THE EFFECT OF PROCURMENT CAPABILTIES AND INNOVATIVE PERFORMANCE ON FIRM PERFORMANCE:

A CASE STUDY ON FORMULA 1 TEAMS FROM 2008-2017, A HIGH-TECH, HIGHLY INNOVATIVE AND COMPETITIVE ENVIRONMENT

MASTER THESIS

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Abstract

It is understood that the procurement department and innovative performance of an organization influence the overall business performance of that organization. The research explaining this matter is based on knowledge based view. This underpins the point of view that human capabilities are one of the firms most valuable assets. Both departments are often linked together and research on the matter showed a positive interaction term between them regarding the business performance of an organization. However, current literature is predominantly based on the view of the management. Procurement managers are asked to grade their own department, and the same goes for the department responsible for innovation.

Furthermore, this leads to a gap in existing literature, where objective data can possibly verify or falsify existing literature. Resulting in the formulation of the following main question; "What effect do procurement capabilities and innovative performance of a Formula 1 team have on the business performance of the team?". The research is performed in an environment that enables unbiased data of Formula 1 teams. The data was extracted form independent sources and if possible, verified two-fold. On team level, ten years of data is gathered and analysed. The analysis used is the Fixed effects model, applicable for longitudinal and for multiple groups.

The results show that both the procurement capabilities and the innovative performance of the Formula 1 teams have a positive significant effect on business performance. Controversially, the interaction effect was found to be negative significant. However, this contradicts current literature on the subject of business performance. Furthermore, this implicates that it is for organizations that are active in a comparable industry as is the Formula 1, investing in both the procurement and innovative department can lead to improved business performance. Even so, the interaction between the two departments might be less than current literature suggests and is of interest for further research.

Keywords: Procurement; Innovation; Formula 1; Teams; Business performance; Resource based view; Knowledge based view; Fixed effects model; Hausmann test.

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1. Introduction

Procurement strategy, as others strategies, has evolved over time. The procurement departments of organizations historically tend to focus on purchasing efficiently. Procurement strategies are focussed on low cost and high quality of the, to be purchased, products or components (Nollet & Beaulieu, 2003; Schiele, 2007a). This procurement strategy focusses all capabilities to be used within organizational structure limitations (Nollet & Beaulieu, 2003). The procurement capabilities often limited in an isolated part within the organization. Moreover, it is not included in decision making in other departments nor at the suppliers side. However, in the last decade the procurement capabilities of an organization are often linked to innovative and overall business performance (C.a, T.b, & M.c, 2013; Carey, Lawson, & Krause, 2011; Luzzini, Amann, Caniato, Essig, & Ronchi, 2015). Thus, creating the need for a broader use of procurement capabilities and knowledge about the effect it can have on an organization (Luzzini et al., 2015).

Currently procurement capabilities are recognised as one of the key sources for improved innovative performance and business performance. Nevertheless, in current literature this seems only the case when there is a high level of integration of the procurement department, within other organizational departments and suppliers. Current literature that for example, this enables a suppliers to add product and process knowledge in the customers organizational product development (Walter, 2003). The quicker an organization and its supplier collaborate, the more efficient and possibly effective the innovation can be (Clark, 1989; Ragatz, Handfield, & Petersen, 2002). However, being able to work extensively with a supplier on innovation is not without constraints. Both parties must be willing to participate and share knowledge, possible creating imbalance in power between supplier and customer. Which on itself is a deterrent for such a relation (Ragatz et al., 2002; Schiele, 2007b).

The literature and theoretical models used in this paper are based upon the resource based view (RBV) (Barney, 1991; Conner, 1991) and knowledge based view (KBV)(Grant, 1996; Kogut & Zander, 1992), which evolved from RBV. With the knowledge of this theories, the difference in business performance is explained on a team level. RBV is used to determine which factors within a Formula 1 team (organization) can make a difference on the procurement capabilities, innovation performance of the team. Creating a theoretical understanding why some organization perform better than their competitors.

Current literature leaves the connection of procurement capabilities, innovative performance and their effect on business performance, yet to be discovered with solid empirical research (Akın Ateş, van Raaij, & Wynstra, 2018; Hong & Kwon, 2012; Luzzini et al., 2015). The link between procurement capabilities, innovative performance and business performance is not completely new. Present research however, is most often done analysing interpretations of managers that are responsible for

procurement capabilities and innovative performance. Creating a possible positive bias (Akın Ateş et al., 2018; Hong & Kwon, 2012; Luzzini et al., 2015). To analyse this aspects of procurement and innovations performance, a complex and innovative market is sought after to which procurement and innovation both play a key role (Houman & Rask, 2003; Williamson, 2008).

In order to gain the necessary data in the right settings, this research applies data from organizations that are not only innovative, but also have measurable in- & output. Organizations that meet this criteria are Formula 1 teams[1] (Castellucci & Podolny, 2017; Jenkins, 2010, 2014). The Formula 1 industry is highly innovative and competitive (Jenkins, 2010, 2014). Additionally, the results from the races are publicly available[2]. Moreover, the fanbase of the Formula 1 creates and stores even more publicly available data[3]. The nature of this industry (innovative, technical and competitive) and the availability of data makes it possible for this research to analyse the procurement and innovation link to business performance.

The aim of this paper is to contribute to existing literature about the effect of procurement capabilities and innovative performance on business performance. This is performed through empirically testing the link between the concepts. This is executed in an environment where procurement capabilities are used and a high level of innovativeness are made measurable. As well as a measurable performance indicator. In one sentence: The goal of this research is to ground the current theoretical knowledge of the link between procurement, innovation and business performance in a highly innovative market, without the bias of managers that have an interest in improving results. The question to be answered in order to achieve this goal is:

What effect do procurement capabilities and innovative performance of a Formula 1 team have on the business performance of the team?

This thesis aims to contribute to current procurement and innovation literature and the possible interaction effect between the concepts regarding business performance. The interaction phenomenon is only recently described in literature and has mostly been tested qualitatively. The study is based on case data from the Formula 1. Therefore, testing current theories in a "real world" case, creating a substantial additive to literature that tries to link procurement strategy with innovation and business performance. Additionally, it can create discussion whether or not current theories are applicable in a highly innovative, highly technical and highly competitive industry. Creating knowledge

[1] Formula 1 teams, are organizations active in the "FIA FORMULA 1 WORLD CHAMPIONSHIP" https://www.fia.com/events/fia-formula-one-world-championship/season-2019/2019-fia-formula-one-world-championship

[2] https://www.formula1.com/en/results.html/2019/races.html

[3] https://www.racefans.net & https://www.f1technical.net/

for companies that seek information about procurement innovation, and the possible effect of innovation on the relation with procurement and business performance.

This thesis is outlined as follows. In chapter 1, the introduction of the Master thesis is done. In the following chapter, the relevant literature is described and explained. The theoretical framework chapter is build on what is already researched and what blanks are still there to be filled. Due to the lack of empirical researches on this topic, and the studies are mostly qualitative. Furthermore, chapter 2 also contains the hypothesises that are to be tested. In chapter 3 the design of the construct is formulated. The research method is explained, as well as how the measurements are performed and how the data is collected and analysed. The data-analysis is done in chapter 4, here the hypothesis that have been formulated in chapter 2 are tested. Chapter 5 contains the conclusion and discussion. This will include the key finding, limitations and advise for future research.

To clarify the abstract terms used in this paper, the definition of two terms are explained. Innovation and business performance are both terms that are multi-interpretable and therefore explained in this section. The definitions are based on definitions from relevant literature on the topic of procurement. First, innovation, according to the European Commission (1995), it is the "Successful production, assimilation and exploitation of novelty in the economic or social environment"(European, 1995). This definition includes the broader view of innovation within an organization**.** In this research it is measured on a level of effectiveness of the innovation

Secondly, the business performance of an organization can be measured to the extend of which an organizational goal is achieved. It can be determined by measuring the effectiveness of the organization in reaching its goal over a certain time period. This therefore is thus is goal dependent and differs per industry an organization is in and the goal an organization has set (Franco-Santos et al., 2007). For this research, the Formula 1 goals are measured and the business performance determined accordingly. Jenkins (2010), describes that the Formula 1 teams, the goal is to maximize the points scored per capital spend in the industry (Aversa, Furnari, Haefliger, Row, & Ecy, 2015; Jenkins, 2010).

2. Theoretical framework and hypothesis formulation

2.1 The effect of procurement capabilities on business performance

This research's goal is to link the procurement strategy of an organization to the innovation performance and business performance. The resource based view (RBV) creates the understanding in theoretical literature that sustainable competitive advantage can be created through resources of the organization(Barney, 1991; Curado, 2006; Penrose, E, 1959). However, the internal paradox of RBV and lack of empirical backing of the theory enabled the theory to evolve in to a more wholistic view (Day & Wensley, 1988; Dierickx & Cool, 1989; Lado et al., 2006; Newbert, 2007).

The evolution of RBV is knowledge based view KBV. KBV is a more wholistic view of the organization(Kogut & Zander, 1992; Newbert, 2007). The new theory focusses on the capabilities of employees as being a vital resource of the organization(Curado, 2006; Grant, 1996; Grant & Grant, 2005; Jensen & Meckling, 1976; Lado et al., 2006; Mathews, 2003). The KBV is vital for this research to embed the procurement capabilities. The capabilities of an organization, according to KBV, can be the source of sustainable competitive advantage. Schiele (2007), investigated the effect the purchasing department maturity stage has on the performance of an organization. The research was based on the assumption that a greater maturity of the procurement department was related to a better performance of the organization (Schiele, 2007a).

Prior to the work of Schiele (2007), research showed that purchasing volume as a percentage of organizations financial budget has expanded and plays an evermore bigger role within an organization(Goh, Lau, & Neo, 1999). This might imply that a further improvement of the procurement department performance has a positive effect on the overall business performance (Goh et al., 1999; Narasimhan & Das, 2001). Schiele (2007) states that the procurement department has a significant positive effect on the business performance. The data used was derived from perceptions from the managers on how "mature" the procurement department was. The data was also not reported with the same method from different firms. This research seeks to standardize the measurement creating a quantitative case study on the highly innovative Formula 1 industry. The following hypothesis is formulated to test this phenomenon:

H1: Procurement capabilities of a Formula 1 team positively influences the business performance

The first hypothesis aims to test the assumption that there is a positive link between procurement capabilities of an organization and the ultimate business performance. This is also based on KBV and RBV and described by Schiele (2007). However, focussed on the improvement of a procurement department on the basis of their ability to reduce costs. Which is not always necessary in order to improve or gain a competitive advantage over a competitor. In this research, the Formula

1 team goals are focussed on maximizing output through innovation. The procurement department plays a vital role in enabling further processes in the organization.

2.2 Innovation performance and business performance

In current literature the link between innovation and business performance has been researched extensively. For example, the research of Neely & Hii (1998) showed that at that time, the connection was already broadly supported by empirical research (Camagni & Capello, 1999). Furthermore, the research found that firms that innovate are able to obtain a higher profit margin and grow faster than non-innovative firms (Geroski & Machin, 1992). However, the measurement of innovation is hard due to the multi-dimensional character. There was no empirical evidence found that a higher level of innovation leads to less business performance (Neely & Hii, 1998).

The positive influence of innovation on business performance is also in line with the RBV and KBV theories. Highly innovative products are rare and are in some ways hard to imitate. The knowledge for innovation is within the employees and therefore based on the capabilities of the employees. More recent research on the topic of innovation and business performance does not contradict the previous understanding of the link (Wong et al., 2016). The research of Wong et al, (2016) again shows an empirical grounded research that finds innovation to be of a great influence on the business performance. The research is performed with data from SME's in Malaysia (Wong et al., 2016).

For this research it is necessary to clarify the meaning of innovative performance of a Formula 1 team to make it measurable. The innovative performance of a Formula 1 team is defined as being the performance of the team on creating the best possible car with the least amount of research. Hence, creating encompassing effectiveness and efficiency of the team on creating the best possible racing car. This leads to the creation of the second hypothesis.

H2: Innovative performance of a Formula 1 team positively influences the business performance

The second hypothesis tests the assumption that an enhanced innovative performance within an organization leads to a better business performance of that organization. This is in line with RBV and KBV theory in the way that innovation often is created by unique capabilities of employees. Furthermore, according to Neely and Hii (1998), innovation creates both new products and processes that improve a firm's competitive position in relation to its rivals. The link The hypothesis aims to further enhance current understanding of highly innovative teams and the effect of innovation on their business performance.

2.3 The interaction between innovative performance and procurement capabilities

The link between innovation and procurement is researched by Luzzini et al. (2007). This research uses KBV to investigate the supplier collaboration and the effect it has on innovation of NPD[4] (Luzzini et al., 2015). The research focusses on two types of advantages gained by the procurement department; supplier collaboration level and strategic sourcing which are grounded in RBV and KBV due to the understanding of capabilities of the procurement department (Luzzini et al., 2015; Ramsay, 2001). In this paper, there is a proposed model. The model is tested in the research of Luzzini et al. (2015).

Moreover, the first hypothesis being that an higher focus on innovation strategy has a positive effect on the effort put in supplier collaboration as well as strategic sourcing. The second and third state that a higher purchasing knowledge leads to more effort on both strategic sourcing as supplier collaboration. The fourth and fifth describe the hypothesis that a greater effort in strategic sourcing and supplier collaboration has a positive effect on the innovation performance (Luzzini et al., 2015). Testing these hypothesis, grounded in KBV creates an the ability to confirm or deny the link between innovation performance and purchasing knowledge.

The hypothesis tested were all found to be supported by the empirical testing. tested with the help of a survey, spread across western Europe and North-American organizations. The survey tested the perspective of "highly qualified purchasing professional"(Luzzini et al., 2015). This creates a result based on the perspective of a group of professionals that all share the "procurement perspective", which might be a potential blind spot in the paper. This drawback is overcome by empirically testing data that is not based on the perspective of just one function or discipline within an organization, by selecting data retrieved from independent databases[5]. The conclusion is that the purchasing capabilities have a significant positive effect on the innovation performance of this organization according to the data provide by the procurement department managers(Luzzini et al., 2015).

H3: The procurement capabilities of a Formula 1 team positively influences the effect the innovative performance has on the business performance

[4] New Product Development

[5] [5] Formula 1 teams, are organizations active in the "FIA FORMULA 1 WORLD CHAMPIONSHIP" https://www.fia.com/events/fia-formula-one-world-championship/season-2019/2019-fia-formula-one-world-championship

[5] https://www.formula1.com/en/results.html/2019/races.html

[5] https://www.racefans.net & https://www.f1technical.net/

The hypothesis tests the assumption that there is an interaction effect between the innovative performance and the procurement capabilities. This effect, according to RBV and KBV, should be positive due to the fact that better procurement capabilities enable more effective innovation. Resulting in a sustainable competitive advantage. Supported by RBV and KBV theories in the way that innovation often is created by the capabilities of employees to communicate and share knowledge between departments. The hypothesis aims to further enhance current understanding of highly innovative teams and the effect of innovation on their performance.

2.4 Empirical model

In order to visualize how the stated hypothesis are combined, an empirical model is developed. The first hypothesis tests a positive relationship between procurement capabilities and the business performance. The second hypothesis tests a positive relationship among the innovative performance and the business performance. The third hypothesis tests an implied interaction effect of a positive relation between innovation performance and business performance that is further strengthened by better procurement capabilities.

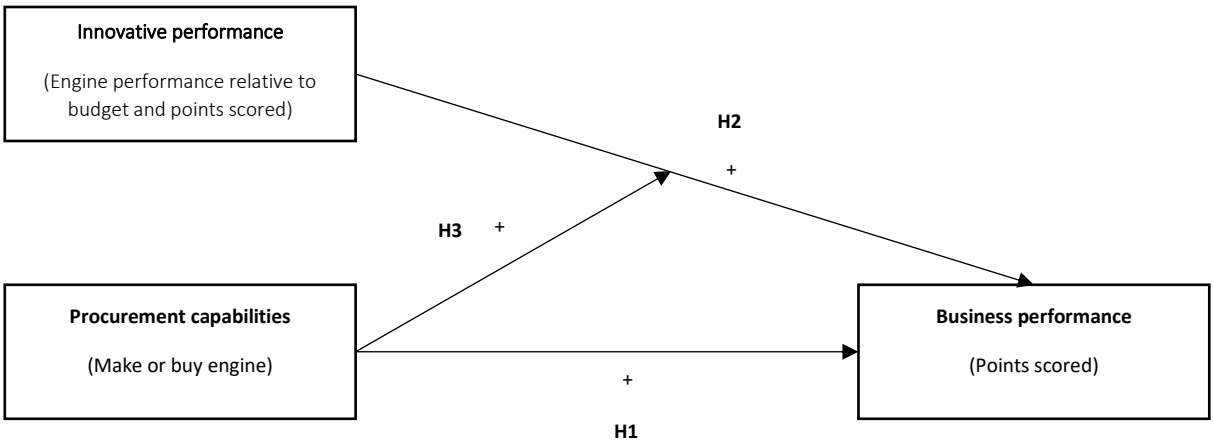

Figure 1 Empirical model

3. Methodology

This research design is grounded on the data created by and for Formula 1 teams. The data is then analysed to research the procurement capabilities and the innovation performance of the teams. Both the variables are used for the empirical testing of the hypothesis in relation to the business performance of the teams. For the validity and reliability of the variables and statistical analysis of the research, the data is collected for the Formula 1 teams from 2008 till 2017. If accessible, ten years of data of each individual team was collected, when teams were not active for the entire period, the remaining available data was used[6]. Therefore, creating a longitudinal and multidimensional dataset, ready for analysis.

The data is divided in to different variables in order to analyse different aspects of the teams and create a valid dataset containing the right variables. The data to create the necessary variables is collected performing a desk research. Data is obtained form different sources from existing literature on the topics of Formula 1, procurement strategy, innovation and business performance literature. The data needed on the Formula 1 teams, official Formula 1 archive, the official team websites and fan based websites[7] are used. The

All the data variables collected and created can be found in appendix 1. At last the statistical analysis is described and explained. The statistical analysis is performed using the fixed effects model, random effects model and the Hausman test. The later to determine if the fixed effects model or the random effects model suited the data best. The analysis is performed using a statistical analysis program named STATA 13. If executed correctly, the steps lead to the correct data collection, statistical analysis and interpretation.

3.1 Data collection

Key in any research is the data, and especially, the source of the data. In this section of the research the data collection is discussed extensively. Due to the empirical nature of this research, the need to ground the theory of the chapter 2 is fulfilled in this section. This is realized by using empirical data on the topic. In order to do so, innovation performance, business performance and procurement capabilities of an organization are made measurable into a variable. The data is obtained by desk research and verified using multiple resources. These resources vary from the Formula 1 official

[6] Teams that were not active for the entirety of the 10 year data set (2008-2017): HAAS (2016-2017), HRT Cosworth (2010-2012), Lotus F1 Team (2010-2014), MRT Mercedes (2010-2016), Super Aguri Honda (2008) & Toyota (2008-2009).

[7] https://www.fia.com/events/fia-formula-one-world-championship/season-2019/2019-fia-formula-one-world-championship & https://www.formula1.com/en/results.html/2019/races.html &https://www.racefans.net & https://www.f1technical.net/ & ie. https://redbullracing.redbull.com/

website to the previously done research on the topic, as well as fan controlled websites on the Formula 1 and websites of the organizations themselves[8] .

The official F1 website has a database with the records of all races from the beginning of F1. From this database we retrieved the drivers name, team names, nationality of the driver, the number of points scored per season. As well as the constructor points and the position in the general rankings per season. The data is retrieved using a web scraping tool named “Octoparse” . The tool was used to minimize the time spent on collecting the data as well as eliminating the human error in the collection of data (Kirwan, Martin, Rycraft, & Smith, 1990). This data was the foundation for further analysis and used to validate other databases.

The Formula 1 database however, does not contain all the necessary information for this research. Further information about the teams is found on the sites of the different teams (organizations) selves and fan sites that keep record of the teams throughout the years. The different variables found are: names, gender and the age of the management team key figures. Additionally, the engine manufacturer was linked to each team. Moreover, the financial budget of each team per season. This data is collected by hand and double checked in order to minimize human error (Kirwan et al., 1990). The data can be found in the digital appendix 1.

3.2 Data Analysis

The data obtained in this research has to be analysed correctly in order to create valid and trustworthy results. Before it becomes clear what analysis type is necessary, the data has to be interpreted. What type of data is there? And what types of analysis should be used to analyse correctly? The data is collected over the Formula 1 teams, if accessible, for a period of ten years from 2008 till 2017. This time period is used in order to create the most recent dataset and therefore the most relevant data. The raw data can be found in digital appendix 1.

The data variables are collected for all the active teams for the ten years. Creating a longitudinal dataset for each team. Not all teams have had the same owner over time, nor have all the teams been active for a period of 10 years. For the teams that changed owners, the teams were named and coded as being the same team over the years. One team entered the Formula 1 later on in the data set and is analysed for it is active years only. This leads to the data being labelled as “Panel Data”, panel data is data in which different individuals or organizations are observed for more than one observation (across time) (Torres-Reyna, 2007).

[8] https://www.fia.com/events/fia-formula-one-world-championship/season-2019/2019-fia-formula-one-world-championship & https://www.formula1.com/en/results.html/2019/races.html &https://www.racefans.net & https://www.f1technical.net/ & ie. https://redbullracing.redbull.com/

3.2.1 Statistical approach

In research there are multiple analysis methods that can be used, however the correct analysis method must be applicable for panel data. The first option, often used in literature, is the Ordinary least squares (OLS). OLS is used to analyse cross-sectional measurements at a specific point in time (Hesselink, 1988; Paulraj, Chen, & Flynn, 2006; Psillaki, Maria; Kaskalakis, 2009). Therefore, the OLS method of statistical analysis does not fit the panel data and cannot be used in this research. In addition to standard OLS method, the two-stage least square model can be used to overcome a multiple time period data base problem that OLS itself cannot overcome. The method however requests the use of independent variables that have no influence on the dependent variable of the second measurement in time (NCSS Statistics, 2019). The dataset of this study has variables that are related to one another over time, creating the need for another statistical model.

The Formula 1 business performance is the dependent variable of this research. The business performance variable is a count variable. Meaning that there is no negative value (no smaller value than 0). This type of variable cannot be assumed to have a normal distribution due to the fact that a normal distribution also includes negative values (Barbour, Chen, & Loh, 1992; Zou, 2004). The normal distribution model do not correctly predict the dependent variable values. Therefore, a Poisson regression is used to predict the dependent variable (Barbour et al., 1992; Zou, 2004). The Poisson regression model is a generalized linear model for count data, and does not include negative values (Barbour et al., 1992; Zou, 2004).

In addition, statistical models that are suitable for the analysis of panel data are the fixed/random effects model (Schmidheiny, 2018; Torres-Reyna, 2007). The fixed effects model (FEM) and random effects model (REM) are a statistical type of multiple regression used to analyse panel data in quantitative research. The models are able to control for omitted variables[9] (Psillaki, Maria; Kaskalakis, 2009; Schmidheiny, 2018; Torres-Reyna, 2007). Furthermore, the models are able to analyse data variables at different time levels, over a longer period of time. Creating the opportunity to analyse groups simultaneously over a longer period of time. Additionally, a Hausmann test has to be conducted to determine whether the FEM or REM is best suitable for use in analysis (FEM/REM).

3.2.2 Variables

The dependent variable in this statistical analysis and test has to reflect the business performance of the Formula 1 teams. Every team wants to perform at the highest level possible and therefore score as much points in the Formula 1 championship as possible. The business performance of the team is consequently made measurable by creating the variable **"business performance"** This

[9] variables the observer cannot measure

variable does includes the constructors points gained by the main drivers of the team. However, there are also drivers in teams that drive for less than a complete season for different reasons. These points are also added to the variable for business performance. The variable therefore shows all the points a team gathered during a season in the Formula 1. Moreover, this creates a more accurate performance measurement variable for the analysis than the normal constructor points of a team.

Starting with the first independent variable discussed in this research **"PROCUREMENT".** The procurement capabilities of a Formula 1 team are hard to collect data of. This is due to the closed nature of Formula 1 teams in general and specially in the way the teams spend their money internally. The teams are not publicly owned and therefore do not have to provide clear and specific data of the organization publicly to their stakeholders. This scarcity of data from the teams, makes it hard to gain insight in their procurement capabilities of the teams. In general, the capabilities are measured by the output and input. Normally the purchasing strategy and capabilities are measured by interviews and questionnaires send to the purchasing managers of organization. Formula 1 teams do not want to share information on this topic to not give competitors insight in their organizations. These circumstances have led to a different view on procurement capabilities measurement.

To measure the procurement capabilities of a Formula 1 organization a non traditional approach is necessary. In order to understand this, it is necessary to know that a Formula 1 team divides the development of the car in two separate pieces, the chassis and the engine.(Triya Nanalal Vadgama, Mr. Arpit Patel, & Dr. Dipali Thakkar, 2015) Six of the ten teams active in the Formula 1 in 2017 produce their chassis in the close proximity to each other in the U.K.. However, not one of the engine manufacturers are located in the U.K.. This shows that, even though teams develop their own engine, another organization in another country develops and builds the engines.

The procurement capabilities can be made measurable on the basis of whether a team that makes its "own" engine or not. Formula 1 teams that make their own engine have to extensively worked together with their own organization, that is total other organization on its own. The teams collaborate with the engine development and co-create a fitting engine and chassis. Teams that buy an engine from them have little to no influence on the development of the engine. The procurement department of these teams do not have to work intensively with their engine supplier. The teams that make their own engine spend more time, effort and money in the process, and therefore have better procurement capabilities than the teams that simply buy a ready made product. This has been made measurable by creating a dummy variable **"**PROCURMENT**"** (1 = Make vs 0 = BUY).

The second independent variable is innovation. The innovation variable is in general made measurable by analysing the budget of an organization spend on research and development, number of employees involved in innovation and strategic orientation (Adams, Bessant, & Phelps, 2006; Geroski & Machin, 1992; Neely & Hii, 1998). However, due to the closed nature of the Formula 1 teams,

these data points are not able to be measured easily. Although, the Formula 1 teams main goal is to maximize business performance and therefore championship points. This can only be done by creating a better car than the competitors, by innovating the cars ability to go around a circuit as quick as possible (Jenkins, 2014).

The engine part of the car also has influence on the business performance. However, the budget of the engines developed by the Formula 1 team self is not included in the teams budget. The teams that build their own engines have a different, seperate organization that builds the engines, which have a different budget. Whereas teams that buy their engine spend a relative low amount of their budget on purchasing that engine as a customer. The money spend on the engine deals with suppliers is not clarified, some teams even receiving payments from suppliers to use their engine. The engine budget is a minor factor in the budget.

To measure the innovative performance of the Formula 1 teams correctly the variable **"INNOVATION"** is created. the innovation performance of a Formula 1 team. The engine performance is measured and per type of engine, which shows the amount of money spent per championship point scored, with a certain engine type, creating a variable for engine performance. The engine performance variable is then multiplied by the number of points the team has scored over the season and divided by the actual budget of the team, creating a relative innovation performance score. This score is than based on how much money a team had as a budget for innovation without the effect the of a potentially better engine.

Additionally, a "PROCUREMENT & INNOVATION INTERACTION" is measured. This interaction effect implies that better procurement enables better innovative performance of teams and that leads to a better business performance. The interaction effect exists of both the procurement as well as the innovation variable. The interaction effect is preformed using the interaction effect function that STATA13 offers for the FEM and REM analysis. The analysis is compared by creating a separate model for both the interaction effect as well as without the effect. According to literature, a positive effect is expected.

Lastly, there is need for control variables. In prior studies it has been proven that certain factors have a potential relationship with the business performance. Prior research showed that the management team of an organization has influence on the business performance, factors that influence the team are gender, age and experience(Castellucci, Padula, & Pica, 2011; Dwyer, Richard, & Chadwick, 2003; Perryman, Fernando, & Tripathy, 2016; Taylor & Greve, 2006). The management team of a Formula 1 team is controlled for age and sex of the team.

3.2.3 Application

In order to test the three hypothesis the fixed and random effects models where used. The program used to complete these tests is STATA 13 64 bit for windows . In order to run the tests, it is necessary to compile the data in an orderly manner. Some of the variables where string variables, the string variables have to be recoded in order to be analysed with the program. After the recoding, the string variables are numeric variables. Furthermore, the “age” variables are standardised in order to analyse them on the same scale as the other variables. The last step before the analysis of the data is the summarization of variables to control for outliers, missing data and other strange variables in the data set.

The analysis of the data is performed wit the fixed and random effects models. The input for both models is the same. For the analysis, two different variable models are made, one with and one without the interaction effects. The fixed and random effects model for both models give a different output. Which makes it crucial to determine which of the two models is best suited with the variable methods. This is done wit the use of the Hausmann test. Both models are compared with each other and a significant results (a >0.05) indicates the use of the FEM in favour of the REM and vice versa. Therefore the most suitable of the two statistical models is picked to analyse the data models. In appendix 2 the code used in STATA is shown.

4. Results

4.1 Descriptive statistics

In the first place the descriptive statistics of the key variables of this research. The descriptive statistics are used to inspect the variables before the further analysis is run to know which analysis and variables to use. Table 2 shows the descriptive statistics. The table includes the Mean, standard deviation, minimum, 25th, median, 75th and maximum percentage. Furthermore, the number of observation, giving insight in the data completeness. All the variables have the same number of observations 110, which is the same as the number of total observation that illustrates that there is no missing data in any of the variables in the dataset. A table with all the variables of this research can be found in appendix 1.

Table 1 Descriptive Statistics (Key variables from table 1)

Variable	Mean	Std.dev	Min	25	Median	75	Max	N
Dependent variable								
BUSINESS PERFORMANCE	156.40	191.64	0	13	72	214	765	110
Independent variables								
PROCUREMENT	0.71	0.46	0	0	1	1	1	110
INNOVATION	0.79	0.62	0	0.26	0.80	1.26	2.64	110
Control variables								
TEAM CHIEF AGE	49.66	8.92	35	42	49	57	70	110
TECHNICAL DIRECTOR AGE	47.31	6.62	34	42	47.5	52	63	110
HEAD OF AERODYNAMICS AGE	47.04	6.70	34	43	46	50	63	110
TEAM CHIEF EXPERIENCE	12.76	11.38	0	5	9.5	15	45	110
TEAM CHIEF SEX	0.09	0.29	0	0	0	0	1	110
TECHNICAL DIRECTOR SEX	0	0	0	0	0	0	0	110
HEAD OF AERODYNAMICS SEX	0.03	0.16	0	0	0	0	1	110

The variable “BUSINESS PERFORMANCE” has a mean of 156,40 which is the average points the teams have scored over the years. The standard deviation is higher than the mean, which indicates that there is a large spread within the variable. This is again confirmed by the percentiles, which show a relative large max in comparison to the mean. It also shows an absolute zero and the median of 72. In the data shows an right skewed variable. This is the dependent variable, it is not normally distributed, but this is not necessary for panel data. (Battese & Coelli, 1995) The variable is suitable for further use in the analysis as being the dependent variable.

The first independent variable “PROCUREMENT” is a dummy variable, the descriptive statistics give a mean of 0.71, where 1 is coded as making your own engine, and 0 being coded for the teams that buy their engine from a third party supplier. There is no missing data or abnormalities. The statistic shows that there are more teams that buy an engine than that make themselves. The descriptive statistics display that the data can be used and is suitable for further analysis. The second independent variable is “INNOVATION”, a variable that scores between 0 and 2.64 (min-max). The values are based on a relative innovation performance, where 1 is a neutral figure and better innovating teams have a value of higher than 1 and vice versa. With the standard deviation of 0.62, the maximum value can be seen as an outlier. This outlier however needs not to be corrected, due to the nature of the dataset.

The control variables are three different categories, the first is age. The age of the Team chef, technical director and head of aerodynamics. All values are comparable and show no abnormalities. The second is experience, the experience of the team chef in Formula 1. The factor shows a lot of variance, ranging from 0 to 45 years of experience. The last category is gender, the gender of the team chef, technical director and head of aerodynamics. Only for the team, gender can play a role in analysing, the other two variables have none, or only one count of different measure and are to small to analyse. All control variables except the gender of the technical director and the gender of the head of aerodynamics can be used to further analyse with the fixed effects model.

The full descriptive statistics can be found in appendix 3. In short, the correlation matrix shows that the variables that are based on the financial variable have a significant positive effect on the dependent variable. Additionally, the age of the team chef also has a significant negative relation with the points scored, this is opposite of what theory prescribes (Castellucci et al., 2011). However, this is a two dimensional outcome that has no further implications. The nature of panel data creates the need for the account for a time factor. To analyse the time factor, the FEM and REM analysis have to be executed.

4.2 Hypothesis testing

After it becomes clear which variables are able to be omitted after the descriptive statistics, the rest of the variables can be used in the further analysis. The variables are analysed using the FEM and REM method, after which the Hausman test is performed. For the sake of conciseness, the Hausman test is discussed first to determine which model must be used to further test the hypothesises. This enables the interpretation of the correct results and the hypothesis testing. In both cases of the fixed effect model and random effect model, are displayed in a table that includes four different models. The models include and exclude the interaction effect and the control variables.

4.2.1 Hausman test

The Hausman test is based on the comparison of the two analysis models fixed effects and random effects. Furthermore, the analysis is done with an interaction effect and without one. This means that there are four different analysis done, one with and one without interaction effects for both the FEM and REM, creating four different analyses. The Hausman test is performed with the comparable models, without interaction effect of the FEM and REM and with the interaction effect for both. In table 2 the results of the Hausman test are shown, after which can be concluded whether the FEM or REM is further used in the analysis of this research.

Table 2 Hausman test with and without interaction effect

Hausman MO1 & MO3	Models = No interaction
Prob>chi2	0.0049
Hausman MO2 & MO4	Models = With interaction
Prob>chi2	0.0466

The Hausman test in table 2 shows the chi square value for both Hausman tests that have been run. The null hypothesis of the Hausman test prefers the Random effects model. The rejection of the null hypothesis therefore favours the Fixed effects model. The result of the first test shows a value of 0.0049 that is lower than 0.05, and favours the FEM in favour of the REM. The second test results in a value of 0.0466, which is also lower than the significance level of 0.05. The test shows that for the models with and without interaction effect, the FEM is preferred. this research will therefore use the fixed effects model for further analysis of the dataset and hypothesis testing.

Besides the statistical explanation of the Hausmann test, there is another way of determining which model suits better. The models both have different places of usage, where the fixed effects model includes all observations as being true and assumes that there is one true effect that is the same in every observation(Barbour et al., 1992; Schmidheiny, 2018; Torres-Reyna, 2007). The random effects model assumes that there is in sample variation that is from within sample heterogeneity. The random effect model is commonly used in meta-analysis to take into account the differences in research samples. This research however does not make use of meta-analysis (Schmidheiny, 2018). The data is obtained from the same resources for each grouping variable and differences are due to chance. Therefore, in agreement with the Hausman test, the fixed effects model is best suited for the analysis of this research.

4.2.2 Fixed effects model

The results of the Fixed effect model are the basis on which the hypothesis can be accepted or rejected. In table 3 the different models are shown. The first model shows all the independent variables with the control variables and without the interaction effect. The second model shows the same as model one, but with the interaction variable. The third model shows only the dependent variables, and the fourth model shows the dependent variables with including the interaction effect. The last two models create the ability to check the control variables and the effect the control variables might have on the overall model.

The dependent variable is the business performance of the team, which is the number of points scored per season per team. The grouping variable used in the analysis is the team name. The grouping variable identified 12 different groups that where each individually analysed. The team with the least observable years had 2 years, and was usable for this research. The maximum number of observations per grouping variable is 10, which is the number of years of the data is gathered from. The remaining variables are used in the analysis as being independent and control variables.

In table 3 the results of the four models are compared with one another. Additionally, the table shows whether the results are significant and the level of significance. The data shows no new data other than the significance level. The data shows the three hypothesis: *H1: Procurement capabilities of a Formula 1 team positively influences the business performance. H2: Innovative performance of a Formula 1 team positively influences the business performance. H3: The procurement capabilities of a Formula 1 team positively influences the effect the innovative performance has on the business performance.* The results of the FEM are now discussed.

Hypothesis 1 expects to find a positive relationship between the procurement capabilities of a formula1 team and the business performance of the team. The procurement capabilities variable is therefore analysed in the all encompassing model including control and interaction variables. The procurement variable showed a positive significant relationship with business performance with a coefficient value of 0.9403 at an α of 0.0001. The predictive power decreases when the interaction effect is not included in the model with a coefficient value of 0.565, but the significance level remains at an α of 0.0001. The data therefore is aligned wit the expectation of H1, leading to the ascertain that there is enough statistical prove to accept hypothesis 1 in favour of rejecting hypothesis 1.

The second hypothesis suggests a positive significant relation between the innovation performance of a Formula 1 team and their business performance. The complete model, including the control and interaction variables is used to statistically analyse the relationship. The model encompassing all the variables shows a positive significant relationship. The relation is significant at an α level of 0.0001 with a coefficient of .8383. the model excluding the interaction term, give a value of 0.6586 at an α of 0.0001.

The positive significant values are as expected in hypothesis 2, leading to the accepting of hypothesis 2 in favour of rejecting it.

Finally, the third hypothesis describes a possible positive interaction effect between the innovative performance and procurement capabilities, regarding the business performance of the team. The fixed effects model including all variables reveals a negative significant result. The model with the control variables has coefficient of -0.3254 and the results is significant at an α of 0.0001. In contrast to what the third hypothesis expected, the relation was found to be significant negative. Consequently, the third hypothesis must be rejected in favour of the acceptance of the hypothesis.

*Table 3 FEM comparison of control variables and all variables except the interaction effect and the last model includes interaction effect *indicates significance level at 0.05 **indicates significance level at 0.01 ***indicates significance level at 0.001*

BUSINESS_PEROFORMANCE	Control variables only	All variables without interaction	All variables with interaction
PROCUREMENT		.565***	.9403***
INNOVATION		.6586***	.8383***
TEAM CHIEF AGE	.0185	-.2135***	-.1666***
TECHNICAL DIRECTOR AGE	.2062***	.2401***	.2433***
HEAD OF AERODYNAMICS AGE	.07438	.02555	.00881
TEAM CHIEF SEX	.7637***	.5418***	.747***
TEAM CHIEF EXPERIENCE	.008***	.01736***	.01419***
PROCUREMENT & INNOVATION INTERACTION			-.3254***

Lastly, the control variables. The age of the team chief is not significant positive in the model including only the control variables. However, a significant negative relation is found in the models including the dependent variables. The age of the technical director is found significant positive 0.2062 at an α level of 0.0001. The age of the head of aerodynamics is positive not significant. And the sex of the team chief is positive significant at an α level of 0.0001. The experience of the team chief is also significant positive at a coefficient value of 0.008 and an α level of 0.0001.

5. Conclusion & discussion

The link between procurement capabilities, innovative performance and their effect on business performance was yet to be researched with empirical data. Current literature is based on a biased perspective. The research was based on the perception of innovation and procurement managers on the role their capabilities and performance played within an organization. This research aimed to find the link between the different aspects on the base of data obtained without the bias of the relevant managers. Therefore, the highly innovative and technical Formula 1 industry is used to obtain unbiased data. The industry lends itself for this research due to the large quantity of unbiased data obtainable online.

The first two hypothesis test the individual effect of procurement capabilities and innovative performance, on the business performance of the team. Both hypothesises are proven in previous literature on the basis of the findings of managers. The hypothesis confirms that improved procurement capabilities have a positive effect on the business performance of the team. Secondly, the innovative performance also positively influences the business performance of a Formula 1 team. This is in line with KBV, where unique capabilities of teams and better resources lead to a better business performance of the Formula 1 teams.

This finding is supported by previous performed research, which was predominantly based on perception of performance and capabilities by the managers of relevant departments (Goh et al., 1999; Narasimhan & Das, 2001; Neely & Hii, 1998; Schiele, 2007a; Wong et al., 2016). The proven relationship between procurement capabilities and business performance strengthens the believe that improved capabilities improve business performance. Therefore, the procurement department can, and should be a place of internal development and investment. This data research displays that this has a high change of contributing to a better business performance.

The relationship between innovation and business performance is also confirmed in the analysis. Consistent with previous research, the innovative performance of an organization does improve business performance positively. Hence, suggesting that investing in innovative performance of an organization to improve the performance can be expected to positively influence the business performance. Concluding, investing and improving both individual factors of the procurement capabilities and innovative performance, has a positive effect on overall business performance.

The third hypothesis tests an interaction effect. Whether the procurement capabilities and innovative performance strengthen each other to improve the business performance even more than the sum of the two individual factors already achieve (as seen in H1 & H2). In contrast to existing literature about the interaction effect of procurement capabilities and innovative performance and their combined effect on business performance, this research found a negative significant relationship.

The rejection shows that, within the Formula 1 industry, the procurement capabilities and innovative performance do not empower each other beyond their own effect on business performance.

The data and analyses led to a confirmation of existing literature. The knowledge based view, evolved from resource based view, is further enforced on the view of personal capabilities as a unique intangible asset of an organization. Two of the three hypothesises are accepted in favour of the expectation supported by the literature research based theoretical model. However, the interaction effect spoken about in existing literature between procurement and innovation has not been found in this case study. This does not necessary means that there is no such interaction effect, due to the nature of a case study there are some limitation.

This study has several limitations. The first one is the generalizability of the used dataset, the Formula 1 is a highly innovative and highly technical environment. The Formula 1 team organizations are often large multinationals, with some exceptions. This means that the data is not representative for most SME's nor other organizations not operating in a highly innovative or technical environment. The second limitation of this study is the measurement of procurement capabilities. In spite of the fact that the variable is a presentation of the procurement department, it is created of only one data point for each team each year. It is also not used as a procurement indicator in other existing literature.

Future research might be in the direction of a more generalizable sample study. Meaning that the data is not just focussed on a specific sector or industry. However, a sample of for example SME's in a certain counties or industries could be of interest. This might boost the usability of the research for the workforce. Furthermore, a better measurement of procurement might be used to determine the procurement capabilities of organizations. Lastly, future research could use a more in depth analysis of organization by for example using interviews to create a possibility to analyse the data with background information. Creating a perspective for the numbers used in the analysis.

The implications for organizations is limited, the nature of a case study always encompasses limitations of the interpretation and usability[10]. Although, the study has several implications for organizations that are active in a highly innovative and technology driven industry. This study implies for them that the procurement capabilities have a significant effect on the business performance of the organization. Moreover, the innovative performance of the organizations has more impact on the overall business performance of the organizations. The link between these departments in an organization is not denied by this research, only not further strengthened. Organizations that suite the high tech, highly innovative and competitive prescription should focus on both of the departments to further improve their business performance.

[10] https://tomprof.stanford.edu/posting/1013

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Appendices

APPENDIX 1 Data variables description

"Driver"	The name of a driver of a Formula 1 car	Nominal
"Nationality"	The nationality of the driver	Nominal
"Team"	Name of the team of the driver	Nominal
"Points"	Individual points of the driver	Ratio
"Constructors"	Total points of the two team drivers	Ratio
"YEAR_00"	The year where the data is from	Nominal
"TEAM_01"	Standardized team name, same each year	Nominal
"ENGINE_02"	The engine used by the team during a year	Nominal
"ENGINE_PERFORMANCE"	Total points in season per engine/money spent by teams with engine	Ratio
"FINANCE_03"	Budget of the team per year per	Ratio
"FINANCE_LOG"	Log of "FINANCE_03" for the purpose of analysing	Ratio
"TEAMCHEF_04"	Name of the team chef of the team that year	Nominal
"TEAM_AGE"	Age of the team chef	Ratio
"TEAM_SEX"	Gender of team chef	Nominal
"TEAM_EXP"	Number of years the team chef is active in Formula 1	Ratio
"TECHNICAL_05"	Name of the technical manager of the team that year	Nominal
"TECH_AGE"	Age of the technical manager	Ratio
"TECH_SEX"	Gender of technical manager	Nominal
"AERODYNAMICS_06"	Name of the head of aerodynamics of the team that year	Nominal
"AERO_AGE"	Age of the head of aerodynamics	Ratio
"AERO_SEX"	Gender of head of aerodynamics	Nominal
"TEAMPOINTS_07" = BUSINESS_PERFORMANCE	Total points of a team scored during a year (including part-time drivers)	Ratio
"ENGINE_MAKEBUY" = PROCUREMENT_D	Dummy variable Engine 1 = Make 0= Buy	Nominal
"INNOVATION"	(ENGINE_Performance* TEAMPOINTS) / FINANCE	Ratio

APPENDIX 2 STATA 13 code used for analysis

/*GENERAL CONVERSIONS DATASET*/

```
encode TEAM_01, gen(TEAM2)

encode ENGINE_02, gen(ENGINE2)

egen ENGINE_PERFORMANCEstd = std(ENGINE_PERFORMANCE)

egen FINANCEstd = std(FINANCE_03)

encode TEAMCHEF_04, gen(TEAMCHEF)

egen TEAM_AGEstd = std(TEAM_AGE)

encode TECHNICAL_05, gen(TECHNICAL)

egen TECH_AGEstd = std(TECH_AGE)

encode AERODYNAMICS_06, gen(AERODYNAMICS)

egen AERO_AGEstd = std(AERO_AGE)

encode Nationality, gen(NATIONALITY1)

egen TEAM_EXPstd = std(TEAM_EXP)
```

/*DESCRIPTIVE STATISTICS*/

```
pwcorr TEAMPOINTS_07 FINANCEstd ENGINE_PERFORMANCEstd ENGINE_MAKEBUY INNOVATION
TEAM_AGEstd TEAM_SEX TEAM_EXP TECH_AGEstd AERO_AGEstd ,st(.05)

summarize TEAMPOINTS_07, detail

summarize FINANCE_03, detail

summarize ENGINE_MAKEBUY, detail

summarize INNOVATION, detail

summarize ENGINE_PERFORMANCE, detail

summarize TEAM_AGE, detail

summarize TECH_AGE, detail

summarize AERO_AGE, detail

summarize TEAM_EXP, detail

summarize TEAM_SEX, detail

summarize TECH_SEX, detail

summarize AERO_SEX, detail
```

/*SET PANEL STRUCTURE*/

xtset TEAM2 YEAR_00

/*fixed effects model*/

xtpoisson TEAMPOINTS_07 TEAM_AGEstd TECH_AGEstd AERO_AGEstd i.TEAM_SEX TEAM_EXP, fe

est store model07

xtpoisson TEAMPOINTS_07 ENGINE_MAKEBUY INNOVATION TEAM_AGEstd TECH_AGEstd AERO_AGEstd i.TEAM_SEX TEAM_EXP, fe

est store model01

xtpoisson TEAMPOINTS_07 ENGINE_MAKEBUY INNOVATION TEAM_AGEstd TECH_AGEstd AERO_AGEstd i.TEAM_SEX TEAM_EXP c.INNOVATION#i.ENGINE_MAKEBUY, fe

est store model02

xtpoisson TEAMPOINTS_07 ENGINE_MAKEBUY INNOVATION, fe

est store model05

xtpoisson TEAMPOINTS_07 ENGINE_MAKEBUY INNOVATION c.INNOVATION#i.ENGINE_MAKEBUY,fe

est store model06

est table model01 model02 model05 model06, stats(ll bic r2 N) equation(1) b(%7.4g) star**/*random effects model*/**

xtpoisson TEAMPOINTS_07 ENGINE_MAKEBUY INNOVATION TEAM_AGEstd TECH_AGEstd AERO_AGEstd i.TEAM_SEX TEAM_EXP, re

est store model03

xtpoisson TEAMPOINTS_07 ENGINE_MAKEBUY INNOVATION TEAM_AGEstd TECH_AGEstd AERO_AGEstd i.TEAM_SEX TEAM_EXP c.INNOVATION#i.ENGINE_MAKEBUY, re

est store model04

est table model03 model04, stats(ll bic r2 N) equation(1) b(%7.4g) star

/*Hausman test*/

hausman model01 model03

hausman model02 model04

APPENDIX 3 Descriptive statistics results (complete)

Variable	Mean	Std.dev	Min	25	Median	75	Max	N
Dependent variable								
BUSINESS_PERFORMANCE	156.40	191.64	0	13	72	214	765	110
Independent variables								
PROCUREMENT_D	0.71	0.46	0	0	1	1	1	110
INNOVATION	0.79	0.62	0	0.26	0.80	1.26	2.64	110
Control variables								
TEAM_AGE	49.66	8.92	35	42	49	57	70	110
TECH_AGE	47.31	6.62	34	42	47.5	52	63	110
AERO_AGE	47.04	6.70	34	43	46	50	63	110
TEAM_EXP	12.76	11.38	0	5	9.5	15	45	110
TEAM_SEX	0.09	0.29	0	0	0	0	1	110
TECH_SEX	0	0	0	0	0	0	0	110
AERO_SEX	0.03	0.16	0	0	0	0	1	110

APPENDIX 4 Correlation matrix

	TEAMPOINTS_07	FINANCE_03	ENGINE_PERFORMANCE	ENGINE_MAKEBUY	INNOVATION	TEAM_AGE	TEAM_SEX	TEAM_EXP	TECH_AGE	AERO_AGE
BUSINESS_PERFORMANCE	1,0000									
FINANCE_03	0.5920*	1,0000								
ENGINE_PERFORMANCE	-0.2469*	-0.2178*	1,0000							
PROCUREMENT_D	-0.4082*	-0.4442*	0.1485	1,0000						
INNOVATION	0.6312*	0.5252*	-0.2035*	-0.3564*	1,0000					
TEAM_AGE	-0.2280*	-0.1177	0.2529*	0.1245	0.0044	1,0000				
TEAM_SEX	-0.0895	-0.1720	-0.0977	0.2025*	-0.1095	-0.3086*	1,0000			
TEAM_EXP	-0.0745	-0.0412	0.0758	0.2199*	0.1015	0.5753*	0.0206	1,0000		
TECH_AGE	0.0551	0.0779	-0.0686	-0.1795	-0.1015	-0.0577	0.0907	-0.1292	1,0000	
AERO_AGE	-0.1136	-0.0648	-0.1323	0.0305	-0.0432	0.0848	0.2779*	-0.0713	0.0814	1,0000