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Citation: Goodall, A. H. & Pogrebna, G. (2014). Expert leaders in a fast-moving environment. *Leadership Quarterly*, 26(2), pp. 123-142. doi: 10.1016/j.leaqua.2014.07.009

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Expert Leaders in a Fast-Moving Environment

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July 7 2014

Forthcoming in
Leadership Quarterly

Abstract

This longitudinal study explores the influence of leaders on performance in the iconic, high-technology, turbulent industry of Formula One. The evidence is evaluated through the emerging theory of expert leadership which proposes the existence of a first-order requirement: it is that leaders should have expert knowledge in the core-business of the organizations they are to lead (holding constant management and leadership experience). The study's findings provide strong support for the 'expert leader' hypothesis. The most successful F1 principals are disproportionately those who started their careers as drivers. Moreover, within the sub-sample of former drivers, it is those who had the longest driving careers who went on to become the most effective leaders. Remarkably, the leader's former experience in competitive racing is a better predictor of current organizational performance than the driving experience of the person who is actually racing for the team. The study's expert-leader findings are consistent with the hypothesis that longitudinal performance improves when a leader's knowledge and expertise correlate with an organization's core-business activity.

Keywords: theory of expert leadership, organizational performance, high technology, F1.

We are grateful to Paolo Aversa, Agnes Bäker, Janet Godsell, Mark Goodall, Dan Hamermesh, Andrea Isoni, Lawrence Kahn, Andrew Oswald, Axel Wendorff, colleagues at both an IZA brownbag and a Cass management seminar, and special thanks to the associate editor and anonymous referees for their very helpful comments and suggestions. Ganna Pogrebna acknowledges financial support from the Leverhulme Trust as a part of the Early Career Fellowship.

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Introduction

The success or failure of organizations naturally depends on many factors (e.g. resources, path-dependence, human resource capability, economic climate, the executive, and so on). CEOs are usually the most highly paid employees which, arguably, reflects the expectations that executive boards, shareholders and the media place on institutional heads. There is a growing research literature that attempts to isolate the influence that leaders have on performance. Such work attempts to separate CEO effects from industry or firm effects to calculate the explanatory power of leaders on the variance in firm profitability (e.g. Lieberman & O'Connor, 1972; Thomas 1988; Finkelstein & Hambrick, 1996; Bertrand & Schoar, 2003; Jones & Olken 2005; Bennesen, Perez-Gonzalez & Wolfenzon 2007; Yukl, 2008; Mackey, 2008; Dezsö & Ross, 2012; Nohe, Michaelis, Menges, Zhang, & Sonntag, 2013; Lazear, Shaw & Stanton, 2013; Hambrick & Quigley, 2014). In this research, the leader effect varies widely from 4% (Thomas, 1988) to 15% (Wasserman, Nohria & Anand, 2010) up to 30% (Mackey, 2008), and recently closer to 40% (Hambrick & Quigley, 2014). This disparity reflects the challenges that researchers face in trying to separate leader effects from fixed effects in real-world settings (Antonakis, Bendahan, Jacquart, & Lalive, 2010; Blettner, Chaddad and Bettis, 2012).

Our study contributes to this literature. However, we simplify both the measurable inputs and outputs: we focus on a single leader characteristic that we suggest is of fundamental importance, and we are able to include performance data that are unambiguous. We examine leadership and performance using data on the entire history of the turbulent high-technology industry of Formula One (hereafter F1). The evidence is evaluated through the emerging theory of expert leadership (such as Goodall, 2009a, 2012) which proposes that there exists a *first-order requirement*: it is that leaders should have expert knowledge in the core-business of the organizations they are to lead (holding constant the background level of management and

leadership experience). The supporting evidence, outlined below, suggests that leader characteristics that most closely align with the core-business activity of the organization are associated, over time, with better performance.

The study is concerned with theory-testing and, in part, theory-building. Its aims are twofold. The first is to make a novel contribution to the leadership literature by taking a small step in the process of developing a theory of expert leadership. Second, we test further the expert-leader hypothesis in a new setting, one that enables us in an unusually sharp way to examine the effect of different kinds of leaders on key followers. In the next section of the paper we review the extant expert-leader literature. In Section 3 we interpret the empirical patterns through the nascent theoretical lens of expert leadership. The paper's hypotheses, which lead to a new test of expert leaders, are presented at the end of this section. The empirical work begins in Section 4, with a detailed description of our F1 data. This is followed by the econometric analysis and regression results in Section 5. In the penultimate part of the paper, we discuss how our empirical findings extend the theoretical claims, and we conclude in Section 7.

2. Antecedent 'expert leader' research

The approach of this study is to identify the key leader-characteristics that are associated with organizational success. The conceptual idea of expert leaders arose from earlier studies that identified a link between the core-business knowledge (termed expert knowledge) held by a leader and organizational performance. Core-business is interpreted as the primary or underlying activity, namely, that which is considered to be the most important or central endeavor in an organization -- its main source of success and profits.

In this section we will summarize the evidence from which ideas of expert leaders have arisen.

The expert-leader claims are based on evidence from research in a number of settings. The first of these studies analyzed the characteristics of university presidents and institutional performance. Two findings were documented: first, a highly significant cross-section correlation was found between the position of universities in a global league table, and the research success of university presidents (Goodall, 2006)¹. The higher up the institution was in the ranking, the higher were the research citations of the president. This simple pattern motivated a second, more in-depth, investigation. In a longitudinal dataset comprising 157 university presidents, a panel of 55 research universities, and 9 years of performance data, a second pattern was identified. It showed that university performance was linked, a number of years later, to the current president's own scholarly success. The regression equations, which adjusted for confounding variables, revealed that 16% of the variance in university performance could be explained by a president's lifetime citations (Goodall, 2009a,b). The institutions in the sample were research universities. Their core-business is doing research and teaching, though promotion of faculty rests primarily on the former.

New research has moved inside universities. It uses longitudinal evidence on departmental chairpersons in 58 US institutions over a 15-year period (Goodall, McDowell & Singell, 2013). The study finds that there is one robust predictor of a department's future performance: after adjusting for a range of personal and institutional characteristics, departmental productivity improves when the incoming department Chair's publications are highly cited. Approximately 7.5% of the variance is explained by the Chair's citations. By contrast, the quality-weighted publication record per se of the incoming Chair has no predictive power.

¹ The same statistical correlation was found in the FT MBA Ranking between the position of business schools and their deans (Goodall, 2009a).

In a different environment, the high-skill setting of US basketball, the impact of coaches on team performance in the National Basketball Association (NBA) between 1996 and 2003 has been examined (Goodall, Kahn and Oswald, 2011). Data on 219 coach-year observations on 68 coaches were used to compute winning percentages and post-season playoffs. The paper documented the fact that brilliance as a player is associated with (much later) winning percentage and playoff success of that person as a team coach. The results revealed that leaders' effects on performance are substantial and are visible in the data within the first 12 months of a new coach being hired.

Evidence has also been published in a cross-sectional study using US hospital data; it showed that hospitals ranked higher (in the 'US News and World Report, Best Hospitals ranking') were more likely to be led by a clinician (MD) than a professional manager (Goodall, 2011). This finding supports earlier work in hospitals suggesting that the separation of clinical and managerial knowledge is associated with worse management (Bloom, Propper, Seiler & Van Reenen, 2010). Bloom and colleagues concluded that the proportion of managers with a clinical degree had a positive and significant effect on hospital performance. In a related study, Veronesi, Kirkpatrick and Vallascas (2013) found that the number of clinicians on a hospital board was associated with better hospital performance.

Finally, in new research with a slightly different focus, one that analyzes leader competence and worker well-being, there is evidence that a boss's technical competence is the single strongest predictor of workers' well-being (Artz, Goodall & Oswald, 2014). In a cross-section of 6000 young U.S. workers, the job satisfaction of employees is positively associated with whether the supervisor worked his or her way up within the company (or started the company). Second, in a cross-section of 1600 British workers, satisfaction levels are higher among individuals

whose supervisor could if necessary step in competently to do that job. Finally, in pooled cross-sections totaling 27,000 individuals, workers' job satisfaction is highly correlated with the competence of supervisors (Artz, et al., 2014)². These results support the claim that both competence – linked to expert knowledge – and industry experience improve workers' job satisfaction. There is evidence that happier workers also make more productive workers (Edmans, 2012).

3. Expert leadership theory and hypotheses

3.1 Emergent theory of expert leadership

In this section we attempt to develop theory that starts to explain the empirical patterns, described above, and make generalizable predictions about leadership in diverse settings (Sutton & Staw, 1995). We suggest a theory of expert leadership to predict that performance is improved when the expert knowledge of a leader is aligned with the core-business of the organization. This, we suggest, can be viewed as a first-order requirement: knowledge of the core business of the organization is of major importance, holding constant a leader's management and leadership experience. Put simply, the suggestion is that hiring panels should look substantially at the expert knowledge/core-business relationship. Once this is established, other important factors can be scrutinized as a secondary process. For example, two individuals may be identified as potential heads because they fit the first-order requirement of being experts in the organization's core business. However, both of these experts might differ hugely in the more subjective attributes, for example, their style of leadership (transactional/transformational), or their personality (charisma/traits), and also in the nature of their relationships (leader–member exchange). These secondary factors are likely to exhibit greater disparities. It is important to

² This body of work includes a further example from UK soccer not summarized for reasons of brevity.

note that expert knowledge is not viewed as a proxy for management skills or leadership experience; these factors are required by all senior executives.

Attention to leaders' core-business knowledge is apposite. Recent evidence shows that major firms have moved away from hiring CEOs who might be considered specialists (with technical degrees), towards instead the selection of leaders who are generalist managers (Frydman, 2007; Bertrand, 2009). Professional managers have replaced experts in leadership positions in a number of industries, of which healthcare is an appropriate example. Hospitals in the US and UK used to be led by doctors. Today, in US hospitals approximately 4% of CEOs are medically trained (MDs) (Gunderman & Kanter, 2009), and there are even fewer in the UK. The evidence from hospital studies outlined above suggests that the pendulum may have swung too far towards managers (Bloom, Propper, Seiler & Van Reenen, 2010; Goodall, 2011; Veronesi, Kirkpatrick & Vallasas, 2013).

Expert knowledge, we propose, incorporates two elements: ability in the core-business activity (i.e. success in scholarship if in a university, or consulting success if in a consulting firm), combined with industry experience (i.e. number of years spent in a sector). We submit that expert knowledge is acquired through technical education, and a combination of domain-specific knowledge and experience (Chase & Simon, 1973; de Groot, 1978). These forms of explicit and tacit knowledge (Nonaka & Takeuchi, 1995) may facilitate leaders' intuitive decision-making, akin to wisdom (Tichy & Bennis, 2007). Performance might therefore be attained through mechanisms of expert decision making, derived from domain-knowledge, experience and practice (Ericsson, Krampe, & Tesch-Romer, 1993; Salas & Klein, 2001; Salas, Rosen & DiazGranados, 2010). The literature on which the expert-leader proposition rests

(presented earlier), suggests that *level* of ability in the core business activity is important; it is not merely experience and technical qualifications that matter³.

Does expert knowledge constitute a trait? Zaccaro, Kemp & Bader (2004) suggest that leader traits should, among other factors, be considered as ‘integrated constellations of attributes that influence leadership performance’ (Zaccaro, 2007. p. 108). ‘Understanding leadership’, Zaccaro argues, ‘requires a focus not only on multiple personal attributes but also on how these attributes work together to influence performance’ (in Zaccaro, 2007. p. 108 citing Yukl & Van Fleet, 1992; Zaccaro et al., 2004). It is difficult to disagree with this logic; however, to unscramble and assess leader inputs and performance outcomes, from an interaction of multiple complex variables, may be particularly problematic. Instead, we attempt to narrow the field of observation, and introduce a sequence of priority. Thus far the empirical evidence suggests that the expert knowledge variable explains on average fifteen per cent of performance. Arguably, traits play a key role in expert knowledge, through motivation and ability (Bray, Campbell, and Grant, 1974) among other attributes. This warrants further investigation in future research⁴.

The suggestion that leaders and followers should share technical expertise in creative work environments has been known for some time. In a study of research institutes, Andrews and Farris (1967) found that the best predictor of a researcher’s creative performance was the leader’s level of technical ability as compared with other factors including motivating others, maintaining group relationships, and the amount of autonomy granted to staff. These results were replicated by Barnowe (1975) and later in other studies summarized in Mumford, Scott, Gaddis, and Strange (2002). Mumford et al. (2002) report, first, that both technical and creative

³ For example, in universities it is possible for an academic to drop out of research early in his or her career to become a full-time administrator. However, as mentioned above, these kinds of leaders were shown not to be beneficial to the performance of research universities; instead, the evidence suggests that the better the scholar as president, the better the future research performance of the university (Goodall, 2009a,b).

⁴ We would like to thank an anonymous referee for bringing to our attention the relevance of the trait literature.

problem-solving skills are necessary when leading creative individuals; this combination informs how leaders create an appropriate work structure, and gives them credibility which enhances a leader's influence (2002, p. 712). Second, they argue that the evaluation of creative people and their ideas is best done by individuals who share their competencies. Third, leaders who share the same creative and technical perspective and motivation as their followers can, they suggest, communicate more clearly; finally, in relation to performance, they can better articulate the needs and goals of the organization (Mumford et al., 2002).

The modest but growing body of research advancing the expert leader assertion directly builds on these studies. However, our F1 study differs empirically and theoretically in distinct ways. First, and, importantly, the data are from a high-technology competitive setting that is very different to the creativity or research environments summarized in Mumford et al. (2002); second, we use empirical tests that differ substantially from those summarized by the authors. These earlier papers report cross-section correlations from a *single* point in time (the only exception is Farris 1969 who had two points in time⁵). Our paper uses longitudinal data; it is a case study that contains information from the whole history of the F1 industry, and we link leader-characteristics to more objectively measured performance outcomes. Third, we include a unique interaction analysis where it is possible to examine the effect of different leader-types on the performance of key followers.

Lastly, our F1 study diverges from Mumford et al. (2002) in its theoretical claims. Although still embryonic, it is intended that the expert leader proposition be advanced as a generalizable leadership theory -- one that may be applicable in different organizational situations, from within knowledge-intensive organizations, to manufacturing and retail, for example. To build theory,

⁵ A table outlining the studies reviewed in Mumford et al. (2002) is in Appendix 3.

arguably, an important part of the process is to establish its empirical boundaries, by performing tests in different settings. Mumford and colleagues state clearly that they only ‘review the available literature examining leadership behaviors contributing to creativity and innovation’ (2002, p. 705); importantly, we do not believe that these authors were intending to establish a comprehensive or generalizable theory of leadership.

Before concluding our theoretical discussion, it is important to briefly acknowledge the rich body of work motivated by upper echelons theory (Hambrick & Mason, 1984) that feeds into the ideas of expert leaders. The upper echelons literature shows, in its simplest form, that top managers make strategic choices that are reflections of their own values and cognitions, derived often from domain knowledge among other influences (see Carpenter, Geletkanycz, & Sanders, 2004 for a review). One possible difference in approach is that upper echelons theory has tended to place greatest emphasis on the characteristics of the top management team, whereas our work, including previous studies, isolates the leader himself or herself.

3.2. Leader taxonomy

F1 is made up of constructors (e.g. Ferrari, Williams, McLaren, etc.) who compete each season in Grand Prix races to win Championships. Constructors are medium-sized companies that employ on average around 400 people. Constructors need to raise an approximate annual amount of \$200-\$300 million dollars to compete in F1. Leaders of constructor teams, called principals, operate in a skilled and stressful environment which requires quick decision-making. The role of the leader in F1 is to run the team. Some differences exist in responsibilities between constructor teams; however, it is usual for the team leader to determine the long-term strategy, to control technical matters, and to make the majority of financial decisions. Leaders also oversee the selection of drivers, who compete for their teams, and have a final say in making tactical

decisions during each race. Some principals -- for example Frank Williams -- own and run their own teams. Owner-leaders have extensive powers. In other cases, principals are hired by owners to manage their teams. Such is the relationship between the beverage company Red Bull and principal Christian Horner. With large automobile manufacturers involved in racing, for example Mercedes, Renault and Ferrari, it is usual for a principal to be appointed, although their direct powers and responsibilities may vary across teams.

In our F1 dataset (described below), it is possible to observe and classify every leader over the complete history of the industry, between 1950 and 2011. The dataset also enables us to measure exact organizational performance. We have objective data on the performance of each leader's organization in each year allowing for minimal measurement error. We also have, within the dataset, the ability to link organizational success today to the leader's characteristics measured when those individuals were much younger.

In this paper we argue that when the core-business activity of the firm aligns with the expert knowledge of the leader, it produces better organizational performance. In F1, the core-business is to win the annual Championship by gaining points in Grand Prix races. In our data, four distinct leader-types are found: those who were managers from other industries, former engineers (with degrees); those who were formerly mechanics; and, finally, former racing drivers. There was little ambiguity in leaders' classification (discussed further below). The leader taxonomy is as follows.

Manager-leader: These were generalist leaders represented by former managers or entrepreneurs, who had significant knowledge about business in general, but knew very little about the core industries related to F1. They typically spent most of their careers in business and moved to F1 from a different (and often unrelated) industry. Manager-leaders tend not to have had much direct experience of the sector or racing driving, nor did they have technical education

in car making or mechanical engineering or a connected field. They were also more likely to have become involved in the industry relatively late in their careers. Manager-leaders, therefore, have the lowest level of expert knowledge.

Engineer-leader: This group obtained degrees at university in mechanical engineering or a related field. They were technical specialists but had no experience of the core business activity (driving). Former engineers tended to have less direct knowledge of how F1 teams function, because they were often a step back from the track. Engineers never raced competitively and they often came into the field later than both mechanics and drivers. Engineer-leaders, therefore, have a low level of expert knowledge.

Mechanic-leader: Former mechanics have the most practical technical experience in car making and mechanical repair. They tend not to have driven competitively, nor had they a degree in mechanical engineering or a related area. However, mechanics often spent many years in the field of automobile racing and they worked very closely with drivers. Mechanic-leaders, therefore, represent experienced leaders although they have no knowledge of the key activity of driving. Former mechanics have a medium level of expert knowledge.

Driver-Leader: Finally, former drivers usually start competitive racing from an early age (around 6-8 years old). They then progress from Go-kart racing to professional racing by their early 20s. Former drivers are experienced specialists; they need to be familiar with the technical side of car making, as well as with mechanical aspects of car improvement and repair. Former mechanics have significant knowledge in the technical domain, some of which is shared with drivers. In addition, drivers have racing expertise and are likely to have a greater understanding of strategy (i.e. they have experience on more than one dimension), because they work with all parts of F1 teams. Drivers are usually the highest paid among team members. Driver-leaders have an advanced level of expert knowledge.

3.3. Hypotheses

In this paper we raise three hypotheses. Hypothesis 1 encapsulates the paper's key theoretical claim, laid out in Section 2, that F1 leaders who were former racing drivers are associated with greater team success. The idea is represented diagrammatically in Figure 1. Team leaders who were formerly drivers -- when compared with team leaders who were formerly managers, engineers and mechanics -- have the highest level of expert knowledge, that we argue is a fundamental contributing factor correlated with later organizational performance. As depicted in Figure 1, the next-highest are the former mechanics, and then the graduate engineers and general managers. Overall, the greater is a leader's expert knowledge, the better is the performance of the F1 team.

Hypothesis 1: *F1 leaders who were former racing drivers have a high level of expert knowledge (long industry experience and high ability in the core-business activity) and thus former drivers are more strongly associated with later organizational performance than other leader types. [See Figure 1.]*

[INSERT Figure 1 HERE]

Hypothesis 2 posits that the more years spent in competitive driving, the better the leader-outcomes a number of years later. This is represented in the matrix in Figure 2. It shows that former drivers with more than five years racing experience are associated with the best performance outcomes as leaders.

Hypothesis 2: *The more years that former racing drivers raced competitively, the better the results when they become team principal.* [See Figure 2.]

Finally, a new empirical insight into expert leadership is advanced in hypothesis 3 and represented again in Figure 2. It suggests that expert leaders – former drivers – have a direct influence on the performance of the key follower – the current driver. Hypothesis 3 proposes that the F1 racing experience of the current driver is less important to race performance than the racing experience of the team leader.

Hypothesis 3: *A former racing driver's competitive experience matters more to leadership and team performance than the F1 racing experience of the current driver (the key follower).* [See Figure 2.]

[INSERT Figure 2 HERE]

4. Data and basic statistics

F1 is estimated to be worth approximately \$6 billion annually (Sylt & Reid, 2011). Constructor teams' profits come from advertising and TV revenue. F1 is the most widely watched sport after the Olympics and Football's World Cup, with over 500 million TV viewers in 2012⁶. A higher finishing position, primarily a podium (first to third), generates more sponsorship and TV income. Increasingly, modern teams are raising money from the development of F1 technologies that spill-over into other industries (McLaren have an associated company, Applied Technologies, as do Williams). It is an interesting industry intellectually because it is subject to a great deal of regulatory turbulence. The Fédération Internationale de

⁶ Christian Sylt, theguardian.com, Friday 15 February 2013.

l'Automobile (FIA) imposes strict conditions that change annually, on all aspects of F1 (the teams, technology, resources, track, tires, drivers, etc.). A link between regulation and innovation has been well documented (see Stewart 2010 for a review). This relationship is embodied in F1; regulation is unambiguously associated with innovation and performance (Jenkins, 2004; Jenkins, Pasternak & West, 2007; Khanna, Kartik & Lane, 2003; Jenkins 2010, Marino, A., Aversa, P., Mesquita, L., & Anand, J. 2013), and regulatory compliance produces a level playing field for all competing teams. Indeed, sometimes rule changes are made with the specific intention of curtailing the dominance of one team, for example with Ferrari and Michael Schumacher in 2003 (Hoisl, 2011).

Teams' common motivation means that relative comparison of teams' performance can be more exact than in settings where different companies make different products: the setting offers an unusual opportunity to compare organizations in a precise way. In addition, the core work-teams in F1 are relatively small (average of 400), which arguably allows a natural and suitable background against which to begin to try to understand the influence of leaders.

We collected data on: the starting and final position of all cars that participated in each race; the constructor teams; their leaders' names, personal information and background; the drivers' personal information and background; and information about each race circuit. For a small number of years, information is also available on team budgets (2006 and 2008). The data were compiled from two main sources. For car entries, circuit, constructor, driver, as well as other detailed Grand Prix race information, we used the FORIX online database of Autosport magazine accessible on <http://forix.autosport.com>. The names and background information on each team leader were taken from the Grand Prix Encyclopedia website <http://www.grandprix.com>.⁷

⁷ In some cases, when more detailed information for any particular leader was required, we have double-checked biographical information with information recorded in official biographies of leaders who currently hold positions

4.1 F1 constructors

The dataset covers the performance of every team in every Grand Prix season since the industry began. This is for six decades of the F1 World Constructors' Championship between 1950 and 2011 (62 seasons) resulting in a total of 19,536 car entries in 858 races. There are 106 constructor teams in these historical data. Constructors contract with numerous auto component suppliers because since 1981, they are obliged to build their own race car chassis, and often also engines (Castellucci & Ertug, 2010). The goal of an F1 constructor is to maximize the number of points gained in races. In recent years each team entered two cars in consecutive races every year. Championship points are awarded based on the final position of each car at the end of the race (the first car wins the largest number of points, with other race points assigned, in a declining way, down to tenth position). Constructor teams are comparable in size. Identical criteria are applied to measure their performance.

In contrast to many industries that greatly vary in size and output, F1 constructor teams are fairly homogeneous in their size, capabilities, and approximate productivity. These characteristics make it scientifically a valuable industry for study. The higher is the position of the car in the final grid, the more points are awarded to its constructor team.

In each racing season the number of constructor teams in the Championship can differ. For example, 21 teams competed in 1960, while only 12 were in the Championship in 2011. The decline in the number of competing teams is primarily due to the cost associated with the sport which has increased over the years. If in 1950s and 1960s amateur mechanics could enter their self-made cars into races, current race car manufacturing requires long-term R&D investments and expensive testing, which is affordable only through a narrow circle of sponsors. The budgets of constructor teams are largely secret. Most of the money is spent on technology which

on TV or in the Fédération Internationale de l'Automobile (FIA) – the F1 governing organization, and sometimes on Wikipedia.

contributes a great deal to a team's winning prospects (Read, 1997; Wright, 2001; Jenkins, 2010). The R&D investment in F1 eventually shows up as new technologies in automobiles that the public drive.

4.2 F1 leaders (independent variable)

As discussed above, we also collected background information about leaders of all F1 constructors (e.g. Ferrari, McLaren, Williams, Mercedes, etc.) for the same sixty year period, 1950-2011. The four distinct leader-types are: those who were managers from other industries, former engineers (with degrees); those who were formerly mechanics; and, finally, former racing drivers. Leaders are fairly evenly distributed across the four background groups. More precisely, in the history of the industry there were 42 (29.8%) managers, 35 (24.8%) drivers, 31 (22.0%) mechanics, and 33 (23.4%) engineers. All leaders in our data were male.⁸

Despite what might be thought about the possibility of ambiguity in leaders' classification, such cases are rare. For example, only 7 leaders out of the 141 are classified as mechanics but also had competitive driving experience, and 4 leaders who are classified as drivers but also had some experience as mechanics. Several leaders had either multi-level experience or different industry experiences. In the few cases of doubt, leaders were assigned to their type according to the highest level of knowledge and primary area of activity.

We collected the entire population of entries into F1 World Constructors' Championship. Some minor omissions were inevitable. All team executives listed by the team as 'principal of the racing team' or 'team principal' could be identified as team leaders. Some teams in F1 history, however, were managed by several executives, i.e., by collective leaders. Since the focus of this paper is on individual leaders, we excluded those collective leaders from

⁸ This is due to the fact that, until the year 2012, women never led F1 teams.

consideration (29 collective leaders, 1,351 car entries). In two further cases we were unable to identify team leaders or locate their biographical information. These observations were also excluded (460 car entries). The resulting dataset, therefore, contains information on 141 individual leaders who at different points of their lives represented 106 constructor teams and entered 17,725 cars into F1 World Constructors' Championship.

4.3 F1 Grand Prix (dependent variable)

Our performance data are on podium positions (that is, teams coming number 1-3 in a race). Podium places award a team the highest number of points, when compared to finishing lower down on a race day, and allow different teams to be compared in a consistent way. The number of races increased in a secular way from 7 in 1950 to 19 in 2011. A myriad of regulations apply in F1 to engine and chassis design, tires, tactics allowed by drivers and so on; noticeably, these rules often changed from one season to the next⁹. This does not interfere with our statistical inference because the changed rules applied to every team in each championship. In the later econometric analysis, we control for the year of competition and therefore take into account these technical alterations from season to season.

Table 1 summarizes the different championship point systems which have existed in F1 between 1950 and 2011.

[INSERT Table 1 HERE]

To allow a consistent measure of performance in the econometric analysis, we therefore use the relative final positions of cars in the race (instead of the number of obtained points). Since most points are awarded for podium positions (that is, for finishing 1, 2 or 3 in a particular race),

⁹ Jenkins (2010) provides a detailed summary of these changes and their impact on F1 technology.

we concentrate on winners of podium positions for each race. Using data on podiums also helps us to have a measure of success which is stable through the years of the industry.

4.4 Control variables

The regression analysis includes variables for other factors that may influence performance. We include controls for each race circuit (which may affect race performance due to a specific track shape or weather conditions). There are 71 race circuits in the dataset. Second, as mentioned above, a control is included for each year of competition (1950-2011); this adjusts for annual differences in the rules and regulations, which are factors that make F1 such a turbulent environment in which to compete. Third, we adjust for the number of cars competing in each race, because those numbers affect competitive pressure.

Finally, we control for each constructor's brand by allowing for team fixed effects. This is a particularly important feature of the analysis. Some constructors perform consistently better than others and that fact has to be incorporated into the estimation. For example, it might be that Ferrari or McLaren often outperform others not because they have successful leaders but because they have a long history of competing in F1 and thus traditionally had better facilities, more sponsorship money, intense public support, and highly experienced human resources. To calculate the influence of leaders, we need to control for these background differences. In the econometric analysis, therefore, a separate variable is included for each constructor brand (one for Ferrari, one for Red Bull, one for McLaren, etc.).

It might be expected that the amount of money each constructor spends would have an impact on outcomes. Unfortunately, teams do not release information about their budgets. Nevertheless, it has been possible for us to locate teams' financial investment for a small number of years (2006 and 2008). We include these results in a separate regression table in Appendix 2.

Importantly, the table shows that inclusion of constructor money does not affect our key findings about leader type (see Appendix 2).

Explanatory variables used in our regression analysis are summarized in Table 2.

[INSERT Table 2 HERE]

Descriptive statistics

Summary statistics are presented in Table 3. They show that between 1950 and 2011 the highest numbers of cars were entered by constructor teams led by former mechanics (7,456), which is explained by a statistical over-representation of mechanics in the early years of famous teams. The statistics reveal that podium frequency (i.e., winning a first, second or third place in a race) and average wins frequency (i.e., coming first in a race) are more prevalent among teams headed by drivers and mechanics as compared with managers or engineers. Drivers and mechanics also have higher average pole frequencies (finishing first in the qualifying, and, as a result, starting the race at the very front of the grid) and average fastest lap (showing the fastest time in the race on any given lap).

[INSERT Table 3 HERE]

In our dataset, the mean propensity to gain a podium position is 0.14 and the standard deviation is 0.34. Therefore, on average, a constructor team has a 14% chance per race of winning a podium.

The mean values in Columns 4 and 5 of Table 3 reveal that the most successful leaders were former drivers closely followed by mechanics. Drivers are associated with a winning team in 7% of races, and they garner a podium position in 17% of races. The performance of teams led by mechanics is similar (winning 6% of the time, and getting podiums 16% of the time). Teams

headed by leaders of a manager type obtain worse results: they win 3% of races and obtain podium positions in 12% of the races. Constructor teams led by engineers fare even less well: 3% wins and 8% podiums. Similar patterns are found for average pole frequency and average fastest lap frequency. These findings are represented in Table 3.

Although the raw patterns reported in Table 3 are of interest, they should not be interpreted in too literal a way. The data provide a preliminary summary without accounting for any control variables. Those variables potentially have an important impact on teams' performance and, therefore, may interact with leaders' types.

5. Econometric Analysis and Results

In this section we use econometric analysis to test the hypotheses in Section 3.

5.1 The impact of leader types on organizational performance

We explore whether constructor teams' performance in F1 depends on leaders' types. In each of the regressions, the dependent variable is a measure of the performance of the team based on the final position of each car in every race. The key explanatory variable is a leader's classification (that is, former: manager, driver, mechanic or engineer). Finally we include control variables for each constructor, the race track, the number of cars competing and each race year.

As reported earlier, the raw data revealed a simple pattern: that two leader-types appear to be associated with the most wins and podium positions. We therefore begin with a preliminary analysis by dividing the data into these two groups: drivers and mechanics, and managers and engineers. We begin with a simple ordinary least squares (OLS) estimator. Model 1 in Table 4 reports an OLS regression model without control variables and then provides results with

controls in Models 2-5. Table 4 treats the data in a cardinal way and estimates an ordinary least squares linear probability model. The dependent variable $\pi_i \in \{0,1\}$ records whether a particular car i has won a podium in a race ($\pi_i = 1$) or did not win a podium in the race ($\pi_i = 0$).

[INSERT Table 4 HERE]

Column 1 of Table 4 reports results of an OLS regression model in which a dummy variable is entered for leaders classified as drivers or mechanics. Since π_i is a simple binary variable, the estimated coefficients of this dummy, in the first column of Table 4, give estimates of the effects of drivers or mechanics as compared with managers or engineers on the propensity to gain a podium position. In each row, the base category is that of manager or engineer.

In Table 4 the coefficient on driver or mechanic in Column 1 is 0.066 (with a t-statistic of 12.56, which implies that the null hypothesis of a zero coefficient can be rejected at 0.001 level). Because the mean probability of securing a podium position for teams headed by leaders of all types is approximately 14%, a coefficient of 0.066 implies that having former driver or mechanic as a leader increases a team's propensity to win a podium position by 6% yielding the mean propensity of approximately 20%.

The remaining columns of Table 4 report specifications after we add control variables to the basic regression analysis. These include the circuit where the race is taking place, the year of competition, the constructor team a particular car represents, and finally, the total number of cars that participate in the race.

Column 2 of Table 4 reveals that after controlling for the circuit, it is drivers and mechanics compared with managers and engineers that are associated with a higher propensity of winning a podium position: the t statistic is 12.50 ($p < 0.001$). In columns 3-5 as we add more controls for

the year of competition, constructor team dummies, and number of cars in each race, the results remain stable. Overall, Table 4 shows that drivers and mechanics are associated with better organizational performance compared with managers and engineers.

Results of the basic analysis reported in Table 4 do not allow us to single out how much of an effect individual leaders' unobserved heterogeneity has on the propensity of constructor teams to gain podium positions controlling for leader types. The dataset has a specific form: each leader (within each constructor team) enters two cars in multiple races within each year. Some leaders (constructor teams) compete in many seasons whereas others drop out after participating in the Championship for one year. Therefore, our dataset represents an unbalanced panel which has more than one observation for each leader within each time period. So that we can incorporate individual underlying differences (unobserved heterogeneity) at the level of each leader -- to account for the binary nature of the dependent variable (winning or not winning a podium position) and to make use of the complex structure of our panel dataset -- we use a multilevel probit regression specified in the following way (see Snijders & Bosker, 1999 for details).

Assume that the dichotomous dependent variable θ is produced by a threshold model with underlying variable $\tilde{\theta}$ given by

$$\tilde{\theta} = \beta_0 + \sum_{k=1}^n \beta_k x_{kij} + u_j + \varepsilon_{ij} \quad (1)$$

where $x_1 \dots x_n$ are explanatory variables; $\beta_0, \beta_1 \dots \beta_n$ are coefficients. Variance $\sigma_\varepsilon^2=1$ and the variance of the random intercept σ_u^2 is estimated jointly with the coefficients. Log-likelihood is approximated using Gauss–Hermite quadrature. The results from this multilevel probit regression were similar to those in Table (there are available from the authors on request).

We also estimate the effect of each leader type (managers, drivers, mechanics and engineers) separately. We run models with unobserved individual heterogeneity at the level of each leader. Table 5 reports the results of the probit estimations which include several confounding variables

(shown in Table 2). In these estimations, we are interested in determining the probability of team leaders with different backgrounds (manager, driver, mechanic, and engineer) securing a podium position for their teams. The impact of leaders' types on propensity to gain a podium position (1-3) is measured compared to that of manager (the omitted base category).

[INSERT Table 5 HERE]

In Table 5, the probit model in Column 1 controls only for each Grand Prix circuit (71 circuits). Compared to managers, teams headed by drivers are statistically more likely to win a podium position, irrespective of the influence of the circuit. The coefficient is slightly greater than 0.20 (z-statistic 5.09, $p < 0.001$). Mechanic-leaders are a little less influential – coefficient is less than 0.20 and z-statistic 6.01, $p < 0.001$). In Table 5 engineers have a statistically significantly negative effect on obtaining first, second or third place in a Grand Prix (coefficient approximately -0.24; z-statistic -5.99, $p < 0.001$).

Column 2 of Table 5 extends the set of independent variables. It includes controls for both the circuit and each year in our dataset (1950 to 2011). This new addition of the year dummies does not change the results appreciably. Drivers and mechanics have a statistically significant effect on the probability of a podium position, whereas engineers have a negative influence.

The results change noticeably in the specification of Column 3 in Table 5. Here we include constructor dummies. Teams like Ferrari show up strongly – with large coefficients. Between 1950 and 2011 Ferrari won 16 World Constructors Championships – more than any other team in the history of F1. The constructors' effects on race performance are evident in the seven-fold increase in the pseudo- R^2 which rises in Table 5 from approximately 0.02 in Columns 1 and 2, to 0.14 after the addition of team fixed-effects.

Column 3 of Table 5 illustrates an important finding: drivers now have a statistically significant and positive effect on the probability of a podium position; the effect of mechanic-leaders is now insignificant, while engineer-leaders remain negative and insignificant. In this estimation, the coefficient on drivers goes up slightly and equals to approximately 0.29 (z-statistic 4.71, $p < 0.001$). The results in the last column of Table 5, with the inclusion of the fourth potential confounding variable -- the number of cars qualifying in each race -- remains similar to those in Column 3. We check the robustness of our results by estimating several multilevel probit models. These results are qualitatively similar (and available from the authors on request).

A further check is whether there is a home-race effect. One of our regression variables allows us to control for the impact of a specific circuit. The home-race effect accounts for the possibility that constructors may have competitive advantage if the race circuit is in the same country where the team headquarters are located. Constructors may be more likely to win a podium position in their home country (akin to the home-effect in soccer for example). To control for the home-race effect, we first compare the frequencies of winning a home race versus winning a race abroad for our entire sample of car entries. We find no relationship between the average frequency of winning a podium position at home as compared with abroad.¹⁰

5.2 The impact of the length of leader's racing experience on performance

The findings in Tables 4-5 suggest that former drivers and mechanics are statistically more likely to lead their constructor teams to win podium positions. Our hypothesis that improved performance is associated with leader-characteristics that most closely align with the core-business activity, can now be examined in a new test. Here the focus is on the number of years

¹⁰ Tables and estimations reporting this result are available from the authors upon request.

leaders spent in competitive racing. This might be viewed as akin to executive tenure, which the upper echelons literature suggests can be used as a proxy for a number of factors (for example, cognition, knowledge, interest and power), that influence a leader's decision making and performance (Hambrick & Fukutomi, 1991). The results from our time-in-industry estimations are reported in Table 6.

Interestingly, in Table 6, the length of the previous experience of the leader as a competitive driver has a positive and highly significant effect on performance in all estimations. Overall, leaders' unobserved heterogeneity within each race accounts for about 30% of variation in winning a podium position when we do not control for the constructor team (e.g., standard deviation of variability of leader's individual effects are equal to 0.302 in Model 1 in Table 6). However, once we add controls for the constructor teams, the individual effect of each leader within each race decreases significantly suggesting that accounting for constructor team is very important (e.g., standard deviation of variability of leader's individual effects are equal to 0.135 in Model 3 in Table 6).

In Table 6 we also present estimations for all leaders with previous experience of practicing as a mechanic (in our dataset there are 31 leaders classified as mechanics; but also 4 drivers and 6 engineers who also spent some time as mechanics). We use equation (2) where $X1_i^t$ is the leader's year of experience as mechanic in the past and $X2_i^t \dots XM_i^t$ are explanatory variables capturing circuit, year, constructor and number of cars in each race $\beta_1 \dots \beta_M$ are marginal effects and α_i is a vector depicting unobserved individual heterogeneity at the level of every leader in each season. Unlike former drivers' experience, mechanics' experience appears to have a negative effect on performance. This result is significant in all three models presented in Table 6. This suggests that while having mechanical experience *per se* is a positive factor for team

performance, as shown by our previous analysis, the length of a leader's experience as a mechanic fails to improve team results.

Part of the explanation for these findings may be that mechanical experience does increase knowledge in the core industry, but it is not alone a sufficient condition for performance improvement when present on its own. Ability in the core business activity also appears to be necessary. Mechanics likely concentrate on the technical side of developing a car, thus when they become leaders they may be able to effectively communicate technical information to their subordinates. However, former drivers understand how technology may directly affect driving ability as well as strategic component of racing.

5.3 The impact of the leader on the key follower – the driver

To this point, the analysis has suggested that the length of leader's previous experience in competitive driving has a significant positive impact on organizational performance in F1 constructor teams: the higher is a leader's experience as a driver in the past, the more likely his team is to win a podium position in a given race. Yet, it is interesting to consider the impact of a leader's previous experience on team performance not only separately, but also in conjunction with the performance of key followers (drivers who compete for the team). This addresses hypothesis 3.

In recent years, constructor teams compete with two cars in each Grand Prix race; however, the number of cars per team has varied throughout F1 history between 1 and 2. Since each observation in our dataset is a car entry, driven by a particular F1 driver and representing a specific F1 constructor team, which takes part in the F1 Constructor Championship, we can look at a combination of leader-driver performance for each entry in our dataset. We consider the length of a leader's experience as a competitive driver in the past in conjunction with the length

of experience of drivers who currently compete for this leader's team. We look at each current driver's experience as a competitive driver in F1.¹¹

For one leader in the dataset, it was not possible to identify drivers. We have thus excluded those 7 car entries from the analysis. Therefore, the resulting data for the analysis of leader-driver experience combinations consisted of 140 leaders, 662 drivers, and 17,718 car entries.

In the remaining dataset, there is considerable individual heterogeneity in terms of length of experience both among 140 leaders (the length of experience ranges from no experience to 17 years of experience with the mean of 7.3 years, standard deviation of 5.1 years and the median of 7 years) and 662 drivers (the length of experience also ranges from no experience to 17 years of experience with the mean of 3.8 years, standard deviation of 3.4 years and the median of 3 years). In order to simplify the analysis and construct a sensible number of leader-driver experience combinations, we identify 3 cohorts of leaders and 3 cohorts of drivers dependent on the length of their experience.

We distinguish between the following cohorts of leaders:

- **Leader None (dr)** – leader's previous experience as a competitive driver is equal to 0 years;
- **Leader Medium (dr)** – leader's previous experience as a competitive driver is equal to 1 to 5 years;
- **Leader Long (dr)** – leader's previous experience as a competitive driver is greater than 5 years.

At the same time, we identify 3 cohorts of drivers:

- **Driver None** – driver's previous experience as a competitive driver in Formula 1 is equal to 0 years;

¹¹ Note that while a leader's experience is measured as number of years a leader participated in various competitions (not only F1) as a competitive driver before becoming an F1 team principal. At the same time, a current driver's experience is measured as an experience of a particular driver in F1 competition to the date of a given race.

- **Driver Medium** – driver’s previous experience as a competitive driver in Formula 1 is equal to 1 to 5 years;
- **Driver Long** – driver’s previous experience as a competitive driver in Formula 1 is greater than 5 years

While each leader’s cohort does not change throughout the dataset (because we take into account leaders’ experience before they have become principals in F1), drivers may move from the cohort DN to the cohort DM and then to the cohort DL throughout the dataset (because they gain experience from one year to the next as long as they stay in F1). Given these cohorts, we can identify 9 combinations of leader-driver experiences:

1. LN(dr)-DN: 1654 (9%) experience combinations from 1950 to 2011;
2. LN(dr)-DM: 615 (3%) experience combinations from 1950 to 2011;
3. LN(dr)-DL: 530 (3%) experience combinations from 1950 to 2011;
4. LM(dr)-DN: 6710 (38%) experience combinations from 1950 to 2011;
5. LM(dr)-DM: 1547 (9%) experience combinations from 1950 to 2011;
6. LM(dr)-DL: 2020 (11%) experience combinations from 1950 to 2011;
7. LL(dr)-DN: 3296 (19%) experience combinations from 1950 to 2011;
8. LL(dr)-DM: 276 (2%) experience combinations from 1950 to 2011;
9. LL(dr)-DL: 1070 (6%) experience combinations from 1950 to 2011.

To explore the extent to which these effects are observed in the data, we conduct a clustered conditional logit regression without and with control variables (circuit individual effects, year of competition, constructor individual effects, number of cars in a race). The dependent variable is

the correlation between podiums and combinations of leader-driver experience (a categorical variable with base category combination LN(dr)-DN). Standard errors are clustered at the level of each individual leader (140 clusters in our dataset). Results of these clustered logit regressions are reported in Table 7.

[INSERT Table 7 HERE]

According to Table 7, the combination LL(dr)-DL is more likely to win a podium position than any other combination. Combinations where leaders have medium or long previous driving experience are more likely to reach podiums than combinations where leaders do not have previous driving experience. Furthermore, regression results suggest that leaders' experience as a competitive driver in the past seems to matter more than the F1 racing experience of the current drivers. In Model 5 with all 4 control variables, the coefficients for combinations with LN(dr) range between -0.78 to -0.27, whereas the coefficients for combinations with LM(dr) range between 0.83 and 1.32 and coefficients for combinations with LL(dr) range between 0.82 and 1.53.¹²

The results tell us that highly experienced leaders paired with highly experienced drivers (combination LL(dr)-DL) gain podiums in 21% of cases (more frequently than any other leader-driver combination). However, it is notable that when a highly experienced leader is paired with a rookie driver (combination LL(dr)-DN), the team reaches podium positions in 19% of cases. This finding is noteworthy because it suggests, first, that only a small difference exists between pairing an experienced F1 driver with a driver-leader (2%), and, second, that leaders with

¹² The same results are obtained in regressions where the dependent variable is the propensity to win a race.

previous driving experience work more effectively with rookie drivers than with those who have 1 to 5 years of driving experience in F1. Figure 2 represents the regression results in a matrix.

6. Discussion

The evidence presented above reveals that the expert leader pattern has been found in a new setting: six decades of the F1 global industry. Leaders who were former drivers are shown to have the greatest later success. To understand why and how driver-leaders might affect performance is an empirical issue; our dataset does not allow us to causally uncover the underlying details of the transfer processes. Nevertheless, a helpful part of theory development is to make predictions about why and how these patterns exist, that can be investigated in future research.

Our data exclude important information -- for example, management skills, which are positively associated with organizational performance (Bloom & Van Reenen, 2007; Bloom, Genakos, Martin & Sadun, 2010). It is natural to assume that F1 principals vary in their individual management and leadership skills. Might drivers make better leaders because of (unmeasured) personality or traits as opposed to expert knowledge?¹³ This is an important conceptual possibility and it seems valuable that future research attempt to scrutinize it in depth. But a number of pieces of evidence currently appear to point against such an interpretation.

It is not feasible to measure the personality types of each driver -- many of whom are no longer alive -- in this historical dataset. However, one reason to be cautious about the hypothesis of an overwhelming influence from personality is that former mechanics also perform relatively well as F1 principals. It is not clear why the personality of mechanics and drivers would be similar to each other. Second, and perhaps more important, within the sub-sample of everyone

¹³ We would like to thank an anonymous referee for this suggestion.

who ever drove, we find that individuals with the longest racing experience make the best leaders. This seems powerfully suggestive of the role of mature expertise rather than solely of personality or traits (though personality might be somewhat implicated in the ability to be driver for a large rather than medium number of years). When a leader has 10 years of racing experience instead of zero years, it translates, according to the data, into a 16 percentage points higher probability of the leader's team gaining a podium position – this is after controlling for the race circuit, the race year, each constructor, and the number of cars that qualified. If race drivers have similar personality traits we would not expect such large differences within the group. Finally, we can run an empirical test that may add weight to the arguments in support of knowledge over sheer personality. We can ask: do drivers who are in constructor teams led by former-drivers, versus other leaders, crash less or more in Grand Prix races? We find that cars in teams led by leaders with no previous driving experience on average crash in 12%-15% of cases, whereas cars in teams led by leaders with high levels of experience crash in 10%-13% of cases¹⁴. Caution is necessary here when drawing conclusions, but one interpretation is that this interaction result may be explained by expert knowledge -- in a way quite independent of personality -- that is transferred from the leader to the way the team performs.

6.1 Why former drivers make better F1 leaders: possible transfer processes

The core-business activity in F1 is racing to win championship points. We label expert leaders as those whose knowledge and experience aligns with the organization's core-business activity. Examples summarized above include: university presidents who have strong research records who lead research universities (Goodall 2009a,b); basketball coaches who were themselves star players in the NBA (Goodall, Kahn & Oswald. 2011), and so on. We suggest

¹⁴ We use a Kruskal-Wallis test and find statistically significance at 0.0004 level. Due to space restrictions we have not included a table.

that former drivers are highly competent in the core-business activity of racing. That drivers are important to F1 constructors is evident in their wages¹⁵. It is usual for drivers to receive the highest salaries in F1 teams.

In this section we propose 4 possible reasons why former drivers may improve team performance. The theoretical suggestion is that these ideas can be generalized into all settings where the expert leader results have been established.

a) Drivers occupy a unique position in the team because they can view all elements of the F1 process; it is the drivers who feed back information about new adaptations to the chassis, engine, tires and other car modifications after races. F1 team principals who had long driving careers, may have gone on to become exceptional leaders because their own career preferences and priorities continue to be aligned with the requirements of the core business of F1 Championships. It is normal for drivers to start racing at an early age, usually go-karting as young children. Possibly because of their early start in racing, driver-leaders develop expert knowledge about the underlying activity of Grand Prix racing; they acquire extensive experience in formulating driving tactics, and may be better able to make decisions under time pressure and stress. Having specialized knowledge about racing might help a leader to use their superior strategic knowledge to make better strategic choices. In addition, they may be better able to effectively communicate strategy to any part of the team.

b) Drivers form relationships with all parts of the team. They may also act as role models, and better understand how to coax high performance out of others. In the context of North American professional basketball, Goodall et al. (2011) argued that having been a former top

¹⁵ Salaries for 2013 available at: <http://www.tsmplug.com/richlist/highest-paid-formula-1-drivers/>

basketball player helps those who become coaches to better manage the egos of their top players. It might be presumed that a leader who has spent time undertaking the core-business activity would have a good understanding about the requisite conditions required for other core workers. Thus, we might expect driver-leaders to create an appropriate work environment, which in turn may influence employee performance. This is supported by the findings from the creativity literature, summarized in Mumford et al. 2002, that suggests leaders need technical expertise to fully evaluate the ideas of other creative people and provide appropriate feedback.

c) Because of their proven track record, former drivers may command more respect; they may be viewed as intrinsically credible since they have ‘walked-the-walk’. Credibility, it is argued, legitimizes leaders’ authority and extends their influence (Bass, 1985; Bennis & Nanus, 1985; Kouzes & Posner, 2003; Mumford, et al., 2002). Having been ‘one of them’ may also signal to future employees that a driver-leader understands the culture and value system, incentives and motivations of their F1 team colleagues (Goodall 2009a; Goodall et al., 2011). Hence, may choose to join the team. Hiring an expert leader may also signpost credibility to a wider audience. For example, it may send out a signal about strategic priorities to external stakeholders such as sponsors, shareholders, customers, suppliers, and the media. To enter a team in Formula 1 is expensive (approximate annual cost is \$200-\$300 million). Therefore, the role of external funders, particularly sponsors, is centrally important.

d) Finally, the credibility generated by having driven successfully may also help to attract new talented personnel. Arguably, hiring the best people is central to the success of any organization. A leader who has raced successfully and has been in the industry for many years might make more informed hiring decisions. They may also be hooked into important networks.

7. Conclusion

The claim that is developed further in this paper is that organizations led by individuals who have expert knowledge of the core business go on to make better leaders. Expert knowledge is described as being a first-order requirement, because it may be generalizable across different industries and be more easily identified and measured, compared with other factors such as style or personality. Expert knowledge in the core business has, it is suggested, two components: industry experience and expert ability in the core business activity (holding constant the level of management and leadership experience). These ideas form the nascent theory of expert leadership.

This paper makes two contributions: first, it summarizes the extant literature supporting the expert leader hypothesis and, based on these findings, makes theoretical claims in support of a generalized concept of expert leadership. Second, it makes an empirical contribution; it takes a new step towards an understanding of the boundaries of the expert-leader assertions by testing them in the extreme high-technology turbulent industry of Formula One (F1) -- a setting where leadership has not before been examined.

The data collected for this study provide longitudinal information on the entire history of F1. We have every leader in the 62 year history of F1 between 1950 and 2011. The dataset offers the unusual advantage of half a century of objective organizational outcomes against which to determine the kinds of leaders associated with optimal performance.

Four leader classifications emerged from our data: former managers who came from industries outside F1, former engineers (with degrees), those who were previously mechanics, and former racing drivers. Our taxonomy, in Figure 1, suggests that expert knowledge is least evident in former managers and most likely in former drivers. To test our hypotheses (in Section

3), we use econometric methods. These allow us to compare teams' performance and determine whether and to what extent leaders' competence in the core-business activity (driving) affects later team performance. We include a number of control variables in the analyses -- the race circuit, the race year, the different constructors (Ferrari, McLaren, Red Bull etc.), and the number of cars qualified. We also test for the effect of money.

As predicted, managers and engineers on average perform least successfully as F1 team leaders. Principals who were mechanics performed well, though less well overall compared with former drivers. In our regression tables, we find, first, that F1 leaders who were former racing drivers and mechanics are associated with the most success in winning podium positions in Grand Prix races. Second, among the sub-sample of leaders who have ever driven competitively, it is leaders who spent the most years racing -- arguably the most successful drivers -- who secure the best results for their F1 teams. We argue that a long racing career might be viewed as an equivalent to, or proxy for, executive tenure or time-in-industry.

Finally, and perhaps notably, we attempt to discern the effects that different leaders have on what might be considered their key employees -- the team drivers. To do this, which we believe to be the first analysis of its kind, we consider interactions between leaders' former driving experience and the F1 racing experience of the current team driver. The evidence suggests that in most circumstances the driving experience of the principal matters more to team performance than the F1 driving experience of the current driver. A highly experienced driver-leader paired with a highly experienced F1 driver gains podiums in 21% of cases (more frequently than any other leader-driver combination). However, when a highly experienced driver-leader is paired with a rookie driver, the team reaches podium positions in 19% of cases. This finding seems striking because it suggests, first, that only a small difference exists between pairing an experienced F1 driver with a driver-leader (2%), and, second, that leaders with previous driving

experience work more effectively with rookie drivers than with those who have 1 to 5 years of driving experience in F1. Leaders who have never raced have the least influence, no matter how much F1 racing experience their driver previously achieved. This is an interesting result because it is a sharp signal that leaders matter.

This paper adds information to the literature examining the influence that leaders have on organizational performance, specifically the size of the effect. The estimated effect that former drivers have on constructor performance is noteworthy: 10 years of experience instead of zero years is associated with an extra 0.16 on the dependent variable. That translates into a 16 percentage point higher probability of the leader's team winning a podium position (after the inclusion of control variables for race track, race year, constructor type, and number of cars). The extra probability of gaining a podium position when a driver has had a decade's experience of competitive racing is about one-in-seven, which corresponds to a doubling of the effect compared with the mean podium frequency in the data of 0.14.

Within the limitations of our historical dataset we cannot explain precisely why the F1 leaders who were drivers outperformed other leaders in the six decades of F1. Nevertheless, we discuss possible explanations and how they may contribute to a general theory of expert leadership. For example, we suggest that drivers sit in a unique position that allows them to view every part of the F1 process. They begin racing as children and then learn how to formulate driving tactics and acquire extensive technical knowledge from an early age. This we believe may contribute later to strategy development. Former drivers may also appear more credible to members of their teams, and those ex-drivers may know, from their deep acquired experience, how to create an appropriate work environment for other team members.

Caution is advisable in the interpretation of any observational study in social science. It is sensible to recall that -- though we have collected the entire longitudinal history of F1 and not a

snap-shot -- at this level of disaggregation any leader sub-samples necessarily become relatively small. Hence care is needed in the assessment of results. Despite such limitations, our findings have made it possible to consider the expert-leader hypothesis in a new real-world setting. This iconic backdrop helps us to understand further its strengths, boundaries, and possible generalizability.

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Figure 1

F1 leaders who have expert knowledge (industry experience and ability in the core-business activity) are associated with better organizational performance.

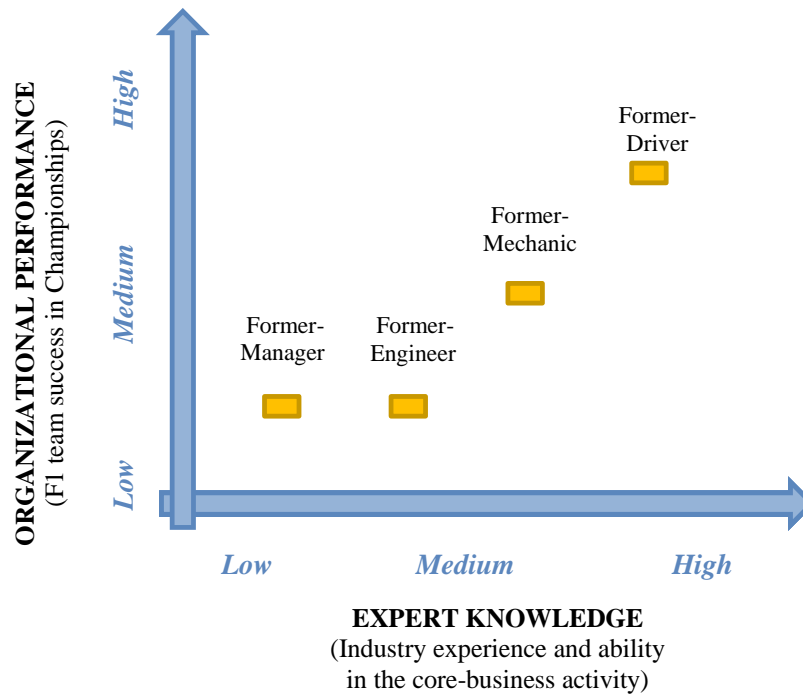


Figure 2

The influence, in different settings, of leaders who were themselves F1 drivers

		Leader's former driving experience		
		Zero years	→ 0-5 years	→ Over 5 years
Current driver's years of F1 driving experience	Zero years	POOR OUTCOME	AVERAGE TO GOOD OUTCOME	BEST OUTCOME
	↓			
	0-5 years	POOR OUTCOME	AVERAGE TO GOOD OUTCOME	GOOD OUTCOME
	↓			
	Over 5 years	WORST OUTCOME	AVERAGE TO GOOD OUTCOME	GOOD OUTCOME

Table 1
The relationship between F1 Champion points and the final position of cars

	Championship point system						
Final position	1950-1959	1960	1961-1990	1991-2002	2003-2009	2010-2011	1950-2011 (averages)
1 st	8	8	9	10	10	25	11.7
2 nd	6	6	6	6	8	18	8.3
3 rd	4	4	4	4	6	15	6.2
4 th	3	3	3	3	5	12	4.8
5 th	2	2	2	2	4	10	3.7
6 th	0	1	1	1	3	8	2.3
7 th	0	0	0	0	2	6	1.3
8 th	0	0	0	0	1	4	0.8
9 th	0	0	0	0	0	2	0.3
10 th	0	0	0	0	0	1	0.2

Table 2
Explanatory variables in the regression equations*

Explanatory variable	Description
<i>CONSTANT</i>	Constant
<i>MANAGER</i>	1 if the leader is classified as <i>manager</i> ; 0 otherwise
<i>DRIVER</i>	1 if the leader is classified as <i>driver</i> ; 0 otherwise
<i>MECHANIC</i>	1 if leader is classified as <i>mechanic</i> ; 0 otherwise
<i>ENGINEER</i>	1 if the leader is classified as <i>engineer</i> ; 0 otherwise
<i>CIRCUIT</i>	Each Grand Prix circuit has a different dummy
<i>YEAR</i>	Each year has a different dummy
<i>TEAM</i>	Each F1 constructor team has a dummy
<i># CARS</i>	Number of cars qualified to race in any particular race

*All executives listed by the team as ‘principal of the racing team’ or ‘team principal’ are identified as team leaders. Those identified as having collective team leaders (more than one person) are excluded (29 leaders, 1,351 car entries). We also excluded 460 car entries in cases where we were unable to identify leaders.

Table 3
Summary statistics on the Formula 1 World Constructors' Championship 1950-2011

Leaders' type	Number of leaders	Number of cars	Average podium frequency	Average win frequency	Average pole frequency	Average fastest lap frequency
<i>Managers</i>	42	3,498	0.12	0.03	0.03	0.04
<i>Drivers</i>	35	2,779	0.17	0.07	0.07	0.06
<i>Mechanics</i>	31	7,456	0.16	0.06	0.05	0.06
<i>Engineers</i>	33	3,992	0.08	0.03	0.03	0.03
Total	141	17,725	0.14	0.05	0.05	0.05

Table 4
Regression results where the dependent variable is whether a car gets a podium position – estimated by an OLS linear probability model

Explanatory variable	Model 1 coefficient (standard error)	Model 2 coefficient (standard error)	Model 3 coefficient (standard error)	Model 4 coefficient (standard error)	Model 5 coefficient (standard error)
Driver or mechanic	0.066*** (0.005)	0.066*** (0.005)	0.066*** (0.005)	0.042*** (0.008)	0.044*** (0.0083)
Manager or engineer	-	-	-	-	-
<i>CIRCUIT</i> dummies included	NO	YES	YES	YES	YES
<i>YEAR</i> dummies included	NO	NO	YES	YES	YES
<i>TEAM</i> dummies included	NO	NO	NO	YES	YES
# <i>CARS</i> included	NO	NO	NO	NO	YES
R²	0.0088	0.0102	0.0103	0.1305	0.1308
<i>N</i> (Observations)	17725	17725	17725	17725	17725
<i>N</i> (Leaders)	141	141	141	141	141

*** - significant at 0.001 level

The mean of the dependent variable (gaining a podium position) is 0.14.

Table 5
Regression equations where the dependent variable is whether
a car gains a podium position - estimated by a probit model

Explanatory variable	Model 1 coefficient (standard error)	Model 2 coefficient (standard error)	Model 3 coefficient (standard error)	Model 4 coefficient (standard error)
<i>MANAGER</i>				
<i>DRIVER</i>	0.202*** (0.040)	0.205*** (0.040)	0.292*** (0.062)	0.300*** (0.062)
<i>MECHANIC</i>	0.197*** (0.033)	0.191*** (0.033)	0.021 (0.063)	0.035 (0.063)
<i>ENGINEER</i>	-0.242*** (0.040)	-0.252*** (0.041)	-0.115 (0.071)	-0.118 (0.072)
<i>CIRCUIT</i> dummies included	YES	YES	YES	YES
<i>YEAR</i> dummies included	NO	YES	YES	YES
<i>TEAM</i> dummies included	NO	NO	YES	YES
# <i>CARS</i> included	NO	NO	NO	YES
<i>Pseudo R</i> ²	0.0156	0.0160	0.1404	0.1409
<i>N</i> (Observations)	17725	17725	17725	17725
<i>N</i> (Leaders)	141	141	141	141

*** - significant at 0.001 level

Table 6
Regression equations where the dependent variable is whether a car gains a podium position -- estimated by random intercept logit model -- in the subsample of leaders who have ever had competitive driving experience¹ and experience as mechanic²

Explanatory variable	Model 1 marginal effect (standard error)	Model 1 marginal effect (standard error)	Model 2 marginal effect (standard error)	Model 2 marginal effect (standard error)	Model 3 marginal effect (standard error)	Model 3 marginal effect (standard error)
Leader's years of experience as a competitive driver in the past	0.106*** (0.012)	-	0.113*** (0.013)	-	0.073*** (0.022)	-
Leader's years of experience as a mechanic in the past	-	-0.028*** (0.005)	-	-0.081*** (0.005)	-	-0.025** (0.008)
Leader in each season individual effect: st. deviation (st. error)	1.854 (0.302)	1.449 (0.098)	1.598 (0.220)	1.651 (0.141)	1.103 (0.135)	1.196 (0.083)
<i>CIRCUIT</i> dummies included	NO	NO	YES	YES	YES	YES
<i>YEAR</i> dummies included	NO	NO	YES	YES	YES	YES
<i>TEAM</i> dummies included	NO	NO	NO	NO	YES	YES
# <i>CARS</i> included	NO	NO	NO	NO	YES	YES
Log likelihood (LL)	-1617.88	-4477.96	-1599.18	-4426.86	-1494.93	-4273.87
<i>N</i> (Observations)	6061	8725	6061	8725	6061	8725
<i>N</i> (Leaders)	45	41	45	41	45	41

*** - significant at 0.001 level

¹ The data include 45 leaders out of 141 (33%) who have entered 6,061 cars in 803 out of 858 races in F1 competitions between 1950 and 2011. These are leaders who have ever had a competitive driving experience. Out of them, 35 are classified as drivers, 7 as mechanics, 2 as managers, and 1 as engineer.

² The data include 41 leaders out of 141 (29%) who have entered 8,725 cars in F1 competitions between 1950 and 2011. These are leaders who have ever had experience as mechanics. Out of them, 31 are classified as mechanics, 4 as drivers, 6 as engineers.

Table 7
Results of clustered conditional logit regression without and with controls (correlation between podiums and combinations of leader-driver experience). Leader's experience is measured as leader's previous experience as competitive driver.

Base category: combination LN(dr)-DN.

[Dependent variable: whether a car won a podium position or not]

Combination	Model 1 coefficient (robust standard error)	Model 2 coefficient (robust standard error)	Model 3 coefficient (robust standard error)	Model 4 coefficient (robust standard error)	Model 1 coefficient (robust standard error)
LN(dr)-DN	-	-	-	-	-
LN(dr)-DM	-0.6589917 (0.7469524)	-0.6775477 (0.7252807)	-0.6620999 (0.7095704)	-0.2799302 (0.4221312)	-0.2731413 (0.4182238)
LN(dr)-DL	-2.092188*** (0.415654)	-2.048483*** (0.4251668)	-1.986393*** (0.4528088)	-0.7888245 (0.549179)	-0.7760258 (0.538188)
LM(dr)-DN	1.037523*** (0.1839944)	1.066706*** (0.1802005)	1.089532*** (0.1794364)	0.6934863*** (0.2026239)	0.695632*** (0.2015751)
LM(dr)-DM	0.8386818† (0.4902904)	0.8324678† (0.478085)	0.8398051† (0.4633605)	0.8348534* (0.396006)	0.8328638* (0.3944819)
LM(dr)-DL	0.7735891† (0.4166392)	0.8230227* (0.425948)	0.8759659* (0.4386714)	1.312192*** (0.2432113)	1.324331*** (0.2390952)
LL(dr)-DN	1.353978*** (0.1951035)	1.408388*** (0.1784429)	1.45925*** (0.1730723)	0.8919771*** (0.2145238)	0.9091598*** (0.2125711)
LL(dr)-DM	0.565194 (0.7308702)	0.5926472 (0.7375657)	0.6422772 (0.728222)	0.8009291 (0.5251208)	0.8203238 (0.5367398)
LL(dr)-DL	1.474793* (0.7149445)	1.518909* (0.7060216)	1.594736* (0.7115901)	1.529971*** (0.3816751)	1.525973*** (0.3739136)
<i>CIRCUIT</i> dummies included	NO	YES	YES	YES	YES
<i>YEAR</i> dummies included	NO	NO	YES	YES	YES
<i>TEAM</i> dummies included	NO	NO	NO	YES	YES
# <i>CARS</i> included	NO	NO	NO	NO	YES
Pseudo R ²	0.0322	0.0348	0.0358	0.1497	0.1500
N (Observations)	17718	17718	17718	17718	17718
Clustered at the level of individual leader (140 clusters)	YES	YES	YES	YES	YES

Abbreviations: LN(dr) – leader's previous experience as competitive driver is equal to 0 years;

LM(dr) – leader's previous experience as competitive driver is equal to 1 to 5 years;

LL(dr) – leader's previous experience as competitive driver is greater than 5 years;

DN – driver's previous experience as competitive driver in Formula 1 is equal to 0 years;

DM – driver's previous experience as competitive driver in Formula 1 is equal to 1 to 5 years;

DL– driver's previous experience as competitive driver in Formula 1 is greater than 5 years

Significance: † - significant at 0.10 level; * - significant at 0.05 level; ** - significant at 0.01 level; *** - significant at 0.001 level

Appendix 1

Summary of F1 performance: Twelve most successful teams 1950 – 2006*

Team	Period of winning Grand Prix	Number of Grand Prix wins	Number of win periods
Ferrari	1951 - 2006	186	7
McLaren	1968 - 2006	148	5
Williams	1979 - 2004	112	5
Lotus	1960 - 1987	79	4
Brabham	1964 - 1985	35	3
Renault (2 entries)	1979 - 1983; 2003 - 2006	33	3
Benetton	1986 - 1997	28	3
Tyrrell	1971 - 1983	23	2
BRM	1962 - 1972	17	3
Cooper	1958 - 1967	16	3
Alfa Romeo	1950 - 1951	10	1
Matra	1968 - 1969	10	1

*Table reproduced from Jenkins, 2010, p 901.

Appendix 2

Table 8
Clustered OLS regression results where the dependent
variable is whether a car gains a podium position

[Estimated for 2 years only where budget data are available:
2006 and 2008] (clustered by year)

Explanatory variable	Model 1 coefficient (robust standard error)
<i>DRIVER or MECHANIC</i>	0.0987* (0.0075)
# CARS included	0.0081* (0.0003)
<i>TEAM BUDGETS</i>	0.0016** (0.000003)
Constant	-0.3782* (0.0091)
R^2	0.0728
<i>N</i> (Observations)	764
<i>N</i> (Clusters = Years)	2

* - significant at 0.05 level;

** - significant at 0.01 level

Notes: We have obtained estimates of budgets for the years of 2006 (http://en.wikipedia.org/wiki/Formula_One) and 2008 (<http://www.f1fanatic.co.uk/2008/09/22/toyota-has-biggest-f1-budget-4456m/>) and conducted OLS clustered OLS regression where we excluded individual leader and team effects but included obtained budget information. This budget information is not official figures (which are a part of each team's commercial secret and therefore are not obtainable) but expert estimates. Our results (presented above) show that even when the team effects are not included, having former driver or mechanic as the head of the team influences team performance more than the team budget. Particularly, while former driver or mechanic leader (rather than former manager or engineer) increases the propensity of team winning a podium position by 9.87%, higher budget increases the chances of winning a podium by only 0.16%. This suggests that our results remain stable even when we include budget estimates in our regressions.

Appendix 3

Methodological information about studies cited by Mumford et al. (2002)

Study	Sample	Team size	# Leaders	Industry/ Org.	Longi- tudinal or one-shot	Method	Main research question
Andrews and Farris (1967)	94 scientists forming 21 small teams	2 to 12 (including leader)	1 per team	NASA research centre (scientists)	One-shot	Questionnaire conducted among non-leader team members and the answers averaged across all teams	How do leaders' technical skills influence innovation in teams
Barnowe (1975)	81 teams, 859 scientists	On average, 11 scientists	1 per project (group may work on several projects so there could be several leaders in the group)	"A large research organization engaged in a mixture of basic and applied research throughout the United States"	One-shot	Questionnaires with scientists (leaders and non-leaders) and interviews (interviews were conducted with 39 administrators –so "project leaders" in this paper are not actually heads of organization and have bosses)	How do leaders' technical skills influence innovation in teams?
Tierney (1999)	191 non-clerical employees (research managers, research scientists, section leaders, project leaders, work group professional and work group technicians)	2-13 (including leaders)	8 levels of leaders	R&D sector of large chemical corporation	One-shot	Survey	How do technical skills affect creativity?

Paper	Sample	Team size	# leaders	Industry/ Org.	Longitudinal or one-shot	Method	Main research question
Farris (1969)	151 engineers	not specified	not specified (looks at people in process of “movement into leadership positions” rather than existing leaders)	Science/ Enginee-ring	Longitudinal but only 2 points in time (6 years difference)	“4 measures of performance were correlated with 6 organizational factors: involvement in work, influence on work goals, colleague contact, diversity of work activities, salary, and number of subordinates”	How is performance affected by involvement in work, influence on work goals, colleague contact, diversity of work activities, salary, and number of subordinates?
Thamhain and Gemmill (1974)	22 project managers and 66 project employees	not specified	1 leader/ manager per project	Project-oriented business division of large electronic company	One-shot	Survey	How can leaders influence workers through expertise rather than authority?
Basadur, Runco, and Vega (2000)	112 managers (mid-level)	not specified	not specified	Large international consumer goods manufacturer	One shot	Field experiment	How leaders’ technical ability affect team creativity?
Farris (1972)	117 professional scientists (including 14 supervisors)	2-17 team members	1 per team	NASA scientists (chemists and physicists)	One-shot	Survey	How do leaders participate in teams’ innovations?
Jung (2001)	53 teams of 3-4 undergraduate students	3-4 team members	1 per team	University students	One-shot	Laboratory experiment	How does technical ability affect creativity?

Paper	Sample	Team size	# leaders	Industry/ Org.	Longi- tudinal or one-shot	Method	Main research question
Sosik, Kahai & Avolio (1998)	159 undergraduat e students, 36 teams	21 teams 4 people each +15 teams 5 people each	1 per team (leaders were confederates – not part of the experimental subject pool)	University students	One-shot	Laboratory experiment	How does technical ability affect creativity?
Sosik, Kahai & Avolio (1999)	159 undergraduat e students, 36 teams	21 teams 4 people each +15 teams 5 people each	1 per team (leaders were confederates – not part of the experimental subject pool)	University students	One-shot	Laboratory experiment	How does technical ability affect creativity?
Mossholder & Dewhurst (1980)	271 scientists and engineers (non-leaders)	not specified	not specified	Large multidiscipli nary nuclear R&D centre	One shot	Survey	What is the relationship between leadership and creativity?
House (1971) Study 1 and 2	199 office employees	not specified	not specified	Heavy equipment manufacturi ng company	One-shot	Survey	How does technical ability affect innovation?
House (1971) Study 3	122 employees including 13 managers	not specified	not specified	Chemical manufacturi ng plant	One-shot	Survey	How does technical ability affect innovation?
Goodall and Pogrebna (2014)	Non- experimental data from the field	Large teams of 600-700 people on average, sometimes more	141 leaders	F1 competition	Longitudi- nal annual data from 1950 to 2011	Econometric analysis of non- experimental data	What is the relationship between expert leadership and team performance?