IESE On

Automotive Industry

IESE Business School
University of Navarra

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5 Building Blocks for Cyber-Physical Value Chains

Marc Sachon

During the global financial crisis, countries with a solid manufacturing base suffered less than service based economies. This was certainly the case for Germany, whose Mittelstand of small and medium-sized firms, many of them manufacturing-based, were able to maintain or increase employment, or even expand, during the crisis. Recognizing that manufacturing contributes greatly to job creation and innovation, the German government laid out its future industrial policy in 2011, called *Industrie 4.0*, a term which has since entered the vernacular. Other countries are following suit, including the United States, with recent administrations aiming to reindustrialize the economy.

Based on interviews, case studies and collaborations with firms at the leading edge of this field, I have identified the key building blocks for the successful implementation of Industry 4.0, which I share in this article. I also highlight the implications, including a need for re-education of the labor force. For industrial companies, the need is clear: their business models are about to change radically, and they must adapt their skill sets to the digital world or get left behind.

A Brief History

Industry 4.0 is a natural progression of past industrial revolutions – starting with the mechanization of manual labor in the 18th century, and continuing in the 21st century with smart, interconnected machines that act independently to manufacture products in highly flexible, reconfigurable systems. See **Exhibit 1**.

INDUSTRY 1.0. The first industrial revolution occurred around 1776, when steam engine power was harnessed in factories, replacing manual work and moving away from rivers and closer to markets or ports. This reduced costs while significantly increasing productivity, particularly in textile manufacturing, a sector that was instrumental in this phase.

Several sectors were disrupted, leading to high levels of unemployment, such as when automated looms displaced manual ones. It also led to a concentration of manufacturing capacity in industrial clusters, which generated population movements from rural areas to those clusters, and gave rise to changes in society, from the emergence of politically powerful industrialists, to the creation of a working class, to the rise of communism.

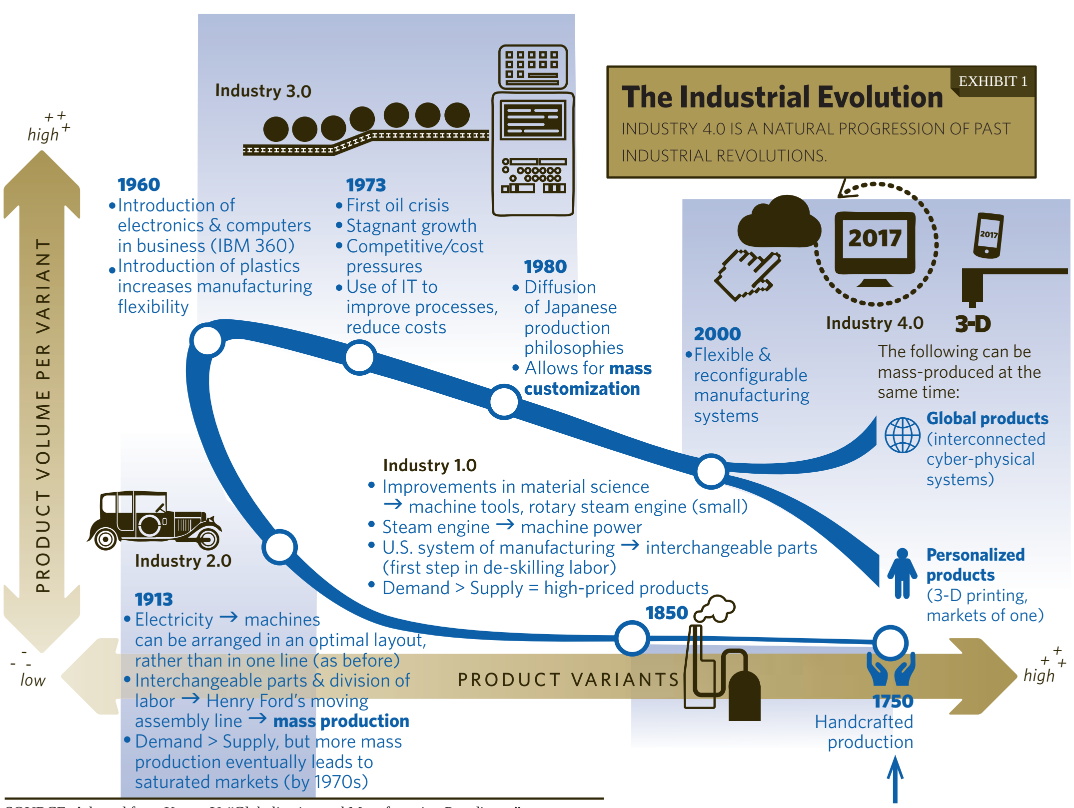
Despite this revolution, high-quality, complex products – such as watch-making, tailoring or, by the end of the 19th century, car-making – still had to be done by hand, as no machine was capable of making customized products in large volumes at low cost.

INDUSTRY 2.0. The second industrial revolution had several triggers: the use of electricity to power factories; advances in material sciences, leading to high-grade steel and interchangeable precision metal parts; and the standardization of work, which shifted specialized skills from workers to machines and tools.

These developments converged in Henry Ford's moving assembly line (1913). For the first time, high-quality, complex products could be manufactured in large volumes at low cost. The trade-off was a narrow product assortment, but customers didn't mind, because the products were affordable for the common person.

Apart from limited variants, another consequence of Ford's conveyor-belt automation was the de-skilling of labor. At the time, this was not a problem: Ford only needed low-skilled labor, and for that, the labor pool was large. The trend started by the steam engine continued: the number of skilled workers declined (in relative terms) and skilled labor moved from the (manual) shop floor to the office.

INDUSTRY 3.0. The third industrial revolution had several defining moments. First came the Intel processor chip in 1971. The emergence of semiconductors allowed process control units to be integrated in machines, and the creation of computer numerical control (CNC) increased machine intelligence and flexibility. With several machines able to be operated at once, fewer workers were needed, and the trend toward more knowledge workers continued.



SOURCE: Adapted from Koren, Y. "Globalization and Manufacturing Paradigms." In The Global Manufacturing Revolution: Product-Process-Business Integration and Reconfigurable Systems, by Y. Koren, 1-40. John Wiley & Sons, 2010.

Meanwhile, the 1970s saw oil and energy crises, which shook up vertical market dynamics. With growth stagnant, markets moved from supply-driven to demand-driven. In such a context, Ford's system of mass production had difficulty adapting to changing customer preferences.

Toyota's solution was to change the management focus from maximizing asset utilization (the U.S. philosophy) to minimizing waste (the concept of lean) and maximizing value added per unit of time (the concept of flow), enabling more products and variants to be made, while keeping quality high and costs low. This proved better than mass production, because it accommodated changing customer needs.

INDUSTRY 4.0. In the 21st century, the following global trends are pushing production systems to their limits:

- **customization:** customers want a product adapted to their specific requirements;
- **globalization:** vast, interconnected supply chains and markets are spread all over the world, increasing management complexity;
- **financial markets:** institutions are still recovering from the 2008 financial crisis;
- **ageing workforce:** in China, Japan, Russia and Western Europe, the average age of a factory worker is increasing, making certain tasks more difficult for them to perform, thus resulting in lower efficiency;
- **sustainability concerns:** energy efficiency, waste reduction and responsible use of natural resources have become priorities;
- **growing population and middle class:** demographic trends are driving growing demand for certain products (e.g., cars in China);
- **information society:** in a connected world, new ideas spread rapidly, accelerating the development of new products, processes and business models, and generating difficult-toserve demand peaks (e.g., iPhone);
- **urbanization:** people are migrating to cities, while factories tend to be located away from them, making it hard to find qualified workers.

These trends require flexible systems that can change quickly and efficiently. To deal with this, the apparel sector developed the "fast fashion" model, epitomized by Zara, which my IESE colleague Victor Martínez de Albéniz has written about extensively. It essentially accelerates the supply chain by eliminating wasted time with flexible production. Other sectors with more complex supply chains, such as automotive and aerospace, have been slower to adapt, given a higher asset base and asset specificity, and a lack of technological solutions that would facilitate an equivalent form of "fast industry." Until now.

Today, smart machines, products and infrastructure can all be connected to collaborate in dynamic ways. This networked model of production – in which all levels of IT systems within a company and across companies in a value chain are connected and share data and information – is the next iteration of everything that came before.

When fully deployed, Industry 4.0 holds the promise of reconfigurable production systems and intelligent, networked tools, machines, facilities and products that communicate among themselves and with the workforce, using augmented reality or other means of communicating relevant data quickly, intuitively and efficiently.

Moreover, smart products and components will provide information, and the production system will automatically adapt to productspecific needs. Tools, machines, facilities and products will contain sensors that provide data necessary for decision-making. Because this can be done in an automated way, people working in this area will focus more on generating value for customers, and less on monitoring machines or production processes.

Five Essential Building Blocks

Industry 4.0 holds implications for value creation, business models, downstream services and work organization. But to reap the benefits, certain building blocks have to be in place. I group these into five clusters.

1. DATA GENERATION AND CAPTURE

First, the physical system needs to be mapped digitally, so that it can be analyzed and optimized. Thanks to smartphones and the internet, the cost of sensors, RFID and other key communication technologies has come down significantly, and they are now ubiquitous enough to be leveraged for Industry 4.0.

In addition, the internet's next-generation protocol – Internet Protocol Version 6 (IPv6) – is finally ready to replace the current standard, IPv4. The limited address space of IPv4 (less than 5 billion unique addresses) has meant that end-to-end connections could not always be established, making a local server necessary, with implications for connection speed and the uniqueness of addresses in use.

IPv6, on the other hand, offers 340 undecillion (a number followed by 36 zeros) unique addresses. This allows unique and faster point-to-point connections, including for mobile devices. More important, with IPv6, everything that can be found in a factory or value chain – machines, tools, individuals, products and customers – can be assigned a unique IP address, which means assets and working capital can be traced and managed more precisely.

For those worried about the huge volumes of data this will generate, the good news is that the cost of storing big data is dropping exponentially. Moreover, the decentralized storage capabilities of the cloud permit multiplatform access, continuous hardware updates and being able to convert capex to opex, without any asset investments.

That being said, the large volumes of data from many different sources, with significant variety and the need to be processed quickly, imply that big data will need to be filtered and condensed, so that it is manageable and does not occupy too much bandwidth. The filters should be applied at the source, both in terms of distributed processing power on the machine, tool or product, as well as only transmitting special event data (statistically significant deviations from the mean, unusual performance patterns or trend data) to the next higher level. These condensed data will be of great value, not just for the task at hand but also at the meta-level, when analyzing company-wide or value-chain-wide data. In this regard, platforms become important.

2. DATA ANALYTICS

Like the cost of data storage, the exponential increase in processing power over recent decades has seen a commensurate drop in computing costs. This is another key piece of Industry 4.0: given the terabytes of data involved, there need to be cyber-physical systems and cyber-physical production systems capable of processing and analyzing the data collected from machines, tools, products and other sources. Fortunately, this is now possible.

When a factory is digitally connected, rich data insights can be gathered, optimized and used, not only to improve operational processes, but also at the strategic level for decisionmaking. Say you have separate manufacturing facilities in Europe and Asia. Data analytics can compare demand patterns, leading to better forecasting or early detection of market trends. Or when similar problems in different facilities emerge, they may indicate a systemic problem with a machine, a process or a supplier, and preemptive or predictive maintenance can be undertaken. Any entity that has access to all these data – preferably via a platform – will gain a better understanding of where things currently stand, as well as trends for economic modelings.

Of course, this calls for more data scientists skilled in analyzing and interpreting these data, and new worker profiles – a point which I'll come to later.

3. HUMAN-MACHINE INTERACTION

The integration of numerous IT systems at various levels of the organization requires sophisticated management. To help, several companies have developed cloud-based platforms for industrial use, including Siemens' MindSphere and General Electric's Predix.

One of the most challenging interfaces, however, is between humans and machines. In situations where human decision-making is necessary, any information that has been generated from data gathered in the production network is only useful if it is presented in an integrated, intuitive way and in the right context.

Products such as Microsoft's HoloLens, a head-mounted holographic computer display, offer solutions to this problem, enabling remote maintenance. Say a machine has a problem that an onsite worker cannot solve. A local user can stream video of the problem to headquarters located on another continent, where a resident expert can talk the user through the steps of repairing the machine, while an app relays relevant information to the user's tablet or smartphone. Social media can also help: company employees or others in the value chain can post problems and get support from the wider community. Cisco, Audi and NASA, among others, are experimenting with these approaches.

4. HIGHLY FLEXIBLE PRODUCTION

Industry 4.0 companies, by virtue of manufacturing tangible goods, tend to be resource intensive, which has generally made them resistant to digital disruption. If you look at the companies that have been the biggest digital disruptors – Airbnb, Alibaba, Amazon and so on – they have succeeded mainly by providing a platform where supply and demand can meet and exchange "value units," which can be financial or intangibles like social value. They lower transaction costs and gain efficiencies by trading at large volumes, often benefiting from network effects (Metcalfe's Law).

For industrial companies, the digital disruption comes from the flexibility it lends to their operations. Recent advances in robotics, automation and additive manufacturing are now capable of giving factories the flexibility they need to respond to changes in demand, leading to more efficient processes and business models.

Consider collaborative robots, or cobots, such as those made by the German company KUKA. Unlike other robots that had to be cordoned off from workers to protect the latter from injury (adding several thousand units of cost for a sensor-equipped fence), KUKA's iiwa cobots have built-in sensors, so they react or stop when they come into contact with a worker. This lets people work closer to them, performing cooperative tasks, as happens at BMW's Dingolfing plant for gear-box assembly. Given their smaller sizes, cobots are of growing interest to Asian manufacturers, like Foxconn, substituting for some of the tedious tasks performed by workers and solving issues of high labor rotation or production ramp-up.

Paired with the correct software, a camera could be the most versatile of all sensors, bringing even more flexibility. A camera-equipped robot could "learn," for example, the best weld spots for manufacturing a car. If such robots were connected to a platform, other robots would benefit from this learning, and the platform would learn from the robots, too. Think of the business applications of such machine learning. Instead of just selling robots to car manufacturers, companies like KUKA, FANUC or ABB could also start selling weld spots, moving to a production-as-a-service business model. They would build, own and operate the robots while also selling the client what it really wants and needs: the best weld spots.

In factories where robots are already positioned at multiple points during the manufacturing or assembly process, companies should be thinking about how data could be collected from those robots at different stages in the process, in a standardized format and shared on a unified platform. Alternatively, the machines of different suppliers could connect to one platform, but that would entail complexity for data standards and translation.

Apart from robots, which add value to goods by manipulating them, additive manufacturing, or 3-D printing, actually creates something from nothing. Unlike traditional "subtractive" manufacturing, where lathes, mills, drills or other machines chip away at material until the final product emerges, additive manufacturing takes a digital model of the product and builds it up, layer by layer, until the final product takes shape out of pulverized raw material. There are numerous advantages to this:

1. First, by eliminating molds, there are no significant economy-of-scale effects.

2. Second, there is practically no waste, as any leftover raw material can be used again.

3. Third, complexity doesn't necessarily translate into higher costs, as it does with traditional manufacturing; with 3-D printing, parts can be as complex as you want them to be.

4. Fourth, parts can be "topologically optimized," meaning material is only added where it is really needed, bringing superior performance).

5. Fifth, the number of parts can be reduced, since complex parts no longer have to be assembled from several different components but can be printed as an integral whole.

The latter benefit is one of the reasons the aerospace industry was an early adopter of additive manufacturing. It reduced costs, new parts could be rapidly prototyped, and – crucial for aeronautics – the parts were lighter, and offered new and better functionality and performance.

Leading companies in industrial 3-D printing, such as Electro-Optical Systems (EOS) and General Electric, recognize that 3-D printing empowers completely new business models, especially long-tail ones selling goods with low or niche demand. Over the past three years, IESE MBA students have carried out several projects on 3-D printing, including one for a German automotive manufacturer, which explored using the technology to produce spare parts. Doing so reduces the working capital tied up in storing slow-moving, long-tail parts in warehouses. Mercedes-Benz has been one of the first automotive companies to make this a reality by establishing a unit that 3-D prints spare parts for its truck and bus businesss.

Another interesting business model is a 3-D printer farm, akin to a server farm. In a networked economy, clients would just send their blueprints to a central printer farm, where different products could be printed for different clients using the same printers. The clients have access to the latest technology and know-how (i.e., 3-D printing experts) without having to make their own upfront investments. The farms benefit from the pooling of demand, higher utilization rates and faster return on investment; they sell the raw materials and their expertise. This would be another example of a business model going from selling a physical product to selling a service.

5. INTELLECTUAL PROPERTY

With data permeating all areas of Industry 4.0, a great deal of thought must be given to cybersecurity in order to protect the internet backbone, the factory systems, the cloud and all devices used in the value chain. Recent global cyberattacks illustrate this importance.

Another area of concern is IP protection. With 3-D printing, anyone with access to the STL or OBJ files (i.e., the blueprints), the right 3-D printer and the raw material would be able to produce "originals." Providing reliable IP protection will be a key requirement for the establishment of platform-based business models in Industry 4.0.

Two interfaces need special attention for their vulnerability to external manipulation: the link between production data and business data; and the link between mobile devices used for human-machine interaction and the corporate IT structure (especially in a bring-yourown-device environment).

Given the complexity of Industry 4.0 systems, the best way to protect your business is to start at the lowest level – where data are created and captured via sensors and at the transmission points. The exponential growth of connected elements makes this a challenging yet vital issue.

Future Implicationss

In her 1988 book, *In the Age of the Smart Machine: The Future of Work and Power*, Harvard's Shoshana Zuboff made three prescient statements:

- Everything that can be automated will be automated.
- Everything that can be informated will be informated.
- Every digital application that can be used for surveillance and control will be used for surveillance and control.

Industry 4.0 is a manifestation of these statements. In the context of manufacturing value chains:

- Every factory process that can be automated will be automated.
- Everything involved in the actual making of products that can be informated will be informated.
- Every sensor, digital application and device that can be used for surveillance, control and distributed decision-making will be used for surveillance, control and distributed decision-making.

Moves in this direction have several serious implications.

WORKER PROFILES. First and foremost, it will change the profiles of people working in industry across all levels. Engineers, for example, will have to learn new approaches to product and process design, as 3-D printing offers much more liberty than current technologies.

The trend from manual to knowledge workers will continue at an accelerated pace. The ubiquity of the internet and the immediate access to the knowledge stored in it will change the concept of knowledge worker from "highly trained expert" to "networked squirrel" who is able to find solutions to complex problems quickly, based on experience and making smart use of the internet. Eventually, it will lead to a "cyberworker."

CYBERSECURITY. As mentioned earlier, when all machines, tools, working capital, IT systems and even people are connected through the internet, any manipulation of data at any level will lead to consequences ranging from suboptimal performance to catastrophic failure.

SOFTWARE-DEFINED DIFFERENTIATION. The move toward networked production assets and smart products with connected sensors and computing capabilities will drive products toward software-based individualization. Hence, product differentiation will be software-defined rather than hardware-driven. This pushes the point of product differentiation to the customer, resulting in significant supply-chain savings and reducing operations complexity.

PLATFORM BUSINESS MODELS. Industry will become more susceptible to platform business models. As Geoffrey G. Parker, Marshall W. Van Alstyne and Sangeet Paul Choudary explain in their book, *Platform Revolution*, "Practically any industry in which information is an important ingredient is a candidate for the platform revolution. The platform provides an open, participative infrastructure... to consummate matches among users and facilitate the exchange of goods, services or some sort of social currency, thus enabling meaningful value exchanges between all participants."

The advantage of platform business models over traditional supply chains is that they scale faster and are more flexible. This implies that established industry leaders and entire sectors will be confronted with new competitive challenges, and they run the risk of being disrupted.

Meanwhile, Industry 4.0 is not happening in a vacuum. Innovations happening in other fields – in process technologies, advanced materials, nanotechnology, cognitive systems and advanced mechatronic systems – have the potential to shake up the whole structure of production systems. These innovations are connected to data and their smart use. When these wider developments are combined with data-driven platform business models, you have the perfect setting for recombinant innovation.

W. Brian Arthur, author of *The Nature of Technology*, describes how "novel technologies arise by combination of existing technologies; existing technologies beget further technologies. We are shifting from technologies that produced fixed physical outputs to technologies whose main character is that they can be combined and configured endlessly for fresh purposes."

Given these features of Industry 4.0, we can anticipate the emergence of platform business models in the asset-heavy manufacturing sector. Siemens, General Electric and others are already moving in this direction, offering products as a service rather than just selling them. Platform business models provide incentives to de-link assets from the value they create. This adds to their tradability and grows the potential user base as marginal cost approaches zero.

We can also expect to see new production technologies – 3-D printing, cobots, sensors – being recombined and begetting other new technologies. The implications are clear: an acceleration of new technological developments, driven in part by the ongoing digitalization of industry, will give rise to untold business models and opportunities.

To play a leading role in this future world, manufacturers will have to continue in their quest of increasing process efficiency. But, most of all, they will have to develop competencies in connected factories, products and services as well as in platform business models.

Only then will manufacturers be able to address one of the biggest challenges of Industry 4.0: the construction of completely new structures that leverage the full potential of the entirely digital factory – a factory with a future.

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The Chinese Auto Industry at a Crossroads

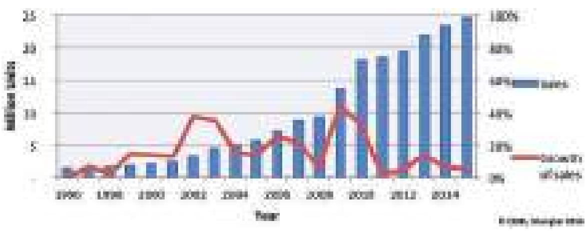
Marc Sachon, Jaume Ribera, Donald Zhang, Yunyi Zhang, Cristina Castillo

China is the world's biggest automobile market, recording sales of over 24 million units in 2015. Given China's enormous population and growing middle class, this shouldn't come as much of a surprise. It overtook the United States as the world's largest auto market in 2010 and hasn't looked back.

What is less well known is that China is also the world's biggest automobile producer, making more cars than the United States and Japan combined (the global industry's No. 2 and No. 3, respectively). China has been the top producer for the last seven years, yet it exports only 3 percent of its production.

This is according to *The Chinese Automotive Industry in 2016* – a book updated biennially since 2012, jointly produced by CEDARS (a consultancy for the Chinese automotive industry), CEIBS (China Europe International Business School) and IESE. According to its team of authors, led by Prof. **Jaume Ribera** and Prof. **Marc Sachon**, there is still a lot more room for growth in this relatively young (and complex) industry.

Ten years ago, there were roughly 600 million automobiles in the world. By 2050 there may be as many as 2.95 billion, according to IMF forecasts. China may have more cars on the road than the United States by 2030 and more cars than the entire world has today by 2050. However, there are doubts as to how many will come from its domestic firms.



A Shifting Narrative

During this fledgling century, the Chinese auto industry's growth has been spectacular. In 1999 – two years before joining the World Trade Organization (WTO) and thus opening up to foreign markets – the country produced fewer than 2 million vehicles. By 2015 that number had reached 24.5 million.

However, the growth rate is slowing down. As the report points out, the average growth rate was much larger between 2006 and 2010 than between 2011 and 2015. The past two years have seen mid-single-digit growth – a trend likely to continue in coming years. Moreover, Chinese local manufacturers have seen their share of domestic sales drop from 60 percent in 2010 to 49 percent in 2015. The situation is even worse for the passenger vehicle market, where local brands took only a 43-percent share in 2015.

One reason for this is that Chinese companies are still technologically weak, despite the government's controversial joint-venture policy of 1994, which requires international auto companies to form joint ventures with Chinese companies if they want to access the local market. The idea was for foreigners to share some of their technical know-how in the JV partnerships, but knowledge transfer has not met Chinese expectations, the authors note.

To improve their image and reputation, both at home and abroad, Chinese brands need to invest more money, time and effort in R&D. As the report indicates, most of the big companies that were ostensibly profitable in 2015 would not have been able to survive without government subsidies and the profits made by their foreign partners. The three biggest players in China are SAIC, FAW and DFM – all supported by the government. Together these three have more than 50 percent of the domestic market share.

The domestic industry's future outlook will depend on the ability of its private sector to move in on the many state-owned enterprises. And for that to happen, the Chinese government should phase out subsidies as well as the 1994 joint-venture shareholding rule, the authors note.

Green Shoots

One area that offers promise for future growth is China's electric-vehicles sector, which the government recently identified as one of the 10 key industries under its "Made in China 2025" national plan. Electric vehicles could help reduce the severe air pollution choking many Chinese cities (assuming the Chinese energy mix moves away from coal to sustainable sources) and clear the way for more sustainable growth ahead. It seems to be on the right track. By 2015, China had sold 450,000 New Energy Vehicles (NEV), just short of the government's target of 500,000 units, set in 2012.

China is now the world's biggest market for electric vehicles. With the recent entry of international players such as Daimler, Samsung and Tesla into the market, this trend is expected to intensify. According to a McKinsey report, by the end of 2014 the Chinese government had spent around 37 billion RMB ($5.47 billion) on the electric vehicle industry, of which around 15 billion RMB went toward subsidies and a further 11 billion RMB was spent on electric infrastructures, a vital component of the electric vehicle revolution.

Room for Improvement

But there is still plenty of room for improvement, in particular with regard to the domestic parts industry and Chinese auto exports. Despite undergoing sweeping transformation, China's industry still struggles to compete with foreign rivals in areas such as technology and brand reputation. Instead of competing on quality and technological development, Chinese companies continue to compete on price, leading to rising trade frictions with other car-producing nations in North America and Europe.

For the moment, Chinese exports are still insignificant compared to domestic sales (just 3 percent vs. 97 percent, respectively). Brands such as Chery and JAC continue to dominate Chinese automotive exports but their cars are still hampered by quality issues, as most models fail to meet European and U.S. safety and quality standards.

Nevertheless, Chinese companies are exporting to markets in Africa, Eastern Europe and South America. The industry is also likely to benefit from the government's "One Belt, One Road" initiative, which promises to boost international trade and foreign investment by better connecting China with the rest of Eurasia, along the lines of the old Silk Road and beyond.

With relatively low car ownership rates, China's automotive sales will surely continue to grow. As for its domestic industry, China is at a crossroads. The future may depend on the government's willingness to loosen its hold on the industry and further its support of electric vehicles and automotive R&D in order to differentiate its offerings.

If you are interested in acquiring the book, please contact a.cid@iese.edu.

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An Apple Car on the Horizon

Apple developing a car illustrates the possibilities that emerge when different trends merge to shake up an established industry

Marc Sachon

Last september, news that Volkswagen had installed technology in its cars designed to cheat diesel emissions tests overshadowed another no less spectacular story. *The Wall Street Journal* reported that "Apple Inc. is accelerating efforts to build an electric car, designating it internally as a 'committed project' and setting a target ship date for 2019." Since then, online forums have been abuzz over the entry of "the world's most valuable company" into the toughest of industries.

Why would Apple enter an industry whose returns are dismal compared with Apple's and which is not even related to consumer electronics? Speculation as to Apple's reasoning reveals some keys for any company considering a similarly bold move into uncharted territory.

1. AVOID TURNING INTO A MONO-PRODUCT COMPANY. Apple's 2015 annual report shows that 66 percent of its net sales come from just one product, the iPhone. Just 9 percent of net sales come from apps and services such as iTunes, and only 4 percent from other offerings like Apple TV and Apple Watch. In most companies, this would be cause for concern. Apple needs a new killer product – and a car could be just that.

2. ASSERT NEW LEADERSHIP. A car offers Apple an opportunity to do what it does best: enter an industry and overturn it, by offering an innovative solution to customer needs. As Apple has proven time and again, whether with mp3 players, smartphones or tablets, you don't have to be the first, you just have to be the best. A company that finds some way to be the best in class can carve out new leadership even in well-established fields.

3. GET AHEAD OF REGULATION. Greater urbanization, congestion and emissions are prompting cities around the world to adopt stricter regulations. A company that can address these challenges will be welcome – provided you listen to your stakeholders. Tesla's Model S electric car is a case in point: the same car that qualifies for a tax credit in the United States received a fine in Singapore for the pollution involved in generating electricity for the car. An astute company will learn from this and go one betters.

4. SEIZE THE MOMENT. When the challenges of an industry have reached the stage where even the experts are exasperated, this may create the perfect storm to revitalize. that industry. The auto industry has certainly reached a critical point: expensive, globally distributed manufacturing facilities; relentless downsizing; a plethora of powertrain systems (traditional, hybrid, battery or fuel cell); ever more models and variants; and pervasive digitalization. All this makes the automotive industry ripe for transformation. The greater weight of electrics, electronics and IT in a car's bill of materials allows for a far simpler assembly process. Apple will grasp the opportunity to develop an extremely user-friendly, highly standardized small urban vehicle. The scale effects would be comparable to those of Ford's Model T in its time, resulting in an extremely low cost base.

5. USE YOUR STRENGTHS. Electric powertrains, environmental regulation, urbanization, digitalization and Millennials are redefining the playing field. A company that can leverage those factors will find itself in a stronger competitive position. Apple has the advantage of being able to integrate a car into its existing ecosystem to provide additional mobility-related services. This would move the car away from being a product that defines itself purely through physical performance toward becoming a device that provides a superior customer experience. Through extensive use of the latest display technology and tight integration with its iPhone ecosystem, Apple would create a truly customized, always-online mobility service solution and set a new industry benchmark.

Is it time to push out in new directions?

6. BUILD ON A LOYAL CUSTOMER BASE. Apple customers are hardcore. If Apple were to market a car, presumably Apple fans would line up to buy one as devotedly as they lined up to buy 231 million iPhones in 2015. If Apple were to price its car similar to Tesla's new Model 3, at $30,000, and appropriate its usual 40 percent gross margin, even if a mere 1 percent of iPhone customers bought a car, it would be enough to add $24 billion to Apple's P&L, surely satisfying the expectations of its shareholders.

Whether Apple unveils a car in 2019 remains to be seen, but analyzing the industrial, political and technological milieu shows why it makes sense to do so. Is it time for your firm to likewise push out in new directions?

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Sachon, Marc, "An Apple Car on the Horizon: Apple developing a car illustrates the possibilities that emerge when different trends merge to shake up an established industry." IESE Insight Review, issue 29, second quarter 2016.

Setting the Wheels in Motion for Sustainable Tansportation

Pascual Berrone, Joan Enric Ricart,
Ana Isabel Duch T-Figueras

In cities, mobility is crucial. Ensuring the distribution of people, goods and services, transportation is essential to cities' social and economic development.

As cities grow, the demand for mobility escalates. This stresses existing urban transport systems and infrastructures, exacerbates widespread traffic, and increases road accidents and fatalities. It also increases greenhouse gas emissions and other pollution, causing serious health concerns and grave environmental repercussions.

How can current systems cope with the rising demand for urban mobility? How can legislators and city planners around the world develop strategies to enhance sustainable, integrated urban transportation systems? In short, what is the future of urban mobility?

Cities and Mobility and Transportation aims to answer these questions. Part of a new series called "IESE Cities in Motion: International Urban Best Practices" by Professors Pascual Berrone and Joan Enric Ricart and researcher Ana Isabel Duch T-Figueras, the book:

- analyzes the main urban mobility and transportation trends and challenges
- compiles international best practices on sustainable urban mobility
- serves as a tool to help city managers and policymakers solve urban mobility challenges and improve accessibility for the benefit of all.

Four Levers for Sustainable Urban Mobility

The IESE Cities in Motion book series defines a framework for analyzing how cities can enact groundbreaking transformations using four main levers of change: technology, public policy, consumer behavior and infrastructure design.

1. New applied technologies and innovations are playing a critical role in delivering urban mobility solutions. For example, smartphones and mobility apps are facilitating on-demand services and increasing choices: users can use their phones to check traffic conditions, plan routes or simply see when their bus is coming.

"Smart parking programs" provide another example. Although "parking" might seem odd in a discussion of mobility, the issue is, in fact, critical: up to 30 percent of drivers in smog-breeding downtown traffic are in search of a spot to stop.

San Francisco's SFpark program counters this problem by using smart parking meters to collect and distribute real-time information about available parking spaces. Drivers can use their phones to access this information and even to "feed the meters," which adapt pricing to meet demand. As a result of the program, parking time fell nearly by half, greenhouse gas emissions by a third, and, remarkably, even meter prices fell slightly. The takeaway: with smart transportation solutions, everybody wins.

2. Policies, legislations and regulations can make an impact by incentivizing mass transit options, creating new alternatives and/or regulating the use of cars.

Stockholm provides a clear success story. In 2006 the Swedish capital decided to fight rush-hour smog by charging vehicles entering or leaving the inner city. As a result, greenhouse gas emissions fell 10-14 percent, traffic was reduced by up to 50 percent and transportation fatalities continue to drop, falling nearly 60 percent between 2011 and 2013 alone. Through its combined sustainable transportation initiatives, Stockholm achieved a total greenhouse-gas-emission drop of 25-35 percent – while the economy grew by 41 percent.

3. Change in people's behavior and preferences. Increasingly conscious of the environmental impact of their choices, people are changing their mobility preferences. The availability of a wider range of choices is also changing the way that people get around.

This is illustrated by the recent surge in bike-sharing programs, which have grown to include more than one million bicycles globally. The Chinese city of Hangzhou, home to some eight million people, operates the world's second-largest program. Hangzhou's 65,000+ bikes complete around a quarter of a million trips per day, attracting commuters, car-owners and public-transport-users alike. Emissions have dropped and the system enjoys the highest satisfaction rate of all the city's development projects: 80 percent. Once again, a win-win.

4. Infrastructure and urban planning are clearly key in shaping cities' mobility systems, since the way cities are designed will help determine what kind of transport will be used. For example, sprawling cities may opt for a Bus Rapid Transit (BRT) system as a cost-effective alternative to digging metro tunnels or installing light rail.

Pioneered in 1974 by forward-thinking urban planners in Curitiba, Brazil, BRT systems serve as a kind of surface subway, with high-level planning for efficiency. As of June 2016, BRT systems spread to service 204 cities across six continents, transporting around 33 million passengers every day.

Johannesburg's BRT system, founded in 2009 on occasion of the FIFA World Cup, transports between 40,000-60,000 passengers per day. As well as reducing annual greenhouse gas emissions by 40,000 metric tons, the system is estimated to be delivering economic returns of close to $900 million. Furthermore, the BRT has significantly increased access to underserved areas – a vital task in a city still living under the legacy of apartheid.

At the end of the day, better connected – and more accessible – cities increase people's wellbeing. The alternative? If left unchecked, current emissions patterns will lead to widespread devastation.

However, the authors are optimistic. They note that current trends in mobility and transportation indicate an important paradigm shift which, if driven by considerable political vision, strategic thinking, and investments, promises to deliver significant improvements. Now it's time to set those wheels in motion.

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