Build To Order

Glenn Parry • Andrew Graves
Editors

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The Road to the 5-Day Car

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Glenn Parry, Senior Research Fellow
Andrew Graves, Chair for Technology Management

School of Management
University of Bath
Bath, BA2 7AY
UK

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It is amazing what you can accomplish
if you do not care who gets the credit.

Harry S. Truman

Foreword

Over the past 100 years the European Automotive Industry has been repeatedly challenged by best practice. First by the United States, through the development of 'mass production' pioneered by Henry Ford and more recently by 'lean production techniques' as practised by the leading Japanese producers, particularly Toyota. It has consistently risen to these challenges and has shown it can compete and even outperform its competitors with world-class products. However, the European industry is now faced with growing competition and growth from new emerging low-cost countries and needs to re-define its competitive advantage to remain at the forefront of the sector. Automotive growth is driven by two factors, new markets and new technologies. Global competition is increasing, with technology and product differentiation becoming the most important sales factors, but with continued cost pressure. Within the market the winners will be more profitable and the losers will disappear.

The Automotive Industry makes a significant contribution to the socio-economic fabric of the European Union. Manufacturing output represents €700 billion and research and development spending €24 billion. European automotive suppliers number 5000 member companies and represent 5 million employees and generate €500 billion in revenues. These are significant figures that generate wealth and high value employment within the EU. European firms must consistently improve their competitive position to ensure that the industry does not migrate to growing new markets.

'Build To Order: The Road to the 5-Day Car' provides us with a vision for a sustainable future European Automotive Industry that is able to meet these challenges and win. Within this book Dr Parry and Professor Graves have been able to integrate the ideas and concepts from the key automotive centres of excellence across Europe. This provides both the technical depth and breadth required, giving a structured approach to Build to Order, from the view point of the market, product, supply chain and most important, delivering a vehicle that "the customer wants when they want it".

The challenge, set out in ‘Build To Order: The Road to the 5-Day Car’, is the transformation of the automotive industry in Europe from mass manufacturer to build to order. The opportunity is currently there, but needs to be acted upon quickly and before new entrants adopt these concepts. This book provides an essential guide to those in the automotive industry taking up the challenge.

Lars Holmqvist
CEO CLEPA
European Association of Automotive Suppliers

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The editors would like to thank the authors for their hard work in producing the text. Additional thanks to Jens Roehrich, Gareth Stone, Janice Legge and Max Dickson for their contributions to editing the manuscripts. Thanks also to Dr Valerie Crute who has supported our work whilst we have been producing the book and to Dr Joe Miemczyk and Dr Mickey Howard for supporting the project within our centre.

In addition, we would like to thank all those colleagues from industry, government and academia who have helped formulate our thinking with regard to build-to-order. In particular, the foresight and encouragement offered by Daniel Jones, chairman of the Lean Enterprise Academy, and Malcolm Harbour, MEP, together with the enthusiasm and knowledge regarding the importance of manufacturing given by Sir John Harvey Jones.

Finally, we would like to thank our wives, Tsui Parry and Dr Claire Graves as we have found that organising and directing a significant part of the ILIPT programme as well as putting a book together is unavoidably intrusive on family life. Producing a book with so many authors has been a challenging experience, but has hopefully provided greater clarity with regard to the BTO vision. This would not have been possible without their ongoing support and occasional editing assistance.

Contents

Part III Collaboration

Chapter 1
Introduction and Overview

Glenn Parry and Andrew Graves

School of Management, University of Bath, Bath, UK

Abstract. This book addresses the conceptual and practical aspects of the automotive industry's next goal – the delivery to the customer of a bespoke vehicle 5 days after placing the order.

We have brought together a selection of leading European automotive experts from across industry and academia to provide insights into the goals of producing cars to order. Whilst the "voices" are all different, the message is the same – build to order is the future of the European motor industry. A compelling need to change has been identified and viable methods to do so have been developed and are presented here. Whilst the research and findings are the result of many years' work in the automotive industry, most have application in many other sectors.

Many car companies are losing money. The mass-production business model of the automotive industry is flawed and perhaps becoming dysfunctional. The industry suffers from global overcapacity and rising stock levels and exhibits inherently low profitability. It has now been nearly two decades since "lean production" was documented and the auto industry in the West set out to employ Japanese best practice and close the productivity gap. While lean efforts have delivered improvements in manufacturing efficiency, they have been largely ineffective in increasing profitability, due to a myopic focus on factory processes. The automotive industry has optimised systems for mass production, but not tackled the problems of capacity and demand. We find ourselves in a position where, following leading practice, a car can be built from flat steel in a production facility within 11 h. A customer ordering a car in a dealership has to wait around 40 days to purchase their desired vehicle, or buy one from stock. How has this occurred?

1.1 Drivers and Followers

Toyota, the originator of lean, which was developed as the Toyota Production System (TPS), has moved ahead of its rivals and is now the global leader in manufacture. Toyota has been very open in letting other car manufacturers come and study its production techniques. In doing so it has ensured that many have spent their time seeking to catch up and following their lead instead of developing their own processes, something that may threaten Toyota's dominance. A spokesman for GM stated "Should the day come where GM is no longer the largest (globally) it will come out fighting the next day" (Kranz 2007). As any racer knows, it is very difficult to catch a moving vehicle from a standing start let alone get past them again, especially when they are world champion. Toyota has focussed on constantly improving its quality as it grows its market share. However, its approach is very different to that of GM, typified by their president, Katsuaki Watanabe "We want to be number one in terms of quality, but we don't pay much attention to catching up with General Motors". And whilst others have been catching up in terms of manufacturing efficiency, Toyota is rising to become the world's biggest car maker, overtaking the Ford Motor Company, Chrysler group and now challenging General Motors, who have held the position for 76 years. It is not so much that quality is lacking in the competition, but Toyota and the other Japanese manufacturers took the lead and hence the customer base. The car buying public is frequently brand-loyal, so a significant and valued differentiator will be required by any company trying to tempt new buyers into their dealerships. This is very difficult when those buyers' previous experience of the product was poor and their subsequent experience at a new dealer positive.

There is also a new and increasing pressure upon the incumbents from the rise of companies from newer automotives markets such as Korea, India and, most significantly. With a low-wage economy and a government thirst to create manufacturing sector work, the Chinese automotive industry is developing its automotive mass production capability. These companies are in their infancy and their products are currently behind the world's best. However, they are moving quickly to catch up. Illustrating the rate of development, the Nanjing Automotive Company (NAC) plant in Nanjing went from brown field to functioning factory in 2 years through purchase of the MG Rover assembly lines and models. They have begun with production of the "Rover 75", a vehicle first seen in Europe in 1998. Whilst this may be seen as old technology, their domestic market is very large and may well buy up all their annual 200,000 units' production. These sales will provide them with the revenue needed to develop their next generation of cars. NAC is not alone. Other Chinese manufacturers such as Chery and Shanghai (SAIC) have also been acquiring automotive know-how through partnerships with automotive companies around the world. Their domestic sales will provide them with the cash flows for future investment. The size of the Chinese home market, together with their speed of expansion and low cost labour market, could rapidly make them a creditable threat on the global stage.

The time is right for a change in the approach of the European Automotive industry. Build-to-order (BTO) systems appear to offer the solution. But what exactly do we mean by build-to-order?

1.2 Defining Build-to-Order

Build-to-order refers to a demand-driven production approach where a product is scheduled and built in response to a confirmed order received for it from a final customer. The final customer refers to a known individual owner and excludes all orders by the original equipment manufacturer (OEM), national sales companies (NSC), car dealers, fleet orders or other intermediaries in the supply chain. BTO excludes the order amendment function, whereby forecast orders in the pipeline are amended to customer requirements, as this is another level of sophistication for a build-to-stock (BTS) system. Build-to-stock is the dominant approach used today right across the automotive supply chain and refers to products that are built before a final purchaser has been identified, with production volume driven by historical demand information. This high stock level, endemic across the auto industry, allows some dealers to find an exact or very close match to the customer's desired vehicle within the dealer networks and supplier parks. The vehicle can then be delivered as soon as transport can be arranged. This has been used to justify stock levels. Whilst providing a rapid response to customer demand, the approach is expensive, mainly in terms of stock, but also transportation as finished goods are rarely where they are required.

A BTO system does not mean that all suppliers in the supplier chain should be producing only when a customer order has been confirmed. Clearly, it would not make economic sense for a manufacturer of windscreen wiper blades to employ BTO. These components should be built to a supplier order, effectively BTS. However, a large expensive item, such as an engine, could and possibly should be BTO. Part of the challenge in a BTO supplier network is in the identification of which suppliers should be BTO and which BTS. The point in the supply chain when this change occurs is called the "decoupling point". Currently, the majority of automotive supply chains lack a decoupling point and the dominant BTS approach has resulted in capital being tied up in stock in the supply chain and billions worth of finished automobiles.

1.3 Advantage of Build-to-Order

Significant advantages are to be gained by the automotive companies who would benefit from a considerable reduction in capital employed, reduced tooling, thus reduced fixed costs and a shift to variable costs. Consequently, the industry will have lower break-even volumes, allowing a greater responsiveness to changes in demand, fashion and regional preference. A leading manufacturer estimated its current inventory located at distribution parks in Europe to be worth €10 billion, reflecting the picture in the US. A press release in the US quantified the finished automobile stock held by the Detroit 3: GM retail inventory 94 days; Ford retail inventory 105 days; Chrysler retail inventory 126 days (Webster 2006). These figures suggest that stock levels are so high that, in theory at least, all production could halt completely for one-third of a year.

Building cars to customer order implies a considerable reduction in capital employed through the virtual elimination of stocks, as well as a reduction in the need to discount. Any company able to free this capital would improve their competitive position and gain access to capital for future product development. However, the implied ramifications for all key players in the system – component suppliers, logistics service providers, retailers and dealerships – have not yet been recognised by most companies; yet, the complexity of the automotive industry and the product itself make it imperative that not only the manufacturers change, but also that the entire supply network reaches the capability to support such drastic change.

The question for many automotive executives is not when, but how exactly will such a radically "different" business model operate?

1.4 The Road to Build-to-Order

It was clear by the late 1990s, that both US and European vehicle manufacturers(VMs) had significantly closed the performance gap on the leading Japanese producers through the adoption of a Lean Production philosophy, as outlined by MIT's International Motor Vehicle Programme (IMVP) in their enterprise benchmarking studies. There was a clear reduction in the variation of best practice performance across regions in final assembly, product development and supply chain delivery. However, it was also evident that most VMs had focussed upon optimising their assembly plant productivity and had developed "shop-floor myopia" at the expense of delivering cars that customers wished to purchase. Customers were increasingly being educated, through the internet and other sales channels, with regard to "instant gratification" or in other words, obtaining the products and services they required, without delay. Few automotive companies were profitable and customers were largely disaffected.

To explore these issues, a collaborative research programme was formed, funded by the UK Government (via the DTI and EPSRC) together with leading industrial partners, in order to develop an organisational and process framework within which a customers' need for a vehicle could be fulfilled in 3 days – from order placement, through manufacture and delivery (see Fig. 1.1). The team comprised leading academics and consultants led by: Professors Dan Jones and Peter Hines of the Lean Enterprise Research Centre at the University of Cardiff; Malcolm Harbour, MEP, of the International Car Distribution Programme; and Professor Andrew Graves, Co-Director of the IMVP, based at the University of Bath.

VMs:	Ford, Honda, Nissan, Peugeot, Vauxhall, Volkswagen
Suppliers:	GKN, Thyssen Krupp Automotive, TI Group (Bundy) Machine Tools Technology Association (MTTA)
Logistics / Distribution:	Axial, Institute of Logistics & Transport Wallenius Wilhelmsen
Retail / Dealers:	Inchcape, Lancaster, National Franchised Dealers Association (NFDA), Pendragon, Quicks
IT:	BEA Systems, Cap Gemini, Keane
Finance:	Goldman Sachs
Government:	DTI (UK), Engineering & Physical Sciences Research Council (EPSRC)

Fig. 1.1 3DayCar Partners (1999–2001)

Three days was set as a possible target for vehicle delivery as, at the time, it was unclear how long the process took. However, the programme's aim was in reality, an attempt to satisfy customer requirements by producing a car that the "customer wanted, when they wanted it".

Research at the core of the 3DayCar programme benchmarked the time taken for a customer's order to transit via the car dealership, sales channels, programme planning, operations and factory capability. From the factory, the finished vehicle was tracked via the distribution outlet and dealer, to the customer. For the first time, research utilising a value stream mapping methodology showed that the VMs took nearly 40 days on average to deliver a vehicle (Fig. 1.2).

• Order entry Dealer-Manufacturer	**3.8 days**
• Order bank	**9.8 days**
• Scheduled orders	**14.1 days**
• Sequenced orders held	**6.0 days**
• Physical production	**1.4 days**
• Loading at factory	**0.9 days**
• Distribution to dealer	**3.8 days**

' 39.8 Day Car ' Capability

Fig. 1.2 Generic model for average delivery time for 3DayCar OEMs

It is clear from the data that physical production takes approximately only 1.4 days. Therefore, the increasing concentration of effort by VMs to improve factory operations, although important, was having little or no effect on the overall order to delivery time (OTD). Even when a theoretical “best practice” was investigated (i.e. best performance of each VM in each area), the OTD lead time was still 12 days – nowhere close to the 3DayCar target. In addition, it was also discovered that up to 50 days of stock was held in the overall system. A key number of problem areas were identified by the 3DayCar team, including:

- Vehicle complexity – the number and variety of models
- Capacity constraints – VMs vs suppliers
- Schedule/build unreliability
- Transparency – via IT legacy systems and lack of standards

The time from order entry to physical factory production was identified as taking a total of over 1 month! Possible solutions put forward by the 3DayCar team suggested a substantial re-engineering of the whole system with particular focus upon four key areas. These were:

- ***Improved communications*** – direct links between marketing, supply, logistics and product and process development
- ***Alternative product strategies*** – e.g. “plug & play” offering “Intel inside” solutions – i.e. “Siemens or Bosch inside”
- ***New assembly strategies*** – micro factories, changing the economy of scale for VMs.
- ***Alternative body structures*** – independent body panels (IBP), new materials

In conclusion, the 3DayCar programme found that the current “push” system of production was inherently inefficient and encouraged over-production and massive stock levels, while at the same time, failing to satisfy customers. The real focus of activity for the VMs, suppliers, logistic providers and dealers, for the 21st century was now to concentrate on real customer demand, rather than factory operations. Also, the need to “build to order” would become an essential tool in the return to profitability that would impact on every player from the customer to dealer, supplier and manufacturer.

1.5 The ILIPT Project

The findings of the 3DayCar programme pioneered in the UK created world-wide interest from both industry and governments with regard to developing the next competitive transformation for the automotive industry. In particular, the European Commission, through its “Intelligent Logistics for Innovative Product Technologies” (ILIPT) programme, proposed a pan-European research project to study the applicability of the 3DayCar findings across the European automotive sector. Of particular interest were the four problem areas identified by the 3DayCar team, as highlighted above, and the possible solutions in relation to European VMs, suppliers and logistics operators. The 3DayCar research results were therefore to be tested and analysed in the wider and more complex European arena. In addition, it was agreed to set a challenging target of 5 days from order to delivery for the European context. This would take into account the complexity of the European manufacturing and supply base and the research findings from the 3DayCar project, giving a theoretical "best practice" for BTO of a minimum of 12 days. To meet this new "5-Day Car" target the necessary improvement in productivity would require a radical restructuring across a broad spectrum of activities, as well as a possible revolutionary change with regard to its technological capacity.

This book therefore seeks to provide some of the answers to the "how to do BTO" question by drawing on expert knowledge generated by the BTO automotive expert participants who contribute to the ILIPT project. The project's aim is simple – to define, validate and operationalise processes, product structures and supply network structures that enable the purchase and on-time delivery of a new, customer-specified car, across Europe within a 5-day window. ILIPT is a 4-year joint European Commission and industry-funded project that will reach completion in the summer of 2008. This European Integrated Project is a consortium of 31 leading automotive-focussed partners with representatives from across Europe and throughout the supply chain. The auto-industry is a major contributor to prosperity throughout the EU and the ILIPT project has the potential to enhance European industry competitiveness, sustainability and will secure benefits for the next generation. The project extends the contribution of the International Motor Vehicle Program (IMVP), which produced the seminal Lean text *The Machine That Changed The World* and the 3DayCar initiative. ILIPT's re-invention of the industry required a global team including partners from eight EU Member States and participants from Russia, Switzerland and Brazil, comprising VMs, all supply tier levels, research establishments and academia.

The originating ILIPT project partners are:

- University of Bath
- BMW Motoren GmbH
- University of Cambridge
- Ceramicx Ireland Ltd
- CLEPA (European Association of Automotive Suppliers)
- DaimlerChrysler
- Dana Corporation
- De-Bonding Ltd
- E-Business und Prozessconsulting EBP GmbH
- EFTEC AG
- FEV Motorentechnik GmbH
- 4Flow AG
- Fraunhofer Institut für Materialfluss und Logistik (IML)
- Fraunhofer Institut für Produktionstechnik und Automatisierung (IPA)
- Fraunhofer-Institut für Arbeitswirtschaft und Organisation (IAO)
- Freeglass
- Hella Autotechnik s.r.o.
- Lear Automative EEDS, Spain S.L.
- University of Lueneburg
- MAN Ferrostaal
- University of Patras

- PLATOS
- Pontificia Universidade Catolica do Rio de Janeiro
- Saint-Gobain Sekurit
- Siemens AG
- Siemens VDO
- The St. Petersburg Institute for Informatics and Automation of the Russian Academy of Science (SPIIRAS)
- Technical University of Dresden
- ThyssenKrupp Automotive
- TRW Automotive GmbH
- VDI/VDE-IT

The industrial co-ordinator of the project is René Esser of ThyssenKrupp Automotive and it is administered by Helmut Kergel of VDI/VDE-IT. The ILIPT project is divided into three main work packages. The first package, ModCar, aims to develop a digital prototype of a 2015 passenger vehicle using an innovative system of flexible body frame panels and modules for rapid build to order. This prototype has been named ModCar. It is supported by the Technical Method Integrator, which examines novel IT tools, and methods needed to deliver "5-day car capable" design and production. Overall, the objective is to minimise complexity in design and production while optimising vehicle delivery and variety to the end-customer. The work package is led by Karl Josef Kerperin of Continental, previously Siemens VDO Automotive AG. The second work package, FlexNet, focuses on the concurrent development of new flexible processes, technologies and supply network organization structures. The work explores concepts of collaborative IT, supply chain planning and automated contract negotiation. It is led by Professor Bernd Hellingrath of the Fraunhofer Institute for Materials and Logistics. The objectives of the final theme, InterPro are to develop new network design tools and novel process simulation methods to test and validate concepts for implementation of a 5 day car process, as well as integrate key results and concepts from the other themes. In addition the work requires the development of an understanding of the transition path towards the future automotive BTO network, how to achieve a 5-day car between 2010 and 2015. This theme is led by Dr Glenn Parry of the University of Bath, School of Management.

The ILIPT project represents a vast European effort to develop new concepts. This book draws upon only a small selected subset of automotive experts from the ILIPT consortium to provide an overview of how the BTO vision may be achieved and provide Europe with a globally leading automotive industry.

1.6 Book Structure

This book's text is divided into five parts (Fig. 1.3).

In the first part we explore automotive industry dynamics. Dr Matthias Holweg from the University of Cambridge presents an overview of the evolution of competition within the automotive sector, and his colleague, Andreas Reichhart, then explores how BTO has evolved. Next, Alexandra Güttner and Thomas Sommer-

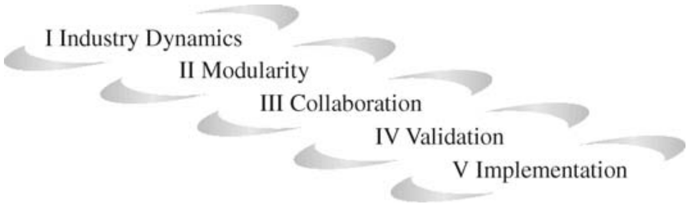

Fig. 1.3 Book layout overview

Dittrich from Daimler AG discuss current issues at OEMs and suppliers, providing an insight from industry as to the practical realities of production and supply chain management. Building upon this, the management and practice of automotive outsourcing is then detailed by Jens Roehrich, University of Bath.

The second part describes the use of modularity. ILIPT's ModCar demonstrator prototype vehicle is used as the focus for exploring the practicalities and technical developments in car body modularity. The chapter begins with Philipp Gneiting and Thomas Sommer-Dittrich of Daimler AG providing the OEMs' perspective. Andreas Untiedt of ThyssenKrupp Automotive provides an insight into the development of a modular lightweight automotive body, which decouples the car structure from its surface, allowing short production times and reduced stock cost. This work is complemented by Dr Maik Gude and Professor Werner Hufenbach from TU Dresden, who explain the design of the car body shell that complements the modular car body architecture. Introducing modularity introduces complexity. The relationship between customer choices in car build combinations and the effects offering these has on production complexity and cost is presented by Jens Schaffer & Professor Heinrich Schleich, from the University of Lueneburg.

Professor Bernd Hellingrath begins the third part with an overview of the key principles for collaborative planning and execution of a network capable of delivering customised production. Siemens AG's Jan-Gregor Fischer and Philipp Gneiting from Daimler AG then describe flexible processes for inter-enterprise collaborative planning. Collaborative execution processes that reduce the time lots between customer order and vehicle assembly scheduling are presented by Jörg Mandel from Fraunhofer-IPA. The information communication technology challenges that need to be overcome to move towards the BTO concepts are discussed by Markus Witthaut and Michael Berger from Fraunhofer-IML with Jan-Gregor Fischer, Siemens AG. The work from this group is then illustrated by modelled scenario examples from Stefanie Ost and Joerg Mandel of Fraunhofer-IPA.

In Part IV we present the work done to validate the approach and tools developed to achieve the 5-day car. The work of EBP Consulting's Katja Klingebiel provides decision support for the transition to a more flexible and stable BTO strategy for all partners in an automotive supply chain, accomplished by the provision of a BTO reference model for high-level network and process design. Thomas Seidel of 4flow AG presents a method of integrating two supply chain modelling approaches into more rapidly produced feasible detailed supply chain scenarios. BMW Steyr's engine plant provides a case example of the implementation of the

ILIPT approaches during its switch to stockless BTO production, by Katja Klingebiel and Michael Toth from Fraunhofer-IML and Thomas Seidel of 4flow AG. An account of how a reduction in the complexity of the engine valve train leads directly to cost reduction, in a case example of the electro-mechanical valve train from Thomas Seidel with Thomas Huth of FEV Motorentechnik. Finally, Kati Brauer and Thomas Seidel present scenarios for supplier networks using a number of distribution concepts.

The final section looks at the broader picture. The motivations and barriers to forming electronic market places that will facilitate BTO systems are investigated by Dr Mickey Howard from the University of Bath. Dr Joe Miemczyk from Audencia Business School questions the received wisdom that that simply locating suppliers in close proximity to OEM assembly plants reduces delivery lead time and inventory. Finally, Gareth Stone and Dr Valerie Crute from the University of Bath present the challenges for transition.

Whilst the work cannot present a complete picture, hopefully it will provide both an overview and sufficient detail to engage the reader in the subject and make a persuasive case for BTO.

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Part I
Industry Dynamics

Chapter 2
The Evolution of Competition in the Automotive Industry[1]

Matthias Holweg

Judge Business School, University of Cambridge

Abstract. At the dawn of the second automotive century it is apparent that the competitive realm of the automotive industry is shifting away from traditional classifications based on firms' production systems or geographical homes. Companies across the regional and volume spectrum have adopted a portfolio of manufacturing concepts derived from both mass and lean production paradigms, and the recent wave of consolidation means that regional comparisons can no longer be made without considering the complexities induced by the diverse ownership structure and plethora of international collaborations. In this chapter we review these dynamics and propose a double helix model illustrating how the basis of competition has shifted from cost-leadership during the heyday of Ford's original mass production, to variety and choice following Sloan's portfolio strategy, to diversification through leadership in design, technology or manufacturing excellence, as in the case of Toyota, and to mass customisation, which marks the current competitive frontier. We will explore how the production paradigms that have determined much of the competition in the first automotive century have evolved, what trends shape the industry today, and what it will take to succeed in the automotive industry of the future.

[1] This chapter provides a summary of research conducted as part of the ILIPT Integrated Project and the MIT International Motor Vehicle Program (IMVP), and expands on earlier works, including the book *The second century: reconnecting customer and value chain through build-to-order* (Holweg and Pil 2004) and the paper *Beyond mass and lean production: on the dynamics of competition in the automotive industry* (Économies et Sociétés: Série K: Économie de l'Enterprise, 2005, 15:245–270).

2.1 All Competitive Advantage is Temporary

The roots of today's motor industry can be traced back to Henry Ford, who, based on the inter-changeability of components and the use of the moving assembly line, laid the foundations for modern-day mass production techniques. Even the basic features of a car have not changed much since Ford's days: a car still has four wheels, is propelled by a gasoline engine and its body is still welded together from pressed metal parts. Despite the profound impact that Ford has had on the "industry of industries"[2], its competitive advantage was short-lived and Ford was soon overtaken by GM, which, based on the visions of Alfred P. Sloan, introduced a more decentralised organisational structure and offered customers the choice they wanted through a much broader product portfolio. While civilian production significantly shrunk during the years of the Second World War, the mass production of cars in the US leveraged the growth of the post-war period until the 1970s saw increasing competition from Japan, where companies like Toyota seemed to be able to offer better deals – in terms of quality and cost – to customers in the US and Europe.

The success story of lean production, leading to the difficult situation faced by the US and European manufacturers in the three decades since 1970, is well known and all major players in the industry have adopted the set of techniques that were first introduced at Toyota in Japan, the Toyota Production System (TPS), or "lean production" as it is more widely known. However, competitive forces are far from being static, and hence vehicle manufacturers can no longer rely on excellence in production only, especially since the performance gap between them has been closing (Holweg and Pil 2004). The automotive industry in the new millennium has seen the advent of three key challenges: regionalisation, saturation and fragmentation of markets, challenges that few manufacturers have addressed successfully to date. New capabilities are required to deal with this competitive situation and return to profitability. There is an increasing number of countries in the world today that have mastered the skills of producing cars with acceptable levels of quality, and often at a much lower cost compared with the US, Europe or Japan.

At the turn of the second automotive century the news from the automotive industry in the established regions is anything but encouraging: record losses are being reported in Detroit, and in Europe household names are, for the first time, being squeezed out of the market. Britain alone has seen the closure of five major car plants over as many years, and one might get the impression that for every factory that closes in the West, (at least) one is opening in Eastern Europe, India or China – suggesting that the days of the motor industry in the western world are numbered. In Japan, several corporate crises and even threats of bankruptcies have been averted, most prominently in the case of Nissan.

But painting a picture of gloom misses the point: the industry is mature, the barriers to entry are high and demand is growing – on average, global car production

[2] A term coined by Peter Drucker in 1946.