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Heritage and Satellite Manufacturing: Firm-level Competitiveness and the Management of Risk in Global Production Networks

ECONOMIC GEOGRAPHY

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abstract

This article explores the role that product- and firm-centered heritage plays as an advantage-creating resource and competitive dynamic in contributing to minimizing risks for firms in global production networks (GPN). Research on the management of risk has been identified as critical for developing an understanding of the underlying determinants of GPN. In the *satellite* industry, key risks relate to launch, extreme conditions in outer space, and challenges concerning repair. These risks are minimized by the development and management of *heritage*. Heritage is a reputational asset founded on proven technology embedded in products and/or firm-based relationships that have values or associations that accumulate and are passed down over time. The risks associated with the space sector are extreme; however, heritage also plays an important but unacknowledged role in other economic sectors, including shipping, nuclear energy, rail, medical technologies, and aviation. The article adds to the economic geography literature in three ways. First, it highlights the central role that regulators and insurance providers play in defining market imperatives for GPN. Second, it identifies and explores heritage as a reputational asset, providing both a source of competitiveness and a competitive dynamic influencing firm-based routines and interfirm relationships. Third, it provides the first in-depth analysis of the satellite industry in the context of heritage—a sector that impacts on the everyday activities of government agencies, citizens, and firms. This analysis of heritage is based on eighty in-depth interviews with representatives from across the UK space sector.

Key words:
risk
heritage
competitive advantage
competitive dynamic
GPN
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regulation
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Recently, the focus of the global production networks (GPN) debate has shifted from a primary focus on governance (Gereffi, Humphrey, and Sturgeon 2005) toward an emphasis on dynamics and the development of the analytical framework GPN 2.0 (Coe and Yeung 2015; Yeung and Coe 2015). Understanding the dynamics of GPN includes exploring the ways in which firm and nonfirm actors manage risk. This article explores these dynamics within the context of the space sector, with a specific focus on the role that *heritage* plays in the management of risk and in mediating the interrelationships between firms and nonfirm actors.

This analysis positions heritage as a reputational asset that provides a source of competitive advantage for satellite manufacturers, while influencing firm-based routines and the dynamics of GPN organization. A competitive advantage is the ability of a firm to maintain a margin over its rivals with respect to product differentiation (Ajitabh and Momaya 2004; Chikán 2008). Heritage is often understood as the “historical record of certain places” (Wyrwich 2012, 424), buildings, or brands. Heritage is created through an accumulation process involving a layering of encounters between people, places, buildings, products, or firms. This layering involves the creation of some form of heritage-based value, narrative, or association. Heritage is also product- and firm-centered, founded on *proven technology* or *firm-based relationships*. For satellite manufacturers, a tangible measure of their heritage is component *flight history* or the number of successful satellite missions involving a firm’s products or employees. The term *heritage* is used by those involved in the space sector and is considered to be a core source of competitive advantage.

Developing and maintaining heritage is a market imperative for satellite manufacturers given that heritage signals technical competency, which is favored by stakeholders (including customers, investors, regulators, and insurers) tasked with minimizing risks. This article explores the relationship between heritage, competitiveness, and risk by considering the following research questions. First, what role do regulators and insurance providers play in defining risk management as a market imperative in the space sector? Second, how does heritage function as a reputational asset by providing a source of competitiveness for firms in high-risk sectors? Third, as a competitive dynamic, how does heritage influence firm-based routines and interfirm relationships?

This study contributes to existing economic geography theory in three ways, which link to the above research questions. First, it highlights the central role that regulators and insurance providers play in defining market imperatives for GPN. This addresses the first research question, specifically focusing on why minimizing risk is a central market imperative for satellite manufacturers, and how this is shaped by the priorities set by regulators and insurance providers. To Coe and Yeung (2015), the primary risks associated with globalizing industries (electronics, automotive) are changing demand, new technology, and financial crisis. Labor and environmental risks are more prevalent across labor-intensive and resource-extractive industries. For the space industry, the risks relate to the extreme conditions the technology is exposed to during launch and operations, combined with the unrealistic costs of in-orbit repairs. Governments enforce stringent regulations to reduce space risks, while insurance regulators impose high premiums on nonproven technology. These standards set by nonfirm actors reinforce the importance of heritage, shaping the sector's organization of production and competitive dynamics.

Second, the article conceptualizes heritage as an advantage-creating resource involved in the mitigation of risks by firms in GPN, contributing to understanding the underlying determinants of GPN (Neilson et al. 2018). To Yeung and Coe (2015, 37) "cost reduction alone … cannot be the fundamental driver of evolving global production networks." Instead, there are other market imperatives or market forces that influence organizational routines and the prioritization of resources that are (re)deployed and (re)configured in GPN. One market imperative is the management of risk, which is particularly relevant in industries characterized by highly specialized technical knowledge, often involving customized products and high value, politically sensitive public procurement projects. This concern with mitigating risk is central to the developing literature on GPN 2.0 (Coe and Yeung 2015).

Perhaps the most important aspect of risk is the identification of risk amelioration strategies. Coping strategies for responding to risk are sector and even firm specific, given sector heterogeneity and the idiosyncratic nature of firms (Boschma and Frenken 2006). A strong risk amelioration strategy can differentiate a firm from its competitors, providing a source of competitive advantage. The development and management of heritage provides satellite manufacturers with a competitive advantage. Additionally, heritage plays an important but unacknowledged role in other high-tech sectors and in procurement relationships. Nevertheless, heritage in the context of corporate competitiveness has been underexplored and merits further consideration. The only exception perhaps is Tokatli (2007), who explores heritage in relation to retro fashion and De Vaan, Boschma, and Frenken (2013), who argue that heritage brings the advantage of experience. This article addresses this gap through the second research question by exploring heritage as a competitive advantage. Satellite manufacturers maintain their heritage by adopting an incremental approach to innovation. Therefore, as well as being an advantage-creating resource, heritage is a *competitive dynamic* (defined as independent variables that drive firm strategies) that influences firm-based routines (Yeung and Coe 2015) and interfirm relationships. This is the focus for the third research question and final part of the article, which aims to deepen the understanding of heritage and its role in risk management in GPN.

Third, this article provides the first in-depth analysis of the space sector in the context of heritage, which is important given the increasing dependence of socioeconomic processes on satellite-enabled applications (including communication, navigation, and earth observation). Any disruption to the production of these applications poses significant security, societal, and economic risk. Thus, satellite technology is defined by the UK government to be critical national infrastructure (Center for the Protection of National Infrastructure 2016). Nevertheless, a firm-level understanding of the satellite industry and its economic geography remains an "undeveloped avenue of inquiry" (MacDonald 2007, 611). This article contributes to addressing this gap by building upon the resource-based view (RBV) of the firm, dynamic capabilities, and evolutionary approaches. The relationships between heritage and these approaches are explored in the next section.

Dynamic Capabilities, Resources, and the Management of Risk in GPN

This article aligns with the recent emphasis on developing a more dynamic GPN theory, explaining "the emergence of different firm-specific activities, strategic network effects, and territorial outcomes" (Yeung and Coe 2015, 29). This includes understanding the interrelationships between risk and actor-specific strategies. Five different forms of risk have been identified that impact GPN: (1) economic (e.g., shifting market or technological conditions); (2) product (e.g., brand damage associated with quality and other issues); (3) regulatory (e.g., shifting rule regimes); (4) labor (e.g., struggles over wages and conditions); and (v) environmental (e.g., pollution or natural disaster) (Yeung and Coe 2015). These risks are generally "beyond the control or confines of individual actors" but instead form part of a common environment that confronts actors collectively (Yeung and Coe 2015, 41).

The management of risk involves economic (lead firms and subcontractors) and noneconomic actors (institutional regulatory bodies and customers) developing coping strategies across production networks. These coping mechanisms are explored by conceptualizing four different actor-specific strategies that configure GPN: intrafirm coordination, interfirm control, interfirm partnership, and extrafirm bargaining (Yeung and Coe 2015). Heritage as a firm-level resource providing competitive advantage relating to risk mitigation needs to be added to this list by exploring the debates on the RBV and evolutionary economics.

The RBV of the firm provides a framework for understanding heritage as an advantage-creating resource. In this approach, non–price-based advantages are founded upon the internal resources of firms (Barney 1991). These may be tangible (land, raw materials, financial assets) or intangible (reputation, relationships, brands, knowledge, skills). Barney (1991) argues that resources that enhance firm competitiveness should be valuable, rare, inimitable, and nonsubstitutable (VRIN). Intangible resources (nonphysical) are usually the most advantage creating, since they are often inimitable and nonsubstitutable (Petrick et al. 1999; Haanes and Fjeldstad 2000; Hatch 2013).

Intangible resources can be divided into four categories: (1) intellectual property assets, (2) organizational assets, (3) capabilities, and (4) reputational assets (Galbreath 2005). To O'Regan and Sims (2008, 410), firm competitiveness is often "multifactorial" and "cannot be attributed to only one resource." Nevertheless, in some sectors, one type of resource is perhaps more critical. For the space sector, the focus must be on reputational assets as an advantage-creating resource and the role these play in the management of risks. Reputational assets are identified as "observers' collective judgement of an organization," based on personal experiences or secondary information (Barnett, Jermier, and Lafferty 2006, 34). There are two components to a firm's reputation: (1) the overall company impression and (2) the product-specific component (Caruana 1997). The overall impression is influenced by factors such as financial stability and stewardship of noneconomic agendas (community/environment), whereas, the product-specific component is the result of characteristics such as quality management and innovation levels (Hughes, Wrigley, and Buttle 2008). These two components have a symbiotic relationship: product-specific reputation contributes to a company's overall impression.

Reputational assets signal quality, reliability, and credibility, serving as a *quality promise* for future transactions (Galbreath 2005; Walsh and Beatty 2007). To mitigate risks, buyers may select their suppliers based on whether or not they signal this quality promise. Therefore, quality associations differentiate firms from competitors, enabling them to "charge premium prices" and to attract customers, investors, and future employees (Fombrun and Shanley 1990, 234; see also Turban, Forret, and Hendrickson 1998). In the satellite industry, heritage forms part of the product-specific component of firms' reputational assets, providing a source of competitive advantage. Heritage is an intangible resource that has a tangible measure, since it is based on a firm's or a product's flight history, measured in days, months, and years, and inclusion in a defined number of flights. To our knowledge, no attempt has been made to conceptualize heritage in this way and present it as an advantage-creating resource.

In addition to being a reputational asset, heritage is a competitive dynamic, acting as an independent variable driving firm strategies and impacting routines. The dynamic capabilities approach, which builds on the RBV, focuses on how firms use their resources to identify and exploit market opportunities (Eusenhardt and Martin 2000). To Phelps and Fuller (2016, 110), dynamic capabilities are "the foundation of a firm's ownership advantages, as they are the organisational capacity and means by which resources are (re)deployed and (re)configured to achieve particular priorities." This approach emerged as economic geographers argued for a shift in analytical "focus from the steady-state processes of equilibrium" (Martin 2010, 22) toward processes that entail path destruction or creation (MacKinnon et al. 2009). In reality, as will be shown in the analysis, heritage has the opposite effect to path destruction by encouraging inertia and path dependency. Nevertheless, the dynamic capabilities approach contributes to this article's theoretical framework by highlighting the relationship between resources and market opportunities and the contribution this makes to attracting customers, investors, and employees. The organizational capacity of a firm is not static but instead continues to evolve via alterations in a firm's dynamic capabilities.

A further element of understanding heritage is recognizing the impact of past decisions and the evaluation of these decisions on firm adaptation (Bathelt and Glückler 2018). Heritage is defined by proven technology or past experiences that influence firms' present structures and activities. Conceptualizing heritage involves exploring historic processes that are part of ongoing debates in evolutionary approaches to economic geography (Boschma and Frenken 2018) that focus on how organizational routines shape "intrafirm and interfirm processes" (Phelps and Fuller 2016, 123). This article's theoretical framework draws upon RBV, dynamic capabilities, and evolutionary theories, since they are all complementary approaches to understanding firms. For instance, the RBV is about the identification of resources providing competitive advantages (Fahy 2002; Barney, Ketchen, and Wright 2011; Knoben 2011), whereas the evolutionary and dynamic capabilities perspectives highlight processes that manage the development or use of these resources (Boschma and Frenken 2006; Bryson and Ronayne 2014). Both processes and resources must be considered when exploring actor-specific strategies that minimize risk in a GPN.

The evolutionary perspective contributes to understanding the role heritage plays in driving firm strategies and impacting on firm routines. Routines are the "day-to-day dealings" or "regular and predictable behavioral patterns" of firm that have "built up over time" (Jensen, Poulfet and Kraus, 2010, 2048; see also Radwan and Kinder 2013). They guide actions and decision-making processes by locking firms into strategies and behaviors (Essletzbichler and Rigby 2007; Christopherson and Clark 2009; Cecere et al. 2014). A firm's strategy and behavior influence the development of and access to resources that are sources of competitiveness (Bryson and Ronayne 2014). For example, realizing new opportunities through innovation requires "relevant learning routines" (Bessant et al. 2012, 1108).

Routines can lead to path dependency, defined as the inability of a firm to "shake free of [its] history" and develop beyond its "established ways of doing things" (Martin and Sunley 2006, 400). The outcome is organizational inertia. A focus on organizational change and the assumption that dynamic capabilities only exist in action (Ambrosini and Bowman 2009) can underplay organizational inertia, which firms rely on to sustain competitive resources. Heritage as a path-dependent reputational asset contributes to characterizing the sources of risk-related inertia that may exist in GPN, alongside the sources of change or dynamics.

Path dependency can negatively impact on firm competitiveness by restricting innovation (Martin and Sunley 2006; Isaksen 2014). For example, Gagliardi and Iammarino (2018, 1178) argue that "firms' attitude towards risk is a key determinant of their successful innovation efforts" and that risky and uncertain market conditions can present obstacles to innovation. This may cause *technological lock-in*, where firms become locked into technologies (i.e., products or processes) that are not necessarily "superior to alternative solutions" (Cecere et al. 2014, 1041). This lock-in may mean firms "struggle to compete and survive" as competitors make disruptive changes and develop superior technologies (Cecere et al. 2014, 1042).

Although technological lock-in is difficult to overcome, it is "often a temporary phenomenon from which escape is possible" (Van der Vooren, Alkemade, and Hekkert 2012, 101). Industry and wider government policies can provide incentives and support firms in overcoming negative lock-in (Radwan and Kinder 2013; Turco and Maggioni 2016). This form of institutional support is particularly important "for highly regulated and relatively rigid sectors" (Steen and Hansen 2018, 192). It is an example of how external factors unlock routines impacting firm-level competitiveness. Porter (1990) also identifies external factors in his analysis of national competitive advantage as "one of the most prominent and frequently applied approaches" to competitive research (Dögl, Holtbrügge, and Schuster 2012, 193). External factors relate to the public governance of the industry, the *system of rules*, or *mechanism of decision-making* imposed by the state (Mayer and Pickles 2010; Levi-Faur 2012).

Nonstate actors (such as credit rating agencies) are other external factors that shape market structures by setting standards and norms across industries (Nadvi 2008; Coe and Yeung 2015). Private insurance is another "central institution of governance beyond the state" (Ericson, Barry, and Doyle 2000, 532); insurance companies have the capacity to "set standards" (in respect of risks) and "enforce compliance" (via payment and premium levels) (Scott 2002, 65). Research on the maritime sector identified that insurers are incentivized to help "manage risk," since "they bear the financial consequences" of any losses they insure against (Bennett 2000, 880). Consequently, insurers often become actively involved in shaping or influencing procurement decisions. Bennett (2000, 87) notes that where insurance is compulsory, an insurer adopts the role of "enforcer" becoming, in effect, a "watchdog over its customers rather than a service provider."

Insurers base their decisions on whether to insure a firm on a range of factors, including financial responsibility, where the firm "must have access to enough capital to meet a specified level of liability" (Bennett 2000, 884). Therefore, it is important to explore the impact of private insurers on UK satellite companies, specifically how the decision-making processes reinforce the importance of heritage. This focus on private insurers addresses the gap in the literature where "lower-level decisions" made by "non-state organizations" have been neglected from studies of "contemporary governance arrangements" (Scott 2002, 56). The approach adopted by private insurers is country specific and evidence of why territorial influences should be considered as an independent variable shaping the practices of lead firms (Neilson et al. 2018). The next section outlines the approach adopted by this article to researching the space sector, and justifies the selected research design and methodology.

Researching the Space Sector

The space industry involves the production of space technology (launch vehicles, satellites, and user ground equipment and terminals) and satellite-enabled services (global positioning systems, telecommunication, and earth observation data) (London Economics 2015). These production activities are divided among the following groups of firms or subsectors:

1. Space manufacturers: manufacture launch vehicles, ground systems, and satellites.
2. Satellite operators: control satellites when in orbit and sell communication bandwidth, positioning signals, or observation data.
3. Satellite application providers: supply space-enabled services such as earth observation imagery and satellite television.

These subsectors are interdependent but comprise different firms, value chains, and financial characteristics. This article explores the activities of UK space manufacturers, which are primarily involved in the production of satellite hardware and subsystems. These manufacturers are less concerned with the manufacture of launch vehicles and ground equipment, since the UK government pulled out of launch/manned space missions in 1970. There are currently no UK launch sites. Consequently, the terms *space industry* and *satellite industry* are often used interchangeably when referring to the UK, since satellites and satellite-enabled services are at the center of the UK's space activities.

To explore the organization of the UK space industry, eighty in-depth interviews were conducted. The data were collected in a single time period, between November 7, 2014, and July 14, 2015. Interview cases were selected from the three subsectors (manufacturing, operating, and satellite-enabled applications). Although the primary focus of this article is on satellite manufacturers, insights from the other subsectors are relevant. Operators and application providers are the manufacturers' customers and define market imperatives shaping manufacturers' sources of competitiveness. Additionally, government organizations (UK Space Agency, European Space Agency, Innovate UK, Satellite Applications Catapult, OFCOM, UK Steering Board, G-STEP, RAL Space) were interviewed to provide an external perspective on the sector. Furthermore, representatives from two insurance companies were interviewed to evaluate the role private insurance plays in shaping the activities of firms involved in the UK space sector. Their inclusion was in response to the manufacturers' interviews, which highlighted the importance of insurance. Similarly, a space legal practitioner was interviewed to provide the necessary context for understanding the origins and complexities of the legal frameworks and international treaties governing the UK space sector.

A purposive sampling method was used to allocate individual cases to the various subgroups. It selected *information-rich cases*, which yielded "insight and in-depth understanding" on "issues of central importance" to the research questions (Patton 2002, 273). The form of purposive sampling used was *stratified*, whereby cases were "selected in proportion to one or more characteristic in the population" (Gorard 2013, 81). The two characteristics were the size (measured by number of employees) and function (manufacturing, operations, and application provision). Two groups of manufacturing firms were represented in the sample: (1) prime satellite manufacturers, who design satellites, divide tasks, and manage the final integration of components; and (2) subcontractors, who supply materials, hardware components, and subsystems. The stratified approach helped to ensure maximum diversity of research participants. This increased the likelihood of competing explanations being investigated, which was important for accurately characterizing the industry and maximizing internal validity (Henderson et al. 2002; Bryman 2012; Gorard 2013).

A database was created of UK satellite firms from the case groups, using the UK Space Directory (2015). The *UK Space Directory* is produced by the Knowledge Transfer Network (KTN) and lists profiles (including the functions) of UK satellite manufacturers, operators, and application providers. The firms in each case group were categorized according to size (as measured by number of employees), using the Financial Accounts Made Easy (FAME) data set, which lists information (e.g., name, location, industry affiliation) on UK VAT-registered firms (FAME 2015).). Nevertheless, FAME is not a comprehensive register; small firms are exempt from reporting their annual accounts, and new market entrants can take up to two years to submit their first annual accounts (Department of Business, Enterprise and Regulatory Reform 2009). Therefore, FAME did not have the details of thirty-three (38 percent) of the cases listed in the *UK Space Directory*. Consequently, extra searches on firm size were undertaken using company websites, trade association membership lists, and LinkedIn.

In total, eighty participants were interviewed. The final response rate was 92 percent. This can be explained by two factors. First, the access strategy targeted individuals by an effective use of social media, including LinkedIn. This avoided the difficulties of working with gatekeepers. Second, the interviewees considered that this research would contribute to raising the space industry's profile. The sample size was determined in the early stages of the research design and was considered an appropriate number for achieving "informativeness, reliability and generalizability" (Smith 2000, 319). The number of participants was flexible around the data needs of the research, with recruitment only ending when it was apparent that new data would not significantly add to the development of theory. Those who declined to participate in the study were replaced by a representative from a case in the same subgroup.

The interviews ranged in length from thirty to ninety minutes and were semi-structured, consisting of a set of prearranged questions. The interview structure was divided into three parts: (1) background/product questions, (2) organization and governance of production, and (3) impact of regulation. These related to the three research questions.

Data collection was undertaken concurrently, with three stages of analysis (transcription and description, classification, and coding) to ensure any knowledge gaps were addressed. Initially, the research questions and theories from the literature provided a set of codes. The analysis was not confined to these preliminary codes, as inductive codes were identified as new themes were observed. The codes across the various transcripts were connected, which involved identifying patterns in the data or similarities and differences between different cases. This highlighted where there was consensus or disagreement in response to research questions. These comparisons or connections that were identified then formed the basis of the research discussion. The next section, in addressing the first research question, focuses on the role of private insurers in setting standards and enforcing compliance in the satellite industry, and the impact of state regulation, in intensifying the importance placed on heritage by the sector.

Regulators and Insurance Providers Defining Risk Management as a Market Imperative

For high-risk sectors, such as the space industry, minimizing risk is a market imperative that has led to the role heritage plays as a competitive resource. This is driven by state and nonstate actors enforcing regulations, which shapes economic activities and competitive dynamics. This section focuses on state and nonstate actors' influence, by considering the role that nonfirm actors play in GPN by shaping the organization of production and competitive dynamics within and across different sectors (Yeung and Coe 2015).

For the space industry, the stringent regulations set by nation-states are a significant nonfirm actor constraint. A space licence must be obtained from the UK Space Agency before a satellite can be launched and an operator can enter the market. This space licensing process was introduced in response to the 1967 Outer Space Treaty[1] (OST), which is the principal treaty for "regulating activities in outer space" and outlines the core principles that guide UN member states in relation to their actions in space (Al-Rodhan 2012, 194). In compliance with the OST, the UK government dictates that "space activities carried out by UK individuals or organizations: (i) do not jeopardise public health or the safety of persons or property; and (ii) are consistent with the international obligations of the UK" (HM Government 2015).

The UK government's licensing process is intended to remove the risks to public health and international jurisdictions, through managing what can and cannot be launched by UK satellite operators. Before satellite operators are awarded a UK space licence, they must answer a set of questions about their technology and the satellite's mission; their facilities may also be subject to "inspection and testing" (HM Government 2015). These checks assess the readiness level of the satellite technology, any national security concerns, and whether the manufacturers and operators involved have experience with space missions and flight history. Similarly, there is a credit check, to assess whether the operator has "the means to carry the activities out and can afford the insurance that we [UK Government] expect to be in place until deorbit" (Interview, GovPolicy3e). Credit checks consider the operator's financial stability but also their flight history, where "if you've got a company that's already operating then you are obviously going to consider their satellite more likely to go ahead" (Interview, GovRegulator1). The technology and credit checks reinforce the importance of heritage in the space sector, which in turn influences firm-level routines such as innovation.

Private insurers are also influencers in the space industry, since a space licence will only be awarded to a satellite operator with the appropriate insurance in place to cover

[1] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, October 10, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205.

the risks. The private insurance firms that manage space insurance are a "relatively small but international community" (Manikowski and Weiss 2013, 151), with only "about 35 satellite insurers worldwide" (Interview, SatelliteInsuranceProvider1). These are concentrated in Europe (London, Paris, and Munich) and the US (New York and Washington, DC), with London accounting for the greatest number, with 30 to 35 percent of the international market.

Until the 1960s, most satellites were launched for military purposes. Historically satellites were uninsured, since they had "no direct revenues associated with them" and any risks were "retained by governments and the Space Agencies that financed" them (Manikowski and Weiss 2013, 151). This is no longer the case for the present commercial space market in which satellite operators are responsible for obtaining their own private insurance to protect their revenues and insure against all identifiable risks. Space insurance allows "the operator to take out risk, safe in the knowledge that if something goes wrong then they will get their money back" (Interview, SatelliteInsuranceProvider2). Insurance also plays an important role in many other global industries (Bennett 2000). However, with space technology, there is the added complexity that once it is launched "you never see it again" (Interview, PrimeSatelitteManufacturer2). This situation is unlike other high-tech industries and encourages a preference for proven technology because, if something goes wrong, "you can't go up there and fix it" (Interview, PrimeSatelitteManufacturer1).

Satellites tend to be insured against known events, including environmental (i.e., space debris and solar flares) and military threats, including deliberate actions by a noninsured party. Nevertheless, damage to a satellite can be caused by anything. For instance, "we had a claim last year because of a piece of Velcro that got stuck in a communications valve; they used Velcro when they put the thermal blanket on the satellite and a stray piece got stuck in the communications valve. And that was a claim of $214 million" (Interview, SatelliteInsuranceProvider1).

There are two types of satellite insurance: (1) *liability insurance*, which protects national interests; and (2) *damage insurance*, which protects the commercial company. All UK satellite launches must have a minimum of £60 million of liability insurance. Liability insurance is based on the Convention on International Liability for Damage Caused by Space Objects (1972)[2] and article 7 of the OST, which stipulates that "launching states are responsible to third parties for any damage induced by one of their satellites" (Montpert 2016, 284). Unlike damage insurance, liability insurance protects the company and the launching state against the financial consequences of damage caused to a third party. This damage could be to the Earth's surface or to objects in the atmosphere.

Meanwhile, damage insurance is "designed to protect operators against the physical loss or the reduction in performance of a satellite" (Manikowski and Weiss 2013, 177). It can be purchased by operators in different forms, which cover satellites for different time periods: launch phase, postseparation, first twelve months, ten years, and satellite design life. The most commonly purchased form is the launch phase, since it covers the most difficult and the most demanding part of a satellite mission, where "for 90 s you have a chance of your entire $400 million going up in smoke" (Interview, SatelliteOperator2). Such policies cover events such as faulty designs, ground operator mistakes, and inadequate testing. Claims can be for full or partial loss, depending on the loss of the satellite service.

[2] March 29, 1972, 24 U.S.T. 2389, T.I.A.S. No. 7762, 10 I.L.M. 965.

Premiums for damage insurance are influenced by the mission to be performed by the satellite, financial stability of the operators, and the heritage of the satellite design defined as the established flight history of the components. This reinforces the importance of heritage: insurance premiums are influenced by the heritage of the satellite design. One firm noted that "even if you said 'this 3cm diameter bolt is new' then the insurance would probably go up by millions and genuinely millions" (Interview, SatelliteComponentManufacturer7). This has implications on the operators' choice of supplier and manufacturers' procurement of components, as they opt for firms or products with heritage. It is evidence of how "lower-level decisions" made by "non-state organizations" can influence firm-level behavior (Scott 2002, 56) and highlights the influence heritage can have on GPN (Neilson et al. 2018). The competitive advantages that heritage provides for satellite manufacturers will be explored in the next section.

Heritage as a Reputational Asset and Source of Competitive Advantage

A satellite is launched into orbit under the following extreme conditions: (1) high levels of vibration, (2) mechanical shock, (3) a temperature gradient of up to 200°C degrees, and (4) rapidly declining atmospheric pressure (Fortescue, Swinerd, and Stark 2011). Together with the harsh in-orbit environment, this exposes satellites to a high risk of component disruption or failure. Satellite manufacturers, operators, insurers, financiers, and regulators all try to mitigate these risks. Risks are reduced by industry stakeholders prioritizing suppliers and components with established heritage. This is encouraged because a firm's evidence of heritage will help to reduce its insurance premiums while also serving as a proxy measure of quality for the space licensing process. Because of the relationship between heritage, insurance premiums, and space licenses, heritage influences the decisions of investors, potential employees, customers, and suppliers (determining who is involved in the GPN). There are two types of space heritage: "the heritage in the product and the heritage in the firm itself" (Interview, SatelliteComponentManufacturer3). Often these exist simultaneously but sometimes separately. A firm may have a proven flight history but not for all of its products. In the satellite industry, heritage forms part of the product-specific component of firms' reputational assets.

Heritage provides firms with a competitive advantage by signaling competence-based trust (defined as the perception of partners on whether they will effectively contribute to a relationship) to key stakeholders (Barney 1991; Galbreath 2005). Competence-based trust is signaled in this way, since heritage demonstrates that satellite manufacturers have worked on previous space missions and thus will have a "better understanding of how things should work" (Interview, SatelliteComponentManufacturer1). Competence-based trust is important because it attracts buyers and encourages repeat purchasing. For example, for a satellite operator "spending $500–600 million on a satellite, they don't want it to break" so they will work with a manufacturer with a proven flight history (Interview, PrimeSateliteManufacturer3). Critically, contracting a manufacturer with heritage also increases the likelihood of the operator obtaining a space licence and avoiding expensive insurance premiums calculated without reductions based on heritage. Additionally, experienced manufacturers are more likely to have a broad range of networks, since "the more projects you do, the more people you know" (Interview, SatelliteComponentManufacturer2). These networks are important as they increase the resources available to a firm and, in doing so, broaden the firm's competencies, which in turn promotes trust. Trust is a key influencing factor for convincing external financiers to lend money to, or invest in, a firm, which is critical to firm competitiveness. This attraction of buyers and investors is valued so highly that it means that it allows firms with heritage to "charge premium prices," avoiding price-based competition (Fombrun and Shanley 1990, 234).

Furthermore, manufacturers with heritage become "well known in the space community" or, in effect, hold a "higher-status" in the market (Interview, SatelliteComponentManufacturer4). Consequently, they find that customers, other firms, and research centers often approach them "with ideas and proposals" (Interview, SatelliteComponentManufacturer4). This assists firms in accessing external knowledge, driving innovation, and helping meet customer requirements. This is an example of *accumulative advantage*, whereby firms that have had early successes in the industry are advantaged in the present market (Podolny 1993). Similarly, heritage attracts skilled employees, as it certifies the firm's credibility and ensures they are well known in the labor market (Interview, SatelliteComponentManufacturer5). In any industry, "attracting and retaining … human capital can provide firms with a sustained competitive advantage" (Turban, Forret, and Hendrickson 1998, 25). This is arguably more significant for the space industry, since there are hard-to-fill vacancies reflecting the technical expertise required to develop satellites. Therefore, there is competition for the graduates who are available, "not just within the UK itself, but also Europe and overseas" (Interview, SatelliteComponentManufacturer6). This competition is even more intense for smaller firms, since they find that the graduates they seek "are generally going to the larger aerospace companies" (Interview, SatelliteComponentManufacturer5). As a result, anything that distinguishes a firm, such as heritage, plays a valuable role in attracting and retaining skilled employees.

The above examples highlight how heritage, as a competitive resource, drives market opportunities in the space sector by attracting customers, investors, and future employees (Eusenhardt and Martin 2000). This conceptualization of heritage is like an additional resource to those identified as intangible sources of competitive advantage in the RBV literature (Barney 1991; Barney, Ketchen, and Wright 2011). It also aligns with the evolutionary perspective, which argues that a firm's innovation potential is dependent on its "existing variety" of capabilities and assets (Boschma and Frenken 2006, 636). All RBV research begins with the explicit or implicit assumption of firm heterogeneity (Lockett, Thompson, and Morgenstern 2009). In the case of satellite manufacturers, not all firms will have heritage, and those who do will need to develop and maintain it through firm-specific routines. The next section explores these firm-specific routines and the contribution they make to the role heritage plays in risk mitigation.

Heritage as a Competitive Dynamic Influencing Firm-based Routines in Satellite Manufacturing and Operations

As well as an advantage-creating resource, heritage is a *competitive dynamic*, acting as an independent variable driving firm strategies and impacting on their routines. This occurs as satellite manufacturers develop and maintain heritage as a reputational asset. Conceptualizing heritage in this way contributes to the development of the GPN 2.0 analytical framework, which aims to understand the relationship between risk and actor-specific strategies.

Developing heritage takes time, since it involves involvement/inclusion in several satellite missions. This means that the product or firm must continue to be involved in the sector, and this involvement is part of an ongoing process of heritage creation and accumulation. This takes two forms: (1) the development of a reputation for successful participation and (2) component and product flight history. Nevertheless, a product/firm must first secure a *first flight* on a satellite mission. This is far from straightforward, since without heritage, stakeholders (customers, investors, collaborators, the Space Agency, etc.) are unlikely to trust or licence the product or firm. The outcome is a *chicken-and-egg*–type scenario. A product or firm must be involved in a satellite mission to develop flight history, but without heritage, it is unlikely to be considered as flight ready and flight safe. Prime satellite or component manufacturers overcome this barrier by giving their first sale for free and paying for their own test flight. This involves speculation and a significant upfront capital investment, but there can be no guarantee of repeat custom. Additionally, firms can pay for a test flight, but it is expensive ("it costs 20,000 Euros to test pilot a cable") and even then firms still need evidence of flight history (Interview, SatelliteComponentManufacturer2). It is also possible for a satellite manufacturer to acquire heritage through mergers and acquisitions of firms with heritage, but this is an expensive option and not always viable.

An alternative option is for firms to bid for institutional grants and projects, funded by the European Commission and European Space Agency (ESA). These projects support technological developments, innovation, and reduce risk, contributing to the creation of heritage. For example, one of the Prime satellite manufacturers benefited from the ESA having funded "a test model going up [into orbit]" of its next-generation satellite. This would have been more difficult for the Prime to achieve commercially "because with insurers it is just impossible" for them to support the launch of new technologies, without issuing "unaffordable premiums" (Interview, PrimeSatelliteManufacturer3). This is an example of how government policies can support firms in overcoming negative lock-out from a GPN on the basis of insufficient heritage, as nonfirm actor interventions can contribute to the creation of heritage (Radwan and Kinder 2013; Turco and Maggioni 2016). Nevertheless, support provided by nonfirm actors is not guaranteed for every project, and smaller firms are often underresourced to be able to manage the ESA grant application process.

Once manufacturers have developed heritage, it is sustained and continually reinforced through procurement routines that emphasize the importance of heritage. For instance, manufacturers only subcontract the production of components to firms that themselves have heritage. This contributes to understanding interfirm coordination in GPN but also the ways in which such coordination is shaped by the activities of nonfirm actors and the finance actors, in this case insurers. For industries where risk is a market imperative, certain value activities will be outsourced to only a select group of suppliers (Yeung and Coe 2015).

Additionally, satellite manufacturers maintain their heritage by making only incremental alterations to products/software/processes. This impacts on innovative routines across the value chain and leads to further technological lock-in. For example, despite being "a very high tech sector," the value placed on heritage makes the UK space industry "very conservative," since, in order to reduce the risk of failure, customers are "reluctant to use new technologies" (Interview, GovPolicy1). This inhibits radical forms of innovation (technologies that are new to the market) despite the potential advantages they might offer. For example, "even if you've got the latest sexy antennae that are going to take a fraction of cost to launch and be far more reliable, no one will go first to take that risk" (Interview, SatelliteComponentManufacturer6). This prevents satellite manufacturers from gaining competitive advantages attached to new forms of technology. It implies that second-mover advantage is better than first-mover advantage in this sector—thus creating a paradox. Instead, firms are limited to *incremental innovations* or minor improvements to existing products, for which the impact is considerably less "pervasive and profound" than with radical innovation (Lengnick-Hall 1992, 402). Consequently, heritage is a source of risk-related inertia that can exist in GPN, alongside sources of change or dynamics.

Similarly, heritage limits diversification. Diversification occurs when firms move outside core areas of competency into other product lines. This can lead to "superior firm performance," maximizing potential business opportunities and increasing returns (Wan et al. 2011, 1338). These impacts would be particularly beneficial for upstream manufacturers, due to the *cyclicality* of the space market, which can leave the manufacturers without work for months at a time. Nevertheless, heritage inhibits diversification as firms become locked-in to "supplying only certain components" in which they have established and recognized heritage. Thus they are locked-in to a specific role in a GPN and find it difficult to break out to develop a different role. Developing heritage in new areas is challenging, and there will always be a more experienced competitor with heritage in that product line (Interview, SatelliteComponentManufacturer1). For example, one of the component manufacturers specialized in cables "but wanted to be more dynamic and make a new microwave component." They responded to an invitation to tender for this product from a Prime, but they lost out to a "microwave manufacturer with heritage" (Interview, SatelliteComponentManufacturer3). Government-funded programs have provided opportunities for firms to be more radical in their approach to innovation and to diversifying their product base. However, it is important that research on the role heritage plays in GPN considers the negative as well as positive impacts it has on firm-level competitiveness and in the shaping of GPN.

Conclusion

The ongoing development of the GPN approach has shifted from exploring the governance of production networks to a more recent focus on dynamics. Central to the dynamics of GPN is a concern with risks and the activities of nonfirm actors. This article engages in these debates by highlighting the ways in which heritage plays a central role in the management of risks and in mediating the dynamics of satellite production networks. It is perhaps surprising that the competitiveness of one of the most high-tech industrial sectors is founded not upon innovation but on heritage. Nevertheless, in nearly every interview, interviewees highlighted the importance of heritage as a primary or core source of competitiveness in the space industry. It is the firms themselves who have added heritage to this analysis.

Production processes involve many different types of risks and uncertainties, including technological change, new competitors and/or alternative products, and the changing nature of demand. All industries have idiosyncratic aspects, but in the space sector, the types of risks firms face are extreme. For example, there are risks related to launch and citizen safety. Additionally, there is the high cost of satellite infrastructure and the fact that once a satellite is *up there* it cannot be easily repaired. Consequently, a spacecraft needs to be resilient against high levels of vibration, extreme temperature gradients, and rapidly declining atmospheric pressure. Reputation and trust go some way to tempering risks such as these in production relationships. In the space sector, trust-based relationships are underpinned by the measurable heritage of products and/or firms. Heritage is a resource, characterized by attributes from a firm's past that act as proxy measures of competency that support a firm's current activities. For satellite manufacturers, the most relevant attribute is flight history or the number of successful satellite missions involving a firm and its products. Heritage is embedded in products that have a history and can be defined as proven products or proven technologies. It is this heritage that enables firms to participate in a space GPN; firms without such heritage are excluded. These products or components reflect firm-level forms of inimitability in which it is difficult for a purchaser/procurer to identify substitute products or providers.

It is important to place heritage in the space sector within the wider context of international regulation and insurance. The emphasis placed on heritage is intensified by the interactions between space manufacturing and insurance, and the requirement for all launches to obtain a government licence that is conditional on appropriate insurance being in place. Insurance with affordable or commercially acceptable premiums can only be obtained for products and firms with established and recognizable heritage. The strategies of UK satellite manufacturers are driven by a requirement to de-*risk* products and processes by relying on proven technology as well as mediating their relationship with global insurance providers and national regulators. This theoretically informed empirical analysis of heritage and space contributes to the development of the dynamic GPN literature by considering the role that firm and nonfirm actors play in shaping the organization of production and competitive dynamics within and across different sectors.

Heritage supports the development of in-house expertise, cannot be imitated, and differentiates firms by signaling competence-based trust to key stakeholders (including customers, investors, and employees). This provides three forms of competitive advantage for UK satellite manufacturers. First, it attracts buyers and encourages repeat purchasing. In the space sector, a buyer's perception of a manufacturer's competency is guided by heritage. This also allows firms with heritage to charge premium prices and avoid price-based competition, since they compete on the basis of their heritage and not price. Second, it reduces the overall cost of product delivery—the satellite—as it reduces insurance premiums to a commercially acceptable rate. Third, heritage attracts collaborators, investors, and skilled employees, since it signals a firm's credibility and ensures the firm is well known in the market. This conceptualization of heritage is a development of the RBV literature emphasis on intangible competitive resources and aligns with the evolutionary perspective that argues a firm's potential is, in part, dependent on its existing assets (Boschma and Frenken 2006; Barney, Ketchen, and Wright 2011).

Heritage is also a competitive dynamic, acting as a variable driving firm strategies and impacting on their procurement routines. It impacts on manufacturers' interfirm coordination, since in wanting to protect their heritage they are very selective about which activities they can outsource and to which independent suppliers (Yeung and Coe 2015). Additionally, satellite manufacturers maintain their heritage by making only incremental changes to their products, which impacts on innovative routines, inhibits diversification, and leads to technological lock-in. Therefore, heritage is a source of risk-related inertia that can exist in GPN, alongside the sources of change or dynamics. Government policies may support firms as they attempt to overcome this form of heritage lock-out.

To understand the complexities of heritage as a firm-based resource and competitive dynamic, further research is warranted. This would involve exploring other industries in which heritage is a critical source of competitiveness (such as maritime, nuclear energy, rail, medical technologies, and aviation), comparing the different types of heritage (technology-based, relationship-based, etc.), and how heritage is developed or overcome (including the roles played by nonfirm actors). Additionally, further research is required to reflect upon the impact of the New Space revolution on technologies and business models in the UK and across the global sector. *New Space* is a term used to describe the emerging private spaceflight industry and venture capitalist-funded small satellite constellations led by *Astropreners* (Thornhill 2017). SpaceX is at the forefront of this, having successfully landed a reusable rocket in the last year, an innovation that reduces launch costs (TechUK 2018). The entrepreneurs leading these new technologies and business models are deviating from the established trajectories by breaking out of the limitations placed on the industry. The New Space firms' self-insure launches are creating new technology pathways and are potentially overcoming forms of heritage lock-out (Steen and Hansen 2018). Further study is needed to understand the impact this is having on the dynamics of the industry and ways in which firm and nonfirm actors manage risk.

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