

'Dominance by birthright'? Reconfiguration of firm boundaries to acquire new resources and capabilities

1. Introduction

Innovative 'green' technologies might remain as niches facing otherwise insurmountable socio-technical regimes. Entrepreneurial 'green' entrants need to compete with the incumbents in order to survive and grow. The literature on industry lifecycles provides a good understanding of new entrant behaviour, survival and shakeout. Each entrant brings along and leverages a distinct set of pre-entry resources and capabilities (R&Cs) into its new operations in the target industry (Teece and Pisano, 1994). Some researchers (Klepper and Simons, 2000; Kim and Park, 2006) argued that the survival of the entrant is their birthright i.e. the survival of new entrant is determined by their pre-entry R&Cs. The persistence of early entrants, however, remains an understudied field (Gomez et al., 2016). Historical study of brewing industry in the U.S. (Walter et al., 2014) also suggested that *de alio* firms with stronger pre-entry R&Cs particularly dynamics capabilities survived the increasing competitive pressure.

The focus on pre-entry R&Cs in firm survival raises two key questions: (i) which pre-entry R&Cs matter most in firm survival in the new industry? and (ii) What are the possible strategies to stay competitive in regard to their pre-entry R&Cs? In order to answer the first question, we need to examine the taxonomy of R&Cs. The ownership of R&Cs determines firm competitiveness and thereby firm survival (Penrose, 1959). Arguably, this view of firm survival is equally applicable to any new entrant who is exploiting its R&Cs in the new industry (Klepper, 2002a). Helfat and Lieberman (2002) distinguish between two categories of entrants' R&Cs – 'core' and 'complementary' – which are context-free. We argue that further classification is required for a more useful taxonomy of entrant R&Cs. There is a potentially long list of core R&Cs ranging from the technology required for production to skills in marketing of the products. The decision to enter into a new industry obviously cannot be based

1
2
3 on complete accumulation of every one of the core R&Cs. Managers need to be able to assess
4 the opportunity of entry and subsequent strategy for survival or growth based on incomplete
5 information. Our study, based on the case of biofuel sector, proposes that core R&Cs need to
6 the further classified based on whether the R&C are criticality and ease of acquisition, which
7 are context dependent and would be more meaningful for managers making entry decisions.
8
9

10
11 As for the second question about competitive strategies for pre-entry R&Cs, studies of firm
12 evolution (e.g., Nelson and Winter, 1982; Jacobides et al., 2009; Helfat, 2015) suggest that a
13 firm's prior experience could lubricate or impose constraints on the evolution of the
14 configuration and governance of the value chain. The embedded historical context of a firm,
15 described as fundamental forces - alongside other market and institutional forces - shapes
16 industrial structure (Geels, 2010). Shifting firm boundaries and the rationale for expanding into
17 other stages of the value chain, thereby changing the vertical structure, are path dependent (Kim
18 and Park, 2006). In a study of the U.S. biofuel value chain, Qian *et al.* (2012) found that a firm
19 has a higher likelihood of internalizing a stage in the value chain where it has pre-entry
20 experience. This is equally applicable to *de alio* firms with integrative capability and *de novo*
21 firms with related founder's experience. Nonetheless, the question remains as to whether a firm
22 should extend to a stage in the value chain where it does not have any pre-entry experience.
23
24

25
26 In weighting their chance of survival and growth in the biofuel sector, entrants actively acquire
27 critical R&Cs, thereby expanding the firm's boundary along the vertical supply chain by
28 internalizing other activities irrespective of their pre-entry R&Cs. We find evidence of path
29 dependency, but also evidence of the possibility of breaking away from path dependency. Our
30 study provides support on the changes of firm boundary particularly in seeking new R&Cs,
31 which are critical for their survival and growth in this new industry. We find evidence in the
32 evolution of the biofuel sector of a trend towards bi-directional vertical integration.
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 Downstream firms integrate backward and upstream firms integrate forward in order to actively
4 pursue R&Cs, contradicting both the path-dependent view and the view that firms will seek to
5 expand to occupy the more profitable, higher value, segment(s) of any value chain.
6
7
8
9

10
11 In Section 2, we present a literature review on past studies of the R&Cs of new entrants. We
12 then offer a brief description of the development of the biofuel sector through 2012 in Section
13 3. Section 4 expands on the methodology and data used in our research. In Section 5, we analyze
14 the major entrants and reclassify their pre-entry R&Cs. We then attempt to explain the
15 phenomenon of bi-directional vertical integration in Section 6, where firms extend their control
16 up and down along the value chain. In Section 7, we propose an extension to the R&C taxonomy
17 for entrants and conclude by describing how firms, building on the advantages found in their
18 pre-entry R&Cs, seek to control critical R&Cs, which they were deprived of at birth.
19
20
21
22
23
24
25
26
27
28
29
30

31 **2. Entrants and pre-entry experience**

32
33 Entrants and their pre-entry experience exert a key influence on industry evolution. A standard
34 theme in the strategy literature is to compare the competitive advantage of an established firm
35 with that of a young and dynamic firm entering a new industry (Ganco and Agarwal, 2009). On
36 one hand, established (or *de alio*) firms diversifying from another industry (Carroll *et al.*, 1996)
37 will possess relevant resources and distinctive competencies gained in their previous industry,
38 which can be leveraged into the new operations (Teece and Pisano, 1994; Klepper and Simons,
39 2000, Uzunca, 2018), rendering *de novo* entrants to have few or no opportunities to survive
40 (Knudsen *et al.*, 2014). There are various theories on different types of 'everagable' R&Cs - or
41 core competencies, which are defined as the 'bundle of skills and technologies' (Hamel and
42 Prahalad, 1994: 199) that enables services to be delivered to customers. On the other hand, new
43 (or *de novo*) start-up entrants (Carroll *et al.*, 1996) do not carry the baggage of older firms
44 (Barnett and Carroll, 1995) nor do they display the same inertia (Haveman, 1992) and are,
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 therefore, more flexible and adaptable in meeting the fresh challenges confronting a new
4 industry. Debate persists over the types and characteristics of industries – e.g. the role of
5 technology innovation, market size and power, or industrial policy (Mingo and Khanna, 2013)
6
7
8 - that can impact on the success of either type of entrant.
9
10
11

12
13 Despite the acknowledged importance of entrant background, there are surprisingly few studies
14 by industrial economists and strategy scholars on 'where entrants come from and how their
15 backgrounds affect their fates' (Klepper and Simons, 2000: 998). The studies that have analyzed
16 the background of firms suggest that their histories do have an effect on their survival (Carroll
17 *et al.*, 1996; Klepper, 2002b; Helfat and Lieberman, 2002; Thompson, 2005). Klepper and
18 Simons (2000) propose that *de alio* firms with prior experience in the value chain are more
19 likely to survive. Empirical studies have been conducted with respect to manufacturing firms
20 in general (Bellone *et al.*, 2008) as well as specific industries such as automobiles (Klepper,
21 2002a); television transmission (Klepper and Simons, 2000); high-technology (Klepper and
22 Sleeper, 2005); shipbuilding (Thompson, 2005); lasers (Buenstorf, 2007), green industries (de
23 Silva *et al.*, 2017), and agricultural biotechnology sector (Moeen, 2017).
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38

39 Moreover, the survival and competitiveness of a firm also depends on the type of R&Cs at the
40 firm's disposal (Penrose, 1959; Wernerfelt, 1984), which highlights the need for a new entrant
41 to capitalize on the R&Cs it brings to the new industry. Vidal and Mitchell (2013) propose that
42 entrants need to develop complementary resources, and Finney *et al.* (2008) point to reinventing
43 the firms' resource base but provide few additional details. Moeen (2017) further demonstrates
44 that a firm's integrative capability, at the stage of initial investment prior to the point of entry
45 into a nascent industry, is an important factor in entry decisions, particularly for technology-
46 related sectors.
47
48
49
50
51
52
53
54
55
56
57
58

59 We adopt the definitions proposed by Helfat and Peteraf (2003: 999): 'A resource refers to an
60

1
2
3 asset or input to production (tangible or intangible) that an organization owns, controls, or has
4 access to on a semi-permanent basis. An organizational capability refers to the ability of an
5 organization to perform a coordinated set of tasks, utilizing organizational resources, for the
6 purpose of achieving a particular end result.' Helfat and Lieberman (2002) provide a useful
7 classification of entrants' R&Cs into 'core' and 'complementary' in making a decision on market
8 entry. 'Core' R&Cs refer to knowledge required to create a product or service such as
9 technological knowledge or customer needs; whereas 'Complementary' R&Cs are needed to
10 support the 'Core' in order to generate profits such as through finance and customer services.
11 However, these context-free classifications have their limitations, particularly in terms of
12 understanding core capabilities –core R&Cs for one industry might not be 'core' for another.
13 Therefore, we propose a further subdivision of core R&Cs into critical or not critical R&Cs,
14 which depends on examining the specifics of different industries. Critical R&Cs might be easily
15 accumulated or acquired within a reasonably short period of time, therefore, the next level of
16 the taxonomy is ease of acquisition. The authors propose the following taxonomic structure of
17 pre-entry R&Cs:
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37

38 [Insert Figure 1 here]

39
40
41
42 Contextual factors can play an influential role in the industry evolution of vertical firm structure
43 (Gibbon and Ponte, 2005: 82; Helfat, 2015). The evolution of vertical structure depends on
44 many factors. The early understanding of this evolution adopts an efficiency perspective. Stigler
45 (1951), building on Adam Smith's division of labor, suggested that new industry evolves from
46 a vertically integrated firm towards vertical dis-integration to reduce production costs as the
47 market size expands and technology becomes more mature in order to support economies of
48 scale at different stages of production. It will then begin to re-integrate after the market size
49 declines. Coase (1973) and later Williamson (1985) extended this argument to include
50
51
52
53
54
55
56
57
58
59
60

1
2
3 transaction costs in addition to production costs in the analysis of the structure of economic
4 organizations. As transaction cost theory was becoming increasingly prominent, Eisenhardt
5 (1989) argued that the principal-agent dilemma warranted taking into account internal
6 managerial costs in vertical integration decisions. Specific factors related to products and
7 technology are equally important, for example, the degree of product standardization and
8 codifiability (Jacobides, 2005), a firm's innovative capabilities and resources (Wernerfelt,
9 1984), and low cost or differentiated innovative products (Helfat and Campo-Rembado, 2016).
10 The other main alternative explanation of vertical structure evolution is an institutional
11 perspective (Williamson, 1996), which involves market power (Stuckey, 1983), barriers to
12 entry (Riordan, 2008), and relational factors (Gereffi et al., 2005)

27 **3. Rapid expansion of the biofuel sector through 2012**

28
29
30 The global biofuel industry expanded rapidly over two decades peaking in 2010. After 2012,
31 global production has roughly stabilized (RFA, 2016), as has policy innovation. We focus our
32 study on the bio-ethanol segment of the industry, rather than biodiesel, since bioethanol
33 production volumes have been much larger and hence the sector is more mature. The production
34 of bioethanol grew from 30.7 billion liters in 2000 to an estimated 104.5 billion liters in 2012,
35 equivalent to an average annual growth rate of 10.7% (F.O. Licht, 2012). The size of the biofuel
36 industry (where fuel-ethanol is the major type of biofuels) in 2017 was about 3% of the global
37 transport energy consumption (2.8 billion tonnes of oil equivalent) (BP, 2018), which is not
38 insignificant. Since 2012, global growth has slowed to about 5% per annum (Based on F.O.
39 Licht's World Ethanol and Biofuels Reports).

40
41
42 Bioethanol has been produced around the globe – Brazil has historically been the largest
43 producer in the world but was overtaken by the U.S. in 2006. By the end of 2012, the U.S. and
44 Brazil were producing about 53 billion liters (51% of world production) and 23 billion liters
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 (22%) respectively.
4
5

6 In terms of the market, roughly 80% of global bioethanol production the first decade of 21st
7 century was supplied to the transportation fuel-ethanol market, as an additive/substitute for
8 gasoline in the transportation fuel market. This market was the main driver of growth in
9 production. The remaining 20% of production serves the rather stable industrial and beverage
10 sectors (F.O. Licht, 2012).
11
12
13
14
15
16
17

18 The development of the fuel-ethanol market is primarily driven by market forces – for instance,
19 high oil prices and relatively lower ethanol prices over the period in question – and government
20 policies with varying objectives such as mitigating climate change, energy security, supply
21 chain management, consumer adoption, rural development, job creation and development of
22 biotechnologies (Wiesenthal, *et al.*, 2009; Chen and Wang, 2017; Ye et al., 2018). By 2010,
23 more than fifty countries had adopted policies either to create domestic markets or to develop
24 production capabilities for biofuels (IEA, 2011), despite the unsettled debate on the
25 sustainability of biofuel industry.
26
27
28
29
30
31
32
33
34
35
36
37

38 Consequently, biofuels rapidly gained market share, especially in Brazil, the U.S., Europe and
39 China. Fuel-ethanol, for example, accounted for about 6% of the global gasoline market in
40 2010, having increased its market share four-fold over the decade from 1.4% in 2000 (EIA,
41 2013). Brazil saw the deepest penetration of fuel-ethanol, rising from 22.4% in 2000 to roughly
42 50% of motor vehicle fuel consumption after 2008. The growth of ethanol penetration was even
43 more rapid in the U.S. – the largest gasoline-consuming country with more than 40% of the
44 world consumption – rising from 1.2% in 2000 to 8.5% in 2010.
45
46
47
48
49
50
51
52
53
54

55 The bioethanol value chain was formed by combining the upstream part of the agro-food chain
56 with the downstream part of the transportation fuel chain. The new value chain can be divided
57 into three distinct production stages - upstream agro-food commodity, midstream
58
59
60

1
2
3 manufacturing, and downstream transportation fuel. As shown in **Figure 2**, the industry diverts
4 raw materials from food-feed agricultural chains to produce a product substituting and
5 competing with the downstream petroleum value chain (indicated by the thinner shaded gray
6 arrows).
7
8
9
10
11
12

13 [Insert Figure 2 here]
14
15
16

17 **4. Methodology and data**

18
19

20 This is a case study on entrants in biofuel industry using multiple sets of data. The primary data
21 is based on semi-structured interviews with producers and expert interviews conducted from
22 2009 to 2012. The key ethanol producers interviewed include large firms e.g. Abengoa, BP,
23 Petro China, and COFCO China, and smaller firms, e.g. Thai Oil, Saigon Petro, Zhongke
24 Tianyuan New Energy (Guangzhou China), Bronzeoak (UK and the Philippines), Petro
25 Vietnam (Petrosetco). We have also interviewed technology providers, e.g. Alfa-Laval, Bosch.
26 The informants were senior leaders and managers including chairs, directors, and top managers
27 of leading producers. The length of the interview varied from relatively short discussions to
28 those lasting for about an hour. In addition, we interviewed other stakeholders, i.e. policy
29 makers and researchers, employees of oil companies, representatives of trade associations,
30 farmers and traders. All interviews were conducted face-to-face. Follow-up questions were
31 done via email, Skype, and telephone. The main language was English with the exception of
32 interviews in China, which were conducted in the Chinese language by one of the co-authors.
33 Interview notes were taken in all instances; some interviewees objected to any audio recording.
34 This textured data is used in thematic analysis to identify the R&Cs in accordance with the
35 proposed taxonomical structure of pre-entry R&Cs (as in **Figure 1**) and the data is presented in
36 greater detail in **Table 2** and **Table 3** in **Section 5**.
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

The secondary data (both quantitative and qualitative) also come from diverse sources, e.g.

1
2
3 industrial reports, company websites, and media coverage. The main data sources are the U.S.
4
5 Renewable Fuels Association (RFA), the Brazilian Sugarcane Industry Association (UNICA)
6
7 and industry reports (e.g. F.O. Licht). Given the global scope and fluidity of this sector, there
8
9 are some inconsistencies in data. It is challenging, for example, to obtain accurate data for
10
11 company production information for a new industry with many firms based in developing
12
13 countries. Nevertheless, these uncertainties do not impede the main analysis and any other
14
15 major discrepancies could be reconciled by triangulating using diverse sources as suggested by
16
17 Huberman and Miles (1994).
18
19
20
21
22

23 *4.1 Identification and Ranking of Global Ethanol Manufacturers*

24

25
26 We identified and ranked the top-thirty ethanol manufacturers (see **Appendix A**) based on a
27
28 review of production levels and installed capacity of the top manufacturers in major producing
29
30 regions and estimating their market share up to the end of 2012. This is because at this point
31
32 the rapid growth of the 2000s was beginning to slow and the industry had reached a more mature
33
34 phase where the turmoil in the ranking of most of the leading manufacturers had begun to settle.
35
36 We acknowledge that this approach inevitably produces a selection bias towards more
37
38 successful firms. Nonetheless, the specifics of firm shakeouts and survival evolution are not the
39
40 aim of our study. We seek to understand how successful large firms evolve after entering the
41
42 biofuel sector, with a focus on entrants and vertical movement. In order to do so, we also track
43
44 the historical evolution to examine when a firm first enters a specific stage of the new value
45
46 chain. We did not take into account the role of many small/start-up firms - particularly those
47
48 involved in the development of advanced biofuels. Despite they might have significant
49
50 influence on the industrial structure in the future, they have a limited influence over the period
51
52 of this study.
53
54
55
56
57
58
59
60

4.2 Classification of entrants and their pre-entry resources and capacities

Based on **Appendix A**, a classification was carried out with respect to the firms' pre-entry industry and the key R&Cs they brought to the new industry. The pre-entry backgrounds of the manufacturers were very diverse and could be classified into two main categories i.e. *de alio* and *de novo*. *De alio* entrants were those entrants with prior involvement in at least some stages of the biofuel value chain. They could be further divided in accordance with the form of prior involvement at the stages of what would become the new biofuels supply chain, as research has indicated systematic differences in performance of entrants with different backgrounds (Helfat and Leiberan, 2002). Based on our sample of the largest manufacturers, *de alio* entrants not only came from agricultural and fossil fuel sectors but also were technology and engineering firms. We therefore proposed four groups of entrants in accordance with their historical core business as shown in **Table 1**: (i) technology, (ii) farming & food processing, (iii) agro-food commodity trading, and (iv) oil & gas¹.

[Insert Table 1 here]

We define *de novo* entrants without differentiating between start-ups and entrepreneurial spin-offs, which are, by definition, lacking in some of the R&Cs owned by the diversified *de alio* entrants (Chen *et al.*, 2012). We acknowledge that entrepreneurial spin-offs, where the founder has prior experience in a related industry or has been employed by an incumbent, could possess certain relevant R&Cs (Shepherd and de Tienne, 2004; Roberts *et al.*, 2011). Despite the

¹ We do not categorize entrants based on their very first business activity but rather on their core business before entry into biofuel manufacturing. There are, of course, some difficulties in categorizing some firms. For example, POET, which began with a farming industry background prior to 1986, moved into developing technology for its ethanol facility. Gradually, the firm grew substantially as a provider of technology and plant building services during the 1990s (POET, 2013), which we use as its core business prior to its major entry into biofuel manufacturing.

possible contribution of a founder's prior experience, there are three reasons for taking this approach to classification. First, we propose that a firm's combinative R&Cs (Kagut and Zander, 1992) is significantly more important than the R&Cs controlled by any individual, given the nature and the scale of operations in biofuel industry. While firms can transfer some combinative R&Cs to the new industry such as via sourcing and securing feedstock or access to marketing channels, this is not possible for an individual founder (Helfat and Campo-Rembado, 2016). Second, the differences in individual-level R&Cs are less significant given the size of the firms in our sample, i.e., the thirty largest global manufacturers. Third, even though individual R&C could be useful, any new entrant could probably acquire those R&Cs without substantial difficulty, as discussed below.

The first group of *de alio* entrants is engineering and technology firms (Group 1). They were among the largest ethanol firms in terms of installed capacity during the study period (**Table 1**). These firms began by providing services in the design and building of ethanol facilities. They entered the ethanol-manufacturing stage to capitalize on their technical knowhow in the operation and management of such facilities. They also have the capabilities to perform R&D on advanced biofuel technologies, potentially gaining key longer-term competitive advantages against other manufacturers primarily depend on ethanol production using traditional (first generation) biofuel technologies.

Group 2 is made up of firms that have been active in the agricultural and food sector, often for many decades. This is a prominent group with a large number of firms (**Table 1**), who were among the earliest entrants, and is the largest group in terms of production capacity. They are farmers, farm cooperatives (particularly in the U.S.), and agro-food and sweetener producers that enjoy a high level of security of feedstock supply due to their extensive pre-entry R&Cs in agriculture-related sectors. These R&Cs in feedstock production and sourcing were built up

1
2
3 over their long history of involvement in cultivation, management, trade and processing of the
4 feedstock used in biofuel production. Their competitive advantage would be difficult to acquire.
5
6
7 Other firms would require a long time to build up these R&Cs, particularly in a market where
8 feedstock liquidity is low. For instance, there are more of these firms in countries (such as
9 Brazil) where feedstock liquidity is low due to asset specificity, compared with countries with
10 higher liquidity in the feedstock market (e.g. U.S.)². Capitalizing on these R&Cs, many firms
11 in Group 2 were able to successfully integrate downstream into ethanol manufacturing and
12 expand their installed capacity substantially within a short period.
13
14
15
16
17
18
19
20
21

22 Similarly, the agricultural commodity traders in Group 3 entered into the production stage by
23 leveraging their pre-entry knowledge of feedstock supply and markets. These firms have a
24 strong ability to couple their access to capital with a good understanding of global supply
25 chains, trade and markets for feedstock and ethanol. These served as their key competitive
26 advantages when they moved from providing services as traders into ethanol production.
27
28
29
30
31
32

33
34
35 Group 4 consists of firms active in the traditional petroleum value chain. Historically, they have
36 been the downstream customers of ethanol manufacturers but some have decided to enter the
37 upstream ethanol value chain directly. We have documented both vertically integrated oil
38 companies and independent refiners investing heavily in ethanol-manufacturing assets. They
39 brought along R&Cs that were nearly impossible for firms in any other groups to match, such
40 as knowledge of blending and the use of additives in the final products, logistics and
41 infrastructure, and distribution and retail networks.
42
43
44
45
46
47
48
49
50

51
52 Group 5 is made up of start-ups with generally little previous background in biofuel-related
53 sectors. They usually entered the market to capitalize on favorable government policies towards
54
55
56

57
58 ² The main feedstock for biofuel production in Brazil is sugarcane, which is costly to transport for a long distance
59 and the quality deteriorates quickly over time. The U.S. biofuel feedstock is mainly corn which is less bulky than
60 sugarcane.

1
2
3 ethanol manufacturing and its use as a transportation fuel. Some of these *de novo* firms
4 expanded quickly, for example, Verasun rose to top the list of global manufacturers for a short
5 time in 2008-9. In general, though, the leading manufacturers in Group 5 were typically smaller
6 in size than firms in other groups (**Appendix A**).
7
8
9
10
11

12
13 Despite their dynamism, these *de novo* firms are vulnerable to the lack of R&Cs in comparison
14 with *de alio* firms found in the other groups. For instance, during the 2008 global financial
15 crisis many Group 5 firms (including Verasun, Pacific Ethanol, Aventine Renewable Energy,
16 Panda Ethanol and Renew Energy) faced liquidity problems. The U.S. oil companies from
17 Group 4 acquired the majority of the assets of firms such as Verasun and Panda Ethanol after
18 they filed for bankruptcy. Without significant upstream-related R&Cs, Verasun, the most high-
19 profile casualty, depended on hedging its feedstock supply, but this strategy turned out to be
20 fatal when feedstock prices fell sharply at the onset of the crisis. Other casualties, such as Pacific
21 Ethanol and Aventine, managed to re-emerge after restructuring.
22
23
24
25
26
27
28
29
30
31
32
33

34 35 **5. Taxonomy of pre-entry resources and capabilities** 36

37
38 The importance of pre-entry R&Cs has also been demonstrated in a number of studies. For
39 instance, Klepper and Simons (2000) argue that the pre-entry experience of a firm is valuable
40 across many industries and will affect their performance and survival in a new industry.
41 However, not all types of pre-entry R&Cs are of equal importance. Previous studies suggest
42 that firms have 'leveragable' assets of dynamic competencies (Teece and Pisano, 1994) or a
43 bundle of skills and technologies (Hamel and Prahalad, 1994) when entering a new industry.
44 But the question remains as to which critical pre-entry capabilities of a firm affect performance
45 and ultimate survival. Some entrant's R&Cs are crucial for survival, for example in the case of
46 the biofuel sector, the capability to source feedstock, particularly at times of severe competition
47 for feedstock and high price volatility, especially in a marketplace where relational factors are
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 important, i.e., where trust and relationships must be built over time (Vangen and Huxham,
4 2003). Therefore, we suggest that core R&Cs should be further classified as critical and non-
5 critical in accordance with industry characteristics.
6
7
8

9
10
11 Previous studies, particularly those adopting a resource-based view, have classified the R&Cs
12 of firms according to a number of hierarchies or taxonomies. For example, Barney (1991)
13 categorizes R&C into three types, i.e. physical, human, or organizational. Helfat and Lieberman
14 (2002) provide a wide range of taxonomies, e.g., type of market entry opportunities, entrant
15 type, mode of entry, core versus complementary R&Cs, and specialized versus generalized
16 R&Cs. These approaches have primarily adopted the perspective of the entrant without
17 considering the bundle of R&Cs required to be competitive in the new industry. An agro-food
18 commodity firm, for example, may enter the ethanol-manufacturing stage, bringing along a
19 bundle of core and complementary R&Cs. Complementary R&Cs are typically common across
20 many industries, such as finance, accounting, human resources, and administration (Helfat and
21 Lieberman, 2002). Core R&Cs are those specific to the industrial operations such as
22 technological knowhow. However, within the subset of common R&Cs, the core R&Cs may
23 not all be of equal importance. Which R&Cs really matter to obtaining sustainable competitive
24 advantage in the new industry? Other classification of R&Cs related to industry- and market-
25 determined factors is Strategic Industry Factors (SIF) suggested by Amit and Schoemaker
26 (1993) on how best to secure organizational rents. These Strategic Industry Factors are context
27 dependent, differing from industry to industry and may be transient or more persistent.
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

50
51 Any mismatch between the entrant's R&Cs and the R&Cs required in the new industry could
52 compromise the competitiveness and survival of the entrant. Within every entrant's R&Cs, there
53 is a subset that is applicable to the new industry or overlapping with the required R&Cs for the
54 new industry. For instance, the agro-food commodity firm may have tacit knowledge of the
55
56
57
58
59
60

1
2
3 feedstock market required in the ethanol manufacturing. Identifying the intersection of the
4 entrant's pre-entry R&Cs and the new industry's required R&Cs is an important task in the entry
5 decision-making process. The entrant would be able to know their strengths and competitive
6 advantages in the new industry. Moreover, the entrant could also identify the missing core
7 R&Cs required in the new industry and make decisions on how best to develop or acquire them.
8
9

10 We thereby propose to extend Helfat and Lieberman's (2002) taxonomy of R&C, by focusing
11 on 'critical' R&Cs, which would satisfy the requirements laid out in the SIF framework. It is
12 thereby important for a manager to fully evaluate their SIF prior to entry. Using ethanol
13 manufacturing as an example, **Table 2** illustrates a set of taxonomies of core versus
14 complementary R&Cs based on interviews conducted with industrial experts and stakeholders.
15 Further, critical R&Cs are those that are central to the competitiveness of the business and could
16 be derived from the market- and industry-determined SIF.
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

32 [Insert Table 2 here]
33
34
35

36 In the case that the entrant does not own all the necessary critical R&Cs to match the SIF, it
37 should logically seek to develop or acquire them and answer several key questions before
38 proceeding. Can these missing critical R&Cs be easily developed within an acceptable
39 timeframe before the entrant's competitiveness is compromised? Alternatively, if these missing
40 critical R&Cs are tradable, can they be acquired and absorbed within the organization in
41 sufficient time post-entry? To reflect these challenges, we propose a further classification based
42 on 'ease of acquisition'.
43
44
45
46
47
48
49
50
51
52

53 **Table 3** summarizes the pre-entry R&Cs of the five groups of entrants within the ethanol
54 industry found in **Table 1**. For example, for Group 1 a requisite pre-entry capability in ethanol
55 distillery process and operations is having a set of core R&Cs useful in ensuring efficient
56 operations. However, ensuring normal operations of the ethanol distillery is not considered a
57
58
59
60

1
2
3 *critical* core R&C since it is commonly available, is rather mature and standardized and could
4
5 be easily acquired.
6
7

8
9 By contrast, the pre-entry R&Cs for Group 2 and Group 3 in the feedstock market are critical
10
11 core R&Cs since they match with the required SIF and are especially important in an illiquid
12
13 market. The ability to manage farmers and suppliers of feedstock is important to the success of
14
15 any manufacturer, as feedstock costs can account for 60% or more of total manufacturer costs
16
17 (Sanchez and Cardona, 2008). In addition, access to feedstock is especially critical during
18
19 periods of tight supply. This capability is particularly difficult to acquire in a relational
20
21 feedstock market.
22
23

24
25
26 [Insert Table 3 here]
27
28

29 **6. Integration to seek out resources and capabilities**

30
31
32 By tracing the evolution of the bio-ethanol sector over two decades, we observe a phenomenon
33
34 of bi-directional vertical integration, where firms predominantly operating in downstream
35
36 stages have integrated upstream and vice versa, as shown in **Table 4**. We find forward
37
38 integration of larger firms in Group 1 (Engineering), Group 2 (agro-food cultivators and
39
40 processors) and Group 3 (agro-food commodity traders) when they entered into the stage of
41
42 manufacturing utilizing their pre-entry R&Cs as shown in **Table 1**. The strategic R&C available
43
44 to the firms could be utilized to gain long-term competitive advantage (Wernerfelt, 1984). For
45
46 example, firms in Group 1 and Group 2 capitalized on their technological knowhow or
47
48 knowledge of the feedstock supply, to develop a new line of businesses in an expanding ethanol
49
50 market.
51
52

53
54
55 [Insert Table 4 here]
56
57

58
59 Moreover, several firms integrated further downstream into marketing, blending, distribution
60

1
2
3 and retailing in order to secure markets for their products. **Table 4** shows the progression of
4 firms integrating downstream, particularly since 2005. In most countries, traditional petroleum
5 firms dominate these downstream stages of the value chain. Although growing, ethanol volume
6 remains relatively small compared to gasoline in the overall blending volume. As there is excess
7 petroleum refining capacity in some parts of the world, refiners can be reluctant to pursue
8 ethanol blending and often seek to erect barriers to government aspirations to mandate any
9 blending. The organizational inertia of incumbents is well known in many other industries
10 (Agarwal and Moeen, 2016), In order to reach retail markets, ethanol manufacturers must often
11 be proactive and integrate into downstream stages, especially into higher blend markets (i.e.,
12 where higher percentages of ethanol are used in the gasoline blend) that might provide one
13 solution to a more passive position towards marketing their products.
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28

29 Another striking example is Cosan in Brazil, which has become the most vertically integrated
30 ethanol firm in the world, occupying all stages along the sugarcane-based ethanol value chain
31 after its acquisition of ExxonMobil's downstream operation in Brazil in 2008 (**Table 4**).
32 Further, Raizen, formed by Cosan and Shell, has owned the fuel distribution and retail stages
33 of both Cosan and Shell in Brazil since 2010. Cosan and Raizen hope for a more sustainable
34 growth path than Verasun, which carried out the most spectacular downstream integration from
35 2003 to 2006. Before filing for bankruptcy, Verasun had become the largest ethanol
36 manufacturer in the world, with eleven operational plants and six new plants under construction
37 or under development. It blended and marketed its own brand of E85 ethanol to 150 retailing
38 stations across 15 U.S. states. Other examples of such vertical integration includes GPRE
39 acquiring Blendstar in 2008 to move into downstream blending and distribution markets, and
40 Pacific Ethanol creating a marketing arm - Kinergy Fuel Marketing.
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57

58 **Table 4** and the discussion above offer some clear examples of forward integration of ethanol
59
60

1
2
3 manufacturers. A number of *de novo* firms and upstream *de alio* firms have integrated further
4
5 downstream to production stages such as marketing, blending, distribution and retail. Ethanol
6
7 manufacturers appreciate that they should not depend on incumbent oil companies to market a
8
9 substitute for their own product and will need to break through the monopolization of oil
10
11 companies at downstream stages of the value chain.
12
13

14
15 As Perry (1988: 206) has suggested, one of the motivations for firms to employ vertical
16
17 integration strategies is not only to secure the market for its product(s), but also to gain the
18
19 ability to sell the quantity of output the firm wishes. This motivation to access the retail market
20
21 appears to be critical in a market where incumbents control the marketing channels of the
22
23 substitutes.
24
25

26
27
28 Three types of backward integration have also been observed in the ethanol sector over the
29
30 period studied. First, firms in the downstream value chain – transportation fuel refining,
31
32 distribution and retailing, have integrated upwards to include the ethanol-manufacturing
33
34 segment. These firms are required to fulfill their regulatory obligations in selling ethanol in
35
36 various jurisdictions and therefore move upstream to enhance the security of their ethanol
37
38 supply. Securing ethanol supply is unlikely to be the sole motivation in markets where liquidity
39
40 in ethanol trading is high. Other motivations for oil companies to move into ethanol
41
42 manufacturing include improving brand identity, building a more environmental-friendlier
43
44 image or seeking additional rents. It is notable though that no international oil company apart
45
46 from Shell has made it to the top thirty in ethanol manufacturing despite their unmatched
47
48 financial capability. Nonetheless, some petroleum refiners, especially those without an
49
50 upstream oil exploration business such as Valero and Flint Hills Resources, have diverted away
51
52 from the increasingly low-margin refining segment and into ethanol manufacturing.
53
54
55
56
57
58
59
60

1
2
3 The backward integration of oil firms into ethanol manufacturing and production of feedstock
4 increased but only slowly over the period of study. This sluggishness was possibly due to inertia
5 or a mismatch between the set of organizational skills required (Teece *et al.*, 1997) for their
6 conventional operations (in oil, especially upstream activities) and those needed for the new
7 venture (in agro-business). Key differences include scale of investment, expectation of returns,
8 lack of experience in agricultural commodity markets, agricultural management and social and
9 political aspects of agricultural activities. Therefore, pre-entry R&C could also constrain a
10 firm's decision to engage in vertical integration as proposed by Nelson and Winter (1982) and
11 Jacobides et al. (2009).
12
13
14
15
16
17
18
19
20
21
22
23

24
25 Second, some ethanol manufacturers have integrated downstream into feedstock trading, and
26 further into feedstock cultivation as well as land ownership. Manufacturers without any pre-
27 entry R&C in feedstock supply have been inclined to integrate upstream to mitigate the risks of
28 uncertainty in feedstock supply and price volatility. In the U.S., those manufacturers operating
29 without a degree of upstream integration, e.g., *de novo* entrants, have been susceptible to high
30 feedstock supply risks. In response, firms most exposed to such risks, such as Verasun, have
31 sought to mitigate them. By contrast, the two leading U.S. ethanol manufacturers – ADM and
32 POET – escaped a similar fate because they had a stronger degree of integration upstream in
33 both trading and cultivation of maize. Firms, such as those in Group 2 and 3, with pre-entry
34 experience in similar industries or supply chains, have demonstrated that they are more resilient,
35 in agreement with the findings of Klepper and Simons (2000).
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50

51 There is a tendency towards backward integration from manufacturing to farming/commodity
52 trading, although this is less prevalent in certain regions, notably the U.S. The high liquidity in
53 the U.S. feedstock market provides less incentive for integration. In addition, barriers to entry,
54 including capital requirements, skills, and land acquisitions, can also be high since farm size is
55
56
57
58
59
60

1
2
3 generally large. By contrast, a large number of Brazilian manufacturers own and lease land for
4 cane cultivation due to favorable social-political and historical factors. There is also less
5 backward integration of manufacturers in countries such as China, Thailand, Vietnam and the
6 Philippines because of unfavorable macro-institutional factors.
7
8
9
10
11
12

13 We conclude with three observations about backward integration. First, firms without pre-entry
14 R&Cs would likely integrate downstream to ensure high security of feedstock supply, which is
15 in line with resolving uncertainty and thereby reducing transaction costs (Williamson, 1996).
16 Security of supply includes the ability to obtain the quantity of feedstock required at a stable
17 and desirable price, since ethanol manufacturers are mostly price takers in the feedstock market.
18 A similar phenomenon can be found in the oil industry's move upstream to secure oil reserves
19 (Buzzell, 1983).
20
21
22
23
24
25
26
27
28
29

30 Second, there are notable exceptions in downstream integration, particularly in certain markets,
31 where institutional forces might undermine attempts to integrate further upstream (such as into
32 cultivation stages). For example, in the case where there are a large number of small family
33 farms at the cultivation stage, and there is political sensitivity and even legal prohibitions on
34 land ownership by large corporations and foreigners, such as in China, Thailand and Vietnam.
35
36
37
38
39
40
41
42

43 The third type of backward integration is the integration of ethanol manufacturers into the
44 engineering and technology stage based on a motivation to enhance economies of scope. In the
45 U.S. for instance, both POET and ADM have the capability to design and build distilleries. A
46 newcomer at this stage is Shree Renuka of India - a sugar-ethanol company with operating units
47 in India and Brazil. In 2007, it acquired KBK, an engineering and construction company based
48 in India, which builds distilleries throughout Asia.
49
50
51
52
53
54
55
56
57
58
59
60

7. Theoretical and practical implications

This study attempts to understand industrial life cycles at their early stages. By mapping out the development of the bio-ethanol sector, we conclude that new entrants need to understand their pre-entry R&Cs and how those match with the critical R&Cs required to survive in their new industry. First, we propose that the R&Cs of new entrants should be classified as either critical or non-critical. Many very successful biofuel firms belong to the *de alio* group. A *de novo* firm's survival rate is expected to be lower than that of a *de alio* firm as suggested by other studies such as Geroski (1995) and Helfat and Lieberman (2002), which has led to the 'dominance by birthright' theory propounded by Klepper and Simons (2000). Successful *de alio* firms have been shown to leverage their critical pre-entry R&Cs when entering into the biofuel market. Experience increases the value of entry and encourages entry into new markets, as found in King and Tucci (2002). However, not all pre-entry R&Cs are equally important. Therefore, we need to classify them in terms of their criticality to the performance and survival of the entrant, which are context specific to an industry or market.

A further classification of entrant's R&Cs in terms of 'ease of acquisition' is also proposed – if any R&Cs could be easily acquired within a short period of time, the competitive advantage of *de alio* firms would diminish rapidly. Similarly, entrants, even those that have grown into sizable firms, may fail because of their inability to build the critical R&Cs in time. Thus, a key post-entry strategy is to identify and acquire critical R&Cs, which an entrant has yet to control.

Therefore, we observe that biofuel firms integrate further up or down along the value chain in order to acquire new R&Cs, since they will be critical for their survival and growth in the new industry. We propose that *de novo* entrepreneurial firms in a rapidly evolving green sector need to quickly identify critical R&Cs in their industry and strategize to acquire and control them in order to survive and growth. Through waves of acquisition and shifting control over critical

1
2
3 R&Cs, the evolution of the biofuel industry demonstrates a consistent phenomenon of bi-
4
5 directional vertical integration.
6
7

8
9 The motivations for vertical integration could be explained by resources-driven integration
10
11 (Eschen and Bresser, 2005) with the intention of avoiding uncertainty as proposed in
12
13 Transaction Cost Theory (Williamson, 1975). It is also consistent with the findings of a recent
14
15 study of the U.S. brewing industry (Walter et al., 2016) where firms actively deployed strategic
16
17 choice (Short and Payne, 2008) to develop the necessary capabilities to avoid being shaken out.
18
19 Kapoor (2018) has also demonstrated the persistence of semiconductor industry to integrate
20
21 vertically despite the waves of specialization. In conclusions, similar to Helfat (2015), we find
22
23 that the evolution towards greater vertical integration depends on the needs to control critical
24
25 R&Cs, which are context specific.
26
27
28

29
30 In addition, our study also suggests that a firm's prior experience could impose constraints on
31
32 post-entry strategic choice of vertical structure, building on studies such as Nelson and Winter
33
34 (1982) and Jacobides et al. (2009). For example, we can see the reluctance of incumbent firms
35
36 (i.e. oil companies) to invest in biofuel manufacturing, which included an unfamiliar upstream
37
38 sector (agriculture) with low returns (at least compared to traditional petroleum).
39
40
41

42 43 *Limitations and future work*

44
45

46
47 Finally, there are two aspects that we do not consider here and would therefore recommend for
48
49 future study. We do not assess the interaction between institutional factors and a firm's
50
51 stakeholders in influencing or facilitating strategic movements along the value chain. We also
52
53 do not take into consideration the implications of advanced technological development in the
54
55 biofuels sector, which although negligible over the period of our study, could be revolutionary
56
57 in changing the configuration and governance of the value chain in the future. For instance,
58
59 three commercial-scale cellulosic ethanol facilities with a combined capacity of 284 million
60

liters have begun production in the U.S. in 2015 (RFA, 2016).

There are a number of other nascent 'green' industries, which would benefit from a similar treatment. Offshore wind and solar photovoltaic panels (which has similar characteristics of a commoditized technology with firms entering from adjacent sectors) or bio-plastics derived from agricultural materials are obvious parallels. Still other even newer industries, such as those involving the Internet of Things, are probably at too early a stage to provide sufficient evidence, but they may be fruitful areas to explore within a few years. Evidence from other sectors could reinforce or expand our understanding of firm survival.

References:

- Amit, R. and Schoemaker, P.J.H. (1993), "Strategic assets and organizational rent", *Strategic Management Journal*, Vol. 14, pp. 33-46.
- Agarwal, R. and Moeen, M. (2016), "Entrepreneurial startups (de novo), diversifying entrants (de alio) and incumbent firms", In Augier, M. and Teece, D. (eds), *Palgrave Encyclopedia of Strategic Management*, Palgrave Macmillan, London.
- Barnett, W.P. and Carroll, G.R. (1995), "Modeling internal organizational change", *Annual Review of Sociology*, Vol. 21, pp. 217-236.
- Barney, J.B. (1991), "Firm resources and sustained competitive advantage", *Journal of Management*, Vol. 17 No. 1, pp. 99-120.
- Bellone, F., Musso, P., Nesta, L. and Quere, M. (2008), "Market selection along the firm life cycle", *Industrial and Corporate Change*, Vol. 17 No. 4, pp. 753-777.
- BP (2018), BP Statistical Review of World Energy, 67th edition. BP Plc.
- Buenstorf, G. (2007), "Evolution on the shoulders of giants: entrepreneurship and firm survival in the German laser industry", *Review of Industrial Organization*, Vol. 30, pp. 179-202.
- Buzzell, R.D. (1983), "Is vertical integration profitable", *Harvard Business Review*, Vol. 61 No. 1, pp. 92-102.
- Carroll, G.R., Bigelow, L.S., Seidel, M-DL. and Tsai, L.B. (1996), "The fates of de novo and de alio producers in the American automobile industry 1885-1981", *Strategic Management Journal*, Vol. 17, pp. 117-137.
- Chen, X. and Wang, X. (2017), "Achieve a low carbon supply chain through product mix", *Industrial Management & Data Systems*, Vol. 117 Issue: 10, pp. 2468-2484.
- Chen, P.L., Williams, C. and Agarwal, R. (2012), "Growing pains: Pre-entry experience and the challenge of transition to incumbency", *Strategic Management Journal*, Vol. 12 No. 1, pp. 252-276.
- Coase, R. (1937), "The Nature of the Firm", *Economica*, Vol. 4, pp. 386-405.
- de Silva DG, Hubbard TP, McComb RP, Schiller AR. 2017. Entry, growth and survival in the green industry. *Regional Studies* 51(12): 1774-1785.

- 1
2
3 Eisenhardt, K.M. (1989), "Agency Theory: An Assessment and Review", *Academy of*
4 *Management Review*, Vol. 14 No. 1, pp. 57-74.
5
6 Energy Information Administration (EIA) (2013), International Energy Statistics (Energy
7 Information Administration, the USA Department of Energy, Washington DC). Last
8 accessed 15 December 2013.
9
10 Eschen, E. and Bresser, R.K. (2005), "Closing resource gaps: toward a resource-based theory
11 of advantageous mergers and acquisitions", *European Management Review*, Vol. 2 No.
12 3, pp. 167-178.
13
14 Finney, R.Z., Lueg, J.E. and Campbell, N.D. (2008), "Market pioneers, late movers, and the
15 resource-based view (RBV): A conceptual model", *Journal of Business Research*, Vol.
16 61 No. 9, pp. 925-932.
17
18 FO Licht (2012), World Ethanol and Biofuels Report, Vol. 10 No. 16, 24 April.
19
20 Ganco, M. and Agarwal, R. (2009), "Performance differentials between diversifying entrants
21 and entrepreneurial start-ups", *Academy of Management Review*, Vol. 34 No. 2, pp. 228-
22 252.
23
24 Geels, F.W. (2010), "Ontologies, socio-technical transitions (to sustainability), and the multi-
25 level perspective", *Research Policy*, Vol. 39 No. 4, pp. 495-510.
26
27 Gereffi, G., Humphrey, J. and Sturgeon, T. (2005), "The Governance of Global Value Chains:
28 An Analytic Framework", *Review of International Political Economy*, Vol. 12 No. 1, pp.
29 78-104.
30
31 Geroski, P.A. (1995), "What do we know about entry?", *International Journal of Industrial*
32 *Organization*, Vol. 13 No. 4, pp. 421-440.
33
34 Gibbon, P. and Ponte, S. (2005), *Trading Down: Africa, Value Chains, and the Global Economy*.
35 Philadelphia: Temple University Press.
36
37 Global Agriculture Information Network Report (GAIN) (2012), Brazil Biofuels Annual
38 Report BR12012. Department of Agriculture: Washington DC.
39
40 Gomez, J., Lanzolla, G. and Maicas, J.P. (2016), "The role of industry dynamics in the
41 persistence of first mover advantages", *Long Range Planning*, Vol. 49 No. 2, pp. 265-
42 281.
43
44 Hamel, G. and Prahalad, C.K. (1994), *Competing for the future*. Harvard Business School Press:
45 Boston.
46
47 Haveman, H.A. (1992), "Between a rock and a hard place: Organizational change and
48 performance under conditions of fundamental environmental transformation",
49 *Administrative Science Quarterly*, Vol. 37, pp. 48-75.
50
51 Helfat, C.E. (2015), "Vertical firm structure and industry evolution", *Industry and Corporate*
52 *Change*, Vol. 24 No. 4, pp. 803-818.
53
54 Helfat, C.E. and Lieberman, L.B. (2002), "The birth of capabilities: market entry and
55 importance of pre-history" *Industry and Corporate Change*, Vol. 11 No. 4, pp. 725-760.
56
57 Helfat, C.E. and Campo-Rembado, M.A. (2016), "Integrative capabilities, vertical integration,
58 and innovation over successive technology lifecycles", *Organization Science*, Vol. 27
59 No.2, pp. 249-264.
60
61 Helfat, C.E. and Peteraf, M.A. (2003), "The dynamic resource-based view: Capability
62 lifecycles", *Strategic Management Journal*, Vol. 24 No. 10, pp. 997-1010.
63
64 Huberman, A.M. and Miles, M.B. (1994), *Qualitative Data Analysis: An Expanded Sourcebook*
(2nd ed.). Sage: London.

- 1
2
3 International Energy Agency (IEA) (2011), Technology roadmap: Biofuels for transport
4 International Energy Agency. Available at
5 http://www.iea.org/papers/2011/biofuels_roadmap.pdf
6
7 Jacobides, M.G. (2005), "Industry change through vertical disintegration: How and why
8 markets emerged in mortgage banking", *Academy of Management Journal*, Vol. 48 No.
9 3, pp. 465-498.
10
11 Jacobides, M.G., Brusconi, S. and Prencipe, A. (2009), "Strategic Dynamics in industry
12 architectures and the challenges of knowledge integration", *European Management*
13 *Review*, Vol. 6 No. 4, pp. 209-216.
14
15 Kagut, B. and Zander, U. (1992), "Knowledge of the firm, combinative capabilities, and the
16 replication of technology", *Organization Science*, Vol. 3 No. 3, pp. 383-397.
17
18 Kapoor, R. (2013), "Persistence of integration in the face of specialization: How firms
19 navigated the winds of disintegration and shaped the architecture of the semiconductor
20 industry", *Organization Science*, Vol. 24 No. 4, pp. 1195-1213.
21
22 Kim, B. and Park, K. (2006), "Dynamics of industry consolidation and sustainable competitive
23 strategy: Is birthright irrevocable?" *Long Range Planning*, Vol. 9 No. 5: pp. 543-566.
24
25 King, A. and Tucci, C. (2002), "Incumbent entry into new market niches: the role of experience
26 and managerial choice in the creation of dynamic capabilities", *Management Science*, Vol.
27 48 No. 2, pp. 171-186.
28
29 Klepper, S. (2002a), "The capabilities of new firms and the evolution of the US automobile
30 industry", *Industrial and Corporate Change*, Vol. 11 No. 4, pp. 645-666.
31
32 Klepper, S. (2002b), "Firm survival and the evolution of oligopoly", *Journal of Economic*, Vol.
33 33 No. 1, pp. 37-61.
34
35 Klepper, S. and Simons, K.L. (2000), "Dominance by birthright: entry of prior radio producers
36 and competitive ramifications in the U.S. Television Receiver Industry", *Strategic*
37 *Management Journal*, Vol. 21, pp. 997-1016.
38
39 Klepper, S. and Sleeper, S. (2005), "Entry by spinoffs", *Management Science*, Vol. 51 No. 8,
40 pp. 1291-1306.
41
42 Knudsen, T., Levinthal, D.A. and Winter, S.G. (2014), "Hidden but in plain sight: The role of
43 scale adjustment in industry dynamics", *Strategic Management Journal*, Vol. 35, pp.
44 1569-1584.
45
46 Mingo, S. and Khanna, T. (2013), "Industrial policy and the creation of new industries:
47 evidence from Brazil's bioethanol industry", *Industrial and Corporate Change*, Vol. 23
48 No. 5, pp. 1229-1260.
49
50 Moeen, M. (2017), "Entry into nascent industries: disentangling a firm's capability portfolio at
51 the time of investment versus market entry", *Strategic Management Journal*, Vol. 38 No.
52 10, pp. 1986-2004.
53
54 Nelson, R.R. and Winter, S.G. (1982), *An evolutionary theory of economic change*. Belknap
55 Press: Cambridge, MA.
56
57 Penrose, E.T. (1959), *The theory of the growth of the firm*. Wiley: New York.
58
59 Perry, M.K. (1988), "Vertical integration", In R. Schmalensee and R.D. Wilig (Eds). *Handbook*
60 *of Industrial Organization*, Vol. 1, Elsevier Science: Amsterdam.
61
62 POET (2013), POET History. Available at <http://poet.com/history>. Last accessed: 30 January
63 2013.
64

- 1
2
3 Qian, L., Agarwal, R. and Hoetker, G. (2012), "Configuration of value chain activities: The
4 effect of pre-entry capabilities transaction hazards, and industry evolution on decisions
5 to internalize", *Organization Science*, Vol. 23 No. 5, pp. 1330-1349.
- 6
7 Raizen. 2013. Our energy generates a better future. Raizen. Available at
8 <http://www.raizen.com/en/raizen/quem-somos.aspx>. Last accessed: 30 January 2013.
- 9
10 Riordan, M.H. (2008) "Competitive effects of vertical integration", In P. Buccirosi (ed.)
11 *Handbook of antitrust economics*, MIT Press: Cambridge, MA. 145
- 12
13 Renewable Fuels Association (RFA) (2013), Global ethanol production statistics.
14 [http://www.ethanolrfa.org/resources/industry/statistics/#1454098996479-8715d404-](http://www.ethanolrfa.org/resources/industry/statistics/#1454098996479-8715d404-e546)
15 [e546](http://www.ethanolrfa.org/resources/industry/statistics/#1454098996479-8715d404-e546). Last accessed: 01 October 2016.
- 16
17 Renewable Fuels Association (RFA) (2016), Annual industry outlook. Washington, DC.
- 18
19 Roberts, P.W., Klepper, S. and Hayward, S. (2011), "Founder backgrounds and the evolution
20 of firm size", *Industrial and Corporate Change*, Vol. 20 No. 6, pp. 1515-1538.
- 21
22 Sanchez, O.J. and Cardona, C.A. (2008), "Trends in biotechnological production of fuel ethanol
23 from different feedstocks", *Bioresource Technology*, Vol. 99 No. 13, pp. 5270-5295.
- 24
25 Shepherd, D.A. and de Tienne, D.R. (2004), "Prior knowledge, potential financial reward, and
26 opportunity identification", *Entrepreneurship Theory and Practice*, Vol. 29 No. 1, pp.
27 91-112.
- 28
29 Short, J.C. and Payne, G.T. (2008), "First movers and performance: Timing is
30 everything", *Academy of Management Review*, Vol. 33 No. 1, pp. 267-269.
- 31
32 Stigler, G.J. (1951), "The Division of Labor Is Limited by the Extent of the Market", *Journal*
33 *of Political Economy*, Vol. 59, pp. 185-93.
- 34
35 Stuckey, A. (1983), *Vertical integration and joint ventures in the aluminum industry*,
36 Cambridge, MA: Harvard University Press.
- 37
38 Teece, D.J. and Pisano, G. (1994), "The dynamic capabilities of firms: an introduction",
39 *Industrial and Corporate Change*, Vol. 3, pp. 537-556.
- 40
41 Teece, D.J., Pisano, G. and Shuen, A. (1997), "Dynamic capabilities and strategic management",
42 *Strategic Management Journal*, Vol. 18 No. 7, pp. 509-533.
- 43
44 Thompson, P. (2005), "Selection and firm survival: evidence from the shipbuilding industry,
45 1825-1914", *Review of Economics and Statistics*, Vol. 87 No. 1, pp. 26-36.
- 46
47 UNICA (2010), Quotes and stats. Available at
48 <http://english.unica.com.br/dadosCotacao/estatistica/>. Last accessed 20 March 2012.
- 49
50 Uzunca, B. (2018), "A Competence-Based View of Industry Evolution: The Impact of
51 Submarket Convergence on Incumbent– Entrant Dynamics", *Academy of Management*
52 *Journal*, Vol. 61 No. 2, pp. 738-768.
- 53
54 Vangen, S. and Huxham, C. (2003), "Nurturing collaborative relation: Building trust in
55 interorganizational collaboration", *Journal of Applied Behavioral Science*, Vol. 39 No. 1,
56 pp. 5-31.
- 57
58 Vidal, E. and Mitchell, W. (2013), "When do first entrants become first survivors?", *Long*
59 *Range Planning*, Vol. 46 No. 4, pp. 335-347.
- 60
61 Walter, L.A., Edelman, L.F. and Hatten, K.J. (2014), "The US brewing industry, strategic
62 windows and survival", *Journal of Management History*, Vol. 20 No. 4, pp. 434-458.
- 63
64 Walter, L.A., Edelman, L.F. and Hatten, K.J. (2016), "Early entry, capabilities and shakeout in
65 the US brewing industry", *Journal of Management History*, Vol. 22 No.1, pp. 24-49.
- 66
67 Wernerfelt, B. (1984), "A Resource-based view of the firm", *Strategic Management Journal*,
68 Vol. 5, pp. 171-180.

- 1
2
3 Wiesenthal, T., Leduc, G., Christidis, P., Schade, B., Pelkmans, L., Govaerts, L. and
4 Georgopoulos, P. (2009), "Biofuel support policies in Europe: lessons learnt for the long
5 way ahead", *Renewable and Sustainable Energy Reviews*, Vol. 13, pp. 789-800.
6
7 Williamson, O.E. (1975), *Markets and Hierarchies: Analysis and Antitrust Implications*. Free
8 Press: New York.
9
10 Williamson, O.E. (1985), *The Economic Institutions of Capitalism*. New York: Free Press.
11
12 Williamson, O.E. (1996), *The Mechanisms of Governance*. Oxford University Press: Oxford.
13
14 Ye, F., Hou, G., Li, Y. and Fu, S. (2018), "Managing bioethanol supply chain resiliency: a risk-
15 sharing model to mitigate yield uncertainty risk", *Industrial Management & Data Systems*,
16 Vol. 118 No. 7, pp. 1510-1527.
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table 1: Industry of origin - Global top-thirty ethanol manufacturers as of end of 2012

Group	Type of entrant - industry of origin	Description	Manufacturers	Global rank
1	<i>De alio</i> - Engineering	Technical & engineering industry background	POET	2
			Abengoa Bioenergy	4
			ETH Bioenergia	5
2	<i>De alio</i> - Farming	Farmer and farmer cooperatives and agro-food and sweetener manufacturers. These firms have a long history in food/sweetener, and some in alcohol production too	Cosan – Raizen*	7
			Guardian Energy	10
			Tereos - Guarani	13
			Shree Renuka	15
			Big River Resources	16
			Jilin Alcohol	18
			TianGuan	26
			Sao Martinho - Nova Frontiera	20
			Greenfield Ethanol	29
3	<i>De alio</i> - Agro-food commodity trading	Main activities are sourcing or marketing agricultural commodities. Some have diversified and also involved in food processing industry	ADM	1
			Louis Dreyfus	8
			Cargill	11
			Bunge	14
			COFCO	17
			The Andersons Group	19
			Noble Group	22
			Marquis Energy	27
4	<i>De alio</i> - Oil and gas	Oil and gas firms and downstream marketers of motor gasoline	Valero RF.	3
			Shell - Raizen*	7
			Flint Hills Resources	9
			Murphy Oil	25
			CNPC	30
			Petrobras-Guarani, N Frontiera **	13; 20
5	<i>De novo</i>	Entrepreneurial spin-offs and start-ups with little or no background in the biofuel supply chain	Green Plains Renewable Energy	6
			Aventine Renewable Energy***	12
			White Energy	21
			BioFuel Energy	23
			Pacific Ethanol	24
			Glacial Lakes Energy	28

Sources: Company websites

Note: *For Raizen, its parent companies, Cosan and Shell, were considered separately (Raizen, 2013).

**Petrobras holds a substantial stake in both Guarani and Nova Frontiera Bioenergy, but does not have a controlling interest.

***Aventine Renewable Energy was merged with Pacific Ethanol in July 2015 demonstrating the continuing evolution of the industry in both expanding scope and scale.

Table 2: Taxonomy of resources and capabilities: Critical R&C of ethanol manufacturers

Core versus complementary resources and capabilities (R&C)		
Core		Complementary
Critical	Non-critical	
Specialised R&C core to operations that match the requirements of SIF, e.g.: <ul style="list-style-type: none"> • Feedstock markets and pricing knowledge • Relationships with feedstock suppliers • Fuel markets and pricing knowledge 	Specialised R&C core to operations, e.g.: <ul style="list-style-type: none"> • Plant operations • Logistics and distribution • Local and country-level knowledge/policy • Co-products markets and pricing knowledge 	Supporting general R&C needed to ensure smooth operation in the new industry, e.g.: <ul style="list-style-type: none"> • Finance and accounting • Administration and HR • Engineering • R&D (short to medium term)

Sources: Authors, based on interviews and analysis of expert opinions.

Table 3: Taxonomy of resources and capabilities: Ease of acquisition of critical R&C

Type of entrant	Core pre-entry R&C	Critical R&C	Ease of acquisition
Group 1: Technology, engineering and construction firms	Process and operations knowledge	Not critical, but it could be significant if advanced technology is developed	Easy to acquire to a satisfactory degree
Group 2: Farmer/farm cooperatives and agro-food manufacturers	Familiarity with feedstock market and control of supply, insurance and risk management	Highly critical at times of scarcity and high volatility	Takes a long time to acquire
Group 3: Agricultural commodities traders	Familiarity with feedstock market, access to credit, insurance, and risk management	Highly critical at times of scarcity and high volatility	Takes a long time to acquire
Group 4: Traditional petroleum firms and downstream marketers	Knowhow in blendstock and additives, control downstream supply chain	Critical in controlling downstream market access	Could be acquired but need capital to build infrastructure
Group 5: <i>De novo</i> entrepreneurial start-ups	Dynamic and entrepreneurial	Not critical but important for long-term growth	Could be acquired or developed but not a critical R&C

Sources: Authors, based on interviews and analysis of expert's opinions.

Table 4: Examples of bi-directional vertical integration in bioethanol sector

2013 Global Rank	Firm (Country)	Upstream		Midstream		Downstream		
		Plantation	Agro-food / service	Ethanol Manufacture	Marketing	Refine/ Blend	Wholesale	Retail
4	Abengoa (Spain)	*	*	2000	2003	2007	2007	
7	Cosan (Brazil)	~1986	~1936	~1970	*	2008	2008	2008
6	GPRES (US)		2007	2007	2007	2008	2008	
22	Noble (Hong Kong)	2007	1994	2007	2007			
7	Shell (Netherlands)		2010	2010	*			
13/20	Petrobras (Brazil)	2010	2010	2010	*			
N/A	Verasun, US			2003	2005	2005	2006	

Source: Data from manufacturers' websites, industry reports and market news reports.

Notes:

- i) Shaded cell(s) indicate the firm's industry(ies) of origin.
- ii) 'Year' or '*' denotes a new position (stage) occupied by the firm and the corresponding year of integration into that specific stage of production along the value chain.
- iii) * - Data not available.

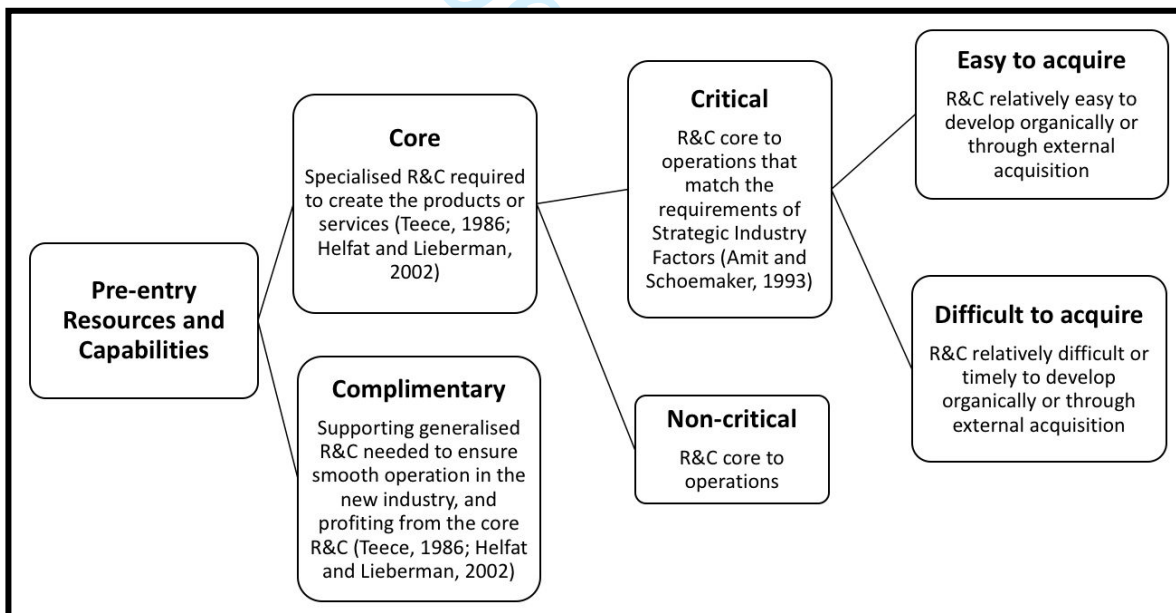


Figure 1: Proposed taxonomic structure for pre-entry resources and capabilities.

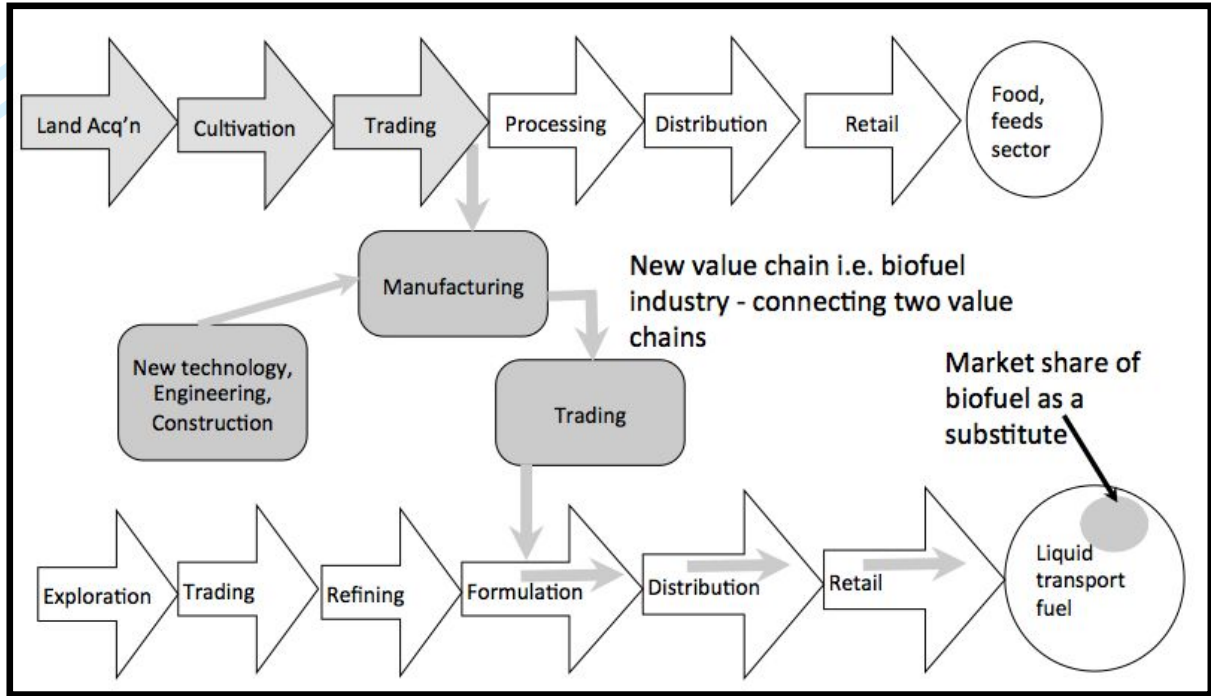


Figure 2: Fuel-ethanol value chain: a crossover of agro-food commodity to energy

Note: Shaded stages represent fuel-ethanol value chain. Produced by the authors.

Appendix A: Top-thirty global manufacturers and market shares, as of end of 2012

Global Rank	Company	Main operating country (HQ)	Global share %	Country share (U.S.) %	Country share (Brazil) %
1	Archer Daniels Midland	U.S., Brazil (U.S.)	5.7	12.6	-
2	POET	U.S.	4.7	10.6	-
3	Valero Renewable Fuels	U.S.	3.2	7.3	-
4	Abengoa Bioenergy Corp	Europe, U.S., Brazil (Spain)	3.2	2.6	0.6
5	ETH Bioenergia	Brazil	2.3	-	7.0
6	Green Plains Renewable Energy (GPRE)	U.S.	2.1	4.7	-
7	Raizen (Cosan & Shell)	Brazil	1.9	-	5.8
8	Louis Dreyfus/Santelisa Vale	Brazil, U.S. (Netherlands)	1.8	-	4.2
9	Flint Hills Resources	U.S.	1.6	3.6	-
10	Guardian Energy (& alliances)	U.S.	1.6	3.6	-
11	Cargill Inc	U.S., Brazil, Europe (U.S.)	1.4	2.2	-
12	Aventine Renewable Energy	U.S.	1.3	3.1	-
13	Guarani (Tereos & Petrobras)	Europe, Brazil (France)	1.3	-	2.0
14	Bunge/Moema	Brazil, U.S. (U.S.)	1.3	1.1	2.6
15	Shree Renuka/Equipav	Brazil, India (India)	1.3	-	3.4
16	Big River Resources LLC	U.S.	1.0	2.3	-
17	COFCO	China	1.0	-	-
18	Jilin Province Alcohol Ind.	China	0.9	-	-
19	The Andersons Ethanol LLC	U.S.	0.9	2.1	-
20	Nova Frontiera Bioenergy (Sao Martinho & Petrobras)	Brazil	0.8	-	-
21	White Energy	U.S.	0.7	1.7	-
22	Noble Group	Brazil, U.S. (Hong Kong)	0.7	-	1.9
23	BioFuel Energy LLC	U.S.	0.7	1.5	-
24	Pacific Ethanol	U.S.	0.7	1.5	-
25	Murphy Oil	U.S.	0.6	1.5	-
26	TianGuan	China	0.6	-	-
27	Marquis Energy LLC	U.S.	0.6	1.4	-
28	Glacial Lakes Energy LLC	U.S.	0.6	1.3	-
29	Greenfield Ethanol	Canada	0.5	-	-
30	CNPC (Jilin Fuel Ethanol)	China	0.5	-	-

Note: (1) Includes plant capacity under construction and plants with significant minority stake. Total world capacity is estimated at 132 billion litres (U.S.=58B; Brazil=43B; rest of world =31B)

(2) '-' = not calculated as not part of top twenty manufacturers in respective country.

Sources: Estimation based on data from EIA (2013); GAIN (2012); RFA (2013); UNICA (2010), firm websites and annual reports.