leakage and may have been unable to secure the venture-capital funding that launched the firm in the first place.

In short: IP rights opened up access in the biopharmaceutical ecosystem by leveling the playing field and enabling startups like Genentech to bargain on equal terms with larger incumbents who enjoyed formidable advantages in the commercialization stages of the pharma supply chain.

After the Humulin launch, IPRs supported Genentech's maturation from a single-product startup into a multi-product firm with a diverse portfolio of drug projects. Genentech was granted patents covering gene expression systems, protein-engineering methods, and upstream research tools that could be deployed across multiple therapeutic programs. This IP-intensive strategy enabled Genentech to convert knowledge assets into financial assets over which it could bargain with large pharmaceutical partners to form licensing, development, and marketing relationships. Through contractual arrangements anchored in its IP portfolio, Genentech limited the knowledge leakage risk inherent to informational exchanges while cultivating the value embedded in its technology through efficient partnerships with larger firms that could offer scale-efficient testing, production, and distribution capacities.

As it grew, Genentech developed in-house testing and manufacturing expertise, which it subsequently deployed to integrate forward into testing and production for some drug projects. In its 1994 annual report, Genentech described how it produced some drugs internally, while entering into collaboration and marketing arrangements with companies for other drugs, typically for certain fields of use or certain geographic regions.[11] Consistent with the reinforcing relationships between secure IPRs, market entry, and transactional freedom, Genentech's IP portfolio enabled it to enter a market that had been dominated by large integrated incumbents and subsequently to challenge those incumbents by electing in some cases to vertically integrate forward on the biotech supply chain. Genentech's IP-based business strategy has been replicated by hundreds of other biotech startups, resulting in an industry ecosystem that exhibits widespread usage of IPRs to protect intellectual capital, robust market entry, and a diverse range of academic research entities, biotech startups, and large pharmaceutical manufacturers that enrich the biomedical ecosystem through a steady flow of new drugs and therapies.

Wireless Communications: Qualcomm

Qualcomm was founded in 1985 by Irwin Jacobs, Andrew Viterbi, and other scientists to develop and commercialize code-division-multiple-access (CDMA) technology for the wireless transmission of audio, textual, visual, and other data through mobile communications devices. Qualcomm's innovation substantially outperformed the existing time-division-multiple-access (TDMA) technology that telecom carriers and device manufacturers had already widely adopted.

To disrupt the existing technology paradigm, Qualcomm undertook two steps.

First, Qualcomm contracted with wafer foundries for production of the semiconductors that embody its technology. This business model implemented an efficient division of labor between an entity that specializes in innovation and entities that specialize in production. Second, Qualcomm entered into licenses with OEMs who committed to pay royalties on handset sales, producing a revenue stream that reflects Qualcomm's contribution to the mobile communications value chain. These relationships distributed CDMA technology throughout the U.S. and global markets, seeding adoption and challenging the incumbent TDMA standard.

The role of IPRs in supporting this innovation success story is two-fold. First, IPRs enabled Qualcomm to exchange valuable information with specialized wafer producers (and vice versa). This enabled massive savings in cost and time since Qualcomm avoided having to spend billions of dollars on constructing and operating production facilities. Second, IPRs, as implemented through contractual agreements, enabled Qualcomm to distribute its technology throughout the device production market, which seeded adoption, challenged the incumbent TDMA standard, and accelerated development of the wireless-enabled ecosystem.

As Qualcomm continued to invest in R&D and the accumulation of a patent portfolio to protect the results of that investment, its technologies became embedded in successive generations of wireless standards. These included the 3G standard that enabled mobile data services (such as email and web browsing) starting in the early-to-mid-2000s, the 4G/LTE standard that enabled the transmission of "rich media" starting in the early 2010s, and the 5G standard, launched in the late 2010s, that supports much of today's digital economy. Qualcomm relied on the revenue streams generated by licensing relationships with OEMs to sustain an iterative innovation platform where the development of next-generation technology took place concurrently with market deployment of current-generation technology. Consistent with the relationship between IP rights, market entry, and transactional choice, this secure IP portfolio also underpins the company's recent shift toward developing semiconductors and software-based solutions beyond wireless communications, encompassing the IoT, robotics, automotive, and AI-enabled sectors.

Solid State Batteries: QuantumScape

QuantumScape, founded in 2010 and based on research originating at Stanford University, develops solid-state lithium-metal battery technology designed to improve electric vehicle range, charging speed, and safety.[12] Rather than vertically integrating into automobile manufacturing or building battery plants on its own, QuantumScape has adopted a specialized innovation model focused on R&D investment and partnerships with battery manufacturers and automotive producers. Its core technological asset – a proprietary solid ceramic electrolyte separator – is protected through a substantial patent portfolio consisting of hundreds of patents and patent applications.

To commercialize this technology, QuantumScape has entered into a partnership with Volkswagen Group (specifically its battery subsidiary PowerCo SE), which contributes the capital-intensive production infrastructure, manufacturing expertise, and distribution relationships required to achieve scale-efficient commercialization. In this structure, QuantumScape retains its core intellectual property assets and grants a limited license to Volkswagen for production and commercialization, which in turn generates an up-front payment and royalties for the innovator.[13] This arrangement implements an efficient division of labor between an entity that specializes in the innovation layer of the EV battery tech stack and a manufacturer that specializes in the production and distribution layers. Structurally, it resembles the landmark transaction in biotech between Genentech, which supplied the core innovation, and Eli Lilly, which supplied the testing and manufacturing infrastructure and expertise to reach market.

The role of IP rights in this structure is two-fold. First, IPRs enable QuantumScape to share sensitive technical information with a large and sophisticated partner while mitigating knowledge leakage risks. Second, IP-backed contractual arrangements allow QuantumScape to monetize its innovation without assuming the fixed costs and operational risks of vertical integration. This model supports continued R&D while accelerating the diffusion of lithium battery technology by partnering with firms with existing production infrastructure and expertise.

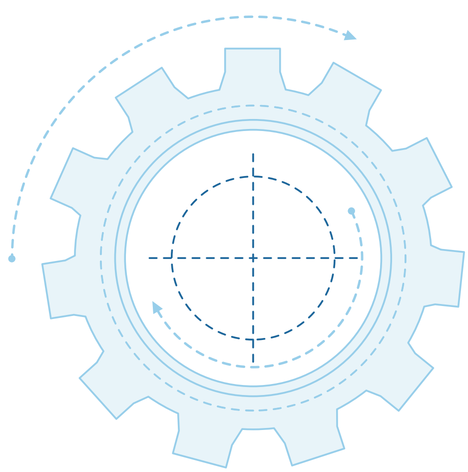
Quantum Computing: IonQ

IonQ, founded in 2015 by Dr. Chris Monroe and Dr. Jungsang Kim, develops trapped-ion quantum computing systems and associated software solutions.[14] The company's origins derive from core technology developed through research at the University of Maryland and Duke University, which license foundational technology to IonQ. IonQ relies on its extensive IP portfolio (as of August 2025, over 1,000 granted, licensed, or pending patents or patent applications[15]) to protect its core technology while competing against some of the largest firms in the world in the quantum computing market, including Alphabet, Microsoft, Nvidia, and IBM. Today IonQ, which currently has a market capitalization of about $12 billion, is one of the few independent companies with a significant presence in the quantum computing industry.

To enter this challenging market, IonQ adopted a partially disintegrated structure: it delivers access to its quantum computing systems to users in the enterprise, academic, and government sectors through partnerships with cloud-computing providers (AWS, Azure, and Google Cloud).[16] Additionally, it appears that IonQ designs hardware components, including ion traps and controls systems, while outsourcing production to specialized manufacturing entities. IonQ has also entered into co-development agreements to develop customized quantum applications for selected commercial and governmental partners.

Each of these business strategies involves some knowledge leakage risk or imitation risk – in particular, in the case of the relationships with AWS, Microsoft and Google who have significant internal quantum computing programs or systems that may compete with IonQ's computing system. IonQ's IP portfolio and related contractual safeguards enable these relationships by protecting against imitation and knowledge leakage risk and consequently permitted flexibility in determining the level of integration across the quantum technology stack. More recently, IonQ has pursued selective acquisitions in the semiconductor and networking layers of the quantum computing stack, in part for purposes of assembling a "trusted" U.S.-based quantum tech stack for the government and defense sector.[17]

Without its IP backstop, IonQ would likely have been compelled to adopt a more fully integrated model from the outset. This may not have been the most efficient monetization structure and may have been financially unviable, discouraging venture-capital investment and precluding entry altogether. The result: a quantum computing market reserved for large integrated incumbents that can maintain end-to-end innovation, production, and distribution pipelines. As a matter of both innovation and competition policy, that would have been an inferior outcome.



PART 2. HOW IPRS SUPPORT DECENTRALIZED MARKETS

Some commentators question whether robust IPRs are necessary to support innovation in technology markets given that some firms apparently can monetize R&D without significant reliance on these rights. The common example is large digital platforms, which rely on "giveaway" business models that provide zero-priced information services to consumers, which in turn drive ad-based sales to businesses. Yet this observation only shows that certain business models – specifically, cross-subsidization models favored by large multi-sided platforms – can capture returns on innovation without significant reliance on IPRs. That raises the possibility that weakening IPRs may adversely impact firms that rely on other business models for sustaining innovation – in particular, business models that are based on substantial investment in R&D followed by licensing and other contractual arrangements that monetize that investment by broadly diffusing the resulting technology across the market.

To appreciate this point, it is helpful to run a simple thought experiment.

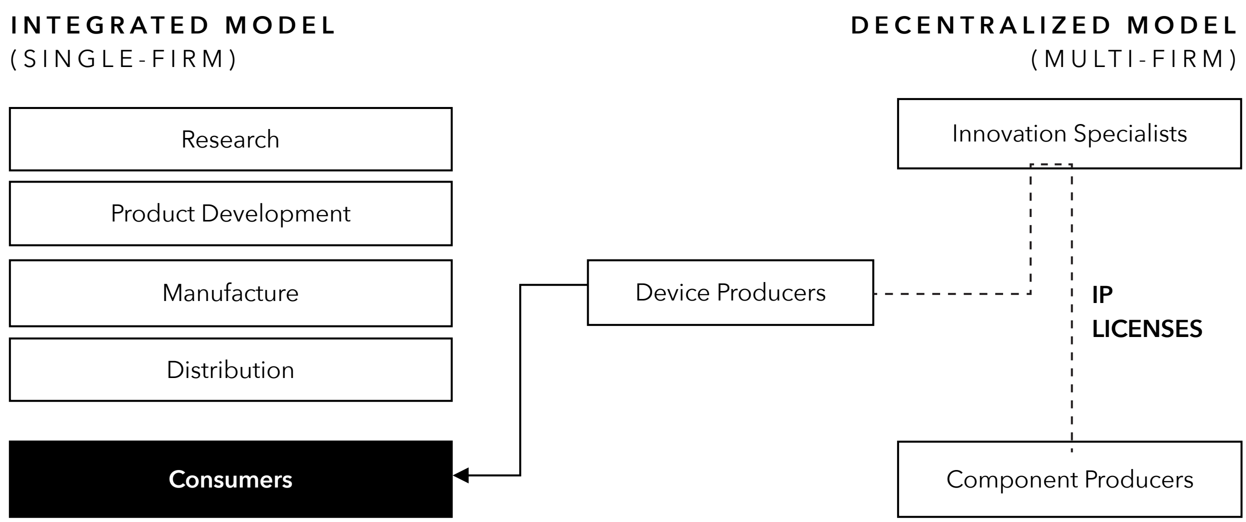
Suppose Dolby or Qualcomm at the startup stage had operated in an environment characterized by no or weak patent protections. Would each firm still have been able to monetize its novel technology? To do so, it would have been forced to integrate forward into production and embody technical knowledge through a production infrastructure that is difficult to replicate. In the semiconductor industry, this could amount to as much as tens of billions of dollars to construct a single fabrication facility, which does not include ongoing operating costs.[18] It is not clear that this would be a financially viable undertaking for a firm at its inception, in which case outside investment would not be forthcoming and market entry might never take place.

While a vertical integration strategy may sometimes be feasible for certain firms depending on capital availability and technical requirements, it is liable to result, if adopted widely, in a silo-based tech ecosystem where knowledge circulates principally within but not across competitors. Moreover, given a de facto requirement to vertically integrate to secure market entry, the number of competitors in the market would be greatly reduced. This is not a hypothetical possibility.

Prior to release of the IBM PC's modular architecture in the early 1980s, computer manufacturers such as DEC, IBM, and Wang typically offered closed systems that required enterprise users to commit to a single provider for all components.[19] This model is used today by only a handful of companies (notably, Apple's self-contained tech stack in personal computing).By contrast, IP-based licensing models that disaggregate innovation and production facilitate market entry and expand consumer choice by cultivating modular ecosystems that can sustain many innovators and larger numbers of device and component producers.

Hence, IPR-based monetization models, which rely significantly on licensing at various levels of the tech stack, tend to distribute technology more broadly among producers than models that do not depend on IP protection but rely on an integrated and hard-to-imitate production infrastructure to generate revenue. In the former case, "wealth" is spread among a large number of stakeholders at different levels of the tech supply chain; in the latter, it tends to concentrate in a small number of integrated walled gardens. Contrary to standard assumptions, IPRs, and the associated set of contractual relationships, tend to open up market structures, by facilitating entry at the innovation, device, and component segments of the tech stack. This intuition is depicted visually below.

Figure 3: Integrated v. Decentralized Business Models in Innovation Markets

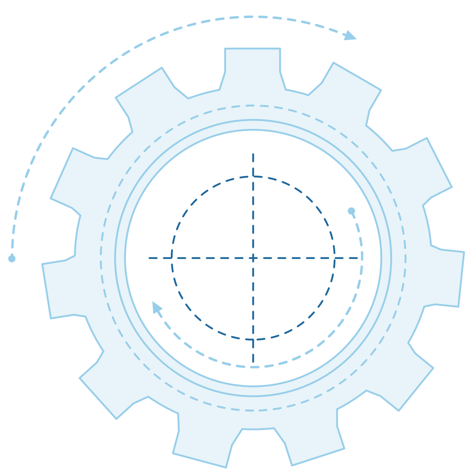


The wireless chip-design industry illustrates the favorable effect of secure IPRs on innovation, market structure, and competitive conditions.

As found by the U.S. Patent & Trademark Office (USPTO), a handful of chip-design firms supply the largest share of technological submissions to industry standards in this sector.[20] Those firms typically monetize their R&D investments through licensing transactions with a larger group of device and component producers around the world. This means that the wireless semiconductor market is constantly innovating and then sharing new technologies broadly among producers, which in turn embody those technologies in devices purchased by consumers. Remarkably, the total estimated royalties paid on average by OEMs to IP owners in the smartphone market account in total for about five percent of the end-user device price.[21] These findings – reached by multiple empirical researchers using different methodologies[22] – run contrary to widely repeated arguments that allege (usually based on models or anecdotal reports) that patent owners are in a position to impose an exorbitant "tax" on device producers and consumers in wireless-enabled device markets. To the contrary: it is producers and consumers – and an even broader pool of complementary product and service providers – that enjoy the largest share of the economic value being generated ultimately by R&D investments at the top of the tech supply chain.

These surprising relationships between IPRs, market structure, and competitive conditions run counter to the common assumption that protecting IPRs "closes down" markets, impeding entry and enabling incumbents to inflate prices. At least in some tech sectors, the opposite is the case — IPRs open up markets that would otherwise be dominated by a handful of integrated entities and, in doing so, propel the development of complementary products and services throughout the tech and tech-enabled ecosystem.

Secure IPRs, and reliable enforcement of licenses and other IPR-dependent contracts, not only encourage innovation but facilitate market entry by enabling firms that specialize in R&D to outsource production and enter at a lower cost and shorter timeline. This also lowers entry costs for OEMs located at the production layer of the supply chain since they can secure the required tech assets through IP licenses rather than incurring R&D costs directly. The same is true for firms that supply complementary products and services that enhance the value of the core technology as it is applied across an expanding range of commercial sectors. Ultimately consumers benefit from a continuous flow of technological innovation, enhanced competition in device production, development of complementary products and services, and, as has been demonstrated in a broad range of U.S. electronics markets, expanding output and declining quality-adjusted prices.[23] These are all classic hallmarks of a competitive and innovative market.



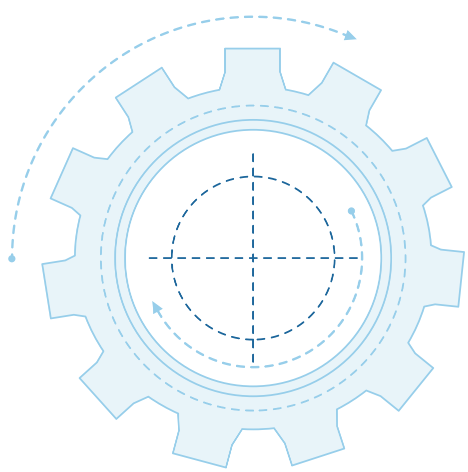
PART 3. HOW IPRS SUPPORT DISRUPTIVE INNOVATION

It might be questioned why innovation policy should seek to preserve the IP-intensive business models favored by firms, both large and small, that specialize in R&D activities but elect not to integrate forward into production and distribution (or may do so only on a targeted basis).Put differently: what is the public interest in sustaining the viability of idea factories in knowledge ecosystems? The answer is that entities such as Edison's idea factory at Menlo Park and its many descendants in tech clusters throughout the U.S. and the world play a critical function in the most robust tech economies. Specifically, theoretical models, business history, and empirical evidence, all tend to show that innovation specialists (large and small) play key roles as disruptors in innovation ecosystems, pushing forward the technological frontier, and challenging the inherent conservatism that characterizes many incumbents.

Management scholarship has identified the critical function played by vertically disintegrated innovation specialists by investing continuously in R&D, which yields innovations that are then distributed through licensing and other transactions in the production and distribution layers of the supply chain.[24] Through these structured information flows among a broad range of stakeholders in the innovation ecosystem, new technologies developed by innovation specialists can influence and disrupt the architecture of the tech stack. [25] In turn, that may invite disruption by device and component makers within specific layers of the tech stack – a highly elaborated form of the creative destruction cycle that delivers new products to consumers and creates new wealth-generation opportunities for a broad range of stakeholders.

IPRs, and the contracts grounded in IPRs, are critical to this process since the upstream idea factory must have a means to structure information exchange with downstream implementers and capture some value – based on empirical research in the smartphone industry, a relatively small portion[26] – from the broader ecosystem that its technologies enable and cultivate. Firms such as ARM, Dolby, and Qualcomm, among others, invest heavily in R&D, rely on industry-wide IP licenses to monetize that investment, and, through adoption of a new technology standard to which they have contributed, can then influence the industry architecture by licensing core technologies to implementers throughout the device and component layers of the tech ecosystem. This market-multiplier effect can be powerful. The diffusion of the 4G/LTE wireless standard through licenses to device producers, resulting in the reliable and rapid transmission of a wide range of audio, video, and visual media, in turn enabled the development of business models and even industries that would not otherwise have been feasible.

Without 4G/LTE technology (now improved further by 5G technology), widely used services such as app-based transportation (such as Uber), app-based food delivery (such as DoorDash), and peer-to-peer accommodation platforms (such as AirBNB) would not be feasible. These are only a few examples of IP-enabled business models that have increased user convenience and product and services variety. Through the "behind the scenes" licensing relationships that connect innovators with implementers, the technological paradigm is constantly being updated in an iterative cycle — the sign of a high-performing knowledge-driven economy. Critically, none of this would be possible without a secure IP infrastructure, and the expectation that contracts grounded in IP rights will be reliably enforced, that supports the revenue streams necessary to deliver returns that reflect the costs and risks borne by innovation specialists.



PART 4. HOW IPRS SUPPORT STANDARDS AND INTEROPERABILITY

Today it is taken for granted that any smartphone device can "talk with" another smartphone device, or that any printer can "talk with" any laptop or desktop device. Yet it is often overlooked that the ubiquitous interoperability that characterizes information technology markets relies on a complex institutional and contractual infrastructure — essentially, the "plumbing behind the walls" — that relies on robust enforcement of IPRs and IP licenses.

Standardization in U.S. tech markets generally arises through standard-development organizations (SDOs), rather than being imposed by a government agency or a dominant monopoly. SDOs rely on the voluntary participation of innovators, implementers, and research institutions to establish a common standard and then work continuously to develop new standards that push forward the technology frontier. In certain technology sectors, it is innovation specialists that are among the most significant contributors of personnel and technology in the standard-development process. As documented in a 2022 report by the USPTO, three of the six largest owners of standard-essential patents declared essential to the 5G wireless standard are innovation specialists (Qualcomm, Ericsson, and Nokia) that dedicate significant resources to R&D and lack internal chip production capacities.[27]

Multiple technology standards have been established and adopted through these cooperative structures, including Bluetooth, Blu-ray, Wi-Fi, USB, LAN, and audio and video codecs. The technologies embedded in those standards are then disseminated through a complex network of licensing transactions, whether bilateral licenses, cross-licensing, or patent-pooling structures, among innovators (who are typically licensors) and implementers (who are typically licensees).[28] While largely unobserved by the public, these licensing and pooling structures play a critical function in promoting adoption of the relevant standard, which is a precondition for achieving interoperability, and in preserving incentives for firms (especially innovation specialists) to participate in the standard-development process.

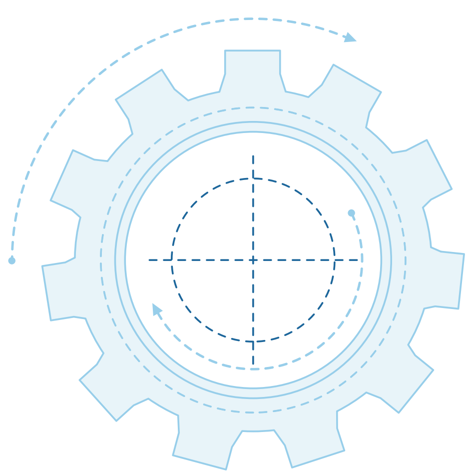
IPRs play three critical roles in sustaining the standard-development process, which in turn preserves the interoperability that characterizes information technology markets and, indirectly, facilitates entry by device and component producers in those markets.

- IPRs protect participants in SDOs from the knowledge leakage risk that arises from the fact that the SDO process necessitates the disclosure of valuable information to actual or potential rivals through technical submissions and other channels.

- IPRs provide assurance that, if a firm's technology is incorporated into the standard, manufacturers of standard-compliant devices will enter into licenses that deliver remuneration to the firms that invested in developing that technology.

- IPRs underlie the licensing transactions that deploy standardized technologies, which in turn promote user adoption and drive the revenue streams that motivate continued participation by innovator specialists in standardization initiatives.

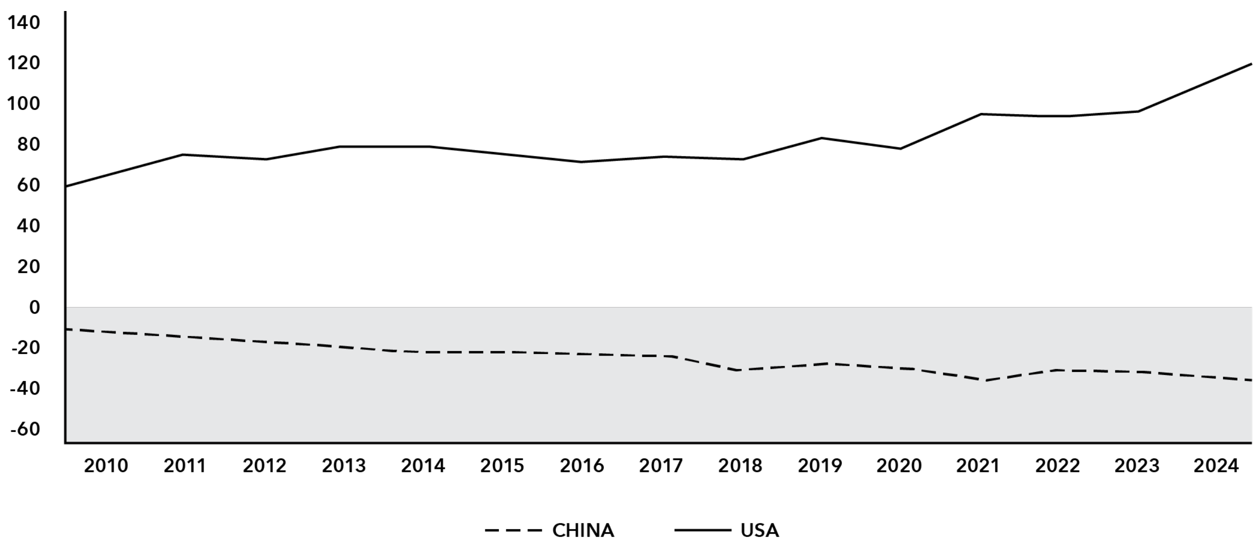
In short: IPRs enable firms to disclose technology in the SDO process and, once the standard is established, to capture returns from implementer-licensees who adopt the standard and underlying IP-protected technology. Without a robust IPR infrastructure, firms would likely have weak incentives to continue participating in the SDO process – especially innovation specialists that rely on licensing revenues – and current interoperability levels would be placed at risk. If standards were not regularly updated or widely adopted, users would continue to search for interoperability solutions, which could only be achieved either by cross-licensing among a small number of large integrated firms or a dominant standard offered by a single company. Compared to a competitive market that operates under a well-functioning SDO and associated licensing structures that facilitate entry by innovation specialists and distribute technology broadly among thousands of device and component producers, either outcome (oligopoly or monopoly) is inferior as a matter of competition policy.



PART 5. HOW IPRS SUPPORT U.S. AND ALLIED TECH LEADERSHIP

While the U.S. stands in a trade deficit with the rest of the world, it has long enjoyed a significant IP trade surplus. Based on the difference between in-licensing and out-licensing income, the U.S. had a trade surplus of $115 billion as of 2024, which has been growing since at least 2005, and especially since 2020.[29] This trend even understates the size of the IP trade surplus since these figures only measure IP assets transferred through formal licensing and other agreements and ignore IP assets embodied in physical goods or software. As a point of reference, China had a $35.7 billion IP trade deficit in 2024, which has been growing since at least 2005. [30] Hence the U.S. tech economy can be understood as the world's "idea factory," for which IP rights are a crown-jewel asset that drives the economic leadership of U.S. companies throughout the world.

Figure 4: Trade Balance of Intellectual Property, 2010-2024 (USD billions)



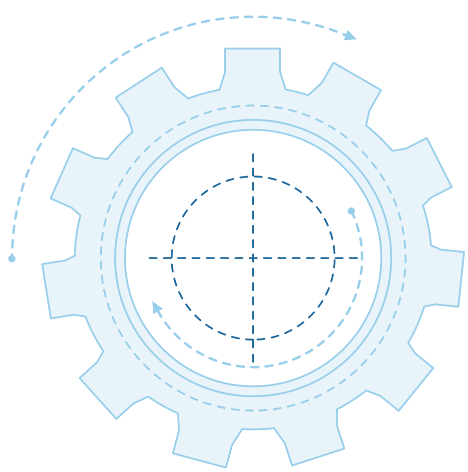
To understand the extent to which the technological leadership of the U.S. and its allies relies on secure IP rights, it is helpful to consider the mobile communications industry and the broader wireless-enabled ecosystem.

As noted previously, a handful of firms in this industry, located primarily in the U.S. and allied countries in Europe have led technological innovation since the industry's inception. Each of these firms (Arm, Ericsson, Nokia, and Qualcomm) has relied substantially on an IP-dependent monetization strategy that generates revenues through licensing agreements with device manufacturers, component suppliers, and chip designers. In the 5G wireless market, there is substantial overlap among firms that lead in R&D intensity, technical submissions to SDOs, and granted patents in this technology sector.[31] As documented in the aforementioned 2022 report by the USPTO, Qualcomm, Ericsson, and Nokia are among the largest holders of 5G wireless communications standards, in addition to Samsung (located in Korea) and Huawei (located in China), which largely rely on vertically integrated business models. When adjusted for quality metrics, they (together with Samsung) are the industry leaders.[32]

In a weak-IP environment, licensing-dependent firms located in the U.S. and Europe would operate at a considerable disadvantage to firms that operate under vertically integrated structures where IP is monetized by being embedded in a bundled suite of devices, services, and infrastructure. That is because an integrated firm primarily derives revenue from sales at other layers in the tech stack (rather than licensing revenues) and hence has a weaker interest (if any) in robust patent protection. Among all leading firms, Huawei already executes this integration strategy through an end-to-end tech stack ranging from telecommunications infrastructure through mobile communications devices. It is therefore not especially dependent on a secure IP-enforcement infrastructure and, like large tech platforms that similarly offer integrated service ecosystems, can be expected to perform well in a weak-IP environment.

From a national competitiveness perspective, any policy action that weakens IPR protections in the information and communications technology sectors runs counter to the U.S. interest in a secure tech supply chain.

In a weak-IP environment, innovation specialists that play key roles in the global tech economy would have reduced incentives to participate in the SDO process, reducing the influence of U.S. companies on the outcome of that process, and potentially ceding influence to vertically integrated China-based firms. Just as innovation specialists can influence the architecture of a segment-specific tech stack through licensing transactions, so too innovation specialists can influence the architecture of the global tech economy through the standards development process. This is especially the case for the handful of R&D-intensive firms, all located in the U.S. and allied countries, that have led advancements in the strategically critical wireless communications industry. More broadly, a lax commitment by U.S. government agencies to secure international enforcement of patent and IP rights impedes the ability of U.S.-based firms to influence global standards adoption through licensing transactions, again ceding ground to China-based firms that do so through integrated and scale-based business models.



CONCLUSION

Innovation specialists play a vital and overlooked role by providing the intellectual fuel that stimulates the process of creative destruction that characterizes the most robust technology ecosystem. In industries ranging from biotechnology to information technology, robust IPRs support IP-based licensing and other transactional structures that generate value by enabling transactions that connect firms that excel in innovation with firms that excel in financing, production, and distribution. Together these symbiotic relationships drive the circulation of knowledge among a broad ecosystem of device producers, component developers, and ultimately, as embedded in products and services, consumers. Concurrently, IPRs support the incentives and capacities of innovation specialists to contribute to standardization processes that drive interoperability and facilitate entry in the implementation layers of the tech ecosystem. These favorable effects of IPRs on innovation and competition ultimately promote the leadership of U.S. and allied companies in the global tech marketplace.

NOTES

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[5] Jonathan M. Barnett, Innovators, Firms, and Markets: The Organizational Logic of Intellectual Property 105-113 (2021).

[6] On semiconductors, see Alexander Galetovic, *Patents in the History of the Semiconductor Industry: The Ricardian Hypothesis,* in THE BATTLE OVER PATENTS: HISTORY AND POLITICS OF INNOVATION 27-68 (eds. Stephen H. Haber & Naomi Lamoreaux 2021), Barnett, *Intellectual Property as a Law of Organization, supra* note 3; and Rosemarie Ziedonis and Bronwyn H. Hall, *The Effects of Strengthening Patent Rights on Firms Engaged in Cumulative Innovation: Insights from the Semiconductor Industry,* in ENTREPRENEURIAL INPUTS AND OUTCOMES: NEW STUDIES OF ENTREPRENEURSHIP IN THE UNITED STATES 133-87 (ed. Gary Libecap 2001), and Peter C. Grindley & David J. Teece, *Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics*, 39 CAL. MGMT. REV. 8, 8–12, 30–34 (1997). On biotech, see Ashish Arora, Alfonso Gambardella, Fabio Pammolli & Massimo Riccaboni, *The Nature and the Extent of the Market for Technology in Biopharmaceuticals*, in R&D, INNOVATION AND COMPETITIVENESS IN THE EUROPEAN CHEMICAL INDUSTRY (eds. Fabrizio Cesaroni, Alfonso Gambardella, and Walter A. Garcia-Fontes eds. 2004); Caroline Haeussler, Dietmar Harhoff & Elisabeth Mueller, *How patenting informs VC investors – the case of biotechnology,* 43 RES. POL'Y 1286 (2014); Gary P. Pisano, *The Governance of Innovation: Vertical Integration and Collaborative Arrangements in the Biotechnology Industry,* 20 RES. POL'Y 237, 245 (1991).

[7] OLIVER E. WILLIAMSON, MARKETS AND HIERARCHIES: ANALYSIS AND ANTITRUST IMPLICATIONS 122 (1975) ("Innovative activity is handicapped by the bureaucratic processes of large organizations… whereas standardized activities benefit from administrative control and scale economies"); ALFRED D. CHANDLER JR., SCALE AND SCOPE: THE DYNAMICS OF INDUSTRIAL CAPITALISM 6–7 (1990) ("Modern industrial enterprises first achieved competitive advantage when they invested simultaneously in large-scale production, distribution, and managerial coordination").

[8] Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, in THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609-626 (1962). On the role of IP rights and licensing in facilitating this division of labor, see Jonathan M. Barnett, *Why Is Everyone Afraid of IP Licensing?*, 31 HARV. J.L. & TECH. 127, 134–35 (2017) (explaining how enforceable IP rights and licensing agreements enable upstream specialists to monetize R&D through licensing arrangements with downstream implementers).

[9] Thomas J. Chemmanur, Xi Chen & Jingxuan Zhang, *The Economics of Patent Licensing: An Empirical Analysis of the Determinants and Consequences of Patent Licensing Transactions* 31 (July 2024), (https://afajof.org/management/viewp.php?n=133532 (finding that licensors increase R&D activities and patent applications following licensing transactions, which suggests that some licensing revenues are being reinvested in R&D and enhancing innovation productivity).

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[12] This section reflects information disclosed in QuantumScape Corporation, Schedule 14A, Notice of Annual Meeting of Stockholders and Proxy Statement 2 (June 4, 2025); QuantumScape, QuantumScape Story, https://www.quantumscape.com/company/; Chris Bryant, *Stanford Scientists Create a Billionaire Factory,* Bloomberg, Dec. 29, 2020, https://www.bloomberg.com/opinion/articles/2020-12-29/stanford-scientists-create-a-billionaire-factory-from-quantumscape-batteries

[13] QuantumScape Corporation, Schedule 14A, Notice of Annual Meeting of Stockholders and Proxy Statement 2 (June 4, 2025), at 64 (describing Collaboration Agreement and IP License Agreement); *Volkswagen, QuantumScape Strike Deal on Solid-State Batteries*, REUTERS (July 11, 2024).

[14] This section reflects information disclosed in IonQ, Inc., Annual Report (Form 10-K 2024), at 4–5, 12-13, 14-15, 41-45; IonQ, About IonQ, https://www.ionq.com/company.

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[18] David Shepardson & Jane Lee, *Intel's $20 bln Ohio factory could become world's largest chip plant,* REUTERS, Jan. 22, 2022 (Intel spending estimate $20 billion on new chip production facility); David Shepardson & Steve Holland, *Trump and TSMC announce $100 billion plan to build five new factories,* REUTERS, Mar. 4, 2025 (TSMC planning to spend $100 billion on five new chip factories).

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[27] U.S. Patent & Trademark Office, *supra* note 20.

[28] For a comprehensive empirical study, see Jonathan M. Barnett, From Patent Thickets to Patent Networks: The Legal Infrastructure of the Digital Economy, 55 JURIMETRICS 1 (2014).

[29] Author's calculations, based on World Bank Group, Charges for the use of intellectual property (Balance of Payments Statistics Yearbook and data files, International Monetary Fund).

[30] Id.

[31] Jonathan M. Barnett, Antitrust Overreach: Undoing Cooperative Standardization in the Digital Economy, 25 MICH. TECH. L. REV. 163, 197, Tbl. 4 (2019).

[32] U.S. Patent & Trademark Office, *supra* note 20**.** When adjusted for various measures of patent quality, the report found that Huawei tends to lag behind other firms that lead in 5G-related patenting activity at major patent offices (US, EU, and Japan).

DISCLOSURE

This report was prepared by Prof. Jonathan Barnett on behalf of ICP Analytics LLC, an independent research consultancy commissioned by Dolby Laboratories, Inc.The views in this report solely reflect those of ICP Analytics LLC.

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