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Dialogue, Debate, and Discussion

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

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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

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(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

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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

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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.

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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.

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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.

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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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