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Dialogue, Debate, and Discussion

What Does the Success of Tesla Mean for the Future Dynamics in the Global Automobile Sector?

Greg Perkins[1] **and Johann Peter Murmann**[2,3]
[1] *University of Queensland, Australia,* [2] *University of St. Gallen, Switzerland, and* [3] *University of New South Wales, Australia*

INTRODUCTION

After reading Jacobides, MacDuffie, and Tae (2016), the success of Tesla in launching a new automobile company in a crowded sector puzzled us. Jacobides, MacDuffie, and Tae (2016) had convinced us that developing the capabilities to become the manufacturer of a complete, safe automobile system would be quite difficult. Since the establishment of the dominant design for the auto in the 1920s, the industry has operated on the premise of massive economies of scale. Original equipment manufacturers' (OEMs) role in taking responsibility for the legal liability of the whole automobile, combined with their extensive supply and marketing chains, has ensured they remained dominant in the sector despite some missteps with modularisation and outsourcing efforts (Jacobides, MacDuffie, & Tae, 2016; Schulze, MacDuffie, & Taube, 2015). No major component supplier has succeeded in forward integrating into becoming an OEM and no new entrants have challenged the dominance of the incumbent OEMs since the earliest days of the auto industry (Jacobides & MacDuffie, 2013).

Researching the development history of Tesla, we have pieced together the key features of how Tesla achieved its successful entry into the automobile sector. From this we have concluded, based on the development time and costs associated with the Tesla Model S, that a well-funded company could develop a new electric vehicle (EV) from scratch and move it into production within 3 to 5 years, by spending $1–2 billion of capital for design, development, and manufacturing. Without a doubt, increasing production to the levels of mass producers would take much longer, but the Telsa example demonstrates that new entry into the industy has become feasible.

Tesla's trajectory, from start-up on the brink of bankruptcy to a company mass producing electric vehicles within 5 years, raises important questions about the future of the global automobile sector. What would prevent Apple and Google, two companies that clearly have the resources to fund $2B in R&D, from entering the market and contesting fiercely with the dominant OEMs such as GM, Ford, VW, Mercedes, and Toyota? There are already many ventures in the Chinese electric automobile sector, such as BYD, Qiantu, NIO, and many more. Inspired by the success of Tesla, why would Chinese software and internet giants such as Tencent and Alibaba not enter this large market given that Tesla did not have prior experience and was able to get a successful car ready for sale within 5 years?

In this perspective piece, we offer our reflections on the implications of the success of Tesla for the dynamics of the global automobile sector. We will appraise the chances that Chinese firms will for the first time become leading players in pushing the frontier of automotive technology, a goal that has eluded them over the past 30 years despite massive government efforts to create strong home-grown auto companies.

HOW DID TESLA DEVELOP CAPABILITIES TO PRODUCE AN ENTIRE AUTO?

Since its founding in 2003, Tesla's vision was to manufacture mass-market battery electric vehicles (EV) that offered a compelling customer value proposition including long range and recharging flexibility, energy efficiency, low cost of ownership and high performance which didn't compromise design or functionality (Tesla Motors, 2010a). Tesla got its start with a $6.5 million investment from Elon Musk and leased a warehouse in Silicon Valley just big enough to assemble a few prototype vehicles (Vance, 2015).

Retrofitting Existing Car with Electric Power

The company focused on developing the Roadster, a premium EV sports car based on the Lotus Elise platform. The intent was simply to replace the internal combustion engine (ICE) powertrain with an electric one, consisting of lithium ion batteries, power electronics, motors, gearbox, and control logic. Tesla used standard 18650 battery cells and combined many thousands in parallel to form a battery pack. Within four months the first prototype of the Roadster was completed with less than 20 employees. However, developing a robust battery required engineering solutions to keep them cool, prevent them from catching fire and causing explosions. In 2005, Tesla engineers performed many fire and explosion experiments, in order to develop a robust and safe battery pack. Being a start-up, Tesla brought a can-do attitude to engineering and manufacturing. This had the advantage of solving individual problems quickly, but slowed down progress when changes in one area of the car had knock-on effects into another area. As a result, while Tesla

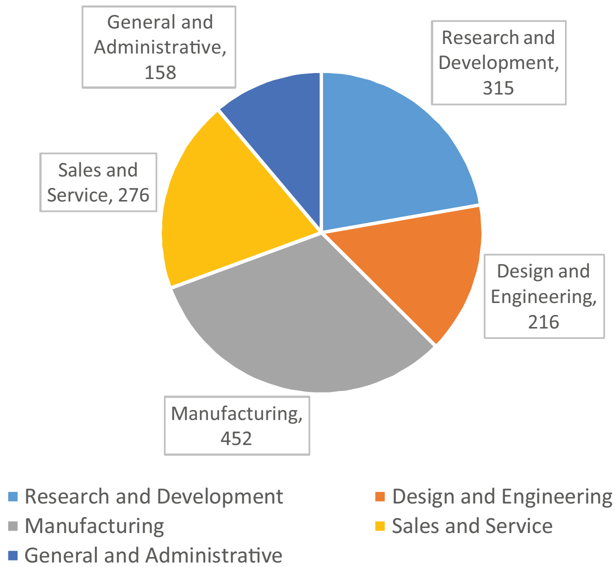

Figure 1. (Color online) Distribution of employees by function at end of 2011 (data from Tesla Motors, 2011)

originally planned to ship the first Roadster in 2006, the delivery date continued to slip due to engineering and manufacturing issues into 2008. Tesla delivered approximately 2,450 Roadsters between 2008 and 2012 (Tesla Motors, 2012).

Hiring Experienced Auto Engineers

Tesla started work on the Model S in 2007 and by March 2009 had finished the prototype design (Davis, 2010). At this time, the company had a few hundred employees and was also manufacturing the Roadster. In contrast to its approach with the Roadster, Tesla hired a team of seasoned automotive engineering and manufacturing specialists to design and develop the Model S, with experience at companies including Audi, BMW, GM, Jaguar, Mazda and Toyota. Engineers from leading automobile companies, were hired, alongside engineers with electrical, electronic and IT backgrounds from leading Silicon Valley firms. This included Franz von Holzhausen, Chief Designer of the Model S (from GM, Audi and Mazda) and Gilbert Passin as VP Manufacturing (from Toyota). In 2010, 2011, and 2012 Tesla had 899, 1417, and 2964 employees, respectively (Tesla Motors, 2010b, 2011, 2012). Figure 1 shows the distribution of employees by function at the end of 2011, when the company was ramping up its preparations to deliver the Model S. Of a total of 1417 employees, Tesla had 315 (22%) in R&D and 216 (15%) in Design and Engineering, which is a much higher percentage than a traditional car company. Tesla stationed its design engineers at the manufacturing facility, reducing total overheads and increasing interaction and feedback between the engineering and production departments (Tech Talker, 2014).

The characteristics of the Model S were a sleek design with an all-aluminium light weight body. Tesla abandoned the conventional ICE layout, and mounted the battery pack on a large rigid and flat floor (Dryer & Furr, 2016). This led to a low centre of gravity and good weight distribution between the front and rear axles, which in turn gave very good handling. Electric motors and the gearbox were located at each wheel and designed around the battery packs. The number of moving parts was very small, reducing noise and vibration.

Making Model S Safe through Design Choices

In terms of the powertrain, Tesla focused on the core intellectual property of four components – the advanced battery pack, the power electronics module, the high efficiency motor and the electronic control software (Tesla Motors, 2011). A key strategy that Tesla adopted was that the battery pack could accommodate different battery cell chemistries and was designed to allow for multiple suppliers. Tesla argues its integration of these components is more valuable than the sum of parts and is therefore a core competency providing the company with competitive advantage (Evanson, 2013).

The Model S design choices led to it achieving the highest safety ratings in history (Vance, 2015) and the car becoming the most awarded car of 2013 (Evanson, 2013). The large floor space enabled Tesla to install battery capacities up to 85 kWh, so that the car could run for up to 300 miles on a single charge – and beyond the requirements of most customers. In addition, the Tesla architecture was designed to be a platform for models beyond the Model S: *'with an adaptable platform architecture and common electric powertrain to provide . . . the flexibility to use the Model S platform to cost efficiently launch new electric vehicle models subsequent to the start of production of the Model S'* (Dryer & Furr, 2016).

The Model S was the first luxury battery EV sedan with high performance, accelerating faster than many sports cars, with some models reaching 60 mph in circa 3 seconds (Tesla Motors, 2015). The Model S also incorporated at lot of innovation from the IT sector, including an electronic dash board and a 17" touch screen, which enabled all controls of the car to be manipulated. The embedded IT functionality, allowed features such as the summon feature, auto parking and autopilot to be incorporated. The combination of a heavier use of electronic components, fewer moving parts and online connectivity, meant that Tesla's cars could be upgraded via software easily and much more substantially than conventional ICE cars (Hettich & Müller-Stewens, 2014).

Tesla's original plan was to make 10,000 Model S sedans per year and spend $130 million on development and manufacturing (Vance, 2015). While CEO Elon Musk had been successful producing the Roadster as the first stage in the master product plan, Tesla was not profitable and faced bankruptcy in December 2008. Critical to Tesla's ability to develop the Model S was the funding it secured in 2009 and 2010. Up to that time Tesla had spent about $185 million and delivered less

Table 1. Approximate cumulative delivery volumes of Tesla Model S and X vehicles

Year	*2012*	*2013*	*2014*	*2015*	*2016*
Model S & X	3,100	25,000	57,000	107,000	186,000

than 1000 Roadsters (which amounted to about 100 million in sales). In mid-2009, Tesla secured a US Department of Energy (DOE) loan of $465 million to support (i) engineering, production and assembly of the Model S and (ii) development of a manufacturing facility to build electric vehicle powertrain components (Tesla Motors, 2010a).

Buying Existing Auto Plant

A major coup for Tesla was the purchase of the NUMMI factory in Fremont, CA for $42 million from Toyota in 2009 (Tesla Motors, 2010a). The factory had produced up to 450,000 cars per year for Toyota and GM and was valued at over $1 billion. The purchase also enabled Tesla to meet the pre-conditions for the release of funds under the DOE loan scheme. Tesla adopted a vertical integration model to a much larger degree than other automobile companies. It produced 95% of its stampings in-house, developed its own software to control the car and installed 185 robots at the NUMMI factory to automate more manufacturing operations than any other car factory in the USA (Tech Talker, 2014). The vertical integration approach helped Tesla learn quickly and maintain control of all the key design details. Tesla went further, vertically integrating its retail sales channel and building its own network of charging stations.

The first Model S sedan was manufactured in June 2012. Table 1 shows the volumes of cars manufactured by Tesla compiled from SEC Filing data (Tesla Motors, 2012–2016).

In addition to the DOE loan, Tesla received tax breaks and incentives from the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA). These totalled $31 million in 2011. Buyers of Tesla vehicles were also entitled to a tax break due to the Zero Emission Vehicle (ZEV) program of up to $7,500 per vehicle (Tesla Motors, 2010b). In 2009, Daimler recognized Tesla's leadership in battery-pack design, agreeing to a battery supply agreement for their Smart cars and later invested $50 million for 9% of the company, valuing it at over $500 million.

In June 2010, Tesla Motors conducted an initial public offering on the New York Stock Exchange, becoming the first new U.S. automobile company to do so since the 1950s (Tesla Motors, 2010a). Tesla raised $226 million from the IPO, valuing the company at $2 billion. In the same year, Panasonic invested $30 million under

Table 2. Tesla capital expenditures for 2008 to 2012 (in thousands)

Year	*2008*	*2009*	*2010*	*2011*	*2012*
Expenditure	10,630	11,884	40,203	184,226	239,228

Table 3. Tesla R&D expenditures for 2006 to 2012 (in thousands)

Year	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Expenditure	24,995	62,753	53,714	19,282	92,996	208,981	273,978

a battery partnership and Tesla raised a further 172 $million in May 2011 and 192 $million in September 2012 via secondary offerings.

Capital expenditures between 2008 and 2012 (when the first Model S was delivered) totalled $486 million and research and development expenditures between 2006 and 2012 totalled $737 million as shown in Tables 2 and 3 (Tesla Motors, 2010a, 2010b, 2011–2016).

The core elements of Tesla's strategy have been: (i) proprietary integrated electric powertrain, (ii) vertical integration from development through to production and retail sales, (iii) significant incorporation of IT capabilities into the auto, (iv) uncompromising focus on battery electric vehicles, and (v) build-out of supercharger network and free charging for customers. However, the above strategy cannot fully explain Tesla's success. Timing and vision played a significant role. Tesla was one of only a handful of pure EV car makers globally in the mid-2000s and probably the first to develop a robust EV powertrain and battery pack. The company was a first mover in betting that lithium-ion battery costs would continue to decrease for many years to come. Tesla's hard charging nature, led by CEO Elon Musk and its unique branding approach enabled it to distinguish itself from other car-makers and attract loyal customers, despite many missed deadlines in the early days of the Roadster and Model S development.

Contrary to our expectation from reading Jacobides, MacDuffie, and Tae (2016), Tesla suggests that at least in the EV space developing the capabilities to produce a safe car is not that difficult. Tesla's journey with the Model S shows that a well-funded company could develop a new EV from scratch and into production within 3 to 5 years, with about $1–2 billion of capital for design, development and manufacturing (and *a bit of luck*).

REFLECTIONS ON THE FUTURE OF THE AUTOMOBILE

The Tesla story suggests that barriers to entry for the automobile industry are coming down. Tesla's big-break came with securing the NUMMI plant for a fraction of its replacement cost and securing favourable DOE loans. New entrants in the automobile sector can take advantage of contract manufacturing (CM), to reduce their upfront capital costs. For example, Valmet Automotive has manufactured cars for large OEMs for decades, and currently makes the Mercedes GLC in Finland. New entrants have already used the services of contract manufacturers such as Valmet to produce their cars. In addition, given the overcapacity in manufacturing they may be able to buy an existing plant as Tesla did with NUMMI. GM last year shut its last plant in Australia and a British EV entrepreneurs is in talks to buy the assets (Davies, 2018).

In the future dynamics of the auto sector, substantial value migration could occur to new entrants that focus on critical aspects of the auto industry value chain or on niche markets in the electro-mobility age. These critical elements are likely to be dominated by sensors, specialised computer hardware (i.e., video recognition), communication and control software. For example, the platform operating system that is used to control the car and communicate between the car and its surroundings, could become a critical battleground over which new entrants and incumbent OEMs fight to obtain, or retain, a dominant position in the industry.

Connectivity via vehicle-to-vehicle and vehicle-to-infrastructure communications will require standards. Could the players developing the platform operating systems become the kingpins in the future auto industry, setting standards and forcing other actors in the auto ecosystem to adopt them (Jacobides & MacDuffie, 2013)? The current three big players in this space are Google, Apple, and Microsoft. Each have already adapted operating systems for the car (Android, IOS, and Windows Embedded Automotive, respectively). In China, Baidu and Alibaba are actively working on similar systems. While the early generations of these products have focused on smart phone connectivity etc., to enhance phone operations and music playing, these platforms could readily form the basis of future features such as advanced driving navigation, partial and fully autonomous driving and communication and connectivity to manage traffic flows. Apple is known to be working on car applications and autonomous vehicle technology (Bergen & Webb, 2017). Already, driving navigation tools leverage online mapping and big data in real time to provide guidance of how to avoid traffic jams. In future, the same systems could manage traffic flows automatically if a sufficient portion of the traffic is connected to the one system.

The large IT companies such as Google, Apple, Microsoft and their Chinese counter-parts Alibaba, Baidu, and Tencent have the financial capacity and technical capabilities to repeat the Tesla journey, or even, to buy an OEM outright. Apple for example in February 2018 is sitting on US $250 billion in cash and its stock value is 15 times as large as GM (US $ billion 900 versus 60 billion). If large IT companies decide that it does not make sense for them to become system integrators outright, then they could focus on capturing value by developing platform technologies that become installed in the cars produced by the OEMs through alliances. Companies such as N-Vidia and Intel are currently adopting this approach (Turner, 2017). For IT companies, this strategy would leverage their existing competitive advantage in hardware, software, smart phones, big data, artificial intelligence and cloud services infrastructure (e.g., see for example Sangameswaran & Nagarajan, 2017). For B2C firms such as Apple, the aim could be to develop ecosystems which seamlessly integrate a user's smart phone, their connected 'smart' home and the 'smart' car; for B2B firms such as Intel, the aim could be to develop an IT vehicle platform that multiple OEMs install in each car. It is conceivable that in the long term controlling the automotive IT platforms may become more valuable than making the car itself, especially if individual ownership substantially declines, reducing the value of automotive aesthetics. This is precisely what happened with the PC three decades ago, when a large portion of the sector value migrated to the producers of the critical components, being the CPU (Intel) and operating system (Microsoft) (Jacobides & MacDuffie, 2013).

Thus, competition in the auto market is increasing, driven by a convergence of trends including electrification of the powertrain, greater use of ride-sharing and the future prospects for autonomous vehicles. New companies are being formed in an attempt to take advantage of the lower barriers to entry, while IT companies are vying to enter the sector directly or develop standards and platforms so they can become kingpins and control the emerging ecosystem(s).

As barriers to entry have come down, competition in the EV space has changed dramatically since the Model S was launched in 2012. New entrants such as the Chinese company Qiantu are attempting to repeat Tesla's success in China and have announced a luxury EV sports car with the intention of developing more models in future (Schuman, 2017). Established companies such as BYD of China already have a range of EV and PHEV cars on sale. Over the coming 3 to 5 years all major OEMs will have hybrid EVs and battery EVs across most major market segments and will be delivering those products at scale. What will be the ramifications for new entrants and even Tesla? Although Tesla, has a current market capitalisation greater than both GM and Ford, it still needs to ramp up production of the Model 3 and compete against rivals such as the Chevy Bolt and forthcoming compact luxury EVs from European and Japanese manufacturers.

In China, the government is backing the development of a local EV industry with substantial funding and tariffs on imported autos. While China's strategy to become a leading manufacturer of ICE automobiles hasn't been fulfilled, the electric vehicle market is less mature and may offer a second opportunity for Chinese manufacturers to develop products which could compete globally. And in China, so-called new energy vehicles, are expected to capture most of the auto sales growth in the country over the next 8 years (Banjo, 2017). A plethora of new entrants have already started manufacturing everything from electric motorbikes and electric delivery vans to electric sports cars. Global start-up NIO (2017), with backing from Baidu, Tencent and several Silicon Valley venture capital firms has developed an electric super-car and announced plans to introduce an all-electric

SUV in China in 2018. BYD has become the world's second largest manufacturer of plug-in hybrid vehicles (behind Nissan) with cumulative production of more than 170,000 units. BYD already produces over 8 GWh of batteries per annum, compared to less than 1 GWh by Tesla.

Chinese internet companies Baidu, Alibaba, and Tencent are investing in autonomous driving technologies, start-up electric car companies and joint ventures with OEMs. Baidu has established an autonomous vehicle division and invested into NIO. Tencent has a 5% stake in Tesla, while Alibaba has a co-operation agreement with SAIC and is actively developing internet connected cars (SAIC Motor, 2016). Given government support, it seems likely that the Chinese internet giants will be in a good position to develop and potentially dictate the autonomous driving platforms used in China.

Emerging manufacturers like Tesla are seeking to become significant OEMs while new IT entrants are working on everything from mapping technologies and smartphone connectivity through to new automobile operating systems and autonomous vehicles. In light of our analysis of Tesla's development, large IT companies could enter automobile manufacturing directly in the next few years. Clearly they do not have to because they can participate in the new automobile ecosystem in many different ways. The automotive industry is now facing its greatest transformation since Edison and Ford argued over whether gasoline combustion or lead-acid batteries should power the automobile a century ago (Israel, 1998).

For management scholars, the success of Tesla, the emergence of new automobile OEMs in China, and the strategic moves by IT companies to establish themselves in new segments of the industry raises important questions whether the future of automobiles will look very different than its past. If one thing is for sure, it is that the success of Tesla has heralded a new era in the automobile industry. As innovation and competition in the automotive sector increases, consumers will be the big winners. There is more choice than ever and new cars are more efficient, safer and have more features than those which came before.

NOTE

This paper was written while Murmann was at the University of New South Wales.

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Dialogue, Debate, and Discussion

Response to Perkins and Murmann: Pay Attention to What Is and Isn't Unique about Tesla

John Paul MacDuffie
University of Pennsylvania, USA

Perkins and Murmann (2018) advance a provocative thesis, based on Tesla Motors, that 'a well-funded company could develop a new electric vehicle (EV) from scratch and move it into production within 3 to 5 years….' This thesis of feasibility – indeed likelihood – of more new entrant EV automakers is at odds with my recent work (e.g., Jacobides, MacDuffie, & Tae, 2016; MacDuffie, 2013) which argues that automotive OEMs have been able to prevent extensive value migration to suppliers and new entrants due to their structural role as system integrators with the capabilities to manage a primarily integral product and organizational architecture. This role is bolstered by societal demands for OEMs to meet regulatory requirements for safety and handle legal liability claims. These structural features have helped automotive OEMs avoid the fate of IBM, which saw massive value migration, after introducing the modular PC, to Intel and Microsoft (suppliers of key components). These same features, I argue, will position these OEMs for continued centrality, forestalling a wave of successful new entrants despite many new, disruptive changes in technology and business models.

Perkins and Murmann use Tesla as a case providing 'existence proof', i.e., if Tesla is successful within 5 years, it means that other new entrants from the tech sector can succeed just as readily. They expect that these new entrants will disrupt the automotive sector, altering the basis of competition through fundamental changes in product architecture, production process, and industry structure. I will argue instead that Tesla's story teaches us something quite different – that a new automotive entrant must master the same integral product architecture, production and supply chain capabilities, and system integrator role as incumbent OEMs. Furthermore, Tesla's idiosyncrasies as a new entrant are many, and a distraction from the larger question of which firms – automakers or tech-based firms like Google, Apple, Baidu – are most likely to usher in the new wave of product, service, and business model innovations in mobility. My answer: firms from both sectors will need to work together (out of necessity, not preference) to integrate the physical and digital worlds successfully.

WHAT'S IDIOSYNCRATIC ABOUT TESLA

To start, consider Tesla in the historical context of the global automotive industry. Henry Ford established the mass market for automobiles with a low-cost vehicle produced in high volumes, with affordability resulting from both product design and production economics of scale. Occupying a completely different niche are firms that compete in the high-end luxury and sports car market, producing in volumes ranging (in 2016) from 8000 (Ferrari) to 16,000 (Bentley) to 42,000 (Maserati) using modern-day craft production methods. Tesla, since its founding, has competed entirely in this small-volume, craft-like market niche – until quite recently. Its introduction of the Model 3 in late 2017 marks its first attempt at the mass market – and notably, in this arena, Tesla is struggling.

The timeline asserted by Murmann and Perkins of 'five years to a new EV' is a bit misleading. Tesla was founded in 2003 and its first model, the Roadster, was delivered in 2008. But the Roadster was the retrofit of an existing car, i.e. a Lotus Elise whose internal combustion engine (ICE) was replaced by an electric drive train. This was no simple task, particularly to reach Lotus-like performance, but if Tesla were only a retrofitter of electric drive trains into the designs of other OEMs, we wouldn't pay it much attention.

My view is that Tesla should be seen as a niche luxury car producer up to the 2017 launch of the Model 3. The Roadster (sports car), Model S (sedan), and Model X (SUV) are all at the high end of the luxury price range, with an Average Retail Price per Unit (ARPU) of $79K (vs. $53K for Mercedes, $48K for BMW, $109K for Porsche). Tesla worldwide sales have depended on attracting wealthy individuals; a 2016 survey of 450 Tesla owners found that the average household income of Model S owners is $267,000 and of Model X owners is $503,000 (https://www.teslarati.com/survey-model-x-owners-income-double-model-s/). Tesla's growth since founding is impressive – vehicle sales of 2,909 in 2012, 31,655 in 2014, 76,243 in 2016, 78,130 in 2017. But these are still niche market volumes – still far lower than global luxury brands such as Jaguar (583,000 in 2016) and BMW (2.37 million in 2016). For perspective, a mass market OEM, e.g. Toyota (10.2 million sold in 2016) is orders of magnitude larger. Tesla's *lifetime* volume (through 2017) is 320,000 vehicles (InsideEVs).

Tesla's strategy, unusually (and perhaps brilliantly), was the reverse of the approach taken by new OEMs from Henry Ford on, i.e., introducing low-cost entry-level products to establish enough volume for economies of scale and to build brand recognition and dealer network, then adding higher-end (and eventually luxury) vehicles to the line-up. Unlike most luxury automakers, Tesla founder Elon Musk's long-term vision from the start was to become a mass producer. From this perspective, to move from the Roadster to the Model 3 in just 14 years

(2003-2017) is truly impressive. Even more impressive – and still elusive for Tesla – would be achieving true high-volume mass production, matching the industry norm of 250,000 vehicles (or more) per factory per year.

Tesla's rise was facilitated by various factors that are unlikely to be duplicated for other EV start-ups. Perkins and Murmann note several public sources of financial assistance, e.g., subsidies via rebates to consumers; loans, e.g. from the U.S. Department of Energy; and tax credits for Zero Emission Vehicles (ZEV) that traditional OEMs purchase from Tesla to help them achieve Corporate Average Fleet Efficiency (CAFE) targets. Further policy moves to incentivize EV adoption could contribute to more new entrants and growth for first-movers like Tesla. However, it's more common for subsidies of new technologies to decline over time; indeed, Tesla will soon reach the threshold of 200,000 sales in the U.S. that will end its federal rebates. Furthermore, public funding isn't enough to launch and sustain a globally competitive EV OEM. Tesla is unique in its success at attracting private as well as public funding. Elon Musk has had an amazing ability to excite investors with his vision of an EV future – and to persuade them that he can execute that vision. No other EV start-up has been nearly as successful at attracting sustained funding from either private or public investors – and the list of EV bankruptcies is large and growing.

Tesla's luckiest break so far is its 2010 purchase of the NUMMI (GM-Toyota JV) plant at a bargain basement price, providing a long-term R&D and production home. Tesla paid $42 million for the NUMMI plant – less than 10% of what Tesla borrowed in 2009 from the U.S. Department of Energy to open a manufacturing plant for the Model S. It's hard to imagine another EV start-up getting a bargain like that.

Of course, every successful firm's evolution features unique twists and turns and 'luck favors the prepared'. Yet Perkins and Murmann imply that the 'new normal' will be for amply-funded startups to bring a 'from scratch' vehicle to market, on average, in 3–5 years. This claim warrants closer investigation.

WHAT'S NOT SO DIFFERENT ABOUT TESLA

The foregoing emphasizes ways in which Tesla's story is idiosyncratic. Also important, and perhaps more surprising, are the ways in which Tesla has had to master the capabilities of all other incumbent automotive OEMs to maintain its share of value.

First and foremost, Tesla is highly vertically integrated, much more than most contemporary OEMs but similar to the norm in the early history of the auto industry. Tesla's choice also fits the predictions of scholars that such integration is particularly valuable early in an innovation life cycle. Perkins and Murmann emphasize Tesla's integrated design approach based on the interdependence of four key components – battery pack, power electronics, high efficiency motor, and electronic control software. This approach seems to challenge the conventional wisdom that electric drive trains are more modular and simpler to design, source, and build than ICEs. Yet for Tesla, emphasizing effective cross-component integration is a way to achieve higher system performance and establish distinctive vehicle characteristics while also controlling quality and developing a distinctive 'look and feel'. Consistent with the Jacobides et al. (2016) argument, Tesla, in taking on the full system integrator role, is doing precisely what long-established automotive OEMs have done to retain value.

Notably, Tesla is still controlling all of these key components internally, from design to manufacturing. Perkins and Murmann emphasize that Tesla's early battery pack design, with its building block of simple, standardized lithium cells, was intended to support multiple suppliers. While true at the start, Tesla quickly switched to internalize battery design and production, working closely with a single supplier (Panasonic) and culminating in the joint venture dedicated 'giga-factory' in Nevada. Even if Tesla outsources more eventually, it will likely conform to the typical OEM system integrator role, i.e., it would 'know more than it makes' by employing engineers with the knowledge to design, procure, evaluate, and integrate the outsourced components.

Many have predicted that EVs, with more modular components, will drive a structural shift towards deverticalization of the auto industry's integrated product and organizational architecture – as the PC did for the computing industry. But Tesla's EVs do not (and, I predict, will never) have a modular product architecture in which independent suppliers control key modules and coordination is guaranteed by pre-defined module interfaces. Tesla's need to deliver high performance along various dimensions (power/acceleration, steering/braking, smooth and quiet ride, comfortable interior, easy-to-use dashboard user interface, aesthetic design plus fit-and-finish of the body) requires a high level of system-level integration across interdependent components. Functionality in a Tesla is not one-to-one (modular) from component to function (as a hard drive provides storage) but one-to-many (one 'chunk' provides part of multiple functions) or many-to-one (many components are needed to complete the full function). For example, regenerative braking in an EV is a highly integrated feature, mor than braking in a typical ICE vehicle, because it requires that the brakes be interconnected with the power electronics. The PC analogy doesn't apply to EVs any better than it applied to conventional ICE vehicles. To reiterate, Tesla has needed to learn to be an effective system integrator, emphasizing vertical integration and knowledge-based coordination like the OEMs that have preceded it.

Another misplaced prediction, in my view, is that new entrant EV OEMs will emphasize design and outsource manufacturing, like Apple's 'designed in California' strategy with production handled by contract manufacturers such as Foxconn. In fact, some past EV start-ups did pursue this template. Coda Automotive was founded in 2009 and its first product was a retrofitted Chinese mass market vehicle, the Hafei Saibao. The Saibao ICE version was designed by

Pinafarina in 2005 based on the chassis of the Mitsubishi Lancer; Coda's engineers converted it to electric propulsion. Components were all from China, including the welded body, but with the twist of doing final assembly in California to allow 'made in America' marketing claims. Coda received, in total, venture funding of $325 million, well below the $1-2 billion level set as the likely investment threshold by Perkins and Murmann. Offered at a price similar to the Nissan Leaf, Coda sold only 117 vehicles before filing for bankruptcy in 2013. Tesla has certainly been better capitalized than Coda, but also kept manufacturing of all key components in-house. For a new EV firm, outsourcing manufacturing may delay the development of necessary capabilities.

Perkins and Murmann make much of Tesla's move to hire experienced auto engineers for the Model S, implying a straightforward path to acquiring necessary industry knowledge. The pursuit of experienced human capital is best regarded as a necessary but not sufficient condition for a new OEM to succeed. Coda, for one, was headed by experienced automotive executives and had ample engineering talent for its conversion of the Saibao ICE. Fisker, a luxury EV competitor, was packed with engineering and managerial talent hired away from traditional auto OEMs but it also went bankrupt. (Fisker is back, with new Chinese ownership.)

Tesla's strategy confirms the necessity of EV makers developing deep automotive industry technical knowledge concentrated at the OEM – because the system integration role is no less crucial for EVs. Even if the components for an electric drive train are somewhat more modular, the overall drive train needs to be fully integrated with all other systems in the vehicle, e.g. steering, braking, suspension, electronics, safety, HVAC. However, more than automotive expertise is needed; Tesla also has many engineers who are experts in digital technologies. These engineers have helped Tesla achieve advanced connectivity – perhaps its most dramatic innovation affecting the relationship between automaker and customer – manifested in its over-the-air software updates. Tesla's ability to integrate digital and traditional automotive technologies – visible in its large central touchscreen that controls many functions as well as guiding Tesla owners to proprietary recharging stations – is indeed central to its success. This required hiring the right technical talent – and indeed incumbent OEMs have had to hire from that same talent pool to keep up. But more crucial was choosing an integral product architecture and then building the (time-honored) capabilities needed for effective system integration.

While being well-capitalized – and able to pay top dollar for technical talent – is helpful, it does not replace the long hard slog to build these capabilities. In this regard, Tesla is also **not** unusual according to historical norms in this industry; it has had to work through the same learning process as any other new OEM in the 100+ years since the industry's birth. The fact that it is the only new EV firm, so far, to achieve this goal just shows how difficult this capability-building is – hardly a basis for predicting that this will become widespread.

WHAT LIES AHEAD FOR EV OEMS – AND FOR THE FUTURE OF MOBILITY?

Perkins and Murmann use the Tesla case to suggest that barriers to entry are coming down in the auto industry. This may be true, although it remains to be seen how many new EV firms will survive this period of transition. Their other predictions arise more from the analogy to the PC than from Tesla's example. For example, they claim new EV auto entrants can draw on contract manufacturers (CM), i.e. find their own Foxconn. They give the example of one CM, Valmet Automotive, in Finland, that has manufactured low-volume models for Saab, Porsche, and Mercedes for 50 years. But Valmet Automotive is one of the only contract manufacturers that has survived, e.g., Karmann and Semcon have gone out of business and Valmet Automotive has purchased their assests. If an Apple-like model of OEMs doing designs and outsourcing manufacturing was becoming more feasible, the set of automotive CMs would be growing, not shrinking.

Certain arguments advanced by Perkins and Murmann (2018) are clearly on the mark. With rapid advances in vehicle connectivity and autonomy, new digital hardware components are becoming more critical (e.g. sensors and cameras; LIDAR, a laser-based radar; specialized chips) and the relative importance of software vis-à-vis hardware is increasing steeply. Multiple firms are working on platform operating systems for connectivity and autonomy – including tech firms like Google, Apple, and Samsung; incumbent automakers that have acquired software start-ups, e.g. Ford acquiring Livio; and software start-ups seeking to partner with hardware makers. Competitive ferment in these new technologies is guaranteed, given the high uncertainty surrounding regulations and technical standards, both of which will critically influence the advance of self-driving vehicles.

But Perkins and Murmann (2018) go on to conclude that the tech firms will hold all the advantage in this competition, particularly since they are wealthy enough to buy whatever talent they will need. Indeed, they claim that large IT companies could buy automotive OEMs outright. This is no doubt true based on market valuations, but it doesn't mean that they are likely to do so. It is much more likely that the automotive and IT/tech sectors will need each other. Neither will be able to achieve as much on their own as they can through effective collaboration. Undoubtedly in some of these collaborations, one partner will have more power than the others. It is probably no coincidence that after Google's self-driving car project (now Waymo) failed to establish a partnership with Ford, it turned instead to an arrangement with FiatChrysler – a weaker OEM – to get the base vehicles (Chrysler Pacifica minivans). Still Waymo has stated outright that it has no plans to build vehicles at any point. Reports from secretive Apple show a scaling back (including layoffs) of an initiative to manufacture its own vehicles. Furthermore, after talks with Daimler-Benz and BMW failed, Apple now has just one AV project – conversion of a Volkswagen van to an EV shuttle that will move employees around its main campus. New mobility service firms Uber and Lyft also have no plans to backward integrate into vehicle design or manufacturing; instead they are working with partner firms, e.g., Volvo (owned by China's Geely) for Uber; GM, Ford, and Magna for Lyft.

The most likely scenario is that the system integrator role will be just as essential in the future automotive/mobility ecosystem. The big questions are how that role will change and who will fill it. My prediction is that *hardware/software integration* will become the most valuable capability for either incumbents or new entrants – and this capability will require a combination of digital tech and automotive expertise. A tech new entrant will need to acquire the automotive expertise and an automotive incumbent will need to acquire the digital tech expertise. In this emergent ecosystem, relationships between specialized firms (from both sectors) possessing complementary assets will be necessary for effective knowledge integration and strategic alignment.

Perkins and Murmann end with a fitting look at the Chinese automotive industry and the rapid development of its EV market. China is now the biggest, fastest-growing EV market in the world. The government is driving this growth with subsidies/incentives, but also via massive investments in charging infrastructure. The Chinese government has also been urging domestic OEMs to move aggressively into EVs, seeing an opportunity to build competitive advantage around a slow-diffusing technology (about 1% of annual global sales).

If the Chinese government succeeds in stimulating a large EV market, its domestic OEMs won't necessarily dominate. Not for lack of trying; Chinese OEM SAIC, JV partner to both GM and VW, plans to introduce up to 30 new EV models in the next 5 years. Western OEMs are certainly paying attention. Indeed, with the Chinese government using both carrot (financial incentives) and stick (requiring that a rising quota of vehicles sold in China must be electric) to build a huge EV market, Western OEMs will certainly rush in with their own models. With ICE models, Western brands proved to be more attractive to Chinese consumers than domestic brands, due not only to brand strength/image but also to better systemic performance attributes (smoother ride, quieter, more reliable) arising from better mastery of integrative design capabilities. This could happen with EVs too.

Despite the strong interest of Chinese IT firms Baidu, Alibaba, and Tencent in the auto sector, I do not share Perkins and Murmann's conviction that they will enter auto design and manufacturing directly. Following a similar thought process to Waymo and Apple, these tech giants will ask themselves why they want to be involved in the highly capital-intensive, logistically complex, organizationally large-scale, and constrained (by regulations, legal liability, and societal expectations) business of auto manufacturing when they could focus instead on platform operating systems where existing automakers will be their customers and collaborators rather than their direct competitors.

CONCLUSION

In conclusion, I take issue with these predictions from Perkins and Murmann: 1) I don't see EV product architecture being substantially more modular; 2) I don't believe contract manufacturing will take on a bigger role in how vehicles are produced, 3) Nor will large IT firms enter automotive manufacturing directly; 4) Any new entrant, even if making solely EVs, will have to learn the same capabilities as current automotive OEMs; and 5) That learning process will be long and slow – and may be best achieved through vertical integration. I definitely do not see Tesla heralding a new era of rapid entry into auto manufacturing by tech firms.

Accordingly, my colleagues in the Program on Vehicle and Mobility Innovation and I will be evaluating these research propositions:

1. Architecture still matters. When modular digital technologies meet the integral architecture of modern-day vehicles, integrality will predominate. The importance of hardware/software integration necessary for both functional and aesthetic features will reward the firms that can best dominate their collaborators.
2. Meeting both consumer and societal expectations will be crucial. Low-to-non existent oversight of new technologies and business models will gradually give way to adaptive laws/regulations and coordination with public mobility actors to establish appropriate levels of functionality, safety, access, and accountability.
3. Mobility will not be 'winner-take-all'. Human needs for mobility are diverse and the demand for individual mobility will continue to grow; demand for local knowledge of geography, routes, and consumer preferences is still valuable, and many competitors have a plausible claim to providing a viable mobility product/service (Keith & Rahmandad, 2018).
4. The magnitude of the automotive 'installed base' will require a prolonged transition. As of 2018, EVs have just reached 1% of annual global sales (nearly 90 million vehicles). No fully autonomous or connected vehicles yet exist. The mix of human-driven and algorithm-driven vehicles increasingly sharing roadways will pose unique challenges that will delay the fully autonomous future.
5. Developing countries will continue to provide the most influential 'new entrants'. The low-cost EV market will be particularly intriguing. A thriving (and illegal) 'grey market' in such vehicles exists in third- and fourth-tier Chinese cities (Chen, 2018). The Renault-Nissan alliance is racing to apply its 'frugal engineering' approach (from Eastern Europe's Logan and India's Kwid) to provide a legal entrant. But in the long run, a 'new entrant' Chinese EV firm is likely to be the firm that wins this market at scale.

What about Tesla's prospects for making the leap from luxury producer to mass market OEM? Amid the intensive focus on the slow and troubled ramp-up of Model 3 production, a recent statement by Elon Musk is noteworthy. He said that it will be better for Tesla to sell the Model 3 only in versions priced from \$60,000-\$75,000. While not publicly abandoning the goal of a mass-market EV, Musk implies that an incumbent competitor – e.g. GM with its \$35,000 Chevrolet Bolt – will do better at that lower price point and with those volume imperatives. Meanwhile Mercedes-Benz and BMW are finally responding to Tesla's conquest of their customers by launching multiple new EV models. Thus, Tesla will be squeezed from above and below as the EV market matures.

Facing these pressures, Tesla will likely settle into a niche of providing near-luxury products coupled with advanced services (e.g. home charging via its Powerwall battery system; its own version of a peer-to-peer 'car sharing' app; its AutoPilot software). Tesla's Model 3 difficulties will cause its stock price and valuation to drop and it could become an attractive takeover target. Even if Tesla becomes the EV division of an existing automaker at some point, the overall Tesla narrative, when we look back in 20–30 years, will shine, not just for its idiosyncratic features and charismatic founder, but also – more powerfully – as 'existence proof' of how many industry-standard capabilities have to be mastered to survive as an automaker in the 21st century.

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Dialogue, Debate, and Discussion

To Be Friends, Not Competitors: A Story Different from Tesla Driving the Chinese Automobile Industry

Hong Jiang[1] **and Feng Lu**[2]
[1] *Chinese Academy of Social Sciences, China, and* [2] *Peking University, China*

This interview contributes to the conversation around the automobile industry by focusing on the Chinese electric vehicle (EV) sector. Both of the discussants' research interests encompass China's industrial competitiveness, innovation, science and technology policy, and the evolution of Chinese manufacturing industries. Professor Feng Lu, the interviewee, has conducted continuous and substantial fieldwork tracing the development of the Chinese automobile industry. He was one of the first experts to urge the Chinese government to help local automobile manufacturers develop innovation capabilities and proprietary products. Further, his 2005 book, *The Policy Choice to Develop China's Automobile Industry with Independent Intellectual Property Rights*, profoundly influenced the national policy transition toward emphasizing in-house innovation.

As with Perkins and Murmann (2018), Lu expects lower barriers to entry within the industry following the introduction of EVs, but he differs with them on whether Chinese companies would replicate the success of Tesla and which group of companies might become dominant. Because it is difficult to develop automobile design capabilities, Chinese internet giants have shifted from competing directly with established internal combustion engine (ICE) car manufacturers to collaborating closely with them when entering the EV sector. As this discussion below will suggest, dominant players in the Chinese automobile industry of the future may not be the two groups strongest at present, but rather some new 'species' that successfully integrates new services and EVs, thus creating a new ecosystem around the automobiles.

HONG JIANG: Are the automobile industry's barriers to entry coming down?

FENG LU: They are. Capability requirements for new entrants have changed significantly since the introduction of EVs. And, for four reasons, it is now much easier for Chinese players, whether internet companies or ICE car manufacturers, to enter the EV sector.

First, while product quality and technical performance make the difference in the ICE car sector, *customer experience* is central to success in the EV sector. This shift in emphasis has opened opportunities for Chinese players who are inexperienced or comparatively weak in ICE car manufacturing, allowing them to compete globally by developing better EVs. Success in the ICE car sector previously required long-term development of technological capabilities, establishing higher technical barriers to entry, and making it difficult for new entrants to challenge the dominant position of early movers and established ICE car manufacturers. In that EVs are intelligent vehicles, however, customer experience has become the focus, including the experience of driving an EV and the enjoyment of those services built into an EV-centered ecosystem. Integrating cars, IT platforms, and internet-based services may be even more important to a company than producing well-functioning cars. Thus, nascent entrepreneurs and existing companies in China attentive to internet-based customer experiences can leverage these capabilities within the EV sector and compete with dominant ICE car manufacturers.

Second, the local industrial system around the Chinese automobile industry is mature and complete, with local component suppliers and a local supply chain of automobile manufacturing now well established in China. More importantly, some Chinese ICE car manufacturers have developed internal capabilities for automobile design, development, and manufacturing, enabling ambitious Chinese players — new entrants or existing manufacturer s— to source and integrate necessary resources and capabilities locally, thereby more easily launching new models.

For example, Chinese ICE car manufacturers that took the lead in launching EVs such as SAIC[1] and Geely are able to design and develop new automobiles in house, while those bound to foreign architecture platforms for automobile design and development lag far behind. Of the three largest state-owned ICE automobile companies that formed joint ventures with dominant foreign players, two (DFAC and FAW) have depended heavily on foreign technologies and platforms in developing new products and have not entered the EV sector. By contrast, SAIC absorbed the imported technologies and developed some new engines and cars independently, while also starting a joint venture with Alibaba in 2016 to develop internet-connected vehicles. Other Chinese ICE car companies that have introduced EVs also enjoy in-house automobile-development potential. For example, Geely entered the automobile industry in 1997 and built in-house capabilities for car design and development, introducing several successful ICE cars after 2002. It acquired Volvo in 2010, a move which significantly enhanced the firm's technological capabilities. Geely created a new brand, LYNK & CO, in 2016, under which it introduced a Volvo-based shareable SUV, available as a hybrid, plug-in hybrid, or full electric propulsion vehicle.

EV startups and internet companies are also facilitated by local capabilities of automobile development and manufacturing. NIO, a Chinese EV startup that has attracted more than fifty strategic investors worldwide, chose to collaborate with JAC, a Chinese ICE automobile manufacturer, and outsourced all its manufacturing to JAC. Large-scale production started in September 2017, and NIO successfully put its first internet connected all-electric SUV on the market in December 2017. It would have been much more difficult for NIO to deliver the new SUV on scale if not for JAC's capabilities in automobile engineering and manufacturing. Chinese internet giants such as Baidu, Alibaba, JD, and Tencent have also collaborated with capable local automobile manufacturers, as in the joint venture of Alibaba and SAIC, thus utilizing the companies' collective experiences and capabilities.

Third, unlike what happened in the ICE car sector, Chinese players are not technologically inferior to foreign counterparts, and they started R&D on EVs around the same time. New entrants have therefore locally sourced advanced technologies more quickly and economically in the EV sector than in the ICE car sector. Compared to other nations, the Chinese government has more actively supported the development of EV technologies, sponsoring R&D projects on EVs on a national level early in the 1990s and initiating projects under the State High-Tech Development Plan in 2001. Moreover, while foreign players initially focused on hybrid vehicle technologies, only gradually shifting to EVs, the Chinese government was determined from the start to advance the technologies of all-electric vehicles. Chinese players can, therefore, parallel foreign competitors in some key EV technologies, such as batteries. Tesla and Panasonic formed a battery partnership where Panasonic would supply all the batteries Tesla needs, but Chinese companies are challenging Panasonic's position as the leading supplier of EV batteries. Considering output volume, the two largest Chinese competitors, BYD and CATL, produced 7.35GWH and 6.72GWH of batteries, respectively, in 2016. Both can match Panasonic in production scale, meaning China will replace Japan as the largest EV battery supplier. In terms of battery quality, while BYD follows a relatively low-cost, low-price technical trajectory for batteries, CATL takes on a more expensive but more advanced trajectory and has become the battery supplier for BMW and several other European car manufacturers. The technological gap between Chinese and foreign players in the EV sector is clearly smaller than it is in the ICE car sector.

Fourth, China is the largest EV market in the world. Chinese consumers purchased over 300,000 EVs last year, favoring Chinese entrants who register local demand. As the Chinese government provided substantial subsidiaries to EV customers, Chinese consumption of EVs expanded quickly. Although government subsidiaries for EV consumption may be cut in 2018, a local market exists. The sharp growth in sales of EVs suggests they will soon replace ICE cars in China. Indeed, while no foreign companies or their joint ventures introduced EVs to the Chinese market until 2014, sales increased dramatically the next year as the number of 'new energy' cars in China went from 75,000 to 331,092. Noting this surge of interest, foreign companies immediately introduced a range of hybrid cars and EVs into China in 2015–2016.

HJ: Will internet giants soon defeat established automobile companies and dominate the Chinese EV industry?

FL: I doubt Chinese internet giants will replicate the story of Tesla by competing directly with established automobile manufacturers. I expect they will collaborate with automobile manufacturers, and get deeply involved in the EV sector, but not attempt to dominate the sector. This prediction is based not on theoretical inferences but rather my observations thus far of the development of the Chinese EV industry.

I expect that collaboration between internet giants and ICE car manufacturers will characterize the development of the Chinese EV industry for three reasons. First, it will take longer than expected for Chinese internet giants to acquire automobile development and manufacturing capabilities. Even Tesla took five years to have an EV for sale. Chinese internet and software companies entered the EV sector aggressively in 2015, but their initial intention was to hire automobile specialists from outside and to launch internet-connected EVs and autonomous EVs independently. Chinese automobile companies were anxious about internet companies reshaping the automobile industry and about automobile manufacturers being degraded to mere OEMs. However, one year later, both groups realized the mutual benefit of collaboration. The internet companies struggled to design and manufacture EVs on their own, a result evident in the case of Tesla's Roadster. EV design cannot be achieved by replacing an ICE powertrain with an electric one or by adding a new electric powertrain to an ICE car. To introduce a new EV requires a thorough redesign, something that is beyond the current capabilities of Chinese internet companies. As competition in the EV sector intensifies, there may not be enough time for Chinese internet companies to take on such tasks internally, which is why, in 2016, certain companies modestly decided to collaborate. Baidu, Tencent, and JD all invested in the startup NIO, for example, while Alibaba started a joint venture with SAIC, and Tencent established a strategic partnership with GAC.

Second, internet giants need not dominate automobile design and manufacturing to capture value from EV businesses. While internet companies have a stake in the EV sector, their business interests differ from those of automobile manufacturers and transcend concerns over EV design or manufacturing. EVs are only part of the broad internet of things (IoT) that internet companies aim to build. These companies would benefit from connecting everything, including EVs, by their services, and by building an ecosystem; but this does not require them to dictate every industry connected through internet services. Internet giants are better served expanding their coverage of internet-based service platforms than investing in learning how to design, develop, and produce cars. For example, Tencent would be happy enough if all the cars, trains, and other transportation vehicles were connected via WeChat (Tencent's IM software), even as the company would not plan to dominate those industries.

Third, for reasons perhaps related to history and relative power, internet companies and automobile manufacturers in China collaborate more easily than their American counterparts. The U.S. automobile industry, symbolized by Detroit, and the heart of American internet enterprises, Silicon Valley, have long distrusted each other. American automobile manufacturers have a glorious history of innovation, such as the Ford Production System, and incumbent automobile companies have developed strong routines of which they are proud. Similarly, the internet industry in the U.S. has, from the start, been dominant, with internet companies also finding their routines and capabilities a good fit for the environments in which they exist. Because of this mutually felt confidence, compromise between them has been a challenge. By contrast, the Chinese internet and automobile industries are capable of working together. In fact, ambitious Chinese internet companies are always looking for chances to innovate in this way, and Chinese ICE car manufacturers, less constrained by history and routines than their American counterparts, are also happy to collaborate with internet companies in the hope of becoming leading players. This is perhaps why Chinese internet companies quickly retired in-house EV-development efforts in 2015, turning instead to external collaboration.

HJ: What will be the potential ramifications of entry in the Chinese EV sector?

FL: I see three ramifications. The first is incumbent ICE automobile companies entering the EV sector independently, such as Geely, which introduced LYNK & CO, a new EV brand. Such incumbents include automobile manufacturers and designers, with an example being Qiantu, a subsidiary of CH Auto. CH Auto, a spinoff of the Beijing Jeep Company, was founded in 2003 to provide automobile design and development solutions. The firm started an EV division in 2010 and tried to collaborate with automobile manufacturers to launch EVs, but there was little interest. CH was therefore determined to transit into EV manufacturing, resulting, in 2015, in the establishment of Qiantu, which will deliver its first all-electric sports car in mid-2018. If it can overcome financial problems and scale up production, Qiantu may become the first upstream enterprise to successfully expand as a manufacturer in the automobile industry.

The second ramification is joint ventures or collaborative relationships initiated by incumbent automobile manufacturers and internet companies, such as the joint venture between Alibaba and SAIC and the strategic partnership between Tencent and GAC are both of this kind. As noted above, Chinese internet companies do not intend to be dominant in these relationships.

The third ramification is disruptive startups whose founders understand both the automobile industry and the internet industry but did not originate within either one. A startup of this kind is NIO. The founder of NIO established an internet startup in 2010 to provide an on-line shopping guide for automobiles, mobile applications for automobile consumers, and internet-integrated marketing solutions for automobile manufacturers. The company is a bridge between automobile dealers, automobile manufacturers, and large web portals, and its founder gained expertise in both industries. Thus NIO quickly integrated internet and automobile specialists from around the world and attracting a number of global internet giants as strategic investors.

HJ: Which ramification is most likely to be the winner in the future EV sector?

FL: The winners in the Chinese EV sector could be neither the current internet giants nor large automobile manufacturers, but rather some new 'species' we cannot currently imagine because a completely new ecosystem will emerge. Some unanticipated internet-connected services have already been introduced to enhance customers' experiences with EVs, but they are not necessarily under the control of incumbent enterprises. For example, NIO plans to make its EVs part of a courier service system, with the trunk of each vehicle connected to a cloud platform. Packages can be delivered directly to a trunk rather than a permanent address, allowing the EV owner to receive a package wherever she/he is at the time. Comparable services are coming soon, and new entrants who take the lead in introducing and integrating them into EVs may become the future leaders. It is hard to tell what these new entrants, or this new 'species', will be like, but it is likely they will emerge from cross-industry entrepreneurs positioned at the convergence between the internet and automobile industries.

HJ: How do you appraise the possibility that China becomes a global leader in the EV industry? What might be the advantages and disadvantage of Chinese players?

FL: China could, for the first time, become a leading player in the global automobile industry, but I cannot say whether the Chinese will win out eventually. If they do, the final winner will be the new 'species' that transcends the limits of both the internet and automobile industries.

One obvious advantage Chinese players have in the global market is that they've introduced many new features that cannot be found in Tesla's EVs, and they will quickly introduce more. NIO's EVs, for example, have been designed to support ride sharing, lifecycle management, and new internet-based services such as express delivery to a vehicle's trunk, as mentioned above. If these new ideas are successfully integrated into EVs, and if the new ecosystem is accepted by customers, Chinese players may become pioneers in delivering good customer experiences with internet-connected EVs. Customers would then be less concerned whether a car comes from BMW or Mercedes, perhaps favoring Chinese EVs well supported by a complete service platform and thus giving Chinese players an advantage over foreign companies.

Chinese players are also served well because they design EVs to meet the local need of the Chinese market, the world's largest one. EVs designed by Tesla and other foreign companies may be technologically advanced but might still not fit well within the Chinese market. Tesla's cars, for example, are very expensive, pegged as they are to their price in the U.S. market. NIO's latest all-electric SUV is only half the price of a Tesla, but even then it's unclear if mainstream Chinese customers, especially younger customers, will be willing to buy one. By building an ecosystem around EVs, however, NIO will be able to attract those younger customers who cannot afford luxury cars, perhaps moving the company into a dominant position within the Chinese market.

HJ: Which way might be more promising for entrants in the EV sector, a vertical integration model like Tesla's or a model based more on outsourcing?

FL: It is hard to determine which is better, because the make-or-buy choice depends on the history and experiences of entrants. Disruptive startups that are inexperienced in automobile manufacturing, such as NIO, have selected contract manufacturing, while incumbent automobile manufacturers such as BYD and Geely, and their joint ventures with internet giants, naturally exploited existing manufacturing capabilities to implement a vertical integration model. It is theoretically possible that a new venture startup that integrates automobile design, development, manufacturing, and retail sales, as Tesla does, can come out in China, but this hasn't happened yet.

HJ: Who developed the software and platform operating system for EV companies in China? When internet companies that develop platform operating systems accumulate enough experiences on EVs, will they become the kingpins in the industry by handling industrial standards?

FL: Developers of operating systems differ across companies. NIO hired industrial specialists and collaborated with external players to develop its software and operating platform, while incumbent automobile manufacturers such as Geely hired experienced software engineers and internally developed an operating system. To do this, the joint ventures between automobile manufacturers and internet companies facilitated human resources from both sides.

There will be competition between different standards and platforms, but it won't come soon. In addition, it will take a while before different standards converge to make a new dominant design. Although Chinese internet companies are currently participating in the transformation of the automobile industry, they have no intention of dominating the industry. They will collaborate with automobile manufacturers to set the new industrial standards but may not compete directly with the latter to become kingpins.

Table 1. Major Chinese Entrants in the EV sector

Type of company	*Company*	*Moves in the EV sector*
Internet giant	Baidu	- Establishing an autonomous vehicle division in 2015 with the intention to deliver autonomous vehicles within five years - Starting to develop autonomous driving software, internet-connected vehicle solutions, and vehicle-based big-data service for car manufacturers - Investing in NIO
	Alibaba	- Collaborating with SAIC in 2015 to develop internet-connected EVs - Developing intelligent driving platform
	Tencent	- Collaborating with GAC and announcing in 2017 a concept EV that is to be delivered on scale in 2018 - Developing internet-connected EV system and intelligent automobile platform - Holding a 5% stake in Tesla - Investing in NIO
	JD	- Investing in NIO
Incumbent ICE automobile manufacturer	SAIC	- Collaborating with Alibaba in 2015 to develop internet-connected EVs - Introducing two models of all-electric vehicles in 2017 under its proprietary brand Maxus - Founding two new joint ventures with CATL in 2017 to develop and produce EV batteries
	DFAC	- Founding a subsidy in 2001 to develop EVs - Having introduced several models of EVs - Holding stake in CATL
	FAW	- Introducing its first all-electric vehicle in 2017
	GAC	- Introducing a model of EV in 2014 under its proprietary brand Trumpchi - Introducing an all-electric SUV in 2017 under its proprietary brand Trumpchi - Establishing strategic partnership with Tencent in 2017 to collaborate in intelligent cars, internet-based services around EVs, and related areas
	JAC	- Introducing an all-electric vehicle in 2014 under its proprietary brand - Collaborating with NIO to manufacture all the new EV models introduced by NIO
	Geely	- Introducing a new model of EV in 2013 under its proprietary brand - Introducing a shareable all-electric SUV in 2017 under its new proprietary brand, LYNK & CO
	Qiantu	- Founded in 2015 as a subsidy of CH Auto to manufacture EVs - Announcing its first all-electric sports car to be delivered on scale in 2018

Table 1. Continued

Type of company	*Company*	*Moves in the EV sector*
Disruptive start-up	NIO	- Founded in 2014 as a global start-up with more than 50 strategic investors all over the world - Collaborating with JAC in 2016 to outsource manufacturing - Introducing an all-electric SUV in 2017 which is to be delivered on scale in 2018
EV battery supplier	BYD	- Founded in 1995 as a battery supplier - becoming one of the largest battery suppliers and integrating into automobile manufacturing in 2003 - Introducing an all-electric car in 2006 which was not approved by the central government to put into market until 2010
	CATL	- Formerly the division of power batteries of ATL - Turning an independent company in 2011 to focus on batteries of new energy automobiles - Collaborating with SAIC and DFAC

NOTE

[1] Brief profiles of the Chinese companies mentioned in the interview can be found in Table 1.

REFERENCE

Perkins, J., & Murmann, J. P. 2018. What does the success of Tesla mean for the future dynamics in the global automobile sector? ***Management and Organization Review***, 14(3): doi:10.1017/mor2018.31.

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Dialogue, Debate, and Discussion

Tesla and the Reshaping of the Auto Industry

David J. Teece
University of California, Berkeley, USA

INTRODUCTION

I've been asked to comment on this collection of three papers, each of which offers deep insights into the forces affecting the auto industry, particularly as concerns the relative positions of incumbent auto firms with respect to new electric vehicle entrants. Taken as a whole, the papers open a lens on the changes roiling the automotive sector. In this essay, I'll attempt to widen the aperture and provide a framework for a more systemic analysis of the forces reshaping the industry and the prospects for new entrants.

MANAGING UNDER CONDITIONS OF DEEP UNCERTAINTY

Incumbents and would-be entrants into the auto industry of the future are presently confronting deep uncertainty. Whereas everyday risk can be managed by assessing expected returns based on assumed probabilities, uncertainty involves the unknown and the unknowable. This makes predictions pointless; but a structured approach can still produce insights.

A firm's ability to manage under uncertainty is critical. The dynamic capabilities framework was crafted to help managers understand how firms can profit when uncertainty is ubiquitous (Teece, Peteraf, & Leih, 2016). It calls on managers to sense and make sense of emerging shifts in the environment, rapidly seize potential opportunities, and transform their organizations to maintain environmental fitness.

In dynamic capabilities terms, uncertainty can be addressed by strong 'sensing', which ensures the earliest possible detection of unforeseen changes in the business environment. For example, incumbent auto firms have all made investments in Silicon Valley, forming alliances with a range of technology companies, in order to gain position in, and a better understanding of, the key technologies that are allowing and requiring transformation. These arrangements can accelerate learning and secure access to complementary technologies and other assets needed to compete as the industry evolves.

Uncertainty actually has different dimensions that can be addressed by different mechanisms for sensing and sensemaking. Koopmans (1957), for example, divided uncertainty into two components. Primary uncertainty is unforeseeable, consisting of random changes in the state of the world. Secondary uncertainty, on the other hand, arises from a lack of communication across decision-making centers within an organization or a network. Direct sensing, such as opening lines of communication among divisions or partners, can reduce secondary uncertainty, as can vertical integration (Helfat & Teece, 1987).

A different form of uncertainty is what March calls 'ambiguity', when 'alternative states are hazily defined' (March, 1994: 178). Ambiguity of this kind can be addressed through what I've referred to elsewhere as sensemaking (Teece, 1998). This involves inductive reasoning, leading to explanations for the available (sensed) facts that are probably (but not definitely) true (Weick, 1995).

In a rapidly evolving business situation, the problem is likely to be less one of ignorance or of ambiguous futures than of confusion about the direction(s) in which the present is evolving. A useful approach is abductive reasoning, which involves building a narrative around what is going on and its likely outcomes (Weick, 1995: 99). Jeff Bezos has Amazon's senior strategy team read multi-page memos rather than look at bullet-pointed slides because 'the narrative structure of a good memo forces better thought and better understanding of what's more important than what, and how things are related'.[1] A narrative thus provides a frame for sensemaking and determines which factors are deemed important for further consideration. All strategies are designed to fit a cognitive frame, but when an existing frame ceases to account for observed facts, it needs to be replaced.

The type of uncertainty where multiple interpretations of the facts can be supported is known as 'equivocal' (Weick, 1979). To manage through equivocality, a manager needs to generate multiple hypotheses about the path of industry evolution, then run 'contests' amongst them. The 'winning' hypothesis can then become the basis for a narrative.

In today's global economy filled with complex, interdependent systems, most of these varieties of uncertainty are present. The processes of sensing, sensemaking, building narratives, and generating and testing hypotheses (which, in the dynamic capabilities framework, are all part of a firm's 'sensing' capabilities) can be used together as a means of reaching a sufficient level of certainty to formulate a strategy (Figure 1). This is a potentially powerful process. An organization's 'reasonable interpretation' of its environment 'may shape the environment more than the environment shapes the interpretation' (Daft & Weick, 1984: 287).

As entrepreneurs and entrepreneurial managers (Teece, 2016) move from making sense out of uncertainty to enacting a strategy, the process will inevitably entail some trial and error. When new evidence contradicts a chosen narrative, new hypotheses must be developed. The 'lean startup' paradigm (Ries 2011), which

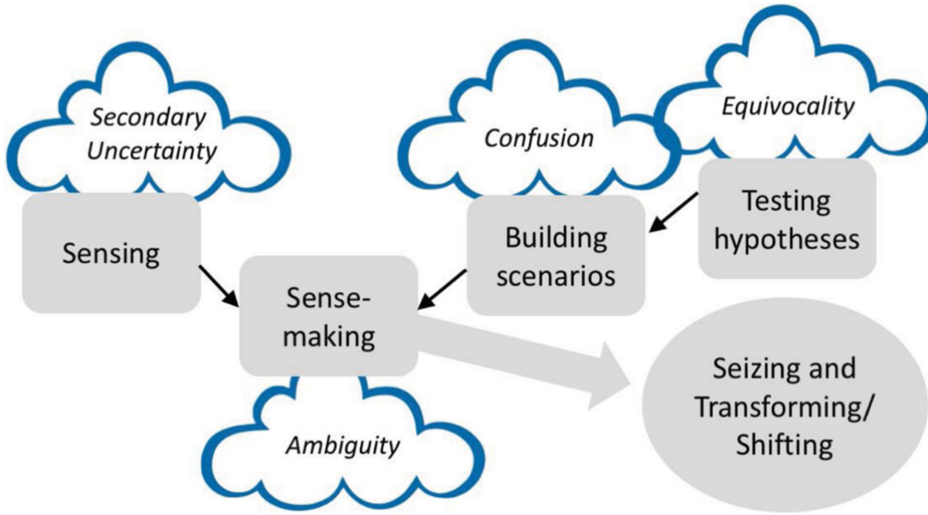

Figure 1. (Color online) Management Under Uncertainty: Sensing and Sensemaking
Note: This framework is an elaboration of Teece (2007) and Cox, Raspin, and Teece (2018).

calls for testing new ideas in the market and 'pivoting as needed', can be applied in companies of all sizes. It's usually better to act and learn than to sit on the sidelines.

In short, uncertainty is not just about unknowable unknowns. Business intelligence and other forms of sensing can support the process of sensemaking. This process, whether done intuitively or formally, can help incumbent auto firms analyze what the Tesla phenomenon says about the future of the industry. The price for misdiagnosing the future evolutionary or revolutionary path of an industry can be colossal, as former cell phone giant Nokia discovered. The fates of regional or national economies is also at stake.

THE DEBATE AS IT STANDS

Perkins and Murmann (2018) use a Tesla case study to estimate the cost of entry into the industry. Their calculation shows that the cost of designing and producing an electric vehicle (EV) is easily within reach of the cash-rich tech giants, especially Alphabet or Apple in the US and Alibaba, Baidu, or Tencent in China, that are already positioning themselves with an array of autonomous and intelligent vehicle projects. They are effectively hypothesizing that such an entry might occur.

Lu (2018) shifts the frame, noting that entry barriers are falling not just in terms of cost but also because the bases of competition are shifting. Consumers will be more concerned with the 'experience' of personal transportation than with the quality of a particular vehicle, which creates opportunities for IT firms with know-how in the creation of compelling human-machine interfaces. He sees the emergence of EVs as an opportunity for Chinese automobile companies to establish a more equal footing with their well-established global rivals in the internal combustion engine (ICE) auto industry.

Unlike Perkins and Murmann (2018), however, neither MacDuffie (2018) nor Lu (2018) expects the IT giants to enter because this would still involve mastering sophisticated manufacturing in which they have no current experience. They see the big tech firms as much more likely to continue collaborating with established auto OEMs that are strong in manufacturing but less experienced in software and machine learning.

Moreover, MacDuffie (2018) is skeptical that barriers to entry for manufacturing have actually fallen. While Tesla was able to carve out an enviable position at the high end, a small-volume luxury success should not be treated as an indicator of the prospects and cost for a mass-market entry. Tesla's current difficulties in ramping up production of its mass-market Model 3 show that producing lower-cost cars in high volume is a very different proposition from limited production of luxury vehicles.

A handful of new EV entrants, including Byton, EVelozcity, Faraday Future, Lucid, and Nio, all with Chinese investors or owners, are also in the wings, but most have yet to deliver more than a handful of vehicles. One of the most amitious is Nio, which has sold thousands of units of its mid-priced electric SUV in China, all of which are being manufactured in a factory owned by an existing auto company known as JAC Motors.

Until an EV-only entrant achieves mass-market acceptance and high-volume manufacturing, it will be hard to argue that lower barriers to entry for EV design and manufacture pose a threat to incumbents.

A WIDER PERSPECTIVE: FOUR PARADIGM SHIFTS

None of the above contradicts the notion that concurrent waves of change are creating potential inroads for new entrants that may pose a serious challenge to established automotive manufacturers. Until recently, automotive has been one of the paradigmatic 'mature' industries, in which the key technological questions have been settled since the 1930s (e.g., Abernathy & Clark, 1985). The industry now faces multiple sources of ambiguity about its potential evolution. In this section, I will undertake a brief sensing exercise before turning to a first pass at sensemaking.

Each of the three papers about Tesla's significance for the industry alludes to the expanding capability requirements in the auto industry, but none of them address these directly. The competitive bases in the auto sector are changing not just in terms of technology, but also in terms of business model and markets. These 'softer' capabilities are often underplayed in academic treatments, although the car companies themselves are acutely aware that they now face capability 'gaps' that they need to close (Teece, 2017). A radical business model innovation can be as disruptive and challenging a change for rivals as any competence-destroying technological development.

Each new capability must be thought of in terms of its distance from existing capabilities on the three dimensions of technology, business model, and market.

The greater the distance, the more effort needed to master the capability – and the greater the risk that a new entrant could emerge from an industry where the capability is already in use.

There are at least four sources of change currently sweeping across the industry, most of which were alluded to by the three papers. It is worth separating out each of the four for analytical purposes.

Electric Vehicles (EVs)

Because of the nature of its powertrain, an electric vehicle has fewer moving parts, which means it is less likely to suffer mechanical failure and needs less frequent service. The main input is a battery, which accounts for a third or more of the total parts cost. As battery makers continue to reduce the cost per kilowatt-hour, the economics of owning an EV become increasingly attractive for consumers.

For car companies, EV technology wipes away the value associated with the portion of their capabilities centered on engine design. While this represents a competence-destroying discontinuity (Tushman & Anderson, 1986), the capabilities needed for designing an electric powertrain aren't entirely foreign to the experience of ICE-based car manufacture and have already been internalized by most car makers.

EVs remain a small part of the auto market. Much of their share to date has been driven by government mandates and subsidies, which are expanding in some jurisdictions and shrinking in others. A mass uptake of EVs faces a complementary asset challenge because consumers report in surveys that they want to see charging stations widely available and/or EV range-per-charge increased. The availability of charging stations could eventually leap ahead if the right entrepreneurial business model helps accelerate the rollout of the charging infrastructure.

Autonomous Vehicles (AVs)

Autonomous vehicles are a partial solution for one of the great challenges of modern life, namely the time lost during long commutes. According to 2017 data from the Census Bureau, workers, of whom three quarters travel alone by car, spend over 200 hours getting to and from work each year.[2] In a fully autonomous vehicle, commute time could be converted to personal or work time, effectively restoring weeks to the average commuter's year. The hardware and especially the deep-learning, real-time control software for autonomy are outside the competences of most car manufacturers, so they have each been forming alliances with one or more of the companies offering autonomy solutions, as noted in the essays. To the extent that autonomy leads to a transition in car ownership from consumers to sharing services, the market for cars will be more fleet-oriented than it is today, which would weaken some of the advantage that incumbent auto firms hold in terms of markets.

Mass rollout of fully autonomous ('Level 5') vehicles is likely at least a dozen or more years away. It will move faster in jurisdictions where governments can bring common standards to the highway infrastructure as well as to vehicles. The acceptance of autonomous vehicles in the US has been hampered by the recent fatal accidents involving cars with software from Tesla and Uber. But, because of the potential benefits, it's a matter of 'when' not 'if' fully autonomous vehicles will be accepted by consumers and in widespread, although by no means universal, use.

Connected Cars

Automobile connectivity, which allows vehicles to access the Internet or other networks, will open new, as yet unforeseen, opportunities that will lead to business model innovation and new markets. Connectivity is already built in to some vehicles. Smart dashboard displays enable on-board shopping and entertainment, route planning, and instant ride sharing. The always-on 3G connection in Tesla's vehicles permits over-the-air software updates that can provide new functionality and/or avoid some recalls. Cars will increasingly support OEM or third-party apps that provide new services and revenue streams (and business models). This requires supplementary competences in software and/or creating a platform for third-party apps. The tech giants, particularly Alphabet (Android Auto) and Apple (CarPlay), are already well positioned to exploit this part of the driving experience because of their entrenched smart device ecosystems. Car makers like Ford and GM began turning from outsourced software to in-house provision several years ago in order to better prepare for the new competitive requirements (Shacklett, 2012).

Personal Mobility Services

Transportation-as-a-service (TaaS, also known as mobility-as-a-service) refers to a business model in which consumers rent the usage of a vehicle as needed (along the lines of what Uber and Lyft currently provide) rather than owning vehicles themselves. The emergence of TaaS has the potential to change the economics of the auto industry, and it is another field of innovation where the tech giants can potentially provide valuable complementary assets.

There are different directions in which the industry could evolve to support TaaS. Vehicle sales could be primarily to fleets owned by car-hire firms rather than to consumers. Or consumers might 'subscribe' to a brand of car rather than buy an individual car. General Motors, for example, is already experimenting with a new model of car ownership that, for a monthly fee, allows customers to switch in and out of different models of Cadillac up to 18 times a year (Colias, 2017). Other car makers are experimenting with car-share services, such as Daimler's Car2Go, which allows one-way usage. The risk of commodification of the automobile looms large behind these efforts. The technologies involved are an extension of the software and data analytics developed for connectedness; but switching the consumer relationship from vehicle sales to frequently recurring interactions would wipe out much of the manufacturers' existing business model and marketing know-how.

SENSEMAKING: THE CHALLENGES FOR INCUMBENTS

In this section, I begin the task of sensemaking by looking at how the four innovation-driven paradigm shifts are challenging incumbent auto firms. As noted in the three papers, paradigm shifts create opportunities for new entrants who could grow into potent rivals. Evidence suggests, for example, that new personal mobility business models, including centrally-owned shared vehicles like Zipcar and person-to-person sharing of consumer-owned vehicles are already eroding individual vehicle ownership (Shaheen, Martin, & Bansal, 2018).

Auto executives have thus been forced to look beyond their frames of reference and begin testing new ideas about how and where they can construct a new advantage. Experimentation is needed to develop any level of certainty in the face of equivocality about which technologies, business models, and markets will prove the most valuable. Tesla, for example, experimented with both battery swapping and fast-charging options for Tesla drivers passing through the rural expanse separating northern and southern California. In 2016, it closed the battery swapping station in favor of investing in more charging stations.

Confusion about the business implications of the four new paradigms is heightened by the complementarities and collisions among them. EVs, it has been claimed, require less maintenance and can cover more mileage in their lifetime than ICE cars (Arbib & Seba, 2017). This makes EVs well-suited to the TaaS model, which is predicated on more intensive use of vehicles than the current personal ownership model. A connected autonomous EV will be able to take itself to a wireless charging station then travel to where it's needed.

Car manufacturers are scrambling to discover what unique selling points they can offer, placing multiple bets to avoid becoming interchangeable parts in someone else's business model. France's PSA Group is even pursuing a 'post-OEM' model in the US, where it doesn't currently sell cars, adopting instead a car-sharing aggregator business model embodied in its Free2Move app.

As Feng Lu observed, incumbent car makers in the West must also pay particular attention to how the innovations impact their position in China. The major global car companies had a comfortable lead in ICE technology. Their wealth of experience in design, integration, and large-scale manufacturing may also give them a source of advantage over entrants, but less so over the best of the integrated Chinese firms, such as Geely, owner of the Volvo brand since 2010. In AVs, connected cars, or mobility services, the playing field is a lot more level than what auto incumbents have been used to. And China has made clear that it intends to promote national champions for EVs and for artificial intelligence, including AV technology.

Table 1. Distances to new capabilities from traditional car manufacturer capabilities

	Three Dimensions of Capability Distance		
	Technology	*Business Model*	*Market*
Electric Vehicles	Medium	Near	Medium
Autonomous Vehicles	Far	Zero	Near
Connected Cars	Medium	Medium	Zero
Personal Mobility	Medium	Far	Far

Note: 'Zero' indicates that the capability for the new technology does not represent a change for incumbent car makers.

Incumbents will need to adapt, but the problem is to know which technology combinations are worth developing. And changes in business models and market focus will require investing in organizational transformation, such as adopting 'agile' methods for the development of consumer-facing software or reconfiguring longstanding arrangements with car dealerships (Leih, Linden, & Teece, 2015).

To encompass the new capabilities in their offerings, the car companies have made a number of critical make/buy/ally decisions as to whether capabilities such as vehicle autonomy need to be brought in-house. Most car companies have opted to form partnerships in that area because it's too challenging to match the wealth of data-driven learning that the companies with a head start have already achieved. However, it is not clear whether the hardware and software required for AVs will be available at competitive rates or will become a bottleneck asset that drains profits from the automotive value chain (Teece, 1986). On the other hand, the deep uncertainty facing car companies favors flexibility, making alliances a much safer route (Teece et al., 2016). The tech giants in the US and China, also seem to have decided that alliance formation is the best way to participate for the time being.

TESTING HYPOTHESES

Table 1 summarizes the key points about the gaps that incumbent auto manufacturers face with respect to the new capabilities they need to own or access. The farther the new capability is from the traditional capability set, the more likely new entrants from other industries will be able to establish a foothold or even a stronghold.

As the table shows, many of the gaps are not so large, and most car companies have been making progress in addressing all of them. The twin dangers of this effort are that a car company is either (1) too wedded to its existing activities to commit sufficient resources to transformation or (2) too distracted by the launch of new activities to properly maintain its existing business.

With this framework in mind, we can now return to the central questions from the three articles. Perkins and Murmann (2018) hypothesized that the barriers for a new entrant to replicate the capabilities to design and manufacture a car had fallen, at least for EV-only entrants. As MacDuffie (2018) observes (and as Tesla's travails demonstrate), the skills involved are still considerable, even if the advent of new manufacturing and powertrain technologies has lowered the bar in some ways. The technology of vehicle manufacturing is not difficult to know, but it is hard to master. Chinese firms, with years of foreign cooperation and considerable government support, have steadily brought their operational capabilities closer to the global best-practice frontier.

As Perkins and Murmann (2018) note in their conclusion, the auto industry is at risk of substantial 'value migration' away from its existing capabilities toward platforms owned by one or more of the tech giants for autonomous driving or transportation-as-a-service. The purpose of this essay has been to show more systematically the factors affecting the relative prospects of incumbent car makers and new entrants. Tech firms definitely see the opportunity where their strengths complement those of the car makers. The eventual value distribution depends on the relative attractiveness of the platforms offered by car manufacturers and the tech firms, on the willingness of (some) car makers to become reliant on one of the tech giants for critical parts of the value chain, and on consumer demand for particular design or branding features. As MacDuffie (2018) notes, the ferment in this area will continue for some time. Consumers will ultimately make the key decisions that determine which platforms and firms come to dominate the new competitive spaces.

To conclude, it is not clear that 'the success of Tesla has heralded a new era in the automobile industry' in the fundamental way that Perkins and Murmann (2018) see it. At most, it heralds a new era for the EV sector, probably speeding the acceptance of the technology beyond what it would otherwise have been. Projections of future EV sales have indeed been rising, but, according to Bloomberg research, ICE-based cars are expected to account for at least half the market through 2040 (Shankleman, 2017). That potentially allows a decade or more for the car makers to shift their asset base so as to continue to provide the products and services that the market demands. It remains to be seen which companies have enough organizational resilience and the strategic vision to forge a path through the new century.

A LOOK AHEAD: CAPABILITIES AND POSSIBLE OUTCOMES

This collection of papers was designed to provide insight into the hypothesis that the competitive landscape will be shaken up by a raft of well-heeled new entrants exploiting the auto industry's current technological transitions. I have applied a capability-based framework with which to analyze some of the numerous sources of uncertainty surrounding this question.

Tesla is the entry point for the discussion. It is deeply involved in the implementation of three of the four new technological paradigms identified earlier, not having yet pursued transportation-as-a-service.

Tesla has garnered a market capitalization of the same magnitude as that of GM or Ford, suggesting that it's seen by investors as part of a new 'Big Three'. This is a tribute to the company's dynamic capabilities. Tesla's capabilities flow to a large extent from Elon Musk, one of the outstanding entrepreneurs of our time. He has succeeded not only with Tesla but also with the reusable rockets developed by another of his companies, SpaceX. Musk has also shown himself to be a masterful salesman, to potential customers and to investors alike.

However, the company's struggles to ramp high-volume manufacturing signals that it hasn't yet mastered ordinary capabilities. In theory, Tesla could reach out to an industry incumbent to access such capabilities under contract and/or through an alliance. However, Musk has been determined to build a vertically integrated company, going so far as buying a German factory automation firm in 2016, although its machines have apparently not yet been installed in California (Geuss, 2018). Musk also believes he can blend the Japanese *kaizen* improvement system with Silicon Valley culture by approaching the factory as if it were a software program, making changes on the fly to fix problems (Stoll, 2018). He may yet succeed.

China's Nio, discussed earlier, is probably the only other pure-EV entrant to rival Tesla at this time. It is reportedly building its own factory, where its next model will be assembled, and is preparing to begin exports to Europe, the second-largest market for EVs after China.[3]

As for the incumbent auto firms, they all have strong, well-optimized ordinary capabilities, so their fates could swing substantially on how strong their dynamic capabilities prove to be. Strong dynamic capabilities can enable incumbents to close the capability gaps shown in Table 1 with differentiated solutions that build advantage over rivals. Venture capitalist Michael Moritz claims that entrepreneurial management, a key element of dynamic capabilities, is scarce in big companies, and that the auto companies ran into trouble because their managers 'forgot to take care of the future' (cited in Rose, 2015).

But the problem is not strictly one of leadership. The established car companies also face an institutional problem that de-incentivizes long-term planning, namely the debilitating drag of the quarterly earnings syndrome. At the 2018 World Economic Forum, Carlos Ghosn, CEO of the Renault-Nissan-Mitsubishi Alliance, observed: 'If you don't have strong quarterly results, you can't afford the luxury to have a long-term plan'.[4] He noted that strategic initiatives for electric or autonomous vehicles typically require seven or eight years, but the median tenure of a CEO at a large-cap firm has fallen to five years (Marcec, 2018). While this article was in the proof stage, Elon Musk announced that he was exploring the possibility of taking Tesla private to escape these short-term pressures. CEOs of new entrants who are able to manage under uncertainty and who find patient investors (or who themselves own large shareholdings) have more freedom to pursue technologies, business models, and markets with long-term strategies that incumbents can find difficult to match.

As the firms in the auto industry grapple with manifold uncertainties in the years ahead, time will tell if Tesla or another new entrant is able to leverage the electric vehicle to build a mass-market auto company. If incumbents demonstrate strong dynamic capabilities and leverage their integration skills, they may still be able to lead and dominate the upcoming industry transformation. However, absent dynamic capabilities, they will surely flail and then fail.

NOTES

I would like to thank Greg Linden for helpful comments and contributions.

[1] The quote is from a 2004 email that was published years later by a former employee. It was reproduced in M. Stone, A 2004 email from Jeff Bezos explains why PowerPoint presentations aren't allowed at Amazon, *Business Insider*, July 28, 2015, http://www.businessinsider.com/jeff-bezos-email-against-powerpoint-presentations-2015-7 (accessed May 8, 2018).

[2] Means of transportation calculated from https://factfinder.census.gov/bkmk/table/1.0/en/ACS/16_5YR/B08101 and commute times calculated based on an average 26-minute one-way commute, per https://factfinder.census.gov/bkmk/table/1.0/en/ACS/16_5YR/GCT0801.US01PR (accessed May 8, 2018).

[3] Nio to build own factory in Shanghai, February 7,2018, http://autonews.gasgoo.com/china_news/70013591.html and S. Hanley, Tesla vs. Nio: some thoughts on doing business in China, April 30, 2018, https://cleantechnica.com/2018/04/30/tesla-vs-nio-some-thoughts-on-doing-business-in-china/ (accessed May 7, 2018).

[4] Transcribed by the author from the video of the panel discussion Towards Better Capitalism, World Economic Forum, published on Jan 23, 2018, https://www.youtube.com/watch?v=xlwqZ0Qprjw (accessed May 8, 2018).

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Dialogue, Debate, and Discussion

Forum on Tesla and the Global Automotive Industry

Liisa Välikangas
Aalto University, Finland, and Hanken School of Economics, Finland

China, the world's largest market for electric vehicles (EV), has put in play a state industrial policy that is seeking to upend global automakers (see *Financial Times*, October 12, 2017 and May 20, 2018). Exemptions from taxes and subsidy programs have favored the purchasing of an EV, which are also exempt from driving restrictions in large cities such as Beijing and Shanghai. Policies that target manufacturers include meeting production targets for EVs (the so-called dual-credit policy by the Ministry of Industry and Information Technology). China may be on the verge of becoming a global disruptor in an industry that has home market advantages of scale, lower fossil fuel imports, and significant reduction of air pollution in cities while exploiting related technologies such as lithium batteries where China has world class industrial competence. It is in China's national interest to be a game changer in the global automotive industry from fossil fuel to electricity. And building infrastructure – supercharging stations included – fits the government-directed approach that aspires to establish the country as an undisputable global leader in a high-tech sector of global significance.

Amidst this background, it is interesting to consider the implications of success or failure of Tesla, the California-based electronic car pioneer. The discussion found its beginning in the suggestion of Johann Peter Murmann to discuss Tesla as a case that challenges the automotive incumbents' hold on car manufacturing in electronic vehicles. The perspective of Greg Perkins and Johann Peter Murmann is the opening shot. And if Tesla, hailing from Silicon Valley, could break in, why not other well-funded (Internet) companies with strong digital capabilities in the US and China alike? John Paul MacDuffie provides a contest to this thesis based on his prior work (Jacobides, MacDuffie, & Tae, 2016; MacDuffie, 2013).

The Forum has produced an evocative exchange that may have implications beyond the success or failure of Tesla, electronic vehicles, and global car manufacturing. The debate can be seen from the perspective of assessing the limits to entrepreneurship – even as powerful as that of Elon Musk, the Tesla founder; the boundedness of executive attention in countering new entrants in a rapidly changing industry; and the emergence of China as a disruptive competitor. David Teece in his overall commentary on the debate, discusses whether the incumbents are able to counter the disruptors and engage in competitive counter attacks on multiple fronts, not merely with Tesla but also with Chinese companies aggressively entering the automotive EV sector as described by Hong Jian and Feng Lu. The debate as it stands offers some interesting research questions beyond the automotive industry.

WHAT IS TESLA A CASE OF?

In this debate Tesla is positioned as a refutation of the argument that incumbents with their deep system integrator capabilities prevent significant value migration. At play are also China's national aspirations and state industrial policies that may add leverage to newcomers beyond Tesla. The Tesla challenge remains open as the discussants point to the company's difficulties in mastering mass manufacturing even if its significance as a luxury car manufacturer that has changed some of the basis of competition in electronic cars is admitted. It appears, as Teece points out, that Tesla falls short of ordinary capabilities in mass manufacturing even when it is effectively challenging the dynamic capabilities of incumbent companies!

This then suggests the question of entrepreneurial power together with its limits. Perhaps Tesla manages to change the basis of competition without ever succeeding in mass manufacturing. By making customer experience a key quality, as Jian and Lu suggest, Tesla may contribute to making the car a vehicle for enhanced personal mobility. The "ultimate driving machine" may become the artificial intelligence-enhanced, high-touch living and working design. Tesla may end up as a case of entrepreneurial disruption without ever challenging the incumbents directly on their scale business of mass manufacturing, opening up the way for other entrants. China, however, is using its very scale as a competitive leverage. The market penetration of EVs in China is still small (1.4% of the light vehicle market) but growing rapidly (70% in 2016) (according to McKinsey & Co, 2017).

The Dilemma Facing Incumbent Manufacturers

It is likely that incumbent manufacturers, already invested in emergent capabilities in the car industry, with their significant resources, can counter the competitive threats if picked one by one over time. However, the incumbents may run into the inherent limits of managerial attention when surrounded by disruptive competitors on all sides. Not only do incumbent car firms compete in traditional internal combustion engine-markets but also increasingly in hybrid and electronic vehicles. Not only do they have to pay attention to the further development of system integrator capabilities, they need to learn new digital capabilities fast, including autonomous driving. Ocasio (e.g., 1997, 2011) advanced the attention-based view of the firm, suggesting limited channels for communications (Joseph & Ocasio, 2012). Laamanen and Wallin (2009) studied the linkages between managerial attention and capability development and found that companies differ in their capability development paths depending on management's focus of attention and sense making of the environment. Managerial attention tends to be prioritized consequentially, which may not give incumbents sufficient time to effectively tackle the near-simultaneity of competitive changes. It is thus likely that the incumbents' key issue in the Tesla-inspired competition is the ability to manage executive attention on multiple fronts simultaneously. Sense making of the ambiguity, underlined important in coping with uncertainty, may become its own entrapment.

The Chinese Challenge

Jian and Lu suggest there might be new 'species' of disruptive competitors emerging in a newly shaped EV industry that represent novel kinds of capability constellations. These competitor ecosystems may become the new value integrators where patterns of value capture are yet to be settled. Something can already be learned from vanguard companies such as Tesla which has been able to drive value with its brand yet is struggling to make it alone, and NIO, a Chinese EV startup with strategic investors that at least initially has outsourced manufacturing to a traditional car manufacturer JAC. Perhaps a new competitive front is already underway involving autonomous, self-driving car-trouble-free lifestyle, rather than emphasizing electricity as a preferable alternative to fossil fuel.

The Forum invites research and discussion on entrepreneurial disruptors that may shift entire competitive landscapes. Such disruptors are also constrained in their ability to deliver on the promise and vision, no matter how formidable the entrepreneur. Nevertheless, their multiplicity may have significant aggregate effects that incumbents will be hard pressed to counter. Incumbents are further challenged by the industrial policy and strategic aspirations of China in dominating the global EV industry. The global automotive industry is on a path-breaker test case of entrepreneurship, state direction, and incumbents' dynamic capabilities in transformation.

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