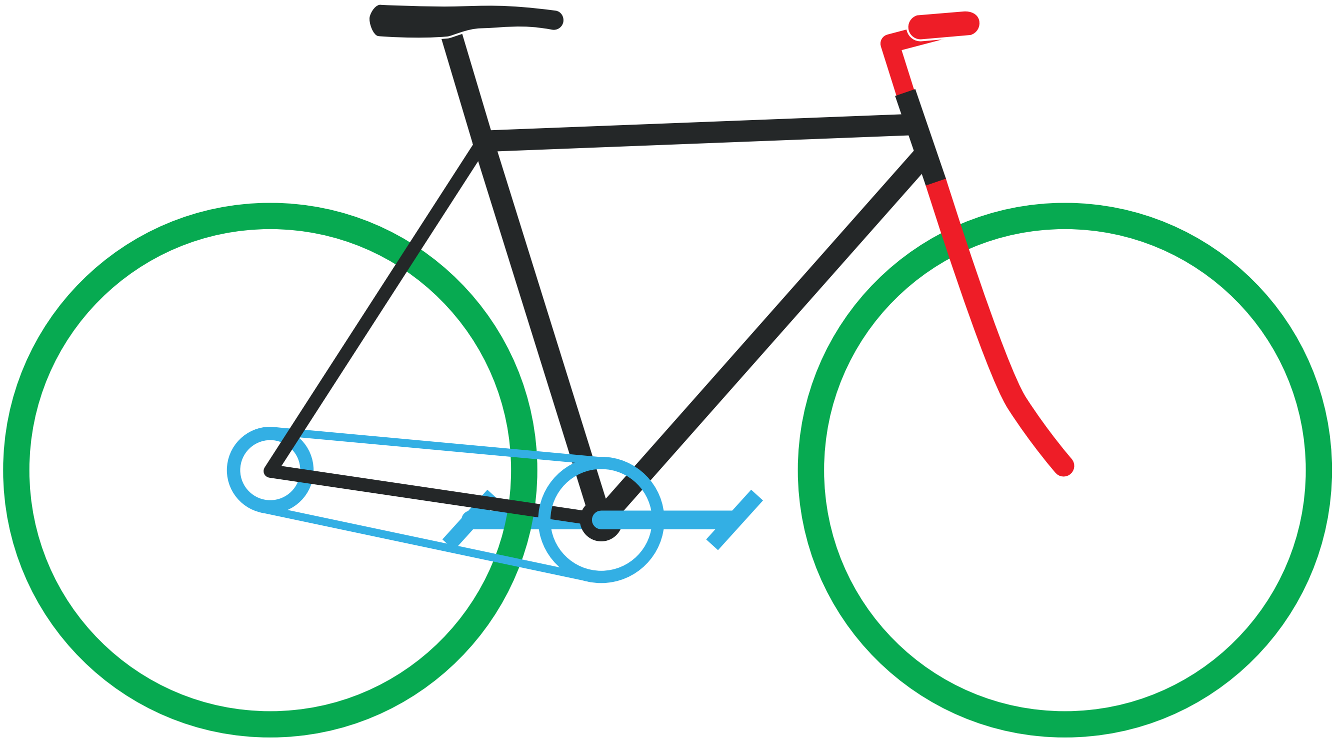


Manufacturing, mass-customisation and reinvention: The curious case of bicycle design.

PEER REVIEWED ESSAY

Robbie Napper

ABSTRACT

This research examines the practice of mass customisation in bicycle design and manufacturing. The dynamics of manufacturing and design in the bicycle market are illustrated in theory and validated in the field, with implications for theory and practice of design and mobility. The research determines that while the principles of mass customisation create ideal conditions for both manufacturer and consumer with regard to the end product, they also set up conditions for reinvention.

Reinvention occurs when consumers conceive of and develop novel product variants, and the bicycle provides an instructive example of design and manufacturing-assembly processes being available at a local level. This more convivial design and manufacturing has implications for how we conceive design, as well as for the effectiveness of the bicycle to provide mobility. The research notes that the design and manufacturing processes extend in time and place beyond the drawing board and the front end of design, into the product's complete life cycle.

Over 200 years of its history, the bicycle has become a ubiquitous vehicle. The successive rises and falls in various cultures of this vehicle overlap with other transport modes such as the horse, railways, and automotive. Technological and social developments continue to shape the bicycle and our views of it.[1] As a manufactured article, the bicycle is subject to a variety of endeavours in design in order to maximise the performance of the manufacturing company; these may be but are not limited to the related metrics of profit and quality; with profit being driven by sales on the demand side, as well as streamlined manufacturing on the supply side.

1. Introduction

This research is concerned with two of the avenues used to improve bicycles; on the supply side, mass customisation and on the demand side, reinvention. In this research I aim to determine whether the manufacturing advantages bestowed by mass customisation to both manufacturer and consumer can also have implications on how the bicycle can be used for utility purposes. Knowing this could assist in a transition to designing bicycles better suited to commonplace, utility or "quotidian" cycling.

Despite, or perhaps because of its ubiquity, the bicycle tends to evade detailed attention. Much research in the field of active transport relates to cycling – the action, rather than the bicycle – a vehicle. That the cycling research deals with the habits, motivations, safety etc. of this action is no bad thing, save for the observation from an industrial design perspective that the design of the object can and does have profound consequences upon the manner in which the object is used. To take but one example, the geometry of the handlebars relates strongly to the affordances of steering the vehicle, comfort of the rider, and entanglement in parking.[2,3]

History shows that cycles (an inclusive term capturing two and three wheeled vehicles) underwent profound changes in design and manufacture in the first 100 years of their development. Successive redesigns refined concepts, brought new innovations to bear, and exploited the emergence of new technologies to arrive at the rear wheel drive safety cycle of 1890.[4] This vehicle, with wire-spoked wheels, was then enhanced with the introduction of the pneumatic tyre and by the late 1890s was a more or less obdurate form; what you and I know as a bike. The essential characteristics of this single-track two wheeled vehicle are shown in schematic form, synthesised from Wilson.[5]

The design and manufacturing of the bicycle are an important a part of this vehicle's history. Pre-1890 cycles were made in smaller quantities by local workshops. Along with the emergence of a dominant vehicle typology was a more serialised manufacturing approach. The safety cycle was manufactured in great quantities in Coventry, UK, as a development of that city's existing manufacturing expertise and capability in sewing machines.[4,6] As the popularity of the bicycle spread, so did the manufacturing. Colonel Pope's facility in Massachusetts, USA developed into the first example of production line manufacture which was to

Preceding Pages
Detail of bicycle spokes. Stock photo.

Opposite
Schematic of rear wheel drive safety bicycle. Black main assembly, red front assembly, green wheels, and blue transmission.

inspire the adoption of this process by cycling enthusiast and industrialist, Henry Ford.[7] Manufacturing at scale requires repeatability and quality control on the factory floor, and this was achieved through design. On the demand side, it was also necessary to accommodate the needs of the consumer – lest they purchase their bicycle from another manufacturer – and hence some necessary variations are introduced into the manufacturing process.[8] Processes which we would later come to call mass customisation. Industrialised manufacture led to the emergence of some dominant technologies, such as the bicycle chain, which over time has settled on stable dimensions. Such sizes of bicycle components have come to be regarded as "standards". It would be more accurate to describe them as obdurate since no higher authority exists to actively standardise these parts, but the observation remains that a lot of bicycle parts became, and still are, interoperable at the factory level. The interoperability is an enabler of reinvention, something that bicycle users have been exhibited to undertake for as long as the vehicle has existed.

Changing focus to the present day, one more introductory point should be made. In response to the profound challenges of anthropogenic climate change [9] and liveable cities in the context of an urbanising global population [10] there is a global push to replace motorised vehicle trips with active and micromobility such as those offered by the bicycle as documented by lobby groups.[11] Examples of this tend to be enacted in local government policy. [12 13] While this challenge is one of the complete transport system, the vehicle is a necessary part of the picture and so this research also aims to determine if there are any favourable implications of the design and manufacturing of bicycles which may be brought to bear on this problem.

2. Literature review

This review will provide a basis from which to analyse bicycle design and manufacture. At first setting out some considerations of the bicycle from basic principles, then design and manufacture. Then a basis is provided in mass customisation and reinvention as a basis for sections 3 and 4.

The Bicycle

As consumer products, bicycles attract media attention as objects of technology, sports, and to a lesser but still important extent, popular culture. There is an abundance of periodicals dealing with bicycles and cycling, which tend to provide guidance and opinion to the bicycle user and consumer. Such periodicals can be general and broad ranging with regard to subject matter and geography, and others can be specialist in both types of cycling, and the readership they target, for example written in a particular language. Most developed countries have their own periodicals catering to the various branches of cycling as a sport. Some of these deal peripherally with utility cycling, a task that is taken up more willingly by support and advocacy organisations such as Australia's Bicycle Network, and the Netherlands *Fietsersbond*. Scholarly literature is far less abundant, and has tended to triangulate on several key works which will be the focus of this literature review.

As introduced above the obdurate form of the bicycle is as the single track, two wheeled rear wheel drive safety cycle. This basic form has been manipulated over the last 100 or so years to produce a variety of derivative designs for different purposes. The terms bike and bicycle will be used in this paper to describe this family of vehicles. I aim to include the range of "cycles" in these terms as well such as trikes, recumbents and velomobiles which are a smaller part of the bicycle market. Bicycle design is strongly related to purpose, and although any bicycle can successfully carry a rider, the manner in which this is done varies accordingly. A key differentiation is made between the purposes of sports and utility. [14] Sports bicycles tend to optimise speed as a design consideration, and as such compromise cost, comfort and durability. They are also designed within the scope of rules for the sport, rules which are determined to prevent unfair advantage in competition. A purpose built utility bicycle will tend to offer a range of practical affordances such as luggage capacity, lights, kickstand, fenders and sometimes electric assist, all of which are in line with the idea that the bicycle is used for non-deferrable trips regardless of weather or time of day. Utility bicycles are mostly based on the double-diamond frame design. At the extreme end of utility bicycles are cargo-bikes, those in which the frame has been manipulated to increase the ability to carry goods or passengers. At their most extreme this can include four or more wheels.

The science of the bicycle relates to all types – that the vehicle is human powered is presented as the main consideration of bicycle science[5], design and engineering.[6, 15] Thus even a utility bicycle will be designed to be as easy to propel as possible and thus is likely to carry over some characteristics from sports bikes. Burrows[15] demonstrates that some characteristics such as aerodynamics, can be directly transferred from the velodrome to the town bike with little harm, but some implications on cost. From a manufacturing perspective this is significant, since any carry-over parts from one type of bicycle to another will produce more end-product permutations than there are components.

While considerable variation exists in bicycle design, there exist dominant forms in each family of functional parts[6]. Taking wheels as an example, while developments in technology continue, much of the work centres around the established wire-spoke wheel. At their outer edge, wheels exhibit a family of sizes in alignment with tyres; and at the middle, hub sizes are found in a small family of variations around which frames can be designed to hold them. This is a matter of convenience for manufacturing and maintenance and so is useful for both supply and demand sides of bicycle manufacturing.

Much mobility research tries to approach the activity of "cycling" by subdivision. This is useful as it can provide an understanding of different individual behaviours as well as cultures. However since bicycles and cycling mean different things to different people and even different things to the same people, these categories can be misleading. The categorisation can also lead to market segmentation which plays out favourably for sales figures in sports and leisure markets but does not seem to provide the specific segmentation in more quotidian uses of the bicycle. Just as we see automotive vehicles applied to a variety of non-specific uses such as the off-roader in the supermarket car park, bicycles too can easily cross boundaries of supposed applications. Forester[16] for example identifies that a bicycle marketed as a touring machine will be quite well suited to middle and long distance commuting, while Burrows[15] notes the benefits of rugged off road bicycle wheels are quite well suited to the structural stresses of utility cycling. Much of the innovation developed on the race track can and does have some impact on utility cycling, so long as the necessities of transport are also accounted for. [17,18]

Cycling: bicycle use and culture

The manner in which bicycles are used varies. At an individual level a user may employ one bicycle for different tasks, or use several bicycles for several tasks; whereas at a cultural level we can see some generalisable uses for the bicycle such as the Dutch and Danish utility culture and the Southern European sporting culture.[19] Generalisations are useful, for example when studying cultural propensities to cycle we can see that the Dutch and Danish have high mode share whereas the Australians and Americans low. Within these broader cultures though there are pockets of individualism, so it is still easy enough to find a *Nederlander* who does not and will not cycle or an *Aussie* who uses little else apart from the bike for mobility. Sticking with the focus on bicycles rather than cycling, what we can see from the various cultures is that they employ different bicycles. There is a correlation between the high rates of bicycle use in the Netherlands and Denmark and their ownership of utility bicycles. Causality is less certain, and Bijker[1] provides the view that taken as a sociotechnical system, the intrinsic properties of something like a bicycle matter less than the socially constructed assessment of them. A utility bicycle is more likely to be socially constructed as a useful transport vehicle than a highly strung, delicate racing bike. From a culture and history perspective, Oosterhuis[19] provides the balanced view that the technological and cultural aspects of bicycle transport interact to form a self-supporting system in which it is both culturally and technologically easy – or difficult – to ride a bicycle.

The transport system requires an interaction of vehicles, ports and ways.[20] The literature on bicycle use for transport, generally called utility cycling, tends to be dominated by discussions of the ways; that is, the infrastructure. While "port" facilities seem to rate a mention in the form of bicycle parking, the vehicle can evade critical attention. One often cited review of the determinants of commuting by bicycle returned no search results about bicycles, and hence provided no analysis of how the bicycle vehicle may be part of this mode of transport.[21]

Manufacturing and design

Full accounts of how design and manufacturing interact are provided in the literature as a means to instruct and improve processes.[22] In a simplistic description, design interacts with the manufacturing process in a two-way negotiation. First, manufacturers aim to sell what they can make. Efforts in sales and marketing will provide some assistance to this process, but the goods on offer must fundamentally appeal to the market. Thus, second, manufacturers make what they can sell; and what they make is determined to some extent by design.

When we consider bicycle manufacturing, two distinct parts deserve our attention. Firstly, the manufacture of bicycle components from basic materials requires the manufacturing capabilities such as forging, moulding and extruding to make tubes for frames, and other operable components such as wheel rims and pedals. Various original equipment manufacturers (OEMs) produce parts in this fashion and make them available to the consumer market as well as to the bicycle OEMs. The bicycle OEMs, in their turn, take tubing materials and manufacture these into bicycle frames. Again these can be sold on to the consumer market but are much more commonly combined with components and assembled into complete bicycles. This second manufacturing activity – assembly – can exploit a wide range of interoperable components to produce a large array of end products. The designer plays a role in all of the above, but increasingly it is the role of a "product manager"[22] to align the assembly of particular bicycles to market demand. Thus the designer's frame may be combined with different components to satisfy different markets.

Product managers and designers mediate between the capabilities of the manufacturing process and the demands of the customer base. Industrial scale, serial production of the same widget will afford a manufacturer economies of scale, however this economy is false if it does not align to market demand. On the other end of the spectrum, bespoke production of unique articles can provide very close alignment to individual consumer or user needs, but with no economy of scale are not viable as the extreme production costs must be passed on to the consumer and are usually more than the market will bear. Exceptions to this include small volume high end products which are niches in their relative end user sectors, for example tailor made suits. Design of components, and the select assembly of these components into bicycles give us the results that we see on the market.

Mass customisation

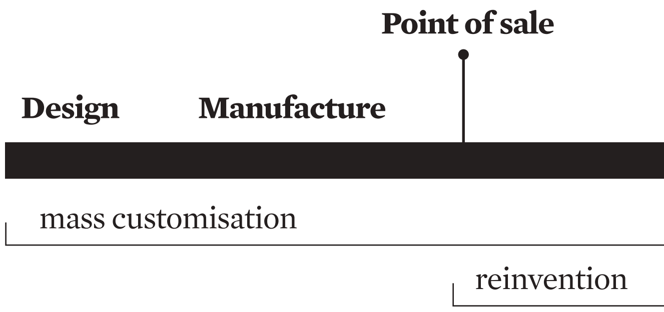
To balance the seemingly irreconcilable approaches of production scale versus consumer taste, the principle of mass customisation (MC) emerged in the 1980s as a management paradigm dismissing this difference as a false dichotomy.[8] Previous decades of mass production had developed new approaches to the "sell what you can make" and "make what you can sell" frames of mind by developing and exploiting approaches in the industrial production complex which offered the scale and repeatability required by manufacturing, as well as the granular appeal of product characteristics to appeal to a wider range of user preferences. An early and clear example of this are the "platform strategies" used by auto manufacturers to produce four or more model variants of cars using one fundamental chassis; a measure which has as much to do with technology as it does marketing.[23] MC is a family of approaches, all of which provide practical ways to navigate consumer and manufacturer needs, the core principle of which is to offer economies of scale in production, and economies of scope in the marketplace. One of the key approaches to this is product modularity, whereby a product can be changed through the modification or replacement of one of its parts. This process is very closely suited to the bicycle manufacturing approach outlined above, whereby the specification of OEM components into a bicycle assembly can create variants to suit consumer demand.

Of particular interest to this research are the MC processes carried out at the point of delivery. Although a customer can expect to find an array of bicycles in the market, there is an opportunity to fine-tune the specification of the bicycle at the point of sale, or even after sale during the bicycle's service life. The modularity of the bicycle which has served the manufacturer well, also serves the consumer at point of sale by affording changes in the bicycle. Bicycles are relatively simple machines and thus it is possible for a bicycle shop's mechanic to undertake all the bicycle assembly tasks which originally occur in the factory. Indeed, completely bespoke assembly of bicycles is a possible – albeit high labour cost – option in the marketplace. A modular system provides the underlying interoperability of components, and the overlap in tools and skills between bicycle repair and bicycle assembly mean that point of delivery customisation provides consumers with the ability to "design" their bicycle to some extent. An important note in this process is that the ability to change a bicycle is not limited to original purchase, but extends throughout the bicycle's life, including renewal and reinvention.

Reinvention

Following on from the design-for-mass customisation ideas above, the resulting modular product is also ripe for reinvention. The term reinvention is used from the diffusion studies tradition and includes notions of do-it-yourself and bricolage.[24] Here, in the context of the bicycle, I frame reinvention as a design and manufacturing phenomenon that is undertaken by the end user. Reinvention of a product occurs for a variety of reasons, both on the supply and demand sides.[25] On the supply, or design, side a product is more apt for reinvention when comprised of a *loosely bundled* set of parts – such as the bicycle, which despite their interdependence, owing to interoperability they can be changed to enhance functionality while still fundamentally working. On the market, or user side, reinvention of a bicycle is quite likely because bicycles can be interpreted in many ways, for example for sport and for transport. General tools with many possible uses tend to be reinvented.[25]

The act of reinvention provides an insight into the socially constructed, and inherent characteristics of product[1]. In the manufacturing process and at the designer's drawing board, a product can be reinvented through reconfiguring in an MC process. Thus it becomes a new product. If this product does not fit a user's socially constructed view of what it should be, then this end user can engage in point-of-delivery customisation and reinvention to make it more suited to purpose. The result is that the typical boundaries between manufacturing, design, and service life are significantly diminished in the case of the bicycle.



Opposite
Design and manufacturing dynamics using bicycle lifespan as baseline.

MC Strategy	MC Method
Product Modularity	Component swapping
	Component sharing
	Cut to fit
	Mix
	Bus
Point of delivery customisation	In store fitting
Cosmetic customisation	Colour variants

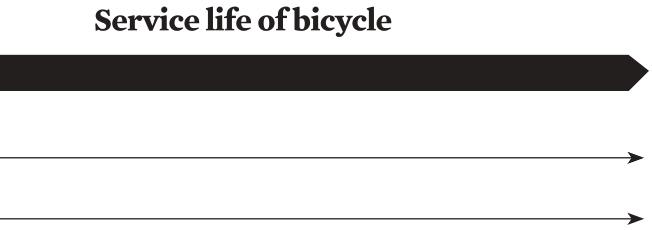
Summary

Design and manufacturing of the bicycle is clearly a broader activity than the confined scope of this research. In the scope of this study, looking at design, manufacturing, mass customisation and reinvention, we see that an interrelated system is emerging that has implications for design, and the mobility culture of the bicycle. It is to these implications that this paper now turns, organised as follows. Section 3 takes a sample from the field to see whether signals of activity are present which represent mass customisation and reinvention and in doing so will determine how the above theories exist in the field. Section 4 brings together the continuum of design, manufacturing and application into a model to explicate the dynamics of this system. Section 5 examines the implications of the system for design and bicycle mobility.

3. Observational study

Mass Customisation in the field

Marketing materials are a direct interface between bicycle manufacturers/assemblers and the consumer. While there are other methods of purchasing a bicycle, for example private sales and custom builds, the sale of complete bicycles dominates the market. A scan of a major manufacturer's marketing materials,[26, 27] reveals several MC practices. Product modularity is the dominant method, with each manufacturer exhibiting several types detailed in table 1.



Observed example
OEM drivetrain components vary to create different price point bicycles on the same frame.
Identical bearing assemblies used across variants
Length of cable assemblies suit frame sizes
Paint colours
Components added to handlebars e.g. bell and reflector.
New bicycles are sold through a dealer network of approved retailers
Frame and component colours

Summarising these sources and table 1 we can see that a manufacturer may have a small family of bicycles which serve a broad purpose, for example a “city” bike. In this category, the manufacturer then has two designs, each of which are available in three variants which carry a different balance of cost and quality. Each variant then has three or four frame sizes available, and perhaps two or more colours. Finally, at the point of sale minor adjustments are made to fit the bicycle to the rider and perhaps add or change some components, for example adjusting the saddle height and replacing tyres. This provides an example of how the design process, by applying MC, extends the manufacturing process through to the shop floor. At the same time, design extends too, transitioning from the top-down drawing board and strategy activity at the manufacturer to a design-to-fit customisation activity with the end user.

Note that there may be some MC practices which are invisible and not communicated to the consumer. For example a large scale manufacturer can manipulate the wall thickness of frame tubing to balance cost, strength, weight and ease of manufacturing[15] but because this manipulation occurs on the inside of the tube wall, it is not visible once the frame is welded together. In addition to MC offered by one manufacturer, it is also important to note that in this example the new bicycle market bears some of the scope of variation. Although at a high level, the bicycles available bear much similarity to one another, the manufacturers tend to follow a differentiation market strategy and thus offer bicycles which vary to their competitors in some way. With some dozens of manufacturers offering products in this market the level of customisation – choice – afforded to a consumer is high.

Reinvention in the field

Does reinvention of the bicycle occur, and if so, what is the nature of this reinvention? To answer this question I used field observation to see if evidence was visible based on the bicycles people ride. A sample of bicycle and rider combinations was photographed in order to detect reinvention and understand the nature of this practice. A statistically representative sample was not attempted as this isn’t the intent of the research. The observational study was carried out under an approved low-risk human research approval from the Monash University Human Research Ethics Committee, number 16987. The observational method was chosen in this instance to minimise inconvenience to users and to base the research on what people do, rather than what they say. Thus the acts of reinvention are noted as variants to bicycles and provide a simple, yet robust insight into the physical changes that are made to the vehicle forming an adequate, designer’s view into the bicycle’s inherent characteristics. An alternative approach would be to conduct interviews with bicycle owners to determine the *intent* of their reinventions and discover how they may conceptualise their bicycles. This would be an area for further research.

Field observation reveals varying levels of reinvention. The first shows a rider on board what appears to be a “stock” bicycle – ridden as if straight from the showroom. The following photograph shows quite the opposite, with the bicycle reinvented into a utility bike with carrying capacity through the addition of a jury-rigged milk crate. We can determine the change in function this reinvention brings by observing the inherent characteristics of the artefact, however it hints at a broader change in “meaning” of this bicycle which would require further research to understand. The field work revealed a variety of treatments representing reinvention of the bicycle, for example the addition of components such as luggage racks and pannier bags. Also noteworthy are the reinvention acts which remove parts from the bicycle, the extreme example of which turns an otherwise ordinary bicycle into a pared down *fixie*.

4. Mass customisation and reinvention in bicycle design and mobility

When we combine theories of design, manufacturing, mass customisation and reinvention in the context of the bicycle, we can gain an understanding of the dynamics of a larger process at play. This should be informative for our understanding of design, and also of bicycle based mobility – or lack thereof. The diagram on this page illustrates a possible combination of these theories.

Starting with a design process as we understand it, we can easily conceive that the bicycle is designed according to some process of research and development, with some concept of application in mind. The application of the bicycle on the drawing board may be specific, for example to win a particular genre of race, or it may be broad, as

Above
Stock bike.
Photography by author.

Opposite
Reinvented bike.
Photography by author.

a utility bicycle. We can expect that in a mature product category there is a strong baseline of knowledge, topped up with current market understanding based on research to inform some kind of prediction as to what will sell.[22] The design process is engaged with manufacturing, which given the mix of OEMs in the bicycle industry is likely to be outsourced at least to some extent – no manufacturer of bicycles makes everything in-house. Thus the designer and product manager engage in an act of mass customisation to create economies of scope and we see one bicycle frame "dressed" with different components to create bicycles which have different prices, and marketing approaches. The consumer is provided with an array of choices across many intersecting bands; price, function, size, colour to name a few. At one point in the bicycle's life it will be purchased new, and at this juncture there is a possible final step of mass customisation where the bicycle shop plays a role in changing or adding some of the components in accordance with the customer's requests. Here we can observe that the bicycle shop staff are at once designers and manufacturers, taking advantage of their position at the coal-face to closely align user needs with the bicycle's inherent characteristics.

At this handover stage there is something of MC and reinvention both at play. Since the bicycle is already "mass-customised" through modularity, continuing to customise at the bicycle shop makes sense. The shop can be conceived as an outpost of the design and manufacturing capability, is just as equipped to make mechanical changes as a factory, and has the benefit of direct end user contact.

Mass customisation then becomes a platform upon which reinvention is facilitated. This adds to what we already know about reinvention – that it is more likely when the innovation has broad uses and the adopters are heterogeneous – effectively removing any mechanical barrier that may be present in the bicycle's inherent characteristics. A skilled bicycle mechanic can easily persuade a bicycle to become a different vehicle altogether.

According to the owner's will, the bicycle can return to the shop at any point over the service life. Thus we can re-engage with the more formal capability of mass customisation as a platform for reinvention as many times as needed. Aside from this, we also understand that as a piece of machinery the bicycle can be modified by the end user. These user-based reinventions exist on a spectrum from highly skilled quasi-mechanical undertakings for the desirous, to simple jury-rigged additions and modifications carried out with nothing more than cable ties. These acts can transform a bicycle from an unlikely machine into a utility thoroughbred, or a collection of rusted parts into a thief-deterring "trashmobile".[16]

The end of life phase for a bicycle is worthy of analysis too, and forms part of the reinvention process. Again owing to their inherent characteristics as mass customised, modular assemblies, a bicycle that may be past the best of its mechanical life can still be employed for less rigorous uses, or disassembled into parts, some of which can become donors for a new bicycle. Social enterprises excel

at activities such as this, and can create significant mobility opportunities at very low costs.[28]

5. Discussion and implications

Configuring new and unique types of bicycle from the same parts is a key activity in readying an offering for the market. The product modularity and point-of-delivery customisation at the heart of this ability leave a residual mass customisation ability after the sale of a bicycle. Extending throughout the bicycle's life, types of mass customisation can be practiced to maintain, change and reinvent the bicycle. The implication for design is that in addition to the industrialised top-down approach, a more convivial, accessible and personal type of design is being practiced. Further, this second convivial practice is in harmony with the industrialised practice rather than in opposition to it. In a way, the bicycle's life capitalises on both very nicely – the industrial practice brings the bicycle to market with suitable quality and cost (to name but two benefits) and then the personalised, continued design practice carries on from the point of sale, enabled by the modularity and component interoperability of MC.

A second implication for design is that the reinvention of bicycles in the field provides visible evidence for the types of bicycles people need. That a consumer can fairly easily reinvent their bicycle – with or without the help of a professional mechanic – means that these acts of reinvention could be considered as a strong signal to the bicycle designer and product manager of consumer needs. Studying the types of bicycles used on the street can, and should form part of our knowledge into the act of transport cycling if we are to understand the vehicles that policy is pressing into service, and would find a natural home in the work of this archive.

For mobility culture

It follows that if we collectively view these reinvented bicycles as a culture, rather than individual vehicles, it begins to tell us something about utility bicycles and the current state of the local bicycle transport culture. Bicycle reinvention is not practiced by all bicycle users, which may mean that some vehicles are fit for purpose as-sold, or may mean that the user can't or won't engage in reinvention. This is a point of departure for another line of reasoning that follows the cultural problem in sustainable transport of "cyclists" versus "people on bicycles". [14] The nature of a "cyclist" label is one of enthusiasm for the mode, and so such a user may be willing and enthusiastic about reinventing their bicycle. The more benign approach of a person who happens to use a bicycle but doesn't fit the label of cyclist may make reinvention less accessible and thus there may be a widening technology gap between these two user groups. This line of reasoning is a matter for further research.

For bicycle mobility

The ability to re-invent an innovation has some important consequences for how that innovation may be adopted.

Above
Detail of bicycle.
Stock photo.

When we consider that the bicycle, as a vehicle category, is put to a variety of tasks this aligns with the understanding of reinvention. Tools with varied applications are more likely to be reinvented.[25] Outside of what may be known behind locked company doors, the phenomenon of bicycle reinvention is an under-studied part of transport and design research. Bicycle design itself does not normally figure in studies of the determinants of cycling[21] which is a shame since the characteristics of the vehicle have a strong effect on how it is perceived and used.[29] In situations like urban Australia, where populations are increasing and government ambitions are to replace car trips with bicycle trips, we would do well to understand the nature of the vehicles on which this policy depends. Field work revealed the practice of reinvention, especially where sports bicycles are given utility bike properties such as luggage capacity.

Conclusion

Manufacturing and design are typically viewed as industrialised practices which occur behind closed doors. In the case of bicycle design, this research has identified that the approach of mass customisation brings design and manufacturing into the realm of the consumer, with one of the main actors in this system being the bicycle shop, which is reconceived as an important outpost of design and manufacturing capability. Mass customisation and the inherent characteristics of the bicycle create conditions for reinvention, where a more convivial practice of manufacturing and design are carried out in the field.

Such practices are noteworthy for design strategy as they work in harmony with existing industrialised practices. In the specific case of the bicycle, the implications for mobility are that the opportunities for reinvention should be equally bestowed on all bicycle users in order that the vehicles can become more fit for purpose as policy shifts towards using bicycles for mobility. In converting a sports bicycle fleet into a utility bicycle fleet such as may be the task for Australia, the act of reinvention could be a determinant in how much of our mobility can be carried out with sustainable modes.

Endnotes

1 Wiebe E Bijker, *Of bicycles, bakelites, and bulbs: Toward a theory of sociotechnical change*, (Cambridge, Mass.: MIT Press 1995).

2 Don Norman, *The design of everyday things: Revised and expanded edition* (New York, NY: Basic books, 2013).

3 Robbie Napper, "What is a parked bicycle? Vehicle fleet characteristics in Australia," *Transportation Research Interdisciplinary Perspectives*, no. 7, (2020).

4 David V. Herlily, *Bicycle: the history*, (New Haven, CT: Yale University Press, 2004).

5 David Gordon Wilson and Theodor Schmidt, *Bicycling science*, (Cambridge, Massachusetts: MIT press, 2020).

6 Tony Hadland and Hans-Erhard Lessing. *Bicycle design*. (Cambridge, Massachusetts: MIT, 2014).

7 Carlton Reid, *Roads were not built for cars: How cyclists were the first to push for good roads & became the pioneers of motoring*. (Washington, DC: Island Press, 2015).

8 B. Joseph Pine, *Mass customization*, (Boston: Harvard Business School Press, 1993).

9 Intergovernmental Panel on Climate Change (IPCC), *AR5 synthesis report: Climate change 2014*, (2014).

10 *World urbanization prospects 2018*. United Nations Department for Economic and Social Affairs, 2018. See https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html

11 European Cyclists' Federation, *Annual Report 2019*, (European Cyclists Federation, 2019).

12 City of Melbourne, *Transport Strategy 2030*. (2019). See https://www.melbourne.vic.gov.au/SiteCollectionDocuments/transport-strategy-2030-city-of-melbourne.pdf

13 City of Moreland, *Moreland Integrated Transport Strategy 2019*. See https://www.moreland.vic.gov.au/globalassets/key-docs/policy-strategy-plan/mits-2019.pdf

14 Melissa Bruntlett and Chris Bruntlett, *Building the cycling city: the Dutch blueprint for urban vitality*, (Washington, DC: Island Press, 2018).

15 Burrows, Mike, and Tony Hadland, *Bicycle Design: Search for the Perfect Machine*, (London: Snowbooks, 2008).

16 John Forester, *Effective cycling*, (Cambridge, Massachusetts: MIT Press, 1993).

17 Kirstin Lovejoy and Susan Handy, "Developments in bicycle equipment and its role in promoting cycling as a travel mode," in *City cycling*, ed. John Pucher and Ralph Buehler, (Cambridge, Massachusetts: MIT, 2012), 75-104.

18 Richard Ballantine and Richard Grant, *Ultimate bicycle book*. (London, UK: DK, 1998).

19 Harry Oosterhuis, "Entrenched Habit or Fringe Mode: Comparing National Bicycle Policies, Cultures and Histories," in *Invisible Bicycle*, ed. Tiina Männistö-Funk and Tim Myllyntaus, (Leiden, Boston Brill, 2019), 48-97.

20 Charles H Cooley, "The theory of transportation," *Publications of the American Economic Association* 9:3 (1894): 13-148

21 Eva Heinen, Bert Van Wee, and Kees Maat, "Commuting by bicycle: an overview of the literature." *Transport reviews* 30. 1, (2010): 59-96.

22 Steven Eppinger and Karl Ulrich, *Product design and development*, (New York, NY: McGraw-Hill Higher Education, 2015).

23 Stephen, Bayley, *Sex, Drink, and Fast Cars*, 1st American ed. (New York: Pantheon Books, 1986).

24 Dick Hebdige, *Subculture the Meaning of Style*, (London, New York: Routledge, 1979).

25 Everett M. Rogers, *Diffusion of Innovations*, 5th Ed. (New York, NY: Free Press, 2003).

26 Trek. "City Bikes." Accessed September 30, 2020. https://www.trekbikes.com/au/en_AU/bikes/city-bikes/c/B551/

27 Specialized. "Transport Bikes." Accessed September 30, 2020. https://www.specialized.com/au/en/shop/bikes/active-bikes/c/active?q=%3Aprice-desc%3Aarchived%3Afalse%3AproductFamily%3ASirrus%3AproductFamily%3ATurbo+Vado%3AproductFamily%3ATurbo+Como&text=#result-list

28 Simone Batterbury and Inès Vandermeersch. "14 Community bicycle workshops and "invisible cyclists" in Brussels" *Bicycle Justice and Urban Transformation: Biking for all?*, ed. Aaron Golub, Melody L Hoffman, Adonia E Lugo, and Gerardo F Sandoval, (London: Routledge, 2016): 189.

29 Donald A Norman, *Emotional design: Why we love (or hate) everyday things*. (New York, NY: Basic Books, 2004).