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The Orbital Circular Economy Framework: Emblematic Evidence from the Space Industry

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Abstract

A means of shifting society to becoming resource-efficient and creating a much-needed "resource revolution" is the so-called Circular Economy. It is intended as an alternative to the traditional linear economy (make, use, dispose) in which resources are kept in use for as long as possible, while extracting the maximum value from their use and then recovering and regenerating products and materials at the end of each service life. However, its implementation as a business strategy has tended to be at a very superficial level. By drawing on the principles of the Circular Economy and on the resource-based view and dynamic capabilities including ambidexterity and business model innovation, we develop a novel framework for scoping and managing the Circular Economy that encapsulates the key stages of progression to sustainable competitive advantage. We then validate this novel framework by examining the experiences of private actors in the Space Sector to assess their engagement with the Circular Economy. We identify key lessons for managers that have broad applicability to other industrial sectors.

Keywords: *new space actors, resource-based view, dynamic capabilities, ambidexterity, business model innovation, managerial lessons*

INTRODUCTION

The term Circular Economy (CE) has a long history, multiple definitions, and distinctive developments in different global contexts. In Europe and increasingly worldwide, a CE framework, originally devised and developed in the UK by the Ellen MacArthur Foundation has been a catalyst at policy level and has become a prominent theme in the business arena (2013). A key reason for the widespread popularity of this framework is that it matches a compelling business rationale with the need to decouple wealth creation from the consumption of limited resources. Moving towards a more CE is indeed desirable as it could deliver benefits such as reducing pressure on the environment, improving the security of the supply of raw materials, increasing competitiveness, stimulating innovation, boosting economic growth as well as creating jobs. The space sector has always been regarded as a cutting-edge field, futuristic and at the forefront of innovation. As such, the sector and its recent dynamics with the advent of reusable launch systems are particularly prolific as a source of inspiration and valuable insights into the broader applicability of the CE to other industries.

The rest of the paper is as follows. By drawing on the relevant literature on the resource-based view and dynamic capabilities including ambidexterity and business model innovation we develop a novel dynamic framework—the Orbital Circular Economy Framework (OCEF)—for the application of the CE. By relying on our extensive work on the space industry (Brennan et al., 2018; Vecchi and Brennan, 2015a; Vecchi and Brennan, 2015b; Brennan and Vecchi, 2011; Vecchi & Ricci, 2016), we describe first some distinctive feature of the space economy and we then validate the OCEF by assessing the experiences of some case examples of the CE in action in the space sector. We describe the benefits that stem from its application and we provide a number of managerial implications. Finally, we offer some concluding remarks.

THE CIRCULAR ECONOMY

Since the industrial revolution, we have been living in a linear economy. Our consumer and "single use" lifestyles have made the planet a "take, make, dispose" world. This linear economy model of mass production and mass consumption is testing the physical limits of the globe. It is, therefore, unsustainable and a shift toward a CE is becoming inevitable (Esposito et al., 2018). Within this context, the CE is intended as an alternative to a traditional linear economy (make, use, dispose) in which resources are kept in use for as long as possible, while extracting the maximum value from their use and then recovering and regenerating products and materials at the end of each service life (Hopkinson et al., 2018).

The CE is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value always. This new economic model seeks to ultimately decouple global economic development from finite resource consumption. The CE addresses mounting resource-related challenges for business and economies, and could generate growth, create jobs and reduce environmental impacts. As the call for a new economic model based on systems-thinking grows louder, an unprecedented favourable alignment of technological and social factors today can enable the transition to the CE. Circular economic activity includes reuse, repair, recycling, eco-design, sustainable supply, and responsible consumption. This profusion of concepts demonstrates that the definition of a circular economy is not set in stone (Esposito et al., 2018). Nonetheless, a baseline level of understanding can be reached through the available literature. Research by the Ellen MacArthur Foundation focuses on designing with circular economy principles from the beginning, in the ideation phase (2013). While their work offers much in the way of creating a CE, it could do more on pathways for firms to transition a linear economy production line to a circular economy model. To enable firms and institutions to develop a model that allows for leveraging the use of underutilized resources, Lacy and Rutqvist (2015) propose a three-phase model development guideline that uses three key drivers—resource constraints, technological development, and socioeconomic opportunity—to create regenerative business models by design that involve the creation of a new breed of services that leverage long-term use and maintenance. They conclude that by following such an approach, business models will be based on reincarnation and efficiencies in product design, systems design, and the use of new materials. Esposito and colleagues (Esposito et al., 2018) further claim that adopting the CE model requires that firms initiate and develop disruptive technology and business models that are based on longevity, renewability, reuse, repair, upgrade, refurbishment, servitization, capacity sharing, and dematerialization. Noting that firms often struggle to change their existing linear business models to circular models, Frishammer and Parida (2019) have proposed a roadmap for circular business model transformation. The pace at which companies are adopting the CE has been accelerating for the last two decades and it has evolved from a specialist concept to a mainstream business strategy. Accenture Strategy recently surveyed more than 500 manufacturing companies with revenues greater than $1 billion and found that more than 90% said they are implementing circular business models

(Accenture Strategy, 2019). Nearly all larger manufacturing companies say they have established circular supply chains for material recovery and recycling. However, often programs remain "skin deep" When it comes to the elements of circular supply chains that companies are prioritizing, recycling comes as one of their first priorities. While recycling wasted materials across a company's operations is certainly a step in the right direction, it is a modest one that only scratches the surface when it comes to fully capturing the value of the CE. While nearly all companies report products are returned for reuse or refurbishing, 75% ultimately destroy 45–75% of the recaptured products and therefore losing the embedded value. Additionally, while 92% of companies surveyed say they are geared up for product life extension, only 30% to 40% are actually doing it. When looking at the adoption of deeper circular economy strategies, there is significant room for improvement. Within this context, the space industry is paving the way toward a new industrial paradigm where the CE can be fully embraced.

THE ORBITAL CIRCULAR ECONOMY FRAMEWORK

The notion that firms are fundamentally heterogeneous, in terms of their resources and internal capabilities, has long been at the heart of the field of strategic management. A basic assumption of the resource-based view is that the resource bundles and capabilities underlying production are heterogeneous across firms. This resource heterogeneity gives rise to differential performance. More specifically, valuable and rare resource endowments are likely to result in superior performance for the firm. Stemming from the resource-based view, dynamic capabilities builds on the notion of heterogeneity of core capabilities but focuses on the role of management in building and adapting these capabilities to address rapidly changing environments. The development was stimulated by the acknowledgement that many successful or dominant firms fail to sustain their superior performance as markets and technologies shift (Harreld et al., 2007). In particular, volatile industries require "organizational agility" (Teece et al., 2016) and dynamic capabilities, "*defined as the ability to continuously create, extend, upgrade, protect, and keep relevant an enterprise's unique asset base*" (Teece, 2007). Many industries are subject to rapid technological change, market entry from global innovators, and volatility in market demand. Companies that cannot anticipate or respond to external disruption are unlikely to survive. In volatile industries, firms need strategies, structures, and processes that enable organizational agility and responsiveness in a shifting competitive landscape. In volatile markets, the functional and operational capabilities that drive competitive success in stable conditions become subject to rapid obsolescence (Teppo and Powell, 2016). Even if a company's advantages are inimitable, disruptive technologies and business models can undermine the underlying drivers of competitive advantage, by thus making conventional advantages irrelevant or misaligned with market conditions and customer requirements. In line with Teece's taxonomy (i.e. sensing, seizing and reconfiguring), the dynamic capabilities view of competitive advantage argues that success in volatile industries requires higher-order capabilities that enable companies to anticipate, shape, and adapt to shifting competitive landscapes. In particular, strong dynamic capabilities are necessary for fostering the organizational agility necessary to address deep uncertainty, such as that generated by fast-paced innovation and the associated dynamic competition (Teece et al., 2016). Within this context, according to Birkinshaw et al (2016), the notion of ambidexterity is relevant in a wide variety of settings. It is particularly useful to understand discontinuous change, because it provides insight into how firms explore new opportunities while continuing to exploit their existing markets and resources.

In the specific case of the space sector, by exploiting their established core capabilities the space firms explore the new opportunities offered by the CE. They do so with an entrepreneurial mindset and with a very high degree of resilience (Bahrami and Evans, 2011) whereby they learn by experimenting—and often from failure (Hill and Hlavacek, 1977). From this experiential learning which encompasses Kolb's four stages (1976)—i.e. concrete experience, reflective observation, abstract conceptualization and active experimentation—

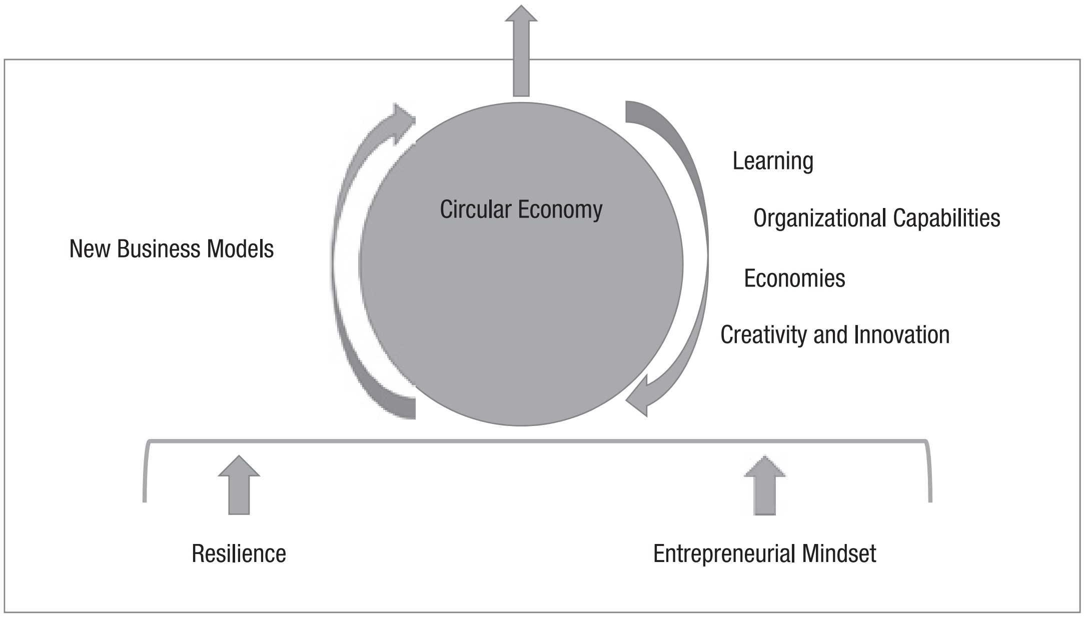

Figure 1: The Orbital Circular Economy Framework

they develop some distinctive organizational capabilities amongst which ambidexterity as well as absorptive capacity (Lichtenthaler & Lichtenthaler, 2010) that allow them to leverage economies of scale and scope (Peters, 1992) with creativity and innovation. Within this context, they make breakthrough radical innovation as a strategic and cultural priority by relying on their creative and international staff, often collaborating with more traditional players and by becoming ambidextrous (Stringer, 2002). Innovation has become for them a business imperative and they make experimentation and risk-taking an integral part of their business practice by tolerating early-failure and rewarding long-term performance (Manso, 2017). This vision ultimately leads them to introduce new efficiency-based business models (Chatterjee, 2013) that allow them to stir from manufacturing towards service provision (Kastalli et al., 2013) as in all our case studies where the space actors are now providing services to payload customers. These business models are apt to reap the benefits associated with the CE and yield sustainable competitive advantage. From our research on the CE in the space sector we have developed a framework, the OCEF, as depicted in Figure 1.

The model depicts the process by which firms and managers can advance to sustainable competitive advantage via engagement with the CE. Such engagement needs to be grounded in resilience and accompanied by an entrepreneurial mindset. Experiential learning involves failure but delivers advances in organisational capabilities which drive economies of scale and scope and lead to creativity and radical innovation. This leads to the development of new business models that can create sustainable competitive advantage. We now validate our framework within the context of the Space Sector, examining the experiences of private actors and their engagement with the CE, by identifying their key stages of progression to sustainable competitive advantage.

THE SPACE ECONOMY

The space sector is particularly inspirational and instructive for several reasons. The evolution of the sector has been highly dynamic where technological innovation has played a dominant role. That evolution has been punctuated by significant and constant technological challenges that have relentlessly pushed the sector forward into stretching its own boundaries and overcoming its own limitations. In the process, it has displayed a remarkable discipline and pragmatism in successfully addressing them. The sector also heavily embodies an international and multicultural dimension both in terms of the collaborative nature of the sector projects and in the composition of space teams. The sector possesses a remarkable heterogeneity in its complex eco-system whereby National Agencies, private large MNEs, very small companies and smaller companies all coexist and are all engaged in a relentless "technological race" while mostly learning by experimenting. The economic importance of the sector is extraordinary. The global space sector is a high-technology niche worth USD 330 billion in revenues worldwide. The sector operates at the cutting edge and requires a highly skilled trained workforce to build, launch, and utilize space assets. The global space sector employed at least 900 000 persons around the world in 2014, including public administrations with responsibilities for managing space activities and publicly-funded research and development programmes, the core space manufacturing industry, direct suppliers to this industry and the wider space services sector (mainly commercial satellite telecommunications). To give orders of magnitude, around 350 000 full-time employees are active in the United States, 200 000 in the Russian Federation, around 60 000 in Europe. However, the ongoing process of integrating space technology into all aspects of life means that other jobs are being created that might not fall into the traditional aerospace categories. Programmers and computer scientists handling "big data" are all likely to find increasing demand for their skills as companies seek to monetize the growing flows of information captured from and flowing through space systems. The industry has proven to be particularly resourceful and creative in attempting to address some specific challenges stemming from its peculiar dynamics. More precisely, the space industry traces its origins to the middle of the last century as an exclusively government/military domain involving the United States and the former Soviet Union. It has evolved to an industrial setting which is increasingly commercialized and internationalized encompassing a host of activities and countries. As the space industry increasingly evolves from one dominated by governments and their military establishments to one which is undergoing rapid commercialization across a wide number of areas, the industry has become especially amenable to the provision of valuable insights that have relevance and applicability to companies from all industries. After years of steady growth, the space industry appears to be on the cusp of a new era of rapid expansion in both capabilities and customers. Within this context, start-up companies are experimenting with novel approaches for building and deploying constellations of spacecraft and delivering services to their customers in innovative ways. Similarly, long-established space players are renewing their offerings by taking advantage of the latest technology to deliver increasingly powerful products at more affordable prices. The space sector is particularly innovative with many innovative products and services stemming from the sector. People increasingly recognize the benefits of space products and services, that help to overcome daily existential challenges and improve lives. Although space technology has many potential uses, it has proved very difficult to develop financially viable applications. In particular, the transition from publicly funded activities to applications relying largely on private resources has been hindered by a deep-seated culture of risk aversion. Finally, as the range of commercial applications increases and as ever more countries become active in space, there is a growing need, at both national and international levels, for an institutional and regulatory environment that fully takes account of the sector's expanding commercial component and that fully supports its growth. This situation is leading a number of countries that are already active in space to reassess their overall space strategy.

Overall, these developments have led firms in the industry to fundamentally change the ways they "do business," in particular, the ways they organize and conduct exchanges and activities across the firm and the industry with customers, vendors, partners and other stakeholders. In this very dynamic context, it becomes an imperative for companies in the industry to reinvent themselves by often introducing innovative business models with more efficient utilization of their resources and capabilities. In particular, companies such as SpaceX, the aerospace company started by the founder of Tesla Motors Elon Musk, Richard Branson's The Spaceship

Company, and Blue Origin, another space-oriented firm founded by Amazon CEO Jeff Bezos, offer a fascinating glimpse of a sustainable industrial future. These companies are embracing the notion of CE—an alternative to the traditional linear (take, make, use, dispose) economy in which resources are kept in use for as long as possible, extracting the maximum value from them whilst in use, then recovering and regenerating their materials at the end of each service life. Remarkable advances both in materials and engine technology have brought the idea of reusability to a completely new level in space activities. These recent developments and their implications are completely reshaping the notion of CE and offer valuable lessons for managers across all industries. As such, the paper supports the idea that space industry can provide valuable lessons that can be broadly applied to firms from other industries at large.

Reusability (and the CE) is a very new concept for the space industry—one that has huge implications not just for business but for mankind. Recent advances in engine technology and materials have rendered single-stage reusable vehicles potentially feasible. The recyclable space race is now well and truly on. A completely reusable orbital launch system has proved elusive; however, several partially reusable launch systems have been created. A reusable launch system is a space launch system that includes the recovery of some or all of the component stages. To date, several fully reusable suborbital systems and partially reusable orbital systems have been flown. No fully reusable orbital launch system has yet been demonstrated. The first reusable launch vehicle to reach orbit was the Space Shuttle, which was not able to accomplish the intended goal of reducing launch costs to below those of expendable launch systems. NASA's Space Shuttle for instance was partially reusable and brought recycling to a new level (The New York Time 8/6/2017). The orbiter which included the main engines and the two rocket boosters were reused after several months of refitting work, but the external tank and the load frame were discarded after each flight.

During the 21st century, commercial interest in reusable launch systems has grown, with several active launchers. The SpaceX Falcon 9 rocket has a reusable first stage and capsule for its Dragon flights and expendable second stage, The Spaceship Company has flown reusable suborbital spaceplanes, and the suborbital Blue Origin New Shepard rocket has recoverable first stages and crew capsules. Differently from the past, the new space race aims to make reuse a core cost-saver—SpaceX claims that reusability can help reduce launch costs from $61 million to about $5–7 million (Space News 25/4/2016). Virgin Atlantic is also developing new reusable cargo vehicles. Similarly, Sierra Nevada Corp has won a key NASA contract to ferry cargo to the International Space Station using its Dream Chaser that can be used at least 15 times and at a far lower cost than the Shuttle thanks to a smarter design and significantly less labour to refurbish it. Blue Origin has also launched the New Shepard spacecraft and its plans involve space tourism and selling its reusable rocket engines to other companies. A fully and rapidly reusable vehicle is the pivotal breakthrough needed to significantly reduce the cost of space access. Following a commercial model, a rapidly reusable space vehicle could reduce the cost of travelling to space by a hundredfold. Within this context, reusability is the key to making human life multi-planetary.

CASE EXAMPLES OF THE CIRCULAR ECONOMY IN THE SPACE SECTOR

By drawing on our extensive work on the space industry (Brennan et al., 2018; Vecchi and Brennan, 2015a; Vecchi and Brennan, 2015b; Brennan and Vecchi, 2011; Vecchi & Ricci, 2016), and by relying mostly on secondary data in the form of newspaper clippings, news, reports and companies' official press releases we assembled three case studies. A "case study" is typically associated with teaching and exploratory research but, as Yin (1984) has pointed out, it can also be used as a research design for theory development and testing via analytical generalization: "*Critics typically state that single cases offer a poor basis for generalizing…This analogy to samples and universes is incorrect when dealing with case studies. This is because survey research relies on statistical generalization, whereas case studies (as with experiments) rely on analytical generalization. In analytical generalization, the investigator* *is striving to generalize a particular set of results to some broader theory*" (Yin, 1984: p. 39). Understood in this light, what the three case studies that follow suggest is that the theory underlying the OCE framework can be analytically generalized to other industrial settings by providing in-depth insights as well as valuable lessons. In particular, these three case studies are exemplar of three valuable key-lessons. First, the experience of Space X clearly demonstrates that the implementation of the OCE might lead to new ventures such as the colonization of Mars. Second, the case study of the Spaceship Company shows that from the implantation of the OCE, new business models can be devised. Finally, the evolution of Blue Origin shows that the economic benefits do not occur immediately but they require a resilient and gradual step-by-step approach.

CASE STUDY: SPACE X

Space Exploration Technologies Corp., known as SpaceX, is a private American aerospace manufacturer and space transportation services company headquartered in Hawthorne, California. It was founded in 2002 by Tesla Motor founder Elon Musk with the goal of reducing space transportation costs and enabling the colonization of Mars. SpaceX believes that a fully and rapidly reusable rocket is the pivotal breakthrough needed to substantially reduce the cost of space access. In that regard, there is a deliberate strategy to increase reusability from the earliest design stage. The reusable launch system technology was initially developed and deployed in the first stages of the Falcon family of rockets. The first controlled vertical splashdown of an orbital rocket stage on the ocean surface was achieved in April 2014 on the ninth flight of a Falcon 9. Two subsequent flights in January and April 2015 attempted to land the returning first stage on a floating platform. Although both boosters were guided accurately to the target, they failed in landing vertically on the drone ship and were destroyed. A historic vertical landing was finally achieved on December 21, 2015, when the first-stage booster of Falcon 9 Flight 20 successfully touched down at Cape Canaveral. On April 8, 2016, Flight 23 achieved the first soft landing on a drone ship in the Atlantic Ocean. SpaceX returned several first stages to both land and drone ships in 2016 to standardise the procedures needed to re-use the boosters rapidly. The company has begun offering pre-flown Falcon 9 rocket stages commercially with the first such relaunching having recently taken place. Although two recent rocket explosions[1)] have dented SpaceX's glory, its launch prices are among the lowest in the world. The company has pioneered the technology of returning expended rocket stages to Earth for later reuse, landing them back on dedicated pads or on oceangoing barges, which in turn should cut costs still further. As a result, the company has obtained a significant amount of orders from private firms and from the American government to fly satellites into orbit and cargo and astronauts to the International Space Station. In March 2017, SpaceX achieved the world's first reflight of an orbital class rocket. Falcon 9 rocket launched a geosynchronous communications satellite on March 30, 2017. This successful reflight represents a historic milestone on the road to full and rapid rocket reusability. The same generation of spacecraft was then used to also ferry cargo into orbit. The first reflight of the commercial cargo spacecraft Dragon C106 was accomplished during the mission on June 3, 2017. These accomplishments were also coupled by two very important achievements—on March 2, 2019, SpaceX was the first private company to send a human-rated spacecraft Crew Dragon Demo-1 to space on Falcon 9 and it was the first private company to autonomously dock a spacecraft to the International Space Station as part of the same flight on March 3, 2019. SpaceX is also developing the fully reusable Starship launch system. The SpaceX Starship is both the second stage of a reusable launch vehicle and a spacecraft that is being developed by SpaceX, as a private spaceflight project. It is being designed to be a long-duration cargo and passenger-carrying spacecraft. It will be used on orbital launches with an additional booster stage -the Super Heavy- where Starship would serve as the second stage on a two-stage-to-orbit launch vehicle. Integrated system testing of Starship began in March 2019 with the addition of a single rocket engine to the first flight-capable propellant structure, Starhopper. SpaceX is planning to launch commercial payloads using Starship no earlier than

2021. Building, testing and reflying identical versions of the spacecraft is expected to reduce factory time and expenses for SpaceX, in the long run. Company executives have said, they foresee potentially dozens of such repeat missions. Company engineers continue to modify Falcon 9 rockets to increase their load capabilities and make them easier to reuse. Dragon capsules also have been optimized for reuse. Company officials hope to reduce refurbishment time, including reducing structural inspections, as they become more proficient at flying used spacecraft. As of August 2019, the only reusable operational orbital boosters are Falcon 9 and Falcon Heavy. The Falcon Heavy is a partially reusable heavy-lift launch vehicle designed and manufactured by SpaceX[2)]. It is derived from the Falcon 9 vehicle and consists of a strengthened Falcon 9 first stage as the centre core with two additional first stages as strap-on boosters. SpaceX conducted the Falcon Heavy's inaugural launch on February 6, 2018. The second Falcon Heavy launch occurred on April 11, 2019 and all three booster rockets successfully returned to earth. The third Falcon Heavy launch successfully occurred on June 25, 2019. Since then, the Falcon Heavy has been certified for the National Security Space Launch program. On Nov 11th, 2019 SpaceX successfully launched 60 communications satellites using a single rocket. This was the second time in less than a year that Elon Musk's company has made such a launch, marking a dramatic increase in the number of satellites in orbit. Reusability is considered to be a pillar of Space X expansion strategy since it is deemed as the key in making human-life multiplanetary. The strategy will be instrumental to the colonization of Mars (McKnight, 2001).

CASE STUDY: THE SPACESHIP COMPANY

The Spaceship Company (TSC) is a British/American spacecraft manufacturing company that was founded by Burt Rutan and Richard Branson in 2005 and was jointly owned by Virgin Group (70%) and Scaled Composites (30%) until 2012 when Virgin Galactic became the sole owner. TSC was founded to own the technology created by Scaled Composites for Virgin Galactic's Virgin SpaceShip program. TSC is Virgin Galactic's aerospace-system manufacturing organization and will sell spacecraft to other customers. Headquartered in Mojave Air and Space Port in Mojave, California, it is building and testing a fleet of White Knight Two (WK2) carrier aircraft and SpaceShipTwo (SS2) reusable spaceships that, together, form Virgin Galactic's human spaceflight system. The SS2 is an air-launched suborbital spaceplane type designed for space tourism. It is carried to its launch altitude by a WK2, before being released to fly on into the upper atmosphere powered by its rocket engine. It then glides back to Earth and performs a conventional runway landing. In October 2009, Virgin Galactic CEO Whitehorn outlined the flight test program for SS2. The test program included seven phases: vehicle ground testing, captive carry under WK2, unpowered glide testing, subsonic testing with only a brief firing of the rocket, supersonic atmospheric testing, full flight into suborbital space, execution of a detailed and lengthy appraisal process to demonstrate the system's robustness and eventually obtain a commercial launch license to begin commercial operations. The spaceship was then officially unveiled to the public on 7 December 2009. On 29 April 2013, after nearly three years of unpowered testing, the first one constructed successfully performed its first powered test flight. Initial projections by Virgin Galactic in 2008 called for test flights to begin in late 2009 and commercial service to start in 2011. This initial schedule was not achieved, with captive carry and glide flight tests beginning in 2010, and the first test flight under rocket power in 2013. Virgin Galactic had planned to operate a fleet of five SS2 spaceplanes in a private passenger-carrying service and has been taking bookings for some time, with a suborbital flight carrying an updated ticket price of US$250,000. In addition to making suborbital passenger launches, Virgin Galactic has marketed SS2 for suborbital space science missions. The spaceplane could also be used to carry scientific payloads for NASA and other organizations. By March 2011, Virgin Galactic had submitted SS2 as a reusable launch vehicle for carrying research payloads in response to NASA's suborbital reusable launch vehicle (sRLV) solicitation, which is a part of the agency's Flight Opportunities Program. The NASA research flights could begin during the test flight certification program for SS2. On 31 October 2014, during a test flight, the first SS2 VSS Enterprise broke up in flight and crashed in the Mojave desert. A preliminary investigation suggested that the craft's descent device deployed too early. The second SS2 spacecraft, VSS Unity, was unveiled on 19 February 2016. The vehicle is undergoing flight testing. VSS Unity will undergo a test regimen similar to VSS Enterprise, then will embark on testing beyond what Enterprise experienced. For each flight test, the WK2 aircraft carries Unity to altitude. Testing began with captive carry flights, in which Unity was not released from its carrier aircraft. Testing then progressed to free-flight glide testing, and will continue with powered test flights. In September 2017, CEO George Whitesides suggested that engine testing was complete, and that only a "small number of glide flights" remained before VSS Unity would begin powered test flights. The first powered flight test took place on 5 April 2018. The first powered test flight of Unity exceeded the altitude of all powered test flights of its predecessor, Enterprise. VSS Unity VP-03, the first suborbital spaceflight of VSS Unity was successfully completed on 13 December 2018, surpassing the 50 miles (80 km) altitude considered the boundary of outer space by NASA and the United States Air Force. Following its flight in February 2019 when VSS Unity carried a third crew member (1 in the passenger cabin) for the first time it began to undergo modifications in preparation for commercial service including installation of the commercial cabin, and changes to cockpit displays.

CASE STUDY: BLUE ORIGIN

Blue Origin, LLC is an American privately funded aerospace manufacturer and spaceflight services company headquartered in Kent, Washington. Founded in 2000 by Amazon founder Jeff Bezos, the company is developing technologies to enable private human access to space with the goal of dramatically lowering costs and increasing reliability. Blue Origin is employing an incremental approach from suborbital to orbital flight, with each developmental step building on its prior work. The company motto is "*Gradatim Ferociter*," Latin for "*Step by Step, Ferociously*." As in the case of SpaceX, Blue Origin on November 23rd 2015 managed to return its New Shepard rocket. The rocket rises vertically at more than 2,800 mph. Three additional test flights were made with the same vehicle in the first six months of 2016. A fifth and final flight of this propulsion module occurred on October 5th 2016 in order to undertake a flight test of the passenger module in-flight abort system. New Shepard flew again for the seventh time on Dec. 12, 2017, from Blue Origin's West Texas Launch Site. Known as Mission 7 (M7), the mission featured the next-generation booster and the first flight of Crew Capsule 2.0. Crew Capsule 2.0 features large windows. M7 also included 12 commercial, research and education payloads onboard. New Shepard flew for the eighth time on April 29, 2018, from Blue Origin's West Texas Launch Site. The mission featured a reflight of the vehicle flown on Mission 7. The 9th New Shepard flight took place on July 18th, 2018 which consisted of sending a capsule on a brief jaunt into space over West Texas to demonstrate a key safety feature for space tourists and scientists riding on the company's future rockets. The 10th New Shepard flight that was scheduled for December 2018, was cancelled due to "ground infrastructure issues." Blue Origins rescheduled the launch for January 22nd 2019, after discovering additional systems that needed repairs as well. This was the tenth flight overall and included several customer payloads. The last one to date took place on May 2, 2019. It was the eleventh flight overall, and included 38 payloads while it was launched from West Texas facility. Beside the science experiments, it has been reported that starting next year, there are plans to use New Shepard to send passengers on jaunts into space. Although Blue Origin has not announced its fees yet, it is expected that tickets will start from a couple hundred thousand dollars per head for an 11 minutes ride, and Bezos anticipates increasing the scale of his offer quite quickly to a few flights a week. Suborbital tourism is just the beginning of his vision for Blue Origin. The second part of his plan is already under construction in a giant factory in Cape Canaveral—an imposing rocket meant for orbit and beyond, the New Glenn. If New Shepard is Bezos' ploy to enable ordinary citizens to become comfortable with space travel, New Glenn is the company's galactic workhorse. New Glenn will not make its first flight until 2020, but Bezos envisions a fleet of them performing a wide range of tasks ranging from commercial satellites, planetary missions, NASA missions and national security missions. So far Blue Origin has completed deals with four companies, including Eutelsat, a French communications company that wants New Glenn to deliver a satellite. The company also plans to sell the engine that powers New Glenn to the United Launch Alliance, a joint venture between more traditional government contractors.

BENEFITS FROM THE CIRCULAR ECONOMY FRAMEWORK

The experiences of SpaceX, The Spaceship Company and Blue Origin all demonstrate how the CE can provide some exemplary lessons for companies from all sectors on how to embrace the CE and the great benefits in terms of efficiency and effectiveness that can flow from doing so. We can observe that in embracing the circular economy via reusability, SpaceX, The Spaceship Company and Blue Origin have all adopted a step-by-step approach. For example, starting with a small suborbital rocket, Blue Origin has gained experience in the development and launch of reusable spacecraft. This process of step-by-step experimentation incorporates experiential learning that builds up organizational dynamic capabilities, including absorptive capacity and ambidexterity that are the basis of the pursuit of more ambitious goals. Embodying this step-by-step approach is a set of action learning cycles that drives organizational learning. In the face of setbacks and failure, SpaceX continued its process of experimentation and learning before ultimately succeeding. Capturing the potential of the CE is not necessarily for the faint hearted and requires resilience. The second insight that emerges from the space sector is the very substantial economic benefits that can ensure from the CE. The cost reductions demonstrated drive the competitiveness of these companies when compared to traditional space actors. But these cost reductions also drive the economic feasibility of new space missions as in the case of SpaceX's plans for Mars. Thus embracing the CE not only drives competitiveness but can also open up possibilities for new ventures. The economies gained are not necessarily incremental in their impact but can in fact have disruptive industry effects that lay the foundations for Blue Ocean strategies. The focus on the CE by SpaceX and Blue Origin has spurred creativity and innovation leading to new capabilities and new horizons. By engaging around the principles of the CE, companies can find themselves in a virtuous circle, where the creativity and innovation that ensues, drives further engagement with the CE and, in turn, that further engagement drives ever-greater creativity and innovation. Therefore, the CE offers the possibility for businesses of the creation of a self-sustaining innovation and creativity engine. Where this operates in tandem with an entrepreneurial mindset it can lead to the emergence of new business possibilities. It has often been observed that the greatest challenge facing the new space entrants is developing a viable business model. Yet the embrace of the CE is playing a crucial role in the development of viable business models for these new entrants. Equally well, the CE can be a wellspring of ideas and initiatives for business model innovation. As companies strive to innovate their business models and develop new business models, engaging with the CE offers the real prospect of not only technological advances but also economic viability. As a result, the CE can serve as the basis for sustainable competitive advantage for managers and their companies.

MANAGERIAL IMPLICATIONS

The following table depicts the main differences that characterise the traditional implementation of the CE with the OCE.

While the traditional CE implementation is "skin deep"—mostly driven by a reactive approach whereby companies seek to comply with the CE implementation as it would for any other market requirements, the space companies have shown a radically different vision by endorsing a much more proactive approach "flash deep" that ultimately yields many tangible benefits that are all well-beyond mere cost-savings stemming from recycling and reuse.

Each of the companies reviewed in the case

Table 1: The implementation of the CE vis-à-vis the OCE implementation

Traditional CE implementation—"Skin Deep"	OCE implementation—"Flash Deep"
Reactive Approach	Proactive Approach
Mostly focuses on recycling, limited return for reuse	Return for reuse is taken to next level by using a step-by-step approach that drives organizational learning
Limited provision for product life extension	Circular supplies, replacing single life-cycle inputs, resource recovery where resources are recovered from disposed products and product life extensions
Some cost-savings	Blue Ocean strategies that rely on creativity and innovation that lead to new capabilities and new horizons Development of new business models that could provide sustainable competitive advantage

study is entering with a CE based business model and is not attempting to implement it into an already existing business model, as would be the case in the automobile industry or pharmaceutical industry, where existing technology/product/market combinations exist and newer combinations, such as electric vehicles or biotechnology must be grafted into the existing business model. In these situations, the development of ambidexterity is most critical. Nonetheless, the implementation of the CE "flash deep" as in the case of the OCE could provide many benefits also to incumbent firms. In particular, the managerial implications are manifold. Just as space actors have benefited from extending beyond their core activities, there are opportunities for managers in other sectors to do like likewise developing additional revenue streams via servitization. It can be advantageous for managers to consider the scope for partnering with space actors and gaining synergies from such partnerships through, for example, the acquisition of new capabilities applied to new frontiers. Relatedly, managers should be alert to the forging of new forms of collaboration that offer the potential for growth. Managers can look to a number of examples from the space sector of innovative forms of financing that flow from the leveraging of their existing activities into other domains. In a similar vein, there are opportunities for managers to leverage their brands into new markets by capitalizing on the allure and fascination of space. Managers can also pursue the development of higher-order capabilities around the configuring and rearranging of their assets so that they can establish a presence in relation to the space industry. The Embrace of the CE has the potential to deliver significant returns whether in terms of cost reduction, the development of a self-sustaining organisational innovation and creativity engine, the opening up of possibilities for new ventures and the establishment of new disruptive business models that drive sustainable competitive advantage. However, if the organisation's embrace of the CE is to realise its potential, managers need to pursue an entrepreneurial vision that is holistic in nature and that calls for the setting and pursuit of ambitious goals. Success from embracing the CE calls for managers to encourage and nurture a mindset and practice that is open to intensive experimentation that includes multiple trial and error iterations and that is infused with action learning. In turn, this demands a high degree of resilience within the organisation. Equally well, an entrepreneurial mindset can sustain the efforts around experimentation but also contribute the capacity to envisage and forge possibilities for new ventures and innovative business models. As our OCE framework indicates, embedding learning via experimentation, action learning cycles, resilience and an entrepreneurial mindset is the critical point of departure if the potential successes and benefits of the CE are to be attained. Ensuring this, calls for effective leadership that combines holistic vision, ambition and resilience.

CONCLUDING REMARKS

Overall the space sector demonstrates the benefits and the advantages that can accrue from embracing the CE. Our analysis reveals that companies such as SpaceX develops organizational capabilities that can produce significant cross-savings as well as unleashing creativity and innovation. Furthermore, as we have analysed in the case of the space sector, embracing the CE can yield new business models that drive sustainable competitive advantage. These new business models include those characterised by circular supplies, replacing single life-cycle inputs, resource recovery where resources are recovered from disposed products and product life extensions. Consistent with the findings of the recent Accenture Strategy study (2019) that reports that first-movers have a holistic vision coupled with effective leadership, we observe similar characteristics among the first-movers in the space sector. The insights provided by the space industry provide valuable lessons that can have broader applicability to all firms from all the other sectors but particularly to those that like the space industry have recently privatised (e.g. as in the utilities sector), heavily rely on R&D (e.g. as in the case of the pharmaceutical industry) and that are exposed to fierce competition (as in most of the knowledge-intensive sectors).

NOTES

1) The first one on June 28th 2015 and the second one on September 1st 2016.
2) The Falcon Heavy has the highest payload capacity of any currently operational launch vehicle, the second-highest capacity of any rocket ever to reach orbit, trailing NASA's Saturn V, and the third-highest capacity of any orbital-class rocket ever launched (behind the Saturn V and the Soviet Energia).

REFERENCES

Accenture Strategy (2019). Full Circle. Turning Waste into Value with your Supply Chain. The report is available at: https://www.accenture.com/nl-en/_acnmedia/PDF-49/Accenture-Full-Circle-POV.pdf

Bahrami, H., and Evans, S. (2011). Super-flexibility for real-time adaptation: Perspectives from Silicon Valley. *California Management Review* 53, no. 3, pp. 21-39.

Birkinshaw, J., Zimmermann, A., and Raisch, S., (2016). How do firms adapt to discontinuous change? Bridging the dynamic capabilities and ambidexterity perspectives. *California Management Review* 58, no. 4, pp. 36-58.

Brennan, L., & Vecchi, A. (2011). *The Business of Space: The Next Frontier of International Competition*. Palgrave Macmillan.

Brennan, L., Heracleous, L., and Vecchi, A. (2018). *Above and Beyond: Exploring the Business of Space*. Routledge, UK.

Chatterjee, S. (2013) Simple rules for designing business models. *California Management Review* 55, no. 2, pp. 97-124.

Ellen MacArthur Foundation, Towards the *Circular Economy* Vol. 2: opportunities for the consumer goods sector, first published January 25, 2013, https://www.ellenmacarthurfoundation.org/assets/downloads/publications/TCE_Report-2013.pdf.

Esposito, M., Tse, T., and Soufani, K., (2018). Introducing a Circular Economy: New Thinking with New Managerial and Policy Implications. *California Management Review* 60, no. 3, pp. 5-19.

Frishammer, J. and Parida, V. (2019) Circular Business Model Transformation: A Roadmap for Incumbent Firms. *California Management Review* 61, no 2, pp. 5-29.

Harreld, J. B, O'Reilly III, C.A., and Tushman, M.L. (2007). Dynamic capabilities at IBM: Driving strategy into action. *California Management Review* 49, no. 4, pp. 21-43.

Hill, R. M., and Hlavacek, J.D (1977). Learning from failure: Ten guidelines for venture management. *California Management Review* 19, no. 4, pp. 5-16.

Hopkinson, P., Zils, M., Hawkins, P., and Roper, S., (2018). Managing a Complex Global Circular Economy Business Model: Opportunities and Challenges. *California Management Review* 60, no. 3, pp. 71-94.

Kastalli, I., Bart Van Looy, V., and Neely, A. (2013). Steering manufacturing firms towards service business model innovation. *California Management Review* 56, no. 1, pp. 100-123.

Kolb, D. A. (1976). Management and the learning process. California Management Review 18, no. 3, pp. 21-31.

Lacy, P and Rutqvist, J. (2015). *Waste to Wealth: The Circular Economy Advantage*. New York, NY, Palgrave Macmillan, 2015.

Lichtenthaler, U., and Lichtenthaler, E. (2010). Technology transfer across organizational boundaries: absorptive capacity and desorptive capacity. *California Management Review* 53, no. 1, pp. 154-170.

Manso, G. (2017). Creating incentives for innovation. *California Management Review* 60, no. 1, pp. 18-32.

McKnight, J. C. (September 25, 2001). "Elon Musk, Life to Mars Foundation." Mars Now, a weekly column. Space Frontier Foundation

Peters, T. (1992). Rethinking scale. *California Management Review* 35: 7-7.

Space News (25/4/2016). SpaceX's reusable Falcon 9: What are the real cost savings for customers? Available at: http://spacenews.com/spacexs-reusable-falcon-9-what-are-the-real-cost-savings-for-customers/#sthash.FIwI7Aty.dpuf

Stringer, R., (2000). How to manage radical innovation. *California Management Review*, 42(4), pp. 70-88.

Teece, D. J. (2007). Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance. *Strategic Management Journal*, 28/13 (December 2007), pp. 1319-1350.

Teece, D., Peteraf, M. and Leih, S. (2016). Dynamic capabilities and organizational agility: Risk, uncertainty, and strategy in the innovation economy. *California Management Review* 58, no. 4, pp. 13-35.

Teppo, F. and Powell, T. C. (2016). Designing organizations for dynamic capabilities. *California Management Review* 58, no. 4, pp. 78-96.

The New York Times (8/6/2017). Recycled Rockets could drop costs, space speed travel. Available at: https://nyti.ms/2oDxZPs

Vecchi, A., & Brennan, L., (2015a). Innovating the Business Model: The Case of Space. *Adoption of Innovation—Balancing internal and external stakeholders in the marketing of innovation*. Brem, A., and Viardot, E. (Eds). Springer, pp. 155-180.

Vecchi, A., & Brennan, L., (2015b). Leveraging Business Model Innovation in the International Space Industry. *Handbook of Research on Global Business Opportunities*. Christiansen, B. (Ed). IGI Global, Hershey, Pennsylvania, USA.

Vecchi, A., & Ricci, F., (2016). The Internationalization of the Space Industry—Anecdotal Evidence from an Italian SME. *Handbook of Research on Comparative Economic Perspectives on Europe and the MENA Region*. Christiansen, B., Herdogdu, M. (Eds). IGI Global, Hershey, Pennsylvania, USA.

Yin, R. K. (1984). *Case Study Research*. Sage.

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