Sites of qualification: the motorcycle rider airbag and the production of safety

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The paper mobilises the distinctive notion of 'sites of qualification' as a means of providing an expansive understanding of how innovative products are designed, produced and brought to consumer markets. We focus on the development of a new safety product for motorcyclists, the rider airbag, in which inflatable body protection is either incorporated into, or worn underneath, textile jackets and leather suits. The paper follows the airbag's trajectory across a range of different sites, including lead firms and their territorial settings; MotoGP racetracks, mobile laboratories and professional riders; courts of law; and showroom and archive locations. The paper's sites of qualification approach expands understandings of innovation by constructing a dialogue between two sets of literatures: actor-network approaches to the qualification of products and narratives of economic innovation as emerging through clusters of agents and firms within industrial districts. The conclusion emphasises that sites of qualification are integral to the ways in which technical products such as the rider airbag are made social.

Keywords: sites of qualification, innovation, safety, rider airbag, product qualification, motorcyclist

Introduction

This paper focuses upon the development of a new safety product for motorcyclists, the rider airbag, in which inflatable body protection is either incorporated into, or worn underneath, textile jackets and leather suits. The development of the rider airbag has involved high levels of technological innovation through laboratory testing, including the performative field practices of elite motorcycle racers. Rider airbags are now available to ordinary consumers; and the complex intelligent technologies of the airbag are being adapted for other protective retail products, ranging from skiing, cycling and equestrian sports, to health and mobility services and construction worker clothing (Ridden 2017; Motorcycle News 2019). Although developed and marketed in European

and North American economies, rider airbag manufacturers are seeking to expand into global mass markets, particularly Southeast Asia (Research and Markets 2017) and India (Overdrive 2013a, 2013b).

The airbag, therefore, is a culturally important object with significant safety implications and lifesaving potential across a range of consumer uses**.** For professional motorcyclists, this high technology product has proved successful in preventing significant injury and death. In turn, the development of airbag technologies is instigating material change to broader practices of motorcycling, as everyday consumers increasingly come to embrace the qualities of this device. Consequently, our choice to examine this distinctive safety object and its emergent sociologies of market attachment has a moral and political purpose. In this regard we follow McFall's (2009, p. 280) argument that

> if materialist pragmatic research has the capability to uncover the conditions in which particular forms of agency and economic life emerge, it also has the capacity to be political and politically informed about the objects in question.

Moreover, in using the case of the motorcycle rider airbag to trace the 'situated, distributed and material character' (McFall 2009, p. 280) of its development, we provide a wider conceptual contribution focussed on the importance of attendant spatialities, revealing how particular places and geographies are integral to the sorting and framing of product qualities and consumer attachments.

A key aim of the paper is to mobilise the distinctive notion of 'sites of qualification' as a means of providing an expansive understanding of how innovative products are designed, produced and brought to consumer markets. Sites of qualification brings into dialogue and offers a bridge between two sets of literatures which in differing ways offer valuable insights, but yet have tended to stand apart.

These are, on the one hand, actor-network approaches to the 'qualification of products' (Callon *et al.* 2002; Latour 1992); and on the other hand, narratives focussing on processes of economic innovation as emerging through clusters of agents and firms within industrial districts (Cooke and Morgan 1999; Storper 1997).

The paper begins with an illumination of the concept of sites of qualification. Following a review of methodological strategies, we then analyse the technological characteristics and trajectories of the rider airbag, highlighting its innovative 'active' protection features. In order to deepen our understanding and to develop an extended sense of how the airbag is qualified, the central sections of the paper assess the important sites of qualification where agents and agency coalesce. We show how the product qualities of the airbag are 'attributed, stabilized, objectified and arranged' (Callon *et al.* 2002, p. 199) by human and non-human agents, including motorsport governing bodies, the racetrack, and rider equipment firms, across a series of distinctive spaces. The territorial settings of key lead firms involved in rider airbag design and manufacture provide the first of these sites. The paper then turns to scrutinise the MotoGP (the foremost international premier championship class of world motorcycle racing) racetrack as a (mobile) field test site, and the performative role and embodied practices of MotoGP riders. In subsequent sections, we appraise two further sites around which agents and agency cohere: courts of law; and consumer-facing showrooms and archives. The paper's conclusion emphasises that attention to sites of qualification significantly strengthens understandings of how innovative technical products are created and brought to market.

Regions of innovation and sites of qualification

The concept of sites of qualification helps expand thinking about the social, material and technological processes that shape a product and its trajectories into consumer

markets. It seeks to capture the specificities of particular spaces where the qualities, framings and sortings of an object happen and the importance of these places to how this happens. The notion of sites of qualification enables us to think about how diverse networks of agents and agencies coalesce in distinctive spatialities of arrangement. We are inspired by Henke and Gieryn's suggestion that whilst webs of connection across networks often have been portrayed as relatively free floating, 'place has consequence for scientific knowledge and practices'; and that we should pay particular attention to the 'materially-situated and symbolically-encrusted "nodes", the places that serve as endpoints for the links comprising heterogeneous networks in the ANT approach' (2008, p. 355).

The idea of sites of qualification also enables us to extend and develop connections between accounts of regional innovation in industrial districts and literatures on the economies of qualities. Research on regional innovation and industrial districts provides an important window onto the economic geographies of innovation by studying local agglomerations of economic activity and how technical collaborations are seen to emerge in regions with embedded craft and traditional skills (Storper 1997, Scott 2000). Within this approach, innovation has been seen to stem from strong interfirm ties (conspicuously, among small- and medium-sized enterprises), cultures of competitive co-operation and untraded interdependencies (for recent reviews see De Marchi *et al.* 2017b; Delgado 2018, Buciuni and Pisano 2018; Belussi and Hervas-Oliver 2018). Many narratives also have taken place-specific and localised artisanal, design and/or aesthetic traditions as a starting point, additionally emphasising the role of local working traditions and local institutional support in agglomerations (Storper 1997; Scott 2000). Industrial district approaches, because they foreground understandings of place and territory, therefore offer valuable insights into one particular site of

qualification, that is, the firm in its territorial setting, including such dynamics as local production systems, interfirm linkages, knowledge creation and innovation within regional clusters.

However in order to deepen understandings of innovation it is important to more fully trace how a technical product is 'made social' (after Akrich *et al.* 2002a, 2002b) across other sites. A conceptualisation of the qualification of products (Callon *et al.* 2002) significantly assists in understanding the roles of "diverse networks of agents and sets of reflexive and dynamic processes (stretching beyond the firm through design, production, distribution and consumption)" (Pinch and Reimer 2012, p. 450). Although an actor network-based notion of product qualification foregrounds producers' efforts to strategically position goods in relation to competitors, products themselves are significantly understood as process: as constructed through a 'sequence of actions' and 'metamorphoses' undertaken by binding agents who 'by adjustment, iteration and transformation define [product] characteristics' (Callon *et al.* 2002, pp. 197-198). Such an interpretation not only importantly appreciates consumers as calculative actors (Grabher *et al*. 2008, p. 255), but also is effective for our purposes here because it views products as dependent upon 'the joint work of a host of actors' (Callon *et al*. 2002, p. 203). Moreover, as Callon's early work (1991, p. 155, fn 7) emphasised, networks are conceptualised to extend beyond just 'pure associations between human beings' to non-human actants, in order to grasp the capacities and effects of the materialities of technologies themselves and how (or not) they attach themselves to social groups. In Akrich *et al.*'s cognate articulation of 'interessement devices' (2002a, p. 205), the character of innovation decisions 'contribute to defining the social groups concerned, setting up some as allies, others as adversaries of sceptics,' whilst technical devices '[distribute] the forces which will support or resist it.'

A qualification of products approach emphasises contingency and unpredictability in the practices and processes that ultimately bring goods to market (Mouat *et al*. 2018; Entwistle 2015, Spinney and Lin 2019). Crucially, it seeks to explore the 'coordinated set of heterogeneous actors which interact more or less successfully to develop, produce, distribute and diffuse methods for generating goods and services,' requiring close attention to the diverse range of intermediaries 'that escort objects on their travels' (Callon 1991, pp. 133 and 137). It has the potential, therefore, to deliver an expansive view of the diversity of agency through networks and the complex socio-material assemblage of human and non-human agents through which innovative products come into being.

At the same time, however, such insights into the diversity of agents and agency lie at the core of what has been seen as problematic for actor network approaches: how to meaningfully trace and guide analysis though the endless potential networks that connect to a product on its journey to market. As Strathern (1996, p. 522) has argued, the 'auto-limitlessness' of networks can prove challenging for analysis, and interpretation must somehow find a way to 'hold objects of reflection stable long enough to be of use.'[1] In this regard Strathern (1996) identifies the need to 'cut' into networks to discover meaningful moments of agency across network heterogeneity.

Mobilising the notion of sites of qualification can assist in this task of cutting into networks by considering important sites at which a 'constellation of characteristics' (Callon *et al.* 2002, p. 199) coalesce. As foregrounded in the industrial districts literature, understandings of place and territory are crucial to any 'socio-technical complex' (Mitchell 2008, p. 1118). However, by explicitly extending our focus beyond that of the firm and its territorial setting (as identified in the industrial district literature) to the heterogeneous networks of agency identified through product qualification

approaches, sites of qualification offers the potential to cut into such networks and attend to important moments of stabilisation and routinisation of practice where agents and agency are situated in space and place.

At certain moments actor network-based approaches do allude to the importance of such sites of qualification. In Latour's original discussion of Pasteur's development of the anthrax vaccine, the relationship between laboratory design and public field displays is paramount (1993 [1988], p. 76). Subsequently, Callon *et al*. (2002, p. 198) emphasised that the

> characteristics of a good are not properties which already exist and on which information simply has to be produced so that everyone can be aware of them. Their definition, or in other words, their objectification, implies specific metrological work and heavy investments in measuring equipment.

Properties 'are "revealed" through tests or trials which involve interactions between agents (teams) and the goods to be qualified' (Callon *et al.* 2002, p. 198). Ibert *et al.*'s (2016) more recent conceptualisation of 'disassociation' also chimes with this observation. Turning on its head economic geographers' work on value construction through associative processes (in which, for example, spatial references may be attached to products and services in order to connote and enhance value), they argue that the little understood mechanisms and performance of dissociation are at least of equal importance in establishing value:

> dissociations denote pro-active relational work undertaken to create value which mainly aims at hiding away potentially problematic aspects of a commodity from the consumers' awareness and seek to conceal or weaken linkages between a product or service and those conditions of provision that will most likely spur moral doubts or discomfort on the consumer's side (Ibert *et al.*, 2016, p. 2).

Nevertheless, a fuller understanding of the specificity within sites, and a fuller appreciation of the range and diversity of sites is required. As Henke and Gieryn (2008, p. 355, emphasis added) indicate,

> There is still a great deal to be learned about laboratories, field-sites, and museums as places of science—however unmoving they might now seem to be—and we argue that the initiative to fold places into *non-geographic* networks actually overlooks important features useful for explaining how science travels.

The reminder of the paper sets about the task of detailing an extended sense of sites of qualification, through an examination of the development of the rider airbag.

Methodological strategies

The paper mobilises the notion of sites of qualification to show how the new safety technology of the motorcycle rider airbag has been 'summoned into being' (McFall 2009, p. 269) to become an established retail product which offers important insights for studying the articulation of culture, economy and value. Our research assembled material from the wide range of print, online and televisual sources through which airbag intermediaries are made apparent, motivated by Callon's (1991, p. 140) contention that 'the social can be read in the inscriptions that mark the intermediaries'. Inscriptions were examined through triangulation of print media trade press and online motorcycle news sources, visits to retail and trade spaces as well as assessment of motorcycle racing broadcasts. As Mouat *et al*. (2018, p. 141) emphasise, newly developing industries 'in the making' frequently make wide use of 'media in all forms', yielding a rich landscape of textual and audio/visual material, including social media. We assessed news and editorial articles, including 35 publicly-available interviews with managers/executives in airbag firms and motorsport personnel more generally (e.g. riders and MotoGP managers), as well as technical discussions in research papers on

airbag technology (e.g. Bellati *et al.* 2006; Cossalter *et al.* 2008; Grassi *et al.* 2018; Lee 2018; Marconi *et al.* 2018). News sources comprised the weekly UK newspaper *Motorcycle News*, monthly magazines *Motorcycle Sport and Leisure*, *Bike*, and *MotorSport*; online outlets such as motogp.com, Visor Down, Cycle News and Cycle World; and broadcasts such as Dorna's MotoGP™ podcast and Eurosport's Full Throttle.[2] Textual and audio sources were subjected to thematic coding in order to 'draw out themes from source material and examine the narratives they contain[ed]' (Craggs 2016, p. 123), allowing us to identify key sites and processes of qualification.

Retail visits included a 2018 launch event for the Dainese London flagship store, and subsequent 'rider events' hosted to coincide with major motorcycle races, such as the British Superbike Championship and the British round of MotoGP. We viewed retailing and display of rider airbags at trade shows including the National Motorcycle Show, and the *Motorcycle News* London show. We also draw upon longitudinal analysis of MotoGP television commentaries during successive race seasons as airbags were introduced (see also Table 1). The broadcaster BT Sport acquired UK rights for MotoGP in May 2013; and since the start of the 2014 season both the breadth and depth of their dedicated coverage has increased, including detailed technical commentary during free practice sessions, qualifying sessions and races; and interviews with riders, team managers and technical directors. Broadcast segments featuring discussion and demonstration of airbag technologies (clips of which are often re-circulated on social media) were captured, re-viewed and interpreted alongside the thematic coding of textual material detailed above.

Technologies of the rider airbag

The rider airbag is the most recent advance in a long line of technological innovation in materials associated with the practice of riding a motorcycle, including enhancing the

durability of leather; the production of abrasion-resistant and breathable fabrics; and the introduction of body armour, back protectors and knee and elbow sliders (Black *et al*. 2005; Varnsverry 2005; De Rome and Stanford 2006; Bougourd and McCann 2009). In many ways, however, the airbag marks a significant shift in this development pathway since it involves active rather than simply passive protection (see Table 1).[3]

Car airbag safety systems have become commonplace, consisting of energy absorbing inflatable textile cushions built into the fabric of the vehicle to protect passengers during a crash from impacts with hard internal surfaces, such as steering wheels, instrument panels, seats and body pillars. Car airbags are activated by collision impact sensors (micro-electro-mechanical accelerometers) that send data to the airbag's electronic control unit (ECU), where crash algorithms determine if the crash event meets the criteria for inflation and triggering a pyrotechnic gas generating firing device. Whilst early experiments with motorcycle airbag systems also were built into the machine itself, the technological trajectory soon shifted to the motorcycle rider (Pruner 2017). Modern rider airbag systems now incorporate inflatable protection into or under the rider's protective clothing, with rapid inflation of a bladder to protect the back, shoulders, kidneys and chest. Microfiliments connect both sides of the airbag interior to allow even and rapid inflation by helium-argon gas cartridges embedded in a rigid back protector. Whilst some systems are triggered mechanically by a tether attached to the motorcycle, others incorporate into clothing the accompanying technological infrastructure necessary for airbag deployment, such as ECUs, sensors, gas cartridges, battery packs and 'intelligent LED' (light emitting diode) systems with status display panels.

> How they work is little short of genius. Microscopic accelerometers and gyroscopes on the suits measure acceleration and lean angle, which is fed back to the internal computerised 'brain' of the system, around 1,000 times per second.

> Dainese uses a GPS [global positioning system] unit to help the ECU work out how fast the bike is moving, while Alpinestars uses an advanced inertial algorithm instead. The ECU uses this data to detect a crash, determine its violence and decide whether to activate the airbag, all in a matter of milliseconds. (Thomson 2018).

This then is why the rider airbag can be considered 'active' protection. Technical mediators, or non-human actants in the form of GPS, ECUs, accelerometers, gyroscopes and embedded algorithms, make normative judgements about bodies and movements in order to decide what counts as a 'crash' and therefore when to inflate, in order to provide protection for the motorcyclist. It is perhaps no surprise that lead firms have sought to emphasise airbag development as a paradigmatic shift in protective motorcycle clothing:

> Well, as our CEO Federico Minoli says, the airbag is a "discontinuous innovation." Before the airbag, the basic type of protection we used could be found in the New York Metropolitan Museum. Half a million years ago, when *they* had to protect soldiers' bodies for battle, they developed armour suits. Although we used different materials, like Kevlar and carbon fibre, our solutions were all similar to those that were studied 500 or 1,000 years ago. The airbag, on the other hand, is much more sophisticated because it's the birth of an intelligent suit. It doesn't take up much space or have much weight, but it activates when you need it. The airbag is a technological leap, not a progression from the past. (Lino Dainese, quoted in Miles 2014).

In order to further understand how this new form of rider equipment has been brought into being, we now need to explore the techno-economic networks (Callon 1991) which span design, production, motorsport racing, consumption and global regulation. The following sections elaborate the operation of agents and agency at key sites of qualification.

Sites of qualification 1: lead firms and territorial settings

A site of qualification about which we know much is the rich territory of lead firms, via regional innovation literatures. Two firms have been at the forefront of the development of the rider airbag. Since the early 2000s, Dainese and Alpinestars have supplied professional motorcycle racers with nascent technology; have monitored its use on the racetrack; and have refined and developed the product. The firms are in relatively close spatial proximity, just over 30 km apart in the dynamic industrial milieu of northeast Italy. Dainese headquarters are in Molvena (Province of Vicenza) and Alpinestars are in Asolo (Province of Treviso). In their regional setting, the two companies are seen as exemplars of innovative, design-oriented success stories within a footwear cluster or 'sports system district' (Bettiol and Micelli 2006; Bettiol and Micelli 2014; Bettiol *et al.* 2010). Local manufacturing processes and organisation has been characterised by strong cohesion and collaboration, stimulating 'reciprocal learning and product improvements' and drawing upon rooted local craft skills (Di Maria and Finotto, 2008, p. 187). Aage and Belussi (2008) foreground the importance of networks of creativity in enhancing aesthetic value amongst firms in the 'sport system' district of Montebelluna, including Alpinestars. Such narratives yield important insight into the ways in which, for example, the regional location of Alpinestars, with its connectivity to other cognate small- and medium-sized skilled craft-based firms, assisted the small manufacturer of ski boots successfully to shift focus to motorcycling boots and protective equipment in the 1970s and grow 'to become a major player with a strong international presence' (Di Maria and Finotto 2008, p. 192).

Beyond the benefits of locally-embedded networks of SMEs as well as supportive local institutional contexts (Antoldi 2007), the two lead rider airbag firms are also connected with other 'discrete spots' of scientific research (Henke and Gieryn 2008, 355). In addition to its dedicated research and development (R&D) centre located

at the Group headquarters in Molvena, Dainese worked closely with Massachusetts Institute of Technology (MIT) on the airbag development project (Bettiol and Micelli 2006); and collaborative research programmes continue with MIT on space suit technologies. Dainese also has worked in partnership with Technopolis in Bari, the Consiglio Nazionale delle Ricerche (CNR) in Milan; and with the University of Padova (the products of this latter research are visible as research papers by Bellati *et al.* 2006; Cossalter *et al.* 2008). Alpinestars has R&D facilities in Asolo, whilst an additional site in Torrance (a coastal city within Los Angeles County) engages in consumer-facing research for Alpinestars' wider apparel and accessories market, including interactions with 'lead users' at the forefront of style and aesthetic trends (Di Maria and Finotto 2008).

It is important to understand how innovation in local and regional clusters is coupled to the dynamics of global value chains, as a number of authors recently have argued (De Marchi *et al.* 2017a; Buciuni and Pisano 2018). A central contention is that lead firms can act as 'bridges, with external markets, knowledge and external technologies connecting local value chains with global value chains [GVCs]' (Belussi and Caloffi 2018, 186). Belussi *et al.* (2017), for example, present Montebelluna firms' (including Alpinestars') shift from small scale, embedded local production to ownership of multiple overseas firms and subsidiaries as an insertion into GVCs. Most recently, Buciuni and Pisano's assessment highlights local-global connectivity (2018, p. 6) in four different northeast Italian manufacturing clusters, including the 'Montebelluna Sports Shoe District'. Both Dainese and Alpinestars now have well-established production networks outside the region, although bespoke racing leathers, including those with integral airbags, are manufactured 'locally' (Dainese Consumer Care, personal communication, 19 July 2019).

Sites of qualification 2: MotoGP racetracks and the mobile laboratory

At the Le Mans MotoGP circuit in May 2017, Australian rider Jack Miller, racing with the Marc VDS Racing team, lost control of his Honda in a free practice session. The momentum of the crash spun the motorcycle several times in the air and smashed it to pieces, whilst Miller was thrown violently into the perimeter barrier at 160 miles per hour. Witnessed by a global audience of millions, Miller got up immediately after what journalists described as a 'terrifying' crash, largely unhurt, and was cleared to race the next day. Providing crucial protection to his upper body, Miller's Dainese airbag also acted as a source of test data for the firm, whilst the crash itself performed a public demonstration of the value of the rider airbag. As Akrich *et al.* (2002a, p. 199) have articulated, 'to innovate is to change the consumer'. The MotoGP racetrack thus acts as a field laboratory for scientific trial and simultaneously as a site of qualification demonstrating and marketing the effectiveness of the product to a viewing public.

As we have argued elsewhere, the MotoGP championship is itself a mobile assemblage as it travels around the world through the racing year (March to November) (Pinch and Reimer 2017). What is crucial for our argument here is the use of MotoGP circuits by Dainese and Alpinestars since the early 2000s to generate data and test algorithms for rider airbags, acting precisely as the 'tests or trials' invoked by Callon *et al*. (2002). Dainese developed a prototype leather racing suit with integrated airbag, a system known as D-Air, in 2000. They constructed a mobile laboratory (called the D-Mobile and specifically described by the firm as a "lab") and took it to MotoGP racetracks from 2001 onwards: 'this mobile research structure is an extension of the R&D department that visits racetracks around the world to identify and test the latest technological innovations' (Mobile Research, 2019). Central to airbag development is the use of electronic sensing and data acquisition technologies to collect real-time data

from riders on track. In between sessions, or after a crash, rider telemetry data is downloaded: the D-Mobile unit thus acts as the travelling division of Dainese's Molvena-sited R&D department.

By 2009 Alpinestars had developed a 'second generation' of a competing TechAir product that

> constantly monitors the exact orientation of the rider's body in relation to the ground and records the overall force and magnitude of any acceleration/deceleration as well as any impacts received. The system also features an integrated GPS which, coupled with the Inertial Motion Unit [IMU] and advanced post processing software, makes it much easier to amass data and fully determine movement and forces being exerted by and on the rider and their exact position, as well as the relationship between data and track location. This means the system can analyse the position of the rider's torso and limbs before, during and after an accident and the points and direction of impact forces throughout the progress of a fall and exactly where and when it happened. (Motorcyclist 2009).

The new IMU was first tested by US rider Kenny Roberts Jr. in a race at Sachsenring, Germany via technology installed in the aerodynamic hump of his suit; and Alpinestars subsequently analysed data from Spanish riders Carlos Checa and Toni Elias.

Fascinatingly, initial research by both Dainese and Alpinestars included detailed recording of riders' heart rates and temperature; and monitored humidity and cooling around the rider's body (Motorcyclist 2009). This was related to early product development assumptions that it might be possible to associate an airbag inflation 'trigger' with physiological measurements of the rider. Founder Lino Dainese reflected:

> Twenty years ago, when I went to MIT with the vision for the airbag, I was told it was impossible. At the time, I wondered if the brain, in a state of fear, might produce some adrenaline or chemical that could activate the airbag—not gyroscopes and accelerometers as we use now. (Miles 2014).

As explained in McCann *et al*. (2009, p. 242), Dainese's D-Tec 'Procom' project in

1998 was based upon

> a system of measurement and control of parameters (like temperature, blood pressure, perspiration, adrenaline etc.) that determine the physical state and comfort of a rider (Briatore 2004, p. 32) and to gauge levels of stress fear, competitive drive and fatigue (Briatore 2004, p. 112).

However, further research indicated that monitoring bodily movement was more effective in predicting a crash, leading to the use of gyroscopes, accelerometers and algorithms to make judgements about rider performance. Movement is codified as large data sets, generated across practice, qualifying and race sessions at every track.

MotoGP race circuits therefore act as test arenas; as 'field laboratories' at which the airbag is trialled, and data is gathered. It should be emphasised that the 'mobile laboratory' described here has contrasting dimensions to so-called 'temporary clusters' portrayed in accounts of trade fairs (Maskell *et al*. 2006), professional gatherings (Henn and Bathelt 2015); and fashion shows (Entwistle and Rocamora 2006). Riders, technicians and equipment manufacturers at the MotoGP racetrack (together with their tools, equipment, laptops and analysis software) are directly engaged in detailed and extensive programmes of research, not simply knowledge circulation and exchange (*cf* Bathelt and Henn 2014); and interactive learning is rarely shared among firms. In fact, as indicated below, firms are more likely to be in bitter competition for markets.

Site of qualification 3: MotoGP riders, performances and celebrity

MotoGP riders are not simply passive test 'dummies' for the non-human technological actants and material systems they wear and transport. Rider feedback regarding the feel and effects of airbag systems on racing performativity has also impacted technological trajectories. For example, the extra weight and restrictive feel of racing suits with integrated airbag systems initially was opposed by many riders. This resistance was

gradually overcome as suits became more flexible; and as refinements to airbag bladder fabrics and other component parts reduced the 1.3kg weight of early prototypes to 600g. Advances in data analysis and improved algorithms led to material enhancements, more efficiently moving compressed air from a reservoir in the rider 'hump' into the inflated airbag. Riders were also persuaded as the sport's highest profile and most influential riders, such as Dainese-sponsored Valentino Rossi and Alpinestars-sponsored Marc Marquez, became enthusiastic early adopters (Miles 2014; Wheeler 2018). The demonstrable benefits of the technology in reducing career threatening injuries, notably broken collar bones from high-side crashes, has further locked in this innovative pathway.[4]

Thus, MotoGP and its riders are an important socio-technical market device and a mobile experiential site where the airbag object is made both visible and spectacular to a viewing public, be it trackside or through broadcast television and social media. Public motorsport such as MotoGP and its globally recognised and marketed celebrity riders provides an 'imagescape' (Stephens and Ruivenkamp 2016, cited Mouat and Prince 2018, p. 317) through which the qualities of airbag technologies are arranged and demonstrated to potential retail consumers. In their moments of greatest instability, crashing MotoGP riders, such as the aforementioned Jack Miller, act to stabilize and frame the qualities of airbag technologies. MotoGP riders can be thought of as performing the object (Shove 2005).

MotoGP riders also are a form of quasi-consumer performing 'qualculative' (Cochoy 2002) evaluation of product qualities for risk free and safe viewers. Television commentary upon such events is also important to this process. For example, during a segment broadcast to UK viewers from Le Mans in May 2018, former rider and BT Sport presenter James Toseland 'tested' to camera the speed and physicality of an

inflating Alpinestars race suit triggered by manufacturer representatives, whilst Toseland stood connected to a laptop.[5]

Enacting rider airbags in MotoGP, therefore, provides a way of enrolling potential consumers into the virtues of airbag technologies, even though the actual algorithms systems of 'off the shelf' consumer airbag products are set up differently to those worn by professional riders. Consumer products, for example, anticipate collisions from the rear when stationary (i.e. by a car), whilst MotoGP suits 'ignore' low speed crashes and small-scale loss of control in order to enable the rider to continue racing (Thomson 2018).

Firms that have developed the rider airbag significantly benefit from demonstrating the safety and effectiveness of the product to the consumer without the consumer directly using and evaluating it—primarily at the racetracks of elite class motorcycling and through the practices (crashes!) of professional motorcycle racers. Potential consumers watching MotoGP, for example, are reassured about crashing and surviving. Such consumer reassurance is important with a product that is problematic to qualify or indeed 'co-produce' with consumers. It is unlikely that motorcyclists wish to be over-exposed to the implications and 'counterperformativity' (see Mouat and Prince 2018, p. 318) of actual life-threatening road accidents, certainly not through experience, nor indeed through graphic visual representations of them. The racetrack, therefore, acts as a space of disassociation (Ibert *et al*., 2016) from the very real risks and practices of quotidian motorcycle mobility (Pinch and Reimer 2012).

Sites of qualification 4: courts of law and centres of governance

An important site in the 'socio-technical complex' (Mitchell 2008, p. 1118) that has brought the airbag into being has been courts of law, specifically as spaces in which patents have been legally contested. Such is the current and future market potential and

value of the rider airbag that Alpinestars and Dainese have been involved in protracted legal disputes over ownership of this technology. The companies have pursued actions against each other relating to infringement of patents, notably involving copyright of particular airbag components rather than dispute over the overall 'item'. The prolonged legal battle is illustrative of an intricate network complexity, not least in relation to legislative sites positioned at different spatial scales. At a mid-level 'Landgericht' court in Munich in 2017, Dainese accused Alpinestars of three patent infringements, but in February 2019, only one was upheld. Alpinestars subsequently sought action in a higher German court, claiming that 'the German decisions have no impact on its Tech-Air kit in the UK or France - and that it's already moving to nullify Dainese's patent claims in Britain' (Thomson 2019). At the time of writing, disputes continue in Italy, France and the UK. Beyond the narrower issue of the significance of patent registrations (to the extent that patent data frequently is analysed as a marker of 'innovation'), our broader point is that the framing of legal systems plays an important role in qualculation (Cochoy 2002) across national and international spaces.

The laws and governance regime of MotoGP itself work further to stabilise airbag product qualities and to shape how 'objectified properties' are singularized and 'adjusted to the buyer's world' (Callon and Muniesa, 2005, p. 1234). Key network actors include Dorna, the Spanish-based television and marketing rights holder for MotoGP and the Fédération Internationale de Motocyclisme (FIM), the Swiss-headquartered international governing body of motorcycle racing. Significantly, Dorna and FIM together in November 2016 announced that the wearing of rider airbags would be compulsory for all riders in this top echelon of motorcycle sport from the start of the 2018 season (Mann 2016). This official endorsement, we would argue, acts to change landscapes and cultures of motorcycle safety, since it forms part of the 'ontological

boundary work' which 'objectifies [something] as inevitable' (Mouat and Prince 2018, 322; see Franklin 2019, Newland 2019). National government legislation performs and defines these boundaries even more conclusively, solidifying and framing markets as for example, in the case of compulsory motorcycle helmet laws or legislation requiring the testing and certification of personal protective equipment (PPE).[6]

Sites of qualification 5: showrooms and archives

Product qualification is further enacted at sites that face the consumer directly, such as retail stores owned and controlled by the major manufacturers. Both Dainese and Alpinestars operate a global network of showrooms engaged in the display of motorcycle clothing, footwear and helmets. Increasingly these sites offer more than traditional product display. Dainese, for example, have launched a series of flagship stores that provide consumer interactivity both with the materiality of its products and with the professional riders who wear them. Dainese flagships have a dedicated space for ordering bespoke leather race suits in which a mock-up of disassembled pieces of Valentino Rossi's suit is displayed. As the most globally recognised MotoGP rider, Rossi has worn Dianese leathers since his career began at the age of 17, qualifying the product not simply through reputational celebrity endorsement but also through a history of embodied practice in riding and crashing. Dainese flagship openings include the London store on Commercial Street in Spitalfields (September 2018), which has hosted MotoGP and British Superbike rider 'meet and greet' events and motorcycle ride-outs. These stores also play a key role in servicing new airbag technologies.

In 2017 Alpinestars opened a week-long pop up shop at Union Garage, Brooklyn, New York, showcasing

> a huge selection of the company's heritage product line—including some new U.S. exclusives—plus they have on-hand, in-stock and for sale the absolute latest in motorcycle safety innovation with the Alpinestars Tech-Air airbag system. Previously available only for MotoGP athletes, the technology is now offered in a select number of street-ready textile jackets—and we'll have the first product available in the U.S. in-store for sales + demo. ('Alpinestars NYC pop up shop', 2017).

As well as being a site of object display, this site sought to invoke 'origin' narratives of craft production. Accompanying Alpinestars products were historic rider photographs and a textual wall display:

> In 1963, a leather craftsman by the name of Sante Mazzarolo brought forth a future icon. Based in the small Northern Italy town of Asolo and with the perennial Alpine Star flower as its namesake, Mr. Mazzarolo began producing the first products bearing the Alpinestars moniker, providing protection for a new sport called motocross.

The geographical imaginary, linking the firm back to its Italian roots, melds craft, performance and memory, with a further textual narrative emphasising 'Alpinestars' legacy of motorcycle racing.'

A new project, DaineseArchivio, has taken consumer 'experience' to another level, utilising contents formerly stored in the Molvena R&D lab and displaying them directly to the public:

> From the very first day, every test, every product, every design has been kept in the company's historical archive in Molvena. An inaccessible vault, which has fostered research and experimentation over time, as a function of innovation that is increasingly at the service of man (sic). Now, a part of that incredible collection is open to the public and available to everyone.
> https://www.dainesearchivio.com/archivio/

The artefacts are not simply sample products as in the high fashion archives of Dior and

Saint Laurent (Sherman 2013), but are actual racing leathers worn by riders, bearing the marks of crashes that have been used for analysis. DaineseArchivio opened on 27 July 2018 in a purpose-built structure next to an existing retail space in Vicenza, providing a site of qualification firmly located in its region of origin. The displays make visible not only a material product lineage for the locally-made craft product (hand stitched leather race suits), but also foreground future project development such as airbag refinements and ongoing work on space suit technologies. Dedicated areas include an 'Intelligent clothing' section detailing the history of rider airbag technological development; and a sector highlighting the relationship between Dainese and MotoGP's treatment unit *Clinica Mobile:* 'Dainese's alliance with the Mobile Clinic enabled its engineers to understand which areas of the human body are most subject to injury, and to learn the physical and biomechanical laws of the rider's body.' (Sections, 2019). Whilst the collection of historic leathers formerly had been available on appointment, for example to journalists (Dainese's secret stash of Rossi suits revealed, 2015), in the space of the new 'archive' building, consumers are directly enrolled by displaying the artefacts of the lab.

Conclusion

Our paper has developed and utilised the notion of 'sites of qualification' in order to provide a more expansive understanding of how innovative products are designed, produced and brought to market. In so doing, we argue that researchers should pay greater attention to place and territory as they assess the diversity of agents and agency across heterogeneous networks. A sites of qualification approach expands conceptualisations of innovation as they have emerged within existing literature on industrial districts, whilst for prevailing work on the qualification of products, our concept offers the possibility of scrutinising important moments at which practices may

be stabilised or routinised in space. Our perspective requires attention both to individual site specificity as well as to the potentially wide range and diversity of sites of qualification.

Through the example of the motorcycle rider airbag we have worked through sites of qualification as the object has transitioned from an 'industry-in-potential' (Mouat *et al*. 2018, p. 136), to its incorporation within specialist racing leathers, through to a product that is now more widely available to consumers. This has involved following the airbag's trajectory across a range of different sites, including lead firms and their territorial settings; MotoGP racetracks, mobile laboratories and professional riders; courts of law; and showroom and archive locations. Our presentation of these sites captures the social, material and technological roles performed by a heterogeneous collection of human and non-human agents, such as designers and technicians; motorcycle riders, airbags, algorithms, GPS systems, gyroscopes and electronic control units.

Sites of qualification are also central to the ways in which consumers are being enrolled into new kinds of understanding of the rider-body; in which protection is more highly valorised through new technological objects. As manufacturers launch ever more adaptable and lower cost vest systems, so rider airbags are starting to become as quotidian as other safety objects, such as car seatbelts and motorcycle crash helmets. In this regard it is interesting to note that Dainese's new lightweight Smart Jacket (launched July 2019), which fits under existing motorcycle clothing, seeks to normalise cultural conventions of its wearing through its marketing strap line 'Never without it'/ 'Mai più senza'. We see important future work in developing this approach to innovation for other consumer objects, precisely because as we have shown, sites of qualification are integral to the ways in which technical products are made social.

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Table 1. Key moments in the development of rider airbag technologies: Dainese and Alpinestars

Date	Technological event	Site/spatial clustering
1963	Alpinestars established as off-road motorcycle boot maker	Asolo, Italy
1972	Dainese established to manufacture leathers for motocross riders	Molvena, Italy
1974	German rider Dieter Braun: first Grand Prix racer officially sponsored by Dainese	Europe
1995	Alpinestars technical apparel line designed & launched to supplement boot market	US and Europe
2000	Dainese reveals D-Air airbag prototype	Munich Motorcycle Show, Germany
2001	Alpinestars begins research into motorcycle airbags	Italy
2001	Dainese creates the mobile research structure, D-mobile	Grand Prix racetracks globally
2003	MotoGP rider John Hopkins: first Alpinestars rider to use an active data logging system	Sachsenring MotoGP, Germany
2007	125 MotoGP rider Simone Grotzkyj Giorgi first to deploy Dainese rider airbag	Valencia MotoGP, Spain
July 2009	MotoGP rider Kenny Roberts Jr. debuts Alpinestars' 'Advanced Safety Technology' (AST) II: second generation of data acquisition system	Sachsenring MotoGP, Germany

2011	Retail launch for Dainese D-Air Racing suit	Europe
2012	Alpinestars launch TechAir Racing and Street vests (requiring compatible jackets/suits)	US and Europe
2012	Dainese D-Air Street vest launched (requiring compatible jackets/suits & motorcycle sensor kit)	US and Europe
2015	Dainese files airbag patent infringement proceedings against Alpinestars at the Tribunale di Venezia and 3 claims in Germany	Italy, Germany
September 2015	D-Air Racing airbag suit available to US market	US
2017	Regional Court finds Alpinestars in violation of Dainese patents relating to D-Air technology. Dainese awarded damages and Alpinestars forced to withdraw TechAir vests from sale in Germany	Munich, Germany
March 2018	Airbags mandatory for all MotoGP riders	all MotoGP races, globally
Summer 2018	Dainese London opens, joining other flagship stores in Italy, Germany & US	London, UK
27 July 2018	Dainese Archivio (DAR) opens: 9500 feet^2 of interactive exhibits, more than 500 authentic suits, 20 themed sections	Vicenza, Veneto, Italy

February 2019	Higher Regional Court upholds patent ruling against Alpinestars, continuing to prohibit the sale of Tech-Air airbag vests in Germany	Munich, Germany
July 2019	Dainese Smart Jacket (airbag vest) on sale across global markets	UK, US, South Africa
January 2020	Alpinestars Tech-Air 5 Autonomous Airbag system launched at Consumer Electronics Show, Las Vegas. Available to consumers March 2020.	UK, US

Source: compiled from Dainese and Alpinestars corporate websites together with relevant trade press reporting.

[1] Many thanks to one of our referees for drawing our attention to Strathern's (1996) paper in relation to our arguments here.

[2] Whilst direct face-to-face interviews potentially would be important for future work assessing the valorisation of rider safety (e.g. a research programme seeking to evaluate commentary from rider airbag consumers), we feel that the wealth of available archival/documentary material is appropriate for our purposes in the present paper.

[3] Although an extended examination is beyond the scope of this paper, we also would argue that social wearing and cultural practices of display are central to the materiality of motorcycle clothing (ranging from the iconic black leather jacket to full-suit racing leathers, to durable textiles for motorcycle touring); and that embodied practices of moto-mobility are neither static nor uniform across space and time.

[4] "Dainese claim that none of the 306 crashes by riders wearing the D-Air Racing System between 2007 and 2013 resulted in fractures to the collarbone and shoulder joint areas, which is remarkable when you consider the forces generated in such high speed spills." (In Gear, 2015).

[5] Toseland articulated the 'first time' nature of his experience, almost as an 'ordinary consumer': having retired from racing in 2011 through injury, he had never worn a rider airbag himself.

[6] In the UK, the 'Motor Cycles (Wearing of Helmets) Regulations 1973′ was passed on 7 February and enforced from 1 June 1973. On the racetrack, the Auto Cycle Union (ACU) made helmets compulsory for the 1914 Isle of Man TT. Other protective clothing for motorcyclists is governed by consumer legislation in the sense that products for sale must meet British Standards stipulations. Whilst the 1989 European directive 89/686/EEC compelled PPE testing and certification by an independent body, manufacturers historically sold textile and leather motorcycle clothing as 'non-protective.' However, in April 2018 the

new European regulation 2016/425 formally classified all motorcycle clothing as PPE (Milbank 2018).