INDUSTRIES AND ECOSYSTEMS

Individual firms operate in *industries* that are embedded in *ecosystems*. This brief will illuminate these two fundamental concepts. Firms in some settings can exert great influence on their ecosystem. Implications follow for firm-level strategy, valuation analysis, and public policy.

1. INTRODUCTION

Analysis of industries is relatively straightforward. Using *line-and-box* charts can illuminate transactions, flows of funds, and how individual firms are organized. Line-and-box charts also reveal that some firms are more vertically integrated than others that procure goods and services from other firms in the industry.

Analysis of ecosystems, by contrast, is not straightforward. Despite a substantial literature *describing* various types of ecosystems, how ecosystems *develop* is not well understood. Individual firms nevertheless need to anticipate and adjust to changes in the ecosystem.

This brief is organized as follows: In Section 2 our discussion of industries emphasizes the importance of understanding contractual relationships – both explicit and implicit – among industry participants. In Section 3 we turn to ecosystems, starting with "the most important" ecosystem in human history. In this section we also consider the types of ecosystems and factors that are typically present, including the ability of participants to observe the actions of others and significance of investments in specific assets and human capital. In Section 4, we consider the strategies related to ecosystems. In Section 5, we discuss the important example of EV charging infrastructure in the US.

2. INDUSTRIES

Transactions are at the core of economic activities. John R. Commons, who was a leading institutional economist during the first half of the 20th century, formulated the problem of economic organization as follows: "The ultimate unit of activity … must contain in itself the three principles of conflict, mutuality, and order. This unit is a transaction" (Commons, 1932, p. 4). Commons recommended that "theories of economics center on transactions and working rules, on problems of organization, and on the … [ways] the organization of activity is … stabilized (1950, p. 21)." His point is simple: With transactions, inputs are purchased, generating revenue for suppliers and resulting in costs for the downstream purchaser. A license agreement to share IP does the same.

Myriads of transactions happen every day, whereby goods, services and financial instruments are exchanged among market participants. Building on Adam Smith's insight from the Wealth of Nations (1776) that the extent of the market influences the extent of specialization of firms and labor, George Stigler (Nobel 1992) explored how specialized activities triggered the creation of firms and the development of industries.

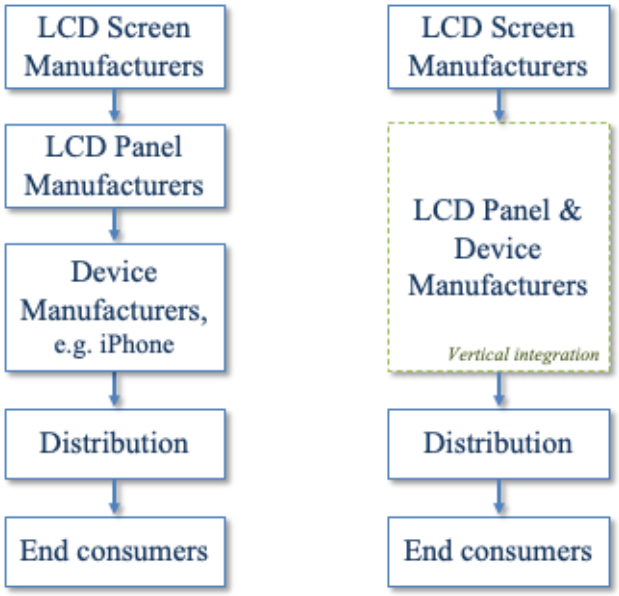
In this light, industries can be viewed as organizing participants and transactions in the production of a set of goods and services purchased by end consumers. How particular industries are organized – whether they involve large vertically integrated firms or a myriad of transactions among diffuse firms – reflects the importance of various types of economies and the difficulty of various governance problems. Firms decide what to make and what to buy as well as how much to invest, how much to produce, how their products and services will be differentiated and how they will be marketed, distributed and priced.

What drives these decisions about the scope of firms in an industry? Ronald Coase (Nobel 1991) and Oliver Williamson (Nobel 2009) focused on the "transactions costs" of using external suppliers, manufacturers, and distributors, etc. relative to the costs of organizing activities inside firms. In high-tech settings, one should focus on investments in know-how that are *specific*[5]. In general, when investments are large and specific, it becomes relatively more difficult to use external suppliers. When firms do so, long-term contracts are often required.

Line-and-box charts are excellent tools for analyzing industries. Within the boxes are either individual firms or firms of a given type. The lines between boxes represent transactions. Goods and services flow down the chart to end consumers. Such charts and accompanying information are excellent tools for organizing information about valuations. Companies, for example, often like to emphasize their roles as technology companies and deemphasize their non-technology lines of business.[6] Doing so tends to increase valuations.

For the LCD industry, depicted below, the top box represents manufacturers of screens. Differences in the extent of vertical integration and, therefore, the number of intermediaries can be reflected in the charts. Note that the right side of the chart below shows that some firms manufacture both LCD panels and the devices that embody panels, e.g., monitors, smart devices, computers, and televisions. That reduces the number of external transactions involving intermediaries by one.[7] Other important firm strategies can be identified in the charts, e.g., whether individual device manufacturers sole-source their inputs or multi-source. Another twist: individual device manufacturers, e.g., Toshiba, may be partially vertically integrated into LCD panels, whereby they have internal sources of supply, but also use outside suppliers. That means that such a firm is both a competitor to rival input suppliers and a customer of these same firms.

Figure 1. Liquid-crystal display industry: completely independent players vs. vertically integrated (illustrative)



Looking across high-tech firms, one sees many examples of efforts to realize economies and expand their operations:

- Didi (initially ride-sharing) moved into taxis, bike sharing, enterprise solutions, and food delivery.

- The early success of Dell Computers was due to then CEO Michael Dell's decision to sell computers direct to consumers, cutting out retailers.

- Netflix moved into its own production of video content.

- IBM and many others are investing in AI capabilities.

One might ask, which high-tech firms have expanded the scope of their activities the most? It appears that firms like Alibaba, Alphabet (Google), Amazon, Apple, Baidu, JD.com, Microsoft, and Tencent have expanded their activities in more dramatic fashion:

- Several of these, e.g., Alibaba, Apple, Amazon, and Tencent have entered *payment systems*.

- Several of these, e.g., Alibaba, Amazon, Microsoft, offer business services such as cloud computing.

- Tencent, originally the provider of free PC-based instant messaging software, is now an integrated platform for eCommerce, gaming, payments, and, of course, communication.

- Meta, which sells advertising on websites and various mobile applications, is investing in its Libra cryptocurrency, AI, and augmented reality capabilities that will use 5G.

- Amazon, originally a platform for bookselling, has moved to a "one-stop shop" for virtually everything and has vertically integrated into distribution.

Regarding the last example, consider that Amazon started out as an on-line book seller:

Figure 2. Line-and-Box for Amazon when it was a book seller.

Amazon now has one of the most complex line-and-box charts in the history of business. Its many strategic decisions include (i) broadening its eCommerce product lines to other goods, e.g., video, clothing, furniture, and household goods, (ii) publishing its own books, (iii) vertically integrating downward into distribution with, for example, warehouses, (iv) acquiring Whole Foods and pushing on-line grocery sales, (v) adding Prime Video, (vi) entering cloud computing, (vii) adding digital advertising, (viii) contractually integrating with some suppliers on its core eCommerce platform, (ix) the expected development of its own satellite communications system. An expanded set of line-and-box charts for Amazon would identify its revenue streams and allow to assess its major competitors by line of business.

3. ECOSYSTEMS

As indicated at the outset, our understanding of ecosystems is far from complete. When confronted with a lack of understanding about phenomena, often a good place is to consider what was the first example and try to figure out why it occurred. That approach takes from business to human history, but the detour is useful.

A. The Most Important Ecosystem in Human History

While the Earth's environment is full of biological ecosystems,[1] we also observe the development of ecosystems among animals. Some of these ecosystems involve species that are *eusocial.* These species include bees, wasps, ants, and, of course, humans.

[1] The marine ecosystem covering most of the earth is incredibly complex with everything from tiny plankton, elaborate plant life, coral reefs, fish, mammals, birds, and natural elements like carbon dioxide and salt (SEG Wiki, 2020). Some natural mechanisms help, to a point, keep an ecosystem in balance.

According to Nicola Plowes (2010), eusocial species are different from the other more than 8 million species on earth because they exhibit these characteristics:

i. Adults live in groups;
ii. Adults cooperate in care of offspring;
iii. Labor is specialized, e.g., not all individuals get to reproduce; and
iv. Activities are organized across overlapping generations.

Eusocial species also exhibit the ability to create new colonies. In the case of leaf-cutter ants, which, after humans form the largest and most complex animal societies, when a young queen ant wins the battle with others, she carries a special mycelium in a pocket of her mouth to start a fungus garden, from which a central mound of a new colony can grow to more than 30 meters across. (Hence, leaf-cutter ant colony could easily take over the courtyard in Yale SOM's Evans Hall. Imagine ten million ants divided up into castes of defenders, foragers, and gardeners).

What about humans? Despite being relatively slow and big, the ancestors of humans survived over 10 million years because of a wonderful interplay of cooperation and competition.[2] Some groups of hominids learned how to track their prey, wearing them out by running 10, 20, or 30 miles. When they caught a big hunk of protein, they shared the bounty. At different times and places, hominids learned how to make fire, move it around, and cook meat to make it last longer. With marathon running, fires and other innovations, Homo Sapiens burst onto the scene about 300,000 years ago – a virtual nano-second in the 3.5 billion-year history of life on earth. Humans spread out of Africa and, as they did, made steady progress in how and what they hunted and gathered.[11]

Then, about 12,000 years ago, came the development of the most important ecosystem in human history: *farming*. Discovery of methods to cultivate grain, improvements of techniques, storage, irrigation, and subsequent collocation of farm animals together enabled the shift from a hunter-gathering society to a settled one, a transition that enabled foundation of modern societies (Harari, 2014).

One can imagine how one observed activity led to another. Rather than collect grains from afar, humans figured out that it was advantageous to plant grains close to villages. Then, why not feed grain to cattle? Then, why not find a way to irrigate the plants and provide water to the cattle? Why not adopt standard protocols and systems for these processes?

This look back at human history suggests that ecosystems involve:

i. Cooperation and competition.
ii. Observability of actions, which prompts complementary actions.
iii. Investments in specific assets, including both infrastructure and human capital.
iv. Potential standardization of assets and equipment to realize efficiencies in production.

[2] Evolutionary scientists H.K. Reeve and Bert Hölldobler emphasize the balance between cooperation across specialized groups as well as internal competitions, what they call "tug of wars" (Reeve & Hölldobler, 2007).

B. Categories of Ecosystems and their Characteristics

When participants in business ecosystems observe the activities of others, they may identify potential complementarities or opportunities to compete more effectively. Observability can also lead to convergence of practices. A contract between a developer of video content and a distributor of content that effectively aligns incentives to produce "hits" may influence future contracts between other parties.

Because both observability and interactions are important, ecosystems often may have a *geographic* aspect to them. Examples include China's River Delta, Silicon Valley, and biotech in Boston, and Israel (start-up nation).

According to Pidun et al. (2019), several characteristics of ecosystems make them different from other means of organizing economic activity, including (i) modularity, (ii) customization, (iii) multilateralism, and (iv) coordination. Regarding modularity, independently designed components provide customers with the choice. Customization results from participants making specific investments, e.g., mobile app developers writing different code for the Android platform and iOS platforms. Regarding multilateralism, relationships and transactions among some stakeholders can be affected by relationships between other stakeholders.

While individual firms exert influence on ecosystems, most do not have formal hierarchical controls. Coordination mechanisms involve rules, processes or standards, such as application programming interfaces (APIs) in digital platforms. Indeed, one often sees standard-setting processes embedded in ecosystems.

The classification below identifies various types of ecosystems:

1. Entrepreneurial / Start-up: These ecosystems include entrepreneurs, technology experts, business developers, venture capitalists, etc. Geographical dimension of these ecosystems means that participants interact with each other, and their actions are visible to and impact others.

2. Sector-based: Centered around a specific sector of the economy, this type includes stakeholders from the sector. In case of the life sciences / biotechnology sector, these would be e.g., hospitals, universities, faculty, students, physicians, pharma companies, technology companies, entrepreneurs.

3. Industry-focused: These ecosystems originate in traditional industries, and over time have evolved into complex networks, involving many stakeholders. In case of the German luxury automobiles, these would be parts manufacturers, vehicle manufacturers, engineers, the government.

4. Function-based: Rooted in specific functions, these ecosystems attract stakeholders with functional expertise, e.g., developers, researchers, content providers.

5. Company-based: Originally focused around a single company's products, these ecosystems connect an array of business partners to advance increasingly complex offerings.

   In the case of Xiaomi, these include its smartphones (introduced in 2010), laptops, internet services, mobile apps, an array of consumer goods.

   In the case of IBM, these include the Watson IoT solutions, IBM's approach to virtual office and Cloud Systems.

In both cases, the company invests in smaller enterprises that are complementary to their businesses.

6. Platform-based: These include ecosystems around Apple iOS or Linux OS, Sony PlayStation, Microsoft XBOX. Centered around the platform, these ecosystems connect developers, data security experts, users, software engineers, app developers, suppliers of inputs, device manufacturers, users, payment system providers.

Ecosystems of the first four types listed above do not fit into "line and box" charts. To some extent, company-based and platform-based ecosystems fit into line-and-box charts because the overall ecosystem is more tightly organized. Consider this incomplete depiction of the iOS ecosystem:

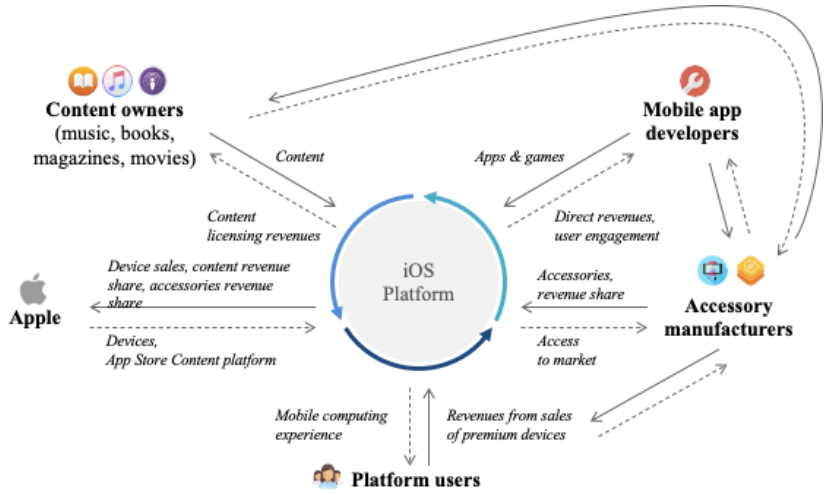


Figure 3. Apple iOS platform ecosystem (illustrative)

Apple's operating system is embodied in various devices that are sold to consumers. The density of users attracts mobile app developers and the supply of various types of content. Given that iOS is proprietary, Apple mobile app developers access the users through Apple's App Store. Missing from this depiction are (i) Apple's role as a content developer, (ii) Apple's role in collecting information about users and what content, e.g., games, is successful, and (iii) the role of governments in protecting intellectual property, defining rules for acquisitions, and regulating the collection and distribution of personal information.

Over the years, Tencent has built a robust cloud-based digital ecosystem, enabling it to launch operations and successfully compete in an increasing number of industries such as gaming, messaging, eCommerce, payments, online groceries, manufacturing, parcel delivery, health, pharmacy, etc.

4. STRATEGIES RELATED TO ECOSYSTEMS

James F. Moore, a respected scholar of business systems, authored The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems in 1966.

Moore made the important point that the traditional approach to strategy – focusing on the industry and the production of products and services within a narrowly defined set of competitors – is incomplete.

His claim, however, about the death of competition is not correct. Ecosystems broaden the strategic choices for a firm, but they do not eliminate competition. A key issue is how to lead and realize the advantages of being central to an ecosystem? (See the diagram for Amazon below for an example.)

Figure 4. Current Amazon's ecosystem. Source: https://files.pitchbook.com/website/files/png/amazon_ft.png

An issue for non-leaders is how to optimize their participation in ecosystems. Analysis of these issues has not yielded clear insights. One reason is that enterprises can be both suppliers and customers to others, both horizontal competitors and parties to vertical relationships.

Another relevant factor for strategy is the speed with which both are transforming. Historically, the process of industries merging, or organically evolving to embrace different kinds of activities, has been happening at a much slower pace than the ecosystems do today. Data-enabled partnerships and business models are the main reason for this shift (McKinsey Quarterly, 2017). As the pace of change accelerates, it becomes more difficult for enterprises to keep up with additions to ecosystems, as is the case for Tencent's WeChat Ecosystem.

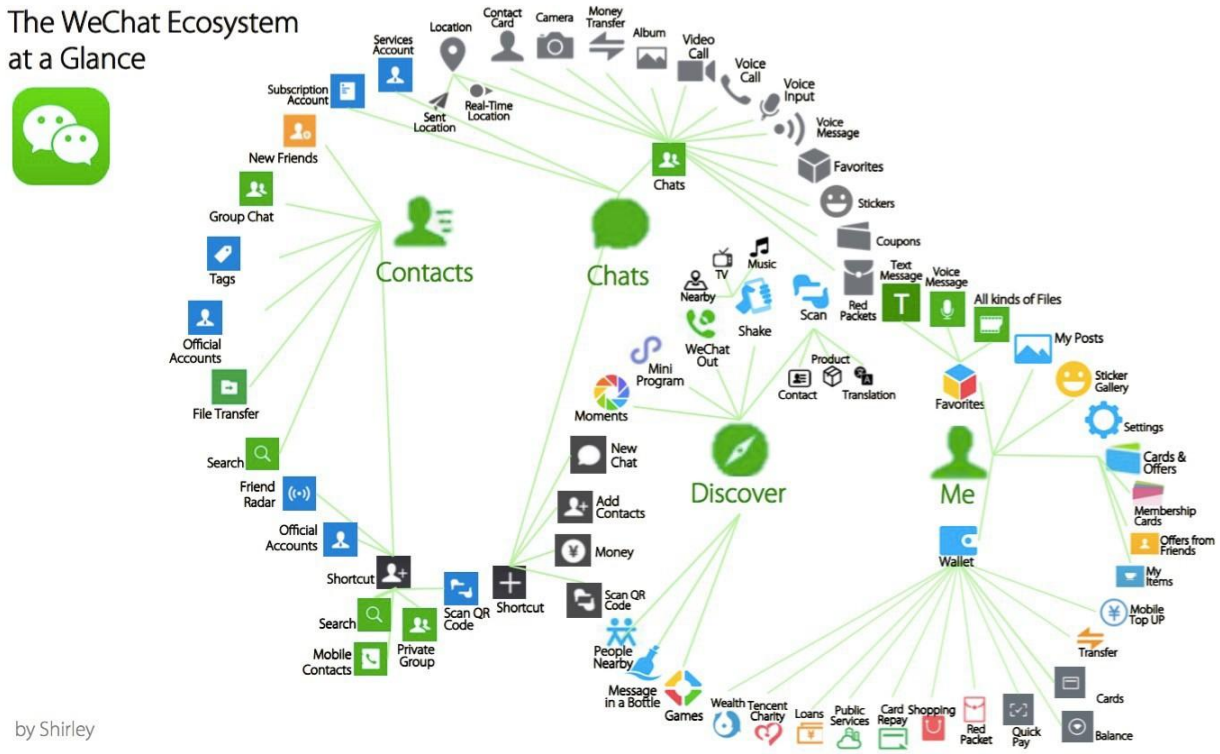


Figure 5. Source: https://www.linkedin.com/pulse/wechat-ecosystem-glance-shirley-deng/

One insight is that an important dimension of strategy is the firm's relationships with other members of their ecosystem. Of note, some expect that the economy will distill into twelve large ecosystems, distributing all the goods and services (McKinsey Quarterly, 2017). Modern day corporate strategies need to take into account both the industry (suppliers, employees, customers, investors, owners of IP), and focus on shaping the ecosystem, bringing together partners, establishing rules for collaboration, and flexibly changing direction when necessary. The impact an individual company can have on an ecosystem will vary, but all firms need to anticipate and respond to changes in ecosystems. Companies that fail to react to the changing environment lose. For example, Nokia, failed to keep up with changes in the mobile devices ecosystems.[3] Similarly, Microsoft and Intel were late to react to the shift to mobility.

Going forward, two changes will command the attention of individual firms throughout the high-tech sector: (i) the advent of 5G standard in mobile connectivity, (ii) the potential development of regional ecosystems as a result of rising global tensions. We can also expect policy changes to influence the development of ecosystems. Historically, Silicon Valley entrepreneurs could develop new businesses with funding by VCs, build out businesses to the threshold of viability, and then exit via acquisition. This ecosystem could change due to stricter M&A policy.

[3] Nokia's CEO Stephen Elop stated in 2011: "Our competitors aren't taking our market share with devices; they are taking our market share with an entire ecosystem. […] The first iPhone shipped in 2007, and we still don't have a product that is close to their experience. Android came on the scene just over 2 years ago, and this week they took our leadership position in smartphone volumes. Unbelievable." (Ziegler, 2011)

5. EV CHARGING INFRASTRUCTURE IN THE US

Industries and ecosystems may develop to solve a specific business problem (Pidun et al., 2019). An important challenge in the US is to develop a robust charging infrastructure for EVs. In contrast to the EU, the percentage of EVs in the US is low, and in contrast to China, population densities are low. These two factors make the infrastructure challenge in the US greater than in the other two regions.

Here's a good summary statement of the underlying economics:

> Characteristically for a two-sided market, EV market growth relies on the ability to develop both sides of the market simultaneously. Specifically, EV adoption (particularly for households that don't have a way to easily charge at home) requires convenient access to fast, reliable charging stations. But private developers of charging stations evaluate their investments based on expected return on the investment, which itself is driven by demand of EV owners.
>
> This is the classic "chicken-or-egg" problem that characterizes two-sided markets relying on indirect network effects to "tip" the market into self-sustaining profitability. Indirect network effects – or the feedback loop whereby value on either side of the market impacts value on the other side – can either boost self-reinforcing growth, or slow initial growth and create potential inefficiency if users wait to adopt the new technology.[4]

So, how is the US infrastructure developing? Two types of plugs exist: (i) Tesla's American Standard, and (ii) the plus for the Combined Charging System (CCS). Until recently, CCS interfaces were used by nearly all other automakers.

In June 2023, General Motors and Ford announced that they are joining the Tesla infrastructure, which is now the largest network. ("What EV owners need to know about Tesla's charging partnership with Ford and GM," *Associated Press*, June 10, 2023.)

This seemed like a big win for Tesla that would lead to a company-centered ecosystem. Tesla would get the benefit of a new revenue stream and could complement its infrastructure with convenient stores, coffee shops, and more.

But wait. One month later, seven major automakers (including GM) announced they would invest $1B in a joint venture to build 30,000 "fast" charging stations.[5] Moreover, the chargers will have CCS plugs that work for most vehicles as well as plugs that work for Tesla vehicles.

So, the current situation embodies a lot of uncertainties. Here are relevant questions about the potential emergence of a Tesla ecosystem for charging infrastructure:

1. What are the underlying economic forces at work? (Think economies of scale, density, network effects.)
2. Why did GM and Ford join Tesla?
3. What revenue stream will Tesla earn?

[4] Erich Muehlegger andJoseph Cavicchi, "If You Build It, Will They Come? Indirect Network Effects and the "Chicken-or-Egg": Dilemma in the Nascent Electric Vehicle Market." *Analysis Group Forum*, July 2023.
[5] Jack Ewing, "Plan to Double Total of Fast Chargers," *New York Times*, July 27, 2023.

4. Will other EV manufacturers will join the Tesla ecosystem?
5. Given the announcement of the joint venture to build new chargers that are compatible with most models (Telsa and others), is Tesla now no longer in the leading position?

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