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A global analysis of innovation and workplace personality

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A Global Analysis of Innovation and Workplace Personality

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A research report submitted to the Wits Business School, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Management in Innovation Studies

Abstract

The study aims to provide an under presented macro view of the relationship between personality and innovation outcomes with greater representation of non-Western nations. It further aims to provide a more nuanced view by utilising a granular model of personality consisting of 32 dimensions that can be linked back to current findings in relation to the Big Five Model. The purpose of this study is to identify specific personality dimensions which could describe macro-level *innovativeness* due to covariance with national innovation outcomes then extrapolate these findings to make sectoral comparisons.

In order to achieve these aims, Global Innovation Index (GII) data from 2013 to 2016 was combined with Occupational Personality Questionnaire (OPQ) data from 2009 to 2016. The GII data comprises of innovation input measures (five pillars consisting of 15 sub-indices) and output measures (two pillars consisting of six sub-indices) for between 128 and 143 countries depending on year. The OPQ data represents the responses of 3 066 905 individuals across 122 countries and 41 sectors.

The study finds that numerous dimensions of personality have significant associations, some positive and some inverse, with innovation outcomes at the national level. There is both overlap and disparities between dimensions that are prominent in cross-sectional versus panel analysis. A high preference for *affiliative* and low preference for *rule following* is highlighted as particularly noteworthy. When examining sectors there is coherence in the relative ranking of sectors when these two key dimensions are considered. In conclusion a deep dive of sector pairs (*pharmaceutical & biotechnology* versus *mining* and *media* versus *banking*) is conducted to illustrate the applications of the study. The study is noted to have relevance to academia; leaders of nations and policy makers as well as leaders of industry and organisational practitioners.

Declaration

I declare that this research report is my own, unaided work. It is submitted in partial fulfilment of the requirements of the degree of Master of Management in Innovation Studies at the Wits Business School in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Dedication

With gratitude to Sophie, Krispy Kreme doughnuts and Gif keyboards.

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Chapter one: Introduction

1.1 Purpose of the study

In an increasingly fast-paced and competitive world, innovation is a key differentiator. With leaders of both industries and nations seeking to drive innovation outcomes, its preconditions are of material interest. While the *innovativeness* of individuals comprising either a nation or an industry, has been identified as a relevant input for achieving innovation outcomes; empirical investigation has proven challenging. Innovation outcomes are diverse, complex in construct and difficult to measure. Outcomes may each be driven by different aspects of *innovativeness* – a construct equally complex with limited comparable macro-level datasets. The relatively recent availability of large psychological datasets provides researchers with a major opportunity, yet to be fully leveraged, to empirically test the relationship of the macro-psychological make-up of geographies or industries with innovation. (Obschonka, Stuetzer, Gosling, Rentfrow, Lamb, Potter, Audretsch, 2015).

The purpose of this study is to identify specific personality dimensions which could describe macro-level *innovativeness* due to covariance with national innovation outcomes then extrapolate these findings to make sectoral comparisons. In order to achieve this, a unique macro-level dataset (combining personality and innovation data) is analysed in three different ways to better understand and describe these associations. The primary analysis serves to provide a cross-sectional view of the relationship between personality and innovation outcomes at the national level. The secondary analysis serves to enhance these findings with a longitudinal assessment. Finally the tertiary analysis, builds on the outcome of the primary and secondary analysis by illustrating applications of the results through the comparison of sectors.

1.2 Context of the study

The studies conducted to date on the role of personality in innovation outcomes have been subject to two perceived limitations. Firstly, the majority of innovation research has been conducted either at the individual, team or organisational level (Anderson, Dreu & Nijstad, 2004; Anderson, Potočnik & Zhou, 2014). The analysis proposed will take place at the macro-level of nations and industries to provide an underrepresented view. Secondly, a highly aggregated model of personality – the Big Five Factor Model – is the conceptual model underpinning the majority of analyses conducted at the macro-level (for example Patterson & Kerrin, 2016; Rossberger & Krause, 2013; Steel, Rinne, Fairweather, 2012). This study aims to leverage a large, global personality dataset - consisting of 32 dimensions rather than five aggregated factors - in an attempt to provide a more nuanced view. The 32 dimensions can be related back to the prevailing Five Factor Model (FFM); however, this more granular view may assist in overcoming previously contradictory findings that are highlighted in the upcoming literature review.

1.3 Significance of the study

The results of this study are relevant to a range of stakeholders in academia, government and industry. While chapter six will bring together specific findings in relation to each of these sets of stakeholders, this section provides the framing for these discussions.

From an academic perspective, one of the challenges of innovation studies is that it can be seen as an, "…academic *mongrel* of somewhat lower academic status rather than a disciplinary *pedigree*" (Fagerberg, Andersen & Martin, 2013, pp 11). However, in many ways this is a product of the concept under study which requires an agile approach able to bridge academic silos (Fagerberg et al, 2013). In this case, organisational psychology will be used as a lens to apply within innovation studies. Innovation studies research has relied heavily on tangible or harder measures, such as research and development (R&D) spend, while some of the softer measures, such as *innovativeness*, remain hidden (Obschonka et al, 2015). The discipline of psychology has long been concerned with surfacing these concepts and being able to measure them validly and reliably

against robust constructs (Widiger, 2017). While the field of entrepreneurship was early to capitalise on the research opportunity presented by linking psychological data to innovation outcomes, these tended to focus at the individual level. Innovation studies have subsequently followed suit but there have been limitations in presenting a macro view (Anderson et al, 2014). This contemporary psychological research approach - underpinned with a notably larger, cross-culturally applicable dataset - can provide initial insights but perhaps more importantly, demonstrate the myriad of possibilities for further research at the intersection of these disciplines.

From a government perspective, this may be a unique opportunity for policy makers to gain an objective understanding of more intangible factors associated with national innovation outcomes.. It is common, as a starting point, to compare countries in terms of their innovation outcomes as a proxy method to rank their innovation performance (Edquist, Zabala-Iturriagagoitia, Barbero & Zofío, 2018). This body of research has progressed to the meta-level, for example endeavouring to better understand the lag of the Global South in relation to the developed world (Albuquerque, Suzigan, Kruss &Lee, 2015). However, when designing innovation policies scholars argue that these rankings alone are not sufficient for policy makers, rather careful consideration should be given to the relationship between inputs and outputs (Edquist et al, 2018)., Anderson, Potočnik and Zhou (2014) specifically note a research-practice gap in relation to understanding the impact of the so called *cultural variable*; particularly when comparing similarities and differences between East and West. While the cultural variable is often operationalised as a broader construct, personality is commonly cited as an interwoven element. As demonstrated by Hofstede and McCrae (2004) who found that personality (as measured by the Five Factor Model) was significantly and substantially correlated with measures of culture at a national level. Therefore, identifying specific relationships between personality dimensions and innovation outcomes, controlling for innovation inputs, could have useful application in addressing this research-practice gap.

An enduring challenge with comparing countries has been sample size. An example of a seminal national study is Rossberger and Krause (2013) where 33 countries were analysed in relation to personality factors, cultural practices and innovativeness. This seminal research was noteworthy

not just for considering these factors simultaneously but also for the large sample size. The study presented in this paper is based on data collected from individuals in 122 countries, therefore comparatively larger than studies relating personality and innovation to date. It also has greater representation for the Global South, for example South Africa (n = 188 260) and Chile (n = 5 285), as well as the East, for example India (n = 423 536) and China (n = 179 224). The finding therefore may be of greater applicability to policy makers outside of Western or Global North contexts.

From an industry perspective, there is keen interest in selecting individuals with specific personality preferences that have been shown to be related to on-the-job innovation results such as creative contribution, openness to change, adaptability and so forth (McEntire & Greene-Shortridge, 2011). Macro findings relating personality dimensions to innovation outcomes including *knowledge and technology outputs* as well as *creative outputs* could challenge long held beliefs that *innovativeness* is only required in select roles. It may provide further credence to the argument that the current typical focus on selecting for *innovativeness* only in leadership and Research and Development (R&D) type roles is somewhat short-sighted.

While the search for *innovativeness* is common practice at the individual level during recruitment, this should not overshadow potential applications across the employee lifecycle including on-boarding, development and promotion. For example, some organisations endeavour to audit the current *innovativeness* of specific teams, departments or their entire firm. These organisations often seek to better understand the profile of their organisational incumbents to identify development initiatives that would demonstrate the greatest return on investment. Ultimately, a scientifically informed profile of *innovativeness* i.e. demonstrated to be associated with innovation outcomes, combined with a means of measurement, has applications in almost all human capital practices. These would include selection, development, succession planning, change management, cultural alignment, employee engagement and so forth.

1.4 Aims of the study

The primary aim of the study is to explore whether specific dimensions of personality co-vary with innovation outcomes at the national level. The secondary aim is to interrogate these findings to test whether the relationships hold over time. The final aim is to use the findings from the primary and secondary analyses to compare the *innovativeness* of sectors, thereby demonstrating the possible application and opportunities for future research.

1.5 Delimitations of the study

The study relies heavily on analysis conducted on a merged dataset from the period 2009 – 2016. The dataset comprises historical records from a proprietary personality instrument (the Occupational Personality Questionnaire) and a publicly available repository of global innovation metrics (the Global Innovation Index). The researcher has not collected primary data for the study, due to practical constraints of the sample size required for macro-level analysis.

The Global Innovation Index (GII) is a publicly available and reputed third generation innovation index (Crespo & Crespo, 2016; Donoso, 2017). A further explanation of this particular dataset and a comparison of similar sources will be provided in the literature review as justification for this choice of super-index[1]. This secondary source used will not be subjected to in-depth interrogation or validation as part of this scope but will be accepted prima facie mindful of two possible limitations raised in the literature review chapter.

The globally collected psychometric scores are the proprietary property of a psychometric test publisher, namely SHL. A research agreement has been concluded in order to gain access to the data for the purposes of this study. An extensive discussion of the instrument, including studies on

[1] Super-index: These indices consist of multiple input and output factors with data amassed on a large scale and most typically reported at a national level. May also be called third generation, composite, multi-dimensional or super-indices (Donoso, 2017).

its reliability and validity, are presented as justification for the choice and assurance of the instrument's robustness.

1.6 Assumptions

The key assumption is the relevance of the macro-level units of analysis chosen – namely sectors and countries. For innovation outcomes, country level analysis is prevalent and widely accepted as a unit of analysis; this is expanded upon further in the literature review. In personality research, macro-level analysis has proven challenging for a number of reasons that will be outlined in the literature review to follow, with some arguing that there is more variation within countries than between. However, studies reporting significant results linking innovation and personality at the national level, for example Rossberger and Krause (2013), support the argument that country level analysis is relevant. From a measurement perspective, this concern is addressed by considering aggregated trends of self-reported workplace personality per country rather than assuming a 'national personality' which would be overly simplistic given intra-country differences. Similarly, industries as a domain can be critiqued due to the degree of inherent heterogeneity with some arguing that ecosystems are a more fitting unit of analysis (Teece, 2014). This study therefore considers sectors, a further breakdown of industries, which is presumed to overcome this concern.

1.7 Definitions of key concepts

Innovation is a central concept and the first important term to clarify. The distinction between *innovation inputs* and *innovation outputs,* as used in this study, is then introduced and depicted in detail. The concept of personality, more specifically workplace personality is then introduced. This leads to the discussion of *innovativeness* – specifically its positioning within the personality construct and its differentiation from innovation. The various concepts are drawn together in defining *macro-level innovativeness* which is the pivotal focus of the study.

i. Innovation

Innovation is a broad term which is used in a range of contexts and carries a plethora of different meanings depending on its application. A Google search will at present return over 600 million hits for the term *innovation* showing both the breadth of the concept's reach and the depth of interest in the topic. The 3rd Edition Oslo Manual defines innovation as, "…the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD, 2005, p. 46). The Manual further identifies four broad categories for innovation types including product, process, marketing and organisation (OECD, 2005). This definition was seminal as it allowed for the concept under study to extend beyond the traditional confines of research labs tasked with producing new products and production methods. This inclusive definition recognised that innovation is a systematic notion that crosses borders and sectors affecting users, suppliers and consumers far and wide. While this definition is useful for the purpose of this study which focuses on innovation outcomes primarily, it can also be critiqued for not truly encapsulating the complexity of the construct.

Innovation can be more broadly appreciated within a framework. An example of a process type view is the Innovation Pentathlon which is appropriate in an organisational context. It proposes that various ideas enter the 'funnel' and must then be evaluated so that those with the most potential are followed through (Goffin & Mitchell, 2005). The process is however not linear and is affected heavily by the context in which the innovation is taking place (Goffin & Mitchell, 2005). This is illustrated in figure 1.

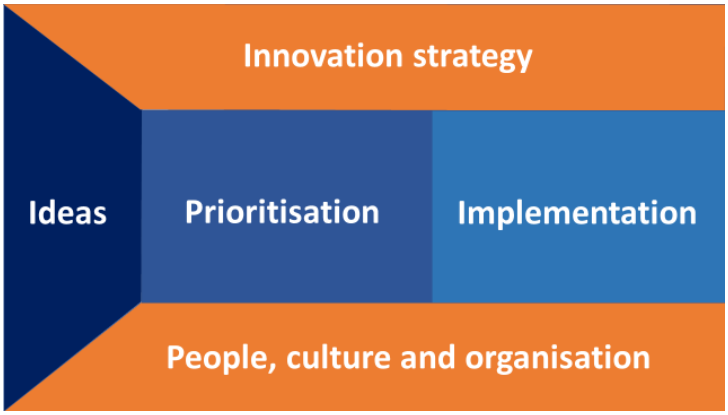


Figure 1. The Innovation Pentathlon (Goffin & Mitchell, 2005, p. 29).

In frameworks more commonly used in macro contexts, such as policy making, innovation can be considered to be a helix – triple, quadruple or quintuple (Monteiro & Carayannis, 2017). This system type view proposes a high degree of inter-relationship between the knowledge economy, knowledge society and knowledge democracy (Monteiro & Carayannis, 2017). These elements are proposed to co-evolve within the broader environment and social ecology (Monteiro & Carayannis, 2017). This is depicted in figure 2.



Figure 2. Multi-level architecture of the Helix Innovation Systems Conceptual Framework (Monteiro & Carayannis, 2017, p. 7).

The OECD definition of innovation outputs is a solid starting point, while the frameworks are useful to more broadly represent innovation as a complex construct. This study will propose a simple distinction between innovation inputs and innovation outputs, which will be further expanded upon when the Global Innovation Index (GII) taxonomy is introduced.

ii. Innovation inputs vs innovation outputs

Innovation is a complex phenomenon, as the understanding has broadened, so have the models as well as measures. Smith (2005, p. 148) stated "an important development has been the emergence of new indicators of innovation inputs and outputs, including economy-wide measures that have some degree of international comparability." One such indicator is the Global Innovation Index (GII) which categorises innovation inputs and outputs as shown in figure 3.

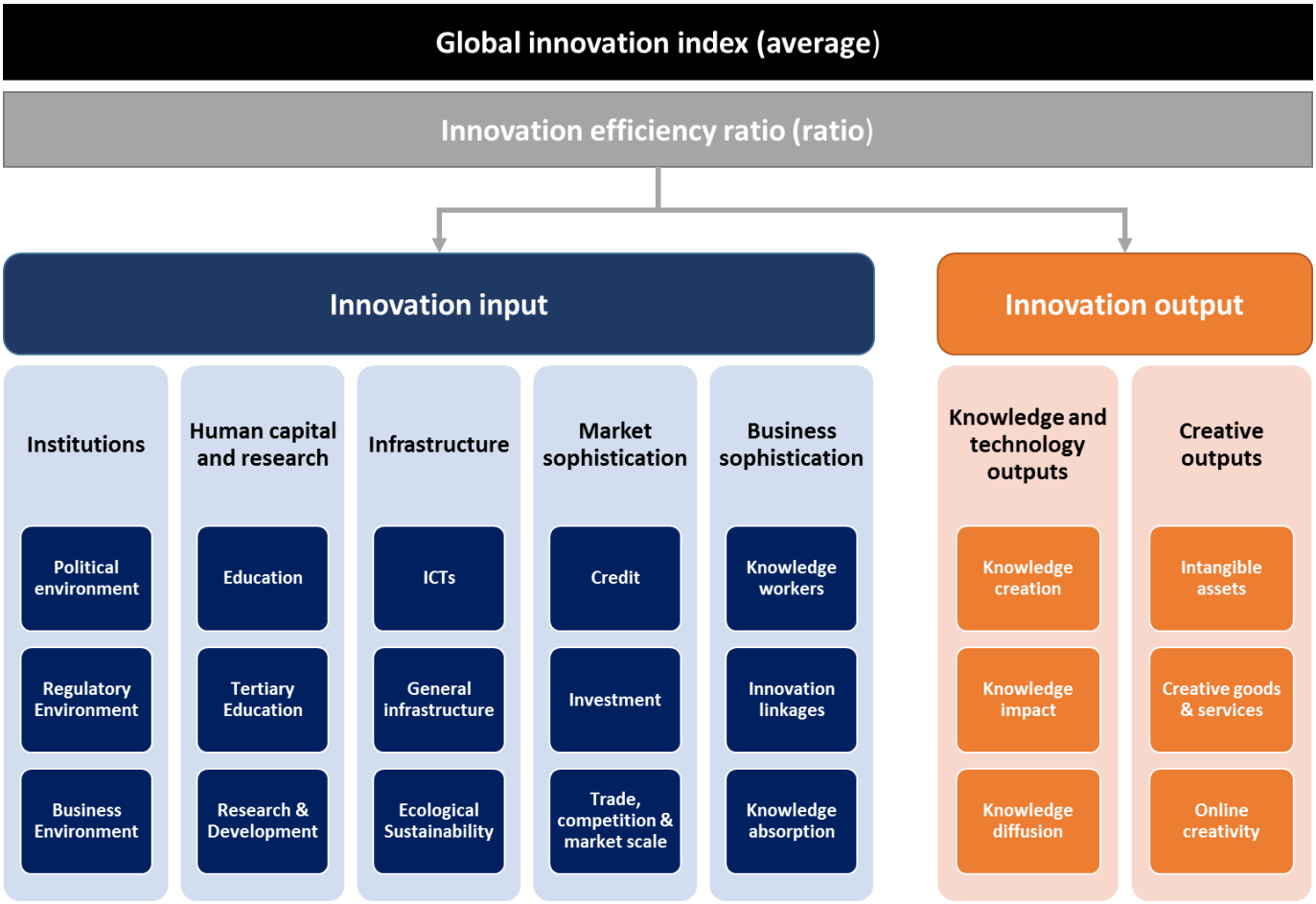


Figure 3. The structure of the GII[2]

Each of the fifteen sub-indices for inputs and six sub-indices for outputs are quantified annually using a list of inputs variables (Cornell INSEAD WIPO, 2016). The complete list of these variables can be found in appendix 1. The GII, as well as the evolution of these third-generation type indices will be discussed in more depth in the literature review.

[2] Refer to appendix 1 for a more detailed view of the GII composition

iii. Workplace personality

From the birth of personality research, a highly diverse set of interpretations and operationalisations of the construct have emerged from schools of thought such as psychoanalysis, behaviourism, cognitivism and humanism, to name a few (Weiten, 2007). These varied understandings of both the origins and impact of personality have had extensive applications in clinical, counselling, consumer behaviour and workplace settings. In this study a trait theory rooted definition of personality as an individual's typical or preferred ways of thinking, feeling and behaving is posited (Bartram, Brown, Fleck, Inceoglu & Ward, 2006).

The definition proposed for this study, can be traced back to the thinking of Sir Francis Galton in the 1860s whose studies of human abilities were instrumental in the foundation of differential psychology[3] and the subsequent design of the first forms of psychometric testing (Weiten, 2007). The definition proposed relies on the fundamental principle that there are stable aspects to personality which are comparable between individuals - a key belief of formative trait theorists such as Allport, Odbert and Cattell (Oliver, Angleitner & Ostendorf, 1988). In the modern workplace context, personality *traits* conceptualisations have garnered the most attention due to their widespread endorsement and quantitative appeal.

Of the myriad of personality trait operationalisations in existence, one of the most common is the Big Five taxonomy (Salgado & Táuriz, 2014; Widiger, 2017). The Big Five model of personality has become a common language and platform for research which has allowed for comparable findings and integration of the research under one theoretical perspective (John, Naumann & Soto, 2008; Widiger, 2017). The taxonomy consists of five supra factors namely extraversion, agreeableness, conscientiousness, emotional stability and openness to experience (Widiger, 2017). The Big Five taxonomy does not replace or compete with other taxonomies in existence rather it creates a cross-culturally validated framework under which most other major taxonomies can be organised (John et al, 2008).

[3] Focuses on the ways in which individuals differ in their behaviour by attempting to identify common underlying processes.

When honing into the workplace context more specifically, personality has been found to be a useful predictor of key outcomes such as attitudes, behaviours, performance and other organisational results (Ones, Dilchert, Viswesvaran, Judge, 2007). The most powerful predictive studies can be conducted when personality is considered not just at the supra level of the hierarchy, i.e. Big Five Factors, but also at the facet or dimension level. To state this more plainly, workplace personality is best understood as a profile with high and low scores on various dimensions rather than just an overall, average score (Bartram et al, 2006). This is illustrated in the example profile provided in appendix 2.

For the purpose of this study, a more granular view of personality will be fitting as it will allow for a deeper interrogation of initial findings around the relationship between innovation and personality using the Big Five Factor model at the macro-level. The framework that will be used was specifically researched and developed in the workplace context and it informed the design of the Occupational Personality Questionnaire (OPQ). The OPQ definition of workplace personality consists of 32 dimensions organised into three key domains, underpinned by a fourth domain related to sources of energy as depicted in figure 4.

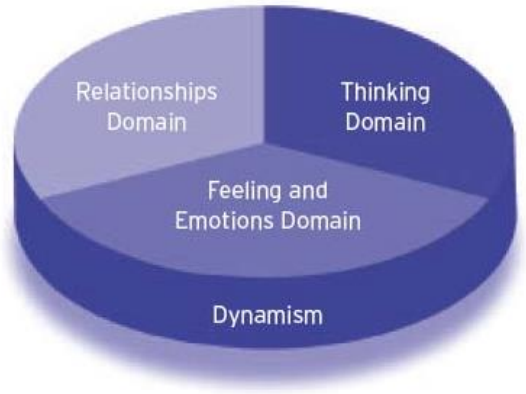


Figure 4: The OPQ model of personality (Bartram, Brown, Fleck, Inceoglu & Ward, 2006, p. 7)

This personality model has been selected specifically due its fit for purpose in the workplace context, however it has also been selected as it can be empirically related to the prevailing Big Five taxonomy. This is a key consideration as it has been noted that studies on personality influences on innovation were fragmented in the initial decades as there was no overarching framework to connect findings, conduct comparisons or allow for meta-research to emerge (Patterson & Kerrin, 2016). The recent organisation of these studies under the Five Factor Model allows for cross-referencing of findings in order to progress the body of research coherently (Patterson & Kerrin, 2016). In order to ascertain fit, a correlation study was conducted and this was confirmed in two or more factor analytical studies (Bartram, 2006). All of the following dimensions have been confirmed as a good fit within the Five Factor Model (FFM) taxonomy:

Table 1. Summary of the OPQ32 dimensions as related to the FFM (Adapted from Bartram et al, 2006, p. 127).

Big Five	**32 Dimensions**
Extraversion	Outgoing Socially confident Affiliative Emotionally controlled (reversed) Persuasive Controlling

Big Five	32 Dimensions
***Agreeableness**	Caring Democratic Independent minded (reversed) Trusting Competitive (reversed)
Conscientious	Conscientiousness Detail conscious Vigorous Forward thinking Achieving
Emotional stability	Worrying (reversed) Relaxed Tough minded Socially confident Optimistic
***Openness to experience**	Innovative Conventional (reversed) Conceptual Variety seeking Behavioural

Two of the big five factors indicated with an asterisk (*) have been found by the literature to date to correlate positively with innovation outcomes at a national level such as creative and scientific outputs (Rossberger & Krause, 2013). This will be covered in more depth in the literature review section exploring the links between personality and innovation.

In summary, the definition of personality as proposed is based on a workplace-specific model consisting of 32 dimensions which can ultimately be related back to the prevailing Big Five Factor model. The organisation of these 32 dimensions into the four domains as well as a precise

definition for the opposing poles of these scales can be found in appendix 2. Since personality has been broadly introduced as well as the manner in which it will be operationalised, it is important to now define innovativeness as the second major construct of focus. Thereafter it will be key to distinguish this from the concept of innovation, already introduced, then finally to frame *innovativeness at the macro-level*.

iv. Innovativeness

Innovativeness refers to the expression of an underlying set of individual characteristics which are thought to drive innovation outcomes. This may refer to a broad range of relatively stable pre-conditions including but not limited to cognitive ability, personality traits, motivation and values (Patterson & Kerrin, 2016). It may also include characteristics that may be more influenced by the environment for example knowledge, mood state, emotional intelligence or values (Patterson & Kerrin, 2016). Innovativeness as a construct has been operationalised at many levels including the individual, group and macro level.

At an individual level the focus is commonly on the consumer, entrepreneur or intrapreneur. *Consumer innovativeness* has emerged strongly in consumer research to delineate the characteristics related to the likeliness of adoption of various products or services - usually those with a technological flair (Kaushik & Rahman, 2014). For the purposes of this study the focus is on the characteristics, specifically personality traits, which drive innovation through both *entrepreneurs* and *intrapreneurs*. The chief difference is that the intrapreneur, as a member of an organisation, drives innovation outcomes from within whereas the entrepreneur tends to take greater risk and has endogenous beginnings (Hisrich, 1990).

To illustrate the complex linkage between *innovativeness* and *innovation* consider the following. *Innovativeness* synonyms include creativeness, imaginativeness, ingeniousness and inventiveness; this demonstrates the misplaced emphasis on the idea generation fragment of the process. While a unique and worthwhile idea is often the catalyst of innovation efforts, without determined follow

through even the best ideas or concepts can fall by the wayside; be adopted only by a few thereby not reaching the mainstream; or simply fail after launch (Moore, 2002). In the case of the *entrepreneur*, the differentiator may be having the resilience to achieve commercialisation of a particular idea. In the case of an *intrapreneur*, this may be the social finesse to obtain internal buy-in and the persistence to see an internal project through to completion despite not directly benefitting (Goffin & Mitchel, 2005). So, while so-called creative characteristics may certainly be one factor in achieving innovation outcomes, there is more to consider when taking a holistic view of innovation.

At a team or organisational level, *innovativeness* may be used as a term to describe properties of the collective make-up thought to drive innovation – be this in product, process, marketing, organisation or a combination as defined in the opening of this section. While this may be a collective of the characteristics at the individual level, studies at the group level may also include contextual factors such as organisational structure, climate and culture. As *firm innovativeness* has been linked to higher firm performance, efforts have intensified to validate these linkages and better understand the antecedents (Hult, Hurley & Knight, 2004; Rubera & Kirca, 2012).

v. Macro level innovativeness

As analyses include larger and larger populations, they tend towards the macro-level. Examples of macro-level units of analysis may be industries (collections of companies similar in nature), nations (collection of citizens), blocs (collection of alliance countries) or continents (collection of proximity countries). This particular study will consider innovativeness at the national and industry, more specifically sector, level. To be more precise, the study considers characteristics, specifically personality dimensions, of all potential individual intrapreneurs[4] and entrepreneurs, that make-up both nations and sectors.

[4] Individuals within established organisations turning ideas into innovation outputs.

In order to investigate *macro-level innovativeness*, as it relates to innovation outputs, the frameworks discussed so far are organised into a single depiction which follows in the conceptual framework.

1.8 Conceptual framework

Figure 5 provides a summary view of the conceptual framework that underpins the study.

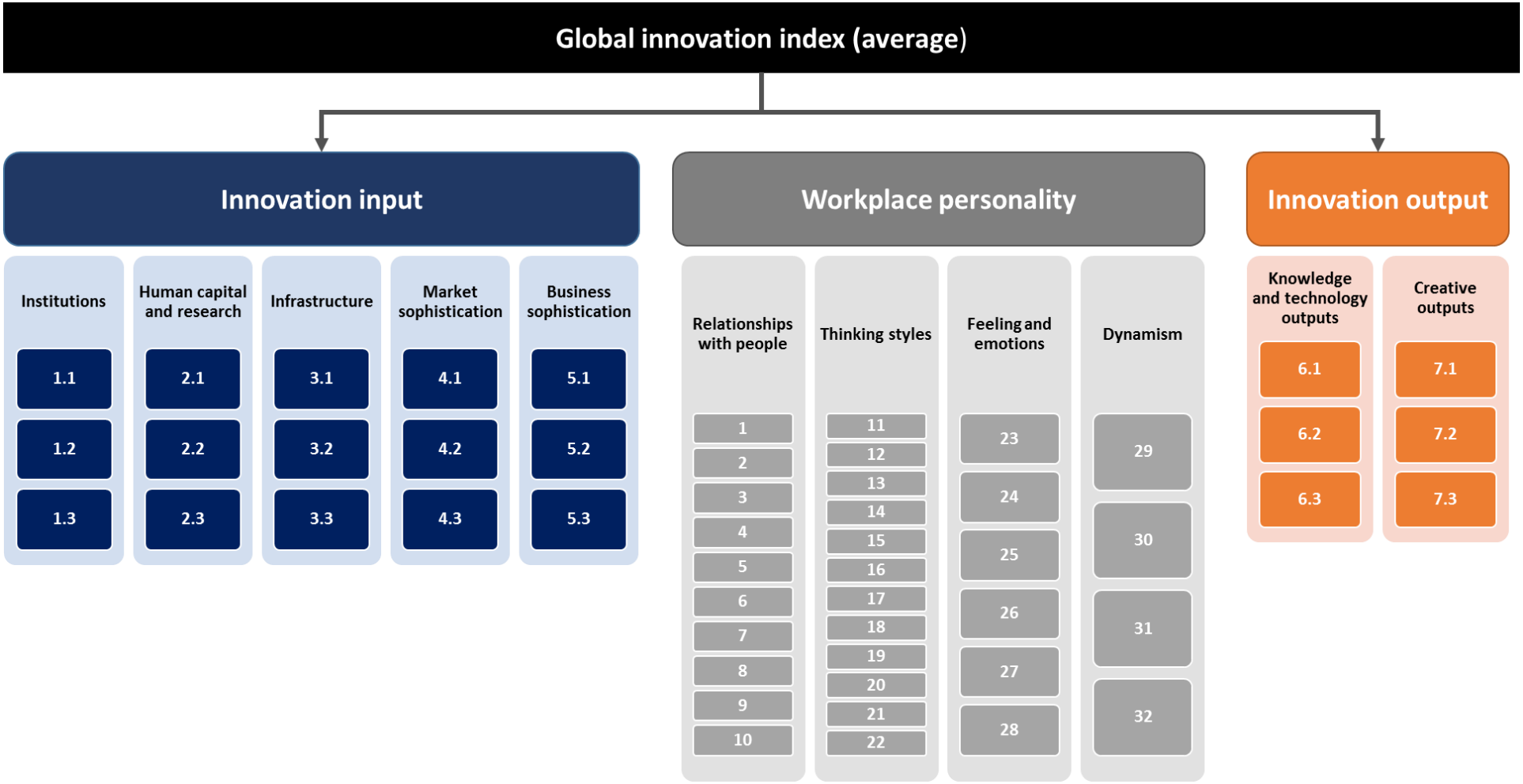


Figure 5. Conceptual framework combining the GII and OPQ

1.9 Outline and structure of the report

This research report consists of six chapters namely:

- **Chapter one: Introduction**
  This preceding chapter has thus far introduced the nature of the study and its bounds. It has included an introduction of the key concepts under study and the manner in which they will be operationalised.

- **Chapter two: Literature review**
  This chapter reviews relevant academic literature to provide a comprehensive context for the study and further explore the gaps the study intended to address. This chapter concludes with the statement of detailed research questions.

- **Chapter three: Research methodology**
  This chapter provides detailed information of the instrument of choice as well as the research sequence. It also provides an overview of factor analysis that was conducted prior to the analyses being run, in an attempt to collapse the 32 Occupational Personality Questionnaire (OPQ) dimensions.

- **Chapter four: Presentation of findings and data**
  There were a large number of analyses undertaken in SAS[5] on the dataset. These results are presented back in a highly summarised format of only significant findings, arranged in relation to the primary, secondary and tertiary analyses.

- **Chapter five: Analysis of the research findings**
  This chapter reflects on the key takeaways and themes that emerged from each of the analyses. Rather than repeating previous findings, it begins to build a narrative commencing with overarching themes and then beginning to discuss the more nuanced findings.

[5] SAS is a statistical software developed by SAS Institute which was used to conduct multivariate analyses.

- **Chapter six: Conclusions and recommendations**
  The final chapter attempts to summarise the plethora of findings into a cohesive set of themes. It also suggests how this research could be of relevance to a variety of stakeholders. In closing, directions for future research are suggested.

1.10 Conclusion

Thus far, core concepts have been defined with a high level view of how they have been operationalised and then further investigated in order to make a contribution to the innovation discipline. To follow will be an overview of pertinent literature with regards to personality and innovation; innovation across nations; as well as innovation across industries.

Chapter two: Literature review

2.1 Introduction

Innovation is a socio-economic phenomenon that is top of the agenda for both the leaders of nations and leaders of industry. From a national perspective, innovation is seen as a key driver of economic prosperity and employment (Fagerberg et al, 2013). The relative innovative performance of nations has become a competitive platform since the systematic collection of innovation-related metrics first prescribed in the *Frascati Manual* (Fagerberg et al, 2013). From an industry perspective innovation is seen as a strategic force that will differentiate industries or sectors that survive, grow and achieve profitability in an ever more competitive and ruthless landscape (Malerba, Nelson, Orsenigo & Winter, 2016).

In their first look of the state-of-the-art of innovation research Anderson, Dreu and Nijstad (2004) found in a meta-review of six years of published works that understanding at the individual, group and organisational level had progressed significantly. One of the recommendations to future researchers was to begin to build greater understanding at a macro-level (Anderson et al, 2004). In their follow-up review Anderson, Potočnik & Zhou (2014) considered published works until from 2002 to 2013 to identify seminal theories and a guiding framework for future research around innovation and creativity. Although this review stated that research has burgeoned, it was still noted that "despite earlier calls for greater research attention (e.g., Janssen, Van de Vliert, & West, 2004), few studies have addressed the role of national culture in organisational innovation." (Anderson et al 2014, p. 1313). Overall, despite the greater prominence of innovation as a topic at the macro-level of nations and industries, a research-practice gap persists.

What has proven to be a more complex endeavour than tracking outcomes; is to understand the wide range of covariates which may play a role in creating the pre-conditions necessary for innovation to emerge. This is due to the complex, integrated nature of the phenomenon under

study. A challenge, only augmented, when considered at the macro-level. The first section in this literature review will discuss in more detail the main covariate of interest – namely personality – or more specifically defined the propensity of individuals to display a set of behaviours that support innovation outcomes. In the sections that follow some of the key findings to date across nations and then across industries will then be explored.

2.2 Personality and innovation

Relevant early research, linking personality and innovation, sought to delineate and measure the creative potential of individuals rather than seeking specifically to explore innovation as a broader construct (Hinton, 1970). This narrow focus was related to a need at the time to select individuals who would be likely to perform well within research and development (R&D) departments (Hinton, 1970). Although creative potential can be considered to be a part of the innovation process – particularly in the first phase in the Innovation Pentathlon funnel, figure 1, often called *idea generation* - it does not provide a complete picture of the quality of these ideas and how these ideas may ultimately be fostered into tangible outcomes (Goffin & Mitchel, 2005).

Research into the relationship between personality and innovation specifically seems to have started outside the academic discipline of innovation studies. One of the early works entitled *Personality and Innovation Proneness* originated from consumer behaviour research which criticised the inconclusive research that had been conducted to that point in time on two fronts (Jacoby, 1971). Firstly, there were not precisely formulated constructs and measures for personality that allowed for specific traits to be measured that had theoretical grounding suggesting their covariance with innovation (Jacoby, 1971). Secondly, the research had been mostly correlation-type in nature and a need for experimental design was identified (Jacoby, 1971). In the management field, works emerged around the same time period such as *Frederick Taylor: A Study in Personality and Innovation* which began to make links, however tenuous between these two constructs (Kakar, 1974). Studies in the management field were most common at the individual level with group level research being concerned chiefly with the characteristics of teams,

organisations or consumers that were more likely to adopt new or novel technology (Diamond, 1977; Stevenson, 1972).

In the late 1980s and early 1990s observations at the individual level began to be extrapolated to the organisational level. Such as this assertion by Gort & Singamsetti (1987):

> A widely held view is that innovative behaviour by firms is determined primarily or exclusively by the chance discovery of opportunities in combination with the external economic constraints to which a firm is subject. An alternative hypothesis is that firms have distinct personalities and that these personalities significantly influence innovative behavior. A firm's personality may evolve as a consequence of a sequence of historical accidents or, alternatively, may be predictable from its structural attributes (p. 115).

However, the operationalisation of *personality* in the above case was a descriptive organisational framework rather than aggregated psychometric data collected from personality measurement tools developed in the sphere of psychological expertise. It was only in the late 1990s and early 2000s that psychometric instruments, specifically designed to measure individual level innovation were being developed (Patterson, 1998). This led to useful insights into commonly cited innovative characteristics such as imagination, inquisitiveness, confidence, independence and energy (Patterson & Kerrin, 2016)). This body of research was still critiqued for being fragmented however, looking at isolated characteristics and outcomes, with findings being difficult to compare (Patterson & Kerrin, 2016).

In more recent years meta-analysis, longitudinal studies and factor interplay investigations have begun to emerge, suggesting a greater maturing of the body of literature relating these two constructs. There has been a wide range of research, for example, suggesting links between personality and both the emergence as well as relative success of entrepreneurs (Zhao, Seibert & Lumpkin, 2010). Most of these more recent studies employed the Five Factor Model (FFM) of personality to allow for a unified framework under which to compare findings (Patterson & Kerrin,

2016). The FFM consists of openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (Salgado & Táuriz, 2014). These are commonly measured using a range of different normative or ipsative type inventories (Salgado & Táuriz, 2014).

In the original 2012 study, Patterson sought to review findings relating personality to innovation within the Five Factor Model (Patterson & Kerrin, 2016). Of al the factors, *openness to experience* was found to be the most commonly positively correlated (Patterson & Kerrin, 2016). When investigating this relationship in more depth, some initial findings suggested a stronger relationship with the ideation than implementation phase; in addition, contextual factors seemed to play a significant mediating role (Patterson & Kerrin, 2016).

Conscientiousness was found, by the majority of studies, to have a negative correlation with innovation (Patterson & Kerrin, 2016). However, this finding was challenged and the need for greater research noted. This factor consists of conceptually contradictory elements and a few studies have emerged suggesting innovation correlates with only with specific elements of the factor (Patterson & Kerrin, 2016). To illustrate, it may be enabling for innovation to be goal-oriented as individuals fitting this description may tend to persist despite setbacks. However, it may be that being quite perfectionistic and systematic is not conducive for the ambiguity and chaos that fundamental innovation efforts may entail. So as both sets of descriptors make up the factor *conscientiousness,* this may lead to inconsistent or contradictory results.

Agreeableness was found to largely negatively correlate with innovation – this is however caveated to only relate to the idea generation and not idea implementation phase (Patterson & Kerrin, 2016). The final two factors of the Five Factor Model, namely *extraversion* and *neuroticism* appeared to have no clear linkages to innovation (Patterson & Kerrin, 2016). The absence of clear linkages however should not lead to these factors outright dismissal, the limitations of the highly aggregated Five Factor Model may be at play and more nuanced views may provide clearer findings.

Rossberger & Krause (2013) conducted the first study of its kind to consider innovation at a national level with personality as a predictor and cultural influences as a mediator. The study further expanded on strong linkages that had been made between aggregated personality and innovation outcomes – specifically confirming findings on two factors from the Five Factor Model – *openness to experience* and *agreeableness* (Rossberger & Krause, 2013).

Individuals reporting on the higher end of the spectrum for *openness to experience* tend to be creative, enquiring, seek new experiences and engage in self-reflection (Widiger, 2017). Those on the lower end of the spectrum are typically more conventional in their approach, preferring the tried and tested over the radical (Widiger, 2017). The research has found a positive correlation between openness to experience and innovation outcomes (Rossberger & Krause, 2013). Conceptually this is sound as those characteristically creative individuals or collectives with greater intellectual curiosity and propensity to question the status quo are more likely to drive innovation outcomes as they tend to have higher levels of comfort and attraction to novel, new and challenging ideas or concepts (Patterson & Kerrin, 2016).

The relationship between *agreeableness* and innovation outcomes is more complex however as it requires a different interpretation at the individual and group level. At the individual level often a negative relationship is found between these two variables meaning that individuals reporting lower agreeableness tend to be more innovative (Anderson 2012; Rossberger & Krause, 2013). One descriptor for *agreeableness* is a discomfort with causing disruption, a narrative often used to explain this negative correlation. To be more explicit, it is hypothesised that individuals high on *agreeableness* are less likely to challenge the status quo or upset others by introducing product, process, marketing or organisational innovation.

In seeming contradiction to these results, it has been found at a national level that agreeableness is positively correlated with innovation outcomes (Rossberger & Krause, 2013). However, if we consider other aspects of this supra-factor then this correlation can be better understood. *Agreeableness* as an archetype tends to support cooperative, solid social interactions and collective

systems (Widiger, 2017). Individuals or groups higher on this aspect are characterised as being trustworthy, honest and altruistic (Widiger, 2017). This suggests that at a collective level of analysis, such as countries or industries, innovation is fostered by agreeable behaviours. This may be as these types of behaviours facilitate the effective diffusion[6] of an idea through the complex networks of the triple helix – universities, business and the government (Goffin & Mitchell, 2005).

The findings in the literature suggesting a strong mediating role played by culture between innovation inputs and outputs are also important to contextualise. The environment in which the set of individuals operates ultimately has a strong impact upon whether or not the preferred ways of thinking, feeling and behaving are expressed. In terms of innovation, specifically factors such as the *innovation climate* or *creative knowledge environment* have been cited to have considerable influence on whether the creative potential of individuals is unleashed to achieve innovation outcomes (Hemlin, Allwood & Martin, 2008; Hunter, Bedell & Mumford, 2007). Two examples of environmental factors at an organisational level include support and autonomy (Hunter et al, 2007). At a national level these may be cultural dimensions such as future-orientation (Rossberger & Krause, 2013). It is also important to note that there is contamination in the measurement of these constructs as they are interdependent. Environment plays a role in shaping personality and the collective personality has a role in shaping cultures, hence strong correlations are found between cultural dimensions and aggregated personality level data (Hofstede &. McCrae, 2004). A useful analogy provided by Trompenaars & Hampden-Turner (2011) is the onion model of culture, which represents the construct as a series of nested spheres as shown in figure 6. The *explicit* manifestation of culture in observable aspects such as language, food or physical buildings is actually informed by deeper *implicit* layers such as a sense of societal expectation or strongly held beliefs on ‘right’ versus ‘wrong’ (Trompenaars & Hampden-Turner, 2011).

[6] Diffusion can be defined as process by which an innovation spreads is using various communication channels over time between members of a social system (Rogers, 2004)

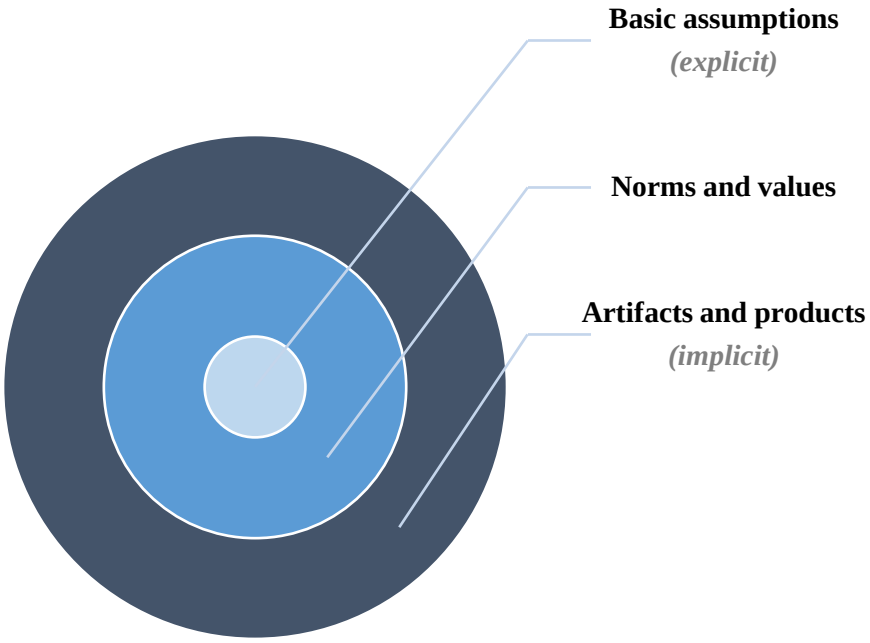


Figure 6. Model of culture (adapted from Trompenaars & Hampden-Turner, 2011, p. 27).

2.3 Innovation across nations

From a state leadership perspective, innovation is heralded as a key imperative not only to increase national yield, but to drive employment under the premise of *inclusive growth* (Frey & Osborne, 2015). It is important to preface that job creation is an outcome highly dependent on innovation type, industry and national context. Although broadly, process innovations have been related to job loss while product innovations have been related to job creation, this is by no means a linear nor predictable relationship (Pianto, 2003). It has been suggested that in the United States 47% of jobs are at high risk and 19% of jobs are at medium risk of being outmoded by automation (Frey & Osborne, 2015). That being said, in advanced nations, technological change may result in changing job types but not necessarily in an overall loss of jobs. There are arguments that, as a positive multiplier, the *job quality* may increase through the outmoding of repetitive, manual types of employment and the replacement with positions demanding greater skill thereby offering variety, challenge and better compensation (Pianto, 2003). In underdeveloped economies the loss of unskilled jobs, commonly through process innovation, has been related overall to *job quantity*

loss – at times on a large scale (Pianto, 2003). While overall the argument is convincing that innovation equates to greater quality and quantity of employment longer term, there are nuances to this relationship that cannot be overlooked. Particularity when being considered in the context of developing or underdeveloped nations where the skilled-worker assumption does not always hold true.

Policy maker's focus on innovation has given impetus to evolve measures to better understand the phenomenon and its relationship to national outcomes – three generations of metrics have been evident to date. The first generation of innovation proxy metrics informing global policy makers up until the 60s were focused very heavily on input related measures for example research and development (R&D) spend, scientist numbers etc. (Donoso, 2017). This was due to the reigning approach to innovation at the time which was large scale, lab-based, insulated and often highly industry-specific for the needs of the era. The original *Frascati Manual* drew an important distinction between inputs and outputs, setting a standard from the late 1960s onwards to collect innovation metrics at a national level in order to compare, contrast and identify trends over time (Fagerberg et al, 2013).

While the presumed benefits of innovation are widely accepted; systematic research garnering the attention of policy makers only gained traction around the 1980s (Fagerberg et al, 2013). In the years that followed, national systems of innovation became ubiquitously accepted as a key unit of analysis for innovation outcomes (Scerri, 2006). This coincided with the transition to the second generation of innovation metrics which focused on outputs such as patents, publications and licensing (Donoso, 2017). These innovation metrics historically served two primary purposes, the first is as a performance monitoring and evaluation (PME) mechanism and the second is to be able to allow comparisons (Scerri, 2006).

With more powerful technology, robust data collection and a multi-faceted understanding of innovation, the third generation of indices emerged (Donoso, 2017). These innovation indices may be called composite, multi-dimensional or super-indices (Donoso, 2017). These indices consist of

multiple input and output factors with data amassed on a large scale and most typically reported at a national level. While these datasets, particularly those made publicly available are attractive to researchers there are important caveats to note. Firstly, there is still typically a high reliance on formal registration – for example patenting – of an idea (Donoso, 2017). Secondly, outputs measured have not fully developed to capture the complexity of the innovation constructs and the contexts in which it occurs (Donoso, 2017).

The debate on the collection of innovation metrics has now progressed to consider whether globalisation has expanded the boundaries of national systems of innovation to blocs, such as the European Union (Scerri, 2006). However the histories and current state of play of various nations across the globe still differ significantly so the relevance of the nation state holds as a unit of containment for innovation measures. In future, blocs may be considered fitting units of analysis however at present there is still sufficient heterogeneity within blocs to consider a country-level analysis to be most valid (Scerri, 2006).

Despite the two cautions raised by Donoso (2017) regarding the use of third generation indices, these represent the most comprehensive set of metrics available at a representative level globally. Examples of super-indices, explored further due to their public availability include the *Science, Technology and Innovation Outlook Reports*, *Innovation Heatmap* and *The Global Innovation Index.*

The Organisation for Economic Co-operation and Development (OECD) publishes twice per year the *Science, Technology and Innovation Outlook* aimed at policy makers and analysts. This report has as a cornerstone the *Frascati manual* which is updated regularly by experts in the OECD member countries and it currently in its sixth edition (OECD, 2017). The manual can be considered a standard not just for the European Union but also for non-member countries. The reports themselves reflects on global science, technology and innovation (STI) patterns with a consideration for potential implications on national and international policies.

The World Economic Forum launched the *Innovation Heat Map* in 2008 which allows users to create a variety of visuals to explore and seek to better understand innovation clusters across the globe. There are over 700 different innovation indicators – pooled from both public and private sources – with data from over 125 countries and 2000 cities (World Economic Forum, 2017). The visualisations, an example is provided in figure 7, can generated by the user on the interactive website which is located at http://weforumihm.org/WEFAPP.html. Figure 7 is an example of a heat map generated for an innovation output factor where green represents stronger results and red weaker results. The platform was created for both policy makers and business leaders in order to better appreciate global trends in innovation.

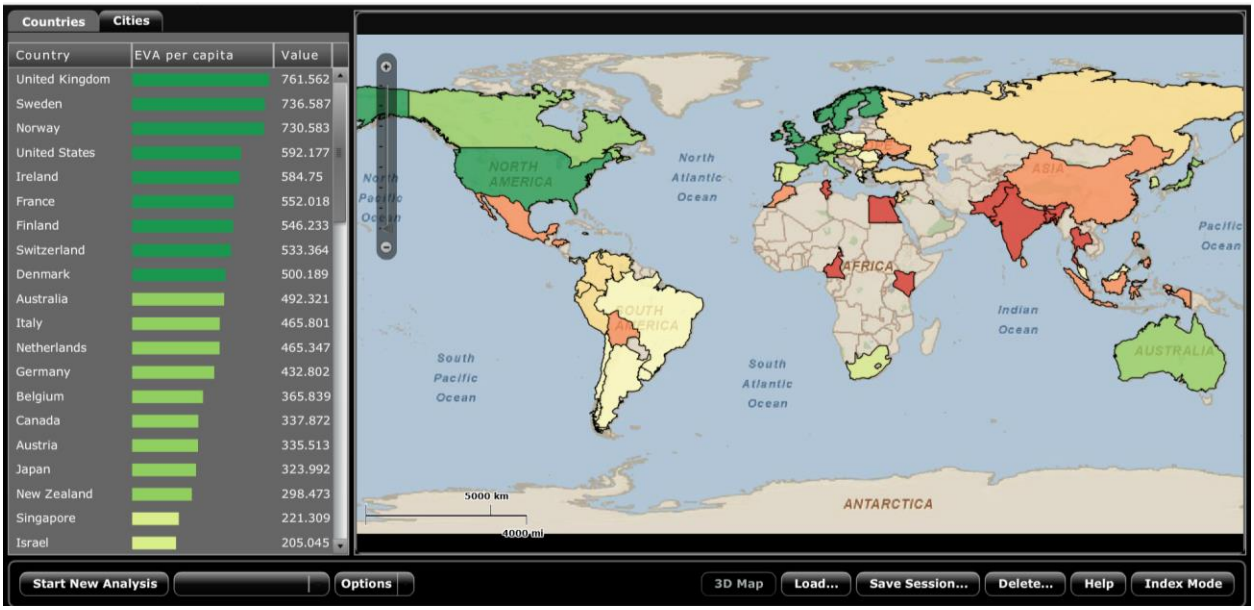


Figure 7. Innovation Heatmap screenshot example (Retrieved from http://weforumihm.org/WEFAPP.html, 2017).

The Global Innovation Index (GII) is a current leader in publicly available innovation data at a national level. The GII is currently in its ninth edition and bring together 30 sources of information. The latest 2016 GII represented 128 economies, 92.8% of the world's population and 97.9% of global Gross Domestic Product i.e. GDP (Cornell INSEAD WIPO, 2016). The datasets can be analysed, compared and downloaded – subject to terms and conditions such as appropriate referencing – for further non-commercially related analysis from https://www.globalinnovationindex.org/analysis-indicator.

This framework is key as it categorises the myriad of factors at a macro-level into a conceptual framework. For innovation inputs, five pillars have been identified within which various types of indices can be further subcategorised into three broad areas. For innovation outputs two pillars have been identified which can also be further subcategorised into three broad areas. This is illustrated in chapter one in figure 3. Each sub-index is also comprised of various input measures collected at the national level and then appropriately weighted. Example measures are provided in table 2 with a complete breakdown in appendix 1.

Table 2. Example measures of the input and output factors of the GII (Adapted from Cornell INSEAD WIPO, 2016).

	Sub-indices	**Measures**
1 Institutions	1.1 Political environment	1.1.1 Political stability and safety* 1.1.2 Government effectiveness*
	1.2 Regulatory environment	1.2.1 Regulatory quality*[a] 1.2.2 Rule of law*[a] 1.2.3 Cost of redundancy dismissal, salary weeks[b]
	1.3 Business environment	1.3.1 Ease of starting a business* 1.3.2 Ease of resolving insolvency* 1.3.3 Ease of paying taxes*

2 Human capital and research	2.1 Education	2.1.1 Expenditure on education, % GDP 2.1.2 Government expenditure on education/pupil, secondary[1] 2.1.3 School life expectancy years 2.1.4 PISA scales in reading, maths & science[a] 2.1.5 Pupil-teacher ratio, secondary[a,b]
	2.2 Tertiary education	2.2.1 Tertiary enrolment, % gross[a] 2.2.2 Graduates in science & engineering, % 2.2.3 Tertiary inbound mobility, %[a]
	2.3 Research and development (R&D)	2.3.1 Researchers, FTE/mn pop 2.3.2 Gross expenditure on R&D, % GDP 2.3.3 Global R&D firms, average expenditure, top 3, mn $US 2.3.4 QS university ranking, average score top 3*
7 Creative outputs	7.1 Intangible assets	7.1.1 Trademarks by origin/bn PPP$ GDP 7.1.2 Industrial designs by origin/bn PPP$ GDP[a] 7.1.3 ICTs & business model creation† 7.1.4 ICTs & organisational model creation†
	7.2 Creative goods and services	7.2.1 Cultural & creative services expenditure., % total trade[a] 7.2.2 National feature films/mn pop. 15–69[a] 7.2.3 Global entertainment & media market/th pop. 15–69[a] 7.2.4 Printing & publishing manufactures, % 7.2.5 Creative goods exports, % total trade
	7.3 Online creativity	7.3.1 Generic TLDs/th pop. 15–69 7.3.2 Country-code TLDs/th pop. 15–69 7.3.3 Wikipedia yearly edits/mn pop. 15–69 7.3.4 Video uploads on YouTube/pop. 15–69

Notes. (*) index, (†) survey question, (a) half weight, (b) higher values indicate worse outcomes.

Overall, the evolution of the range of metrics being collected across geographies to compare innovation performance is staggering (Scerri, 2006). This does create opportunity for far more powerful analysis at the macro-level, particularly with freely available public data, to better support the leaders of nations in making informed policy decisions related to innovation. While these composite indicators are not without cautions, the final rankings across countries remain quite consistent across major indices (Archibugi, Denni & Filippettia, 2009) Of the three super indices explored, the Global Innovation Index (GII) is the largest, most recently updated set of data driven by the most powerful technology. It also divides metrics decisively between inputs and outputs – the outputs consist of two key pillars and six total factors. It is for these reasons that the GII dataset was selected for this particular study.

2.4 Innovation across industries

From as early as the 1980s researchers have been developing taxonomies that would explain sectoral patterns of *technical change* (Pavitt, 1984). These taxonomies continue to be updated and revised as our delineations between industries evolve and new industries emerge. For example in 2016 a refreshed Pavitt Taxonomy was posited; partially in response to the industry classifications framework Statistical Classification of Economic Activities in the European Community - commonly referred to as NACE - being updated to revision two (Bogliacino & Pianta, 2016). To this day there is no single universally utilised framework for industry classification. Examples of those commonly used for global research are the North American Industry Classification System (NAICS) codes, The Global Industry Classifications Standard (GICS) and the Industry Classification Benchmark (ICB) (Bhojraj, Lee & Oler, 2003).

This study employs the Industry Classification Benchmark (ICB), a taxonomy launched in 2005 supported by the ICB Database and maintained by FTSE International Limited. FTSE Russel (2018) claim it to be comprehensive, versatile and representative thus being a dependable depiction of the global industrial landscape. The classification system consists of four levels which are illustrated in figure 8.

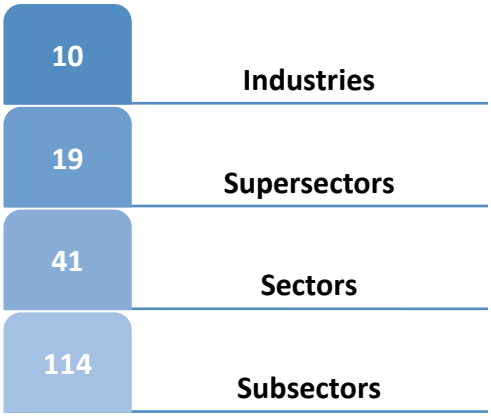


Figure 8. Industry Classification Benchmark structure (FTSE Russel, 2018).

All of these classification systems can be challenged based on the observation that there may be a high degree of heterogeneity within industries, both in terms of their geographic spread and their organisational disparities. Some scholars therefore reject industries as a useful domain and suggest to rather consider firms in relation to the *ecosystem* in which they operate (Teece, 2014). While this may be a useful approach for firm-to-firm competitive analysis, it does make analysis at the global level problematic as there is no proposed taxonomy for ecosystems which would readily allow for the comparison of thousands of firms. In order to reduce the risk of overlooking substantial heterogeneity at the industry level, the study will focus on sectors which may mitigate, to some degree, concerns around the relevance of the domain.

Regardless of differing stances on global taxonomies, overall there continues to be a rising popularity in theorising how industries or sectors have evolved as a result of innovation efforts (Malerba et al, 2016). Organisations are constantly changing to meet undershot or overshot customer needs; introducing radical new directions in products and business models; as well as pushing institutional and governance boundaries (Christensen, Anthony & Roth, 2013). Organisations at the forefront of innovation - as well as surprise entrants - are changing the very nature of the industries or sectors in which they operate.

Often these surprise entrants are called *disruptors* who may quickly rise to monopoly status, with commonly cited examples being in the computer sector. However, this dominant status may be short-lived, particularly in sectors with less barriers to entry where technological discontinuities are frequent (Malerba et al, 2016). In these *disruptor-sensitive* industries, innovation activities are related to highly skewed returns where massive losses ensue as a result of being left behind or failing with a new product or service. On the contrary, successes lead to exponential gains hence these industries are often useful archetypes when researching high innovation-intensity. In the information technology industry for example, it has been found that in sectors particularly sensitive to this skewing effect, such as software, companies are willing to pay significantly higher salaries for top talent as their *innovativeness* will be a key competitive differentiator (Andersson, Freedman, Haltiwanger, Lane, Shaw, 2009).

Overall, the research suggests that highly competitive industries tend to produce better innovative outcomes (Weerawardena, O'Cass & Julian, 2013). This is increasingly relevant against an economic landscape where even traditional, long-standing industries are struggling, shrinking or disappearing altogether. *Mining* is a useful archetype of an enduring sector which has experienced significant economic and political shocks during its history with structural changes anticipated over the course of the coming decades (Mikesell & Whitney, 2017). After a massive depression in the 1980s, the sector experienced a relative boom in the 2000s, but it has more recently been in a decline driven by volatile commodity prices, among other factors (Mikesell & Whitney, 2017). While innovation-led growth and transformation is heralded as a saviour for the sector, this may prove challenging due to inherent inflexibility, higher risk and longer-term sustainability concerns (Fan, Yan & Sha 2017).

It has been demonstrated that newer and smaller entrants to the market are also more likely to survive and thrive over time in industries where innovation activity is important (Audretsch, 1995). One such example is the *news media* sub-sector. After comparing the evolution of the sub-sector across 16 European countries Van Kranenburg (2017, p. 5) reflects:

> "In the last decade, Europe, like the rest of the world, has witnessed a transformation in the news media landscape. New techniques, new approaches, new technologies and new competitors have upset the old order and changed the rules of the game."

These new entrants are often the *disruptors* changing the face of existing industries or sectors, challenging the boundaries or establishing new domains. In the case of the news media subsector these disruptors have taken advantage of deregulation, technological advances and the confluence of previously disparate capabilities such as media, entertainment and electronics (Van Kranenburg, 2017).

In the ranks of longer standing industries, *pharmaceuticals* have garnered significant interest in innovation research due to their research and development intensity. When the costs of a new drug are broken down, 20% to 40% can be attributed to research, development and licenses (Gassmann, Reepmeyer & von Zedtwitz, 2013). Investment in research has also steadily risen from an estimated 11.4% of sales in 1970 to 18.5% of sales in 2001 (Gassmann et al, 2013). Despite being a mature sector, pharmaceutical sales have grown year-on-year at an average rate of 11.1% when the period 1970 to 2002 is considered with continued growth expectations of between 5% and 10% (Gassmann et al, 2013). These growth figures are useful to compare to other mature industries which only tend to grow at 1% or 2% year-on-year (Gassmann et al, 2013). Still, this sector is not without its challenges – research and development (R&D) costs are on the rise; truly innovative drugs are fewer and farther between; and in addition, high administration as well as legal costs eat into margins (Gassmann et al, 2013).

Although there are certain sectors that garner the majority of interest in innovation research such as pharmaceutical, manufacturing and information technology – innovation has become a more prevalent topic across all sector types. The *services* industry in particular has historically been overlooked, when compared to other industries, as a source of innovation (Haynes & Grugulis, 2014). However, a survey of six European countries between 1994 and 1996 provided an indication that 41% were undertaking innovation activities and 36% has introduced a new service or method (Haynes & Grugulis, 2014). This trend is interesting to follow given shrinkages seen in

manufacturing and the relative continued expansion of services. Particularly within advanced economies, services already contribute significantly to Gross Domestic Product (GDP) and are often lauded as a key sector in which to foster competitive advantage. This trend warrants a research agenda that can question findings, models and assumptions around innovation that are often derived from formative works in the manufacturing sphere (Haynes & Grugulis, 2014).

The *banking* sector has been in the spotlight in recent years specifically due to the evolution of its service landscape. This has been in part driven by technological advances that, for example, enable digital payments (Bajada & Trayler, 2015). This has also been driven by increasingly discerning customer demands as well as increased risk burdens relating to data protection, regulatory requirements and fraud (Bajada & Trayler, 2015). The resultant service innovations have allowed the sector overall to endure by providing greater convenience to their customers while often in parallel being able to reduce their own staffing and operating costs by reducing branches (Bajada & Trayler, 2015). Banks have reported in-branch transactions dropping by 30% from 2010 to 2015, also that more than 50% of consumer lending is completed without the customer physically going to a branch (Osborne and Frey, 2015). However, this evolution has not been without its causalities and the banking sector has been critiqued for being rigid, callous and monolithic therefore not always truly understanding the expectations and challenges of customers when historically introducing innovations, such an online banking (Aladwani, 2001). In tracing innovation history in banking there have been limited advancements in relation to transformational products, with the controversial sub-prime mortgage, being cited as a lone exemplar in (Frame & White, 2014). In terms of transformation of organisational form these examples are equally limited and more recent (Frame & White, 2014).

Fine (1999) coined the term *clockspeed* which has subsequently been used as a conceptual tool to compare the internal evolutionary capabilities and the related overall rate of technological evolution of overarching industries or more specific sectors. Across the globe, management practices are being informed by findings that show industry *clockspeed* in innovation can be an important factor when it comes to the success of acceleration or deceleration efforts at the firm level (Schimmer & Patel, 2015). It can therefore be stated that it would be of interest to industry

leaders to be able to compare the relative *innovativeness* of industries or sectors across all possible input and output measures. While this is frequently done in relation to innovation outputs, it would be similarly useful to have comparative views of hypothesised antecedents, such as the personality profile compositions of the industries or more specific sectors.

2.5 Summary

With the core constructs of personality and innovation already defined in chapter one, this literature review commenced with a consideration of the academic evolution of the enquiry into the relationship between personality and innovation. It was noted that there is still limited research at the macro-level and a high reliance on aggregated measures of personality which can lead to contradictory and inconsistent findings. The chapter then progressed to consider various tools for tracking innovation outcomes at the national level, with the Global Innovation Index (GII) being noted as a fit for purpose repository for this study. Finally, the relevance comparing the innovativeness of sectors was highlighted with particular observations noted for the *mining, media, banking* and *pharmaceutical* sectors. Chapter two will conclude with a statement of the research questions proposed to address the perceived gaps in the literature before the methodology chapter commences.

2.6 Statement of research questions

Primary: How do innovation inputs and personality dimensions associate with innovation outcomes?

I. When controlling for GII inputs, how do personality dimensions associate with innovation outcomes?
II. When fitted into a model, which dimensions or inputs explain the most variance in the innovation output factors?

Secondary: How do innovation inputs and personality dimensions associate with innovation outcomes year on year?

I. When controlling for GII inputs, how do personality dimensions associate with innovation outcomes in a longitudinal analysis?
II. When fitted into a model, which dimensions or inputs explain the most variance in the innovation output factors in a longitudinal analysis?

Tertiary: How could the *innovativeness* of sectors be compared?

I. How do sectors 'stack up' relative to one another when significantly associated personality dimensions are considered?
II. How could particular sectors be explored, or compared, in greater depth when linking their personality profiles to innovation outcomes?

Chapter three: Research strategy and methodology

3.1 Introduction

For this topic, there is a significant body of literature which has been tied together in the supporting conceptual framework. There are two sets of data namely the GII (Global Innovation Index) and the OPQ (Occupational Personality Questionnaire), which were merged and mined in order to address specific research questions ordered into three themes. These research questions are primarily reliant on statistical analysis of the data, so the bulk of the analysis is quantitatively driven (Morse, 1991). This chapter will open with an in-depth discussion of the key instrument, namely the OPQ. An overview of the research sequence is then presented with each step discussed in more depth. In conclusion of the chapter, anticipated limitations are discussed.

3.2 Research instrument: the Occupational Personality Questionnaire

The plethora of personality constructs have borne a wide range of instruments for different applications in different contexts (Salgad & Táuriz, 2014). The literature review has highlighted the importance of unifying studies of personality and innovation under the Five Factor Model (Anderson, 2012). As the focus of the study is at the macro level, it is also key to be able to tap into a singular dataset providing comparable application-specific, cross-culturally applicable personality data that is globally representative but also sufficiently nuanced. The operationalisation of workplace personality using the OPQ as described in section 1.7 iii. is therefore critical to the differentiation of the proposed study.

i. Occupational Personality Questionnaire background

The Occupational Personality Questionnaire (OPQ) is an umbrella term used to describe a series of psychometric instruments specifically designed to measure the construct of personality for occupational applications. Research into the OPQ began in the early 1980s with the original version being published for use in the United Kingdom in 1984 (Bartram, Brown, Fleck, Inceoglu & Ward, 2006). The most recent version was completed in 1995 following a five year research project (Bartram et al, 2006).

The personality constructs measured are considered to be universally applicable to the modern day workplace, particularly for use with managers and professionals. The OPQ is currently available in 34 languages and is used in over 110 countries across the globe (Bartram et al, 2006). The assessment is used for a variety of applications including selection, individual development, team intervention and organisational diagnostics.

ii. Instrument details

The instrument has two forms – an ipsative (sometimes called 'forced-choice') and a normative form (Likert type scale). The more commonly used version is the ispative which consists of 104 questions with two forced choices across triplets (Bartram et al, 2006). The instrument is designed to be administered unsupervised online (Bartram et al, 2006). An example question from the ipsative form follows in figure 9.

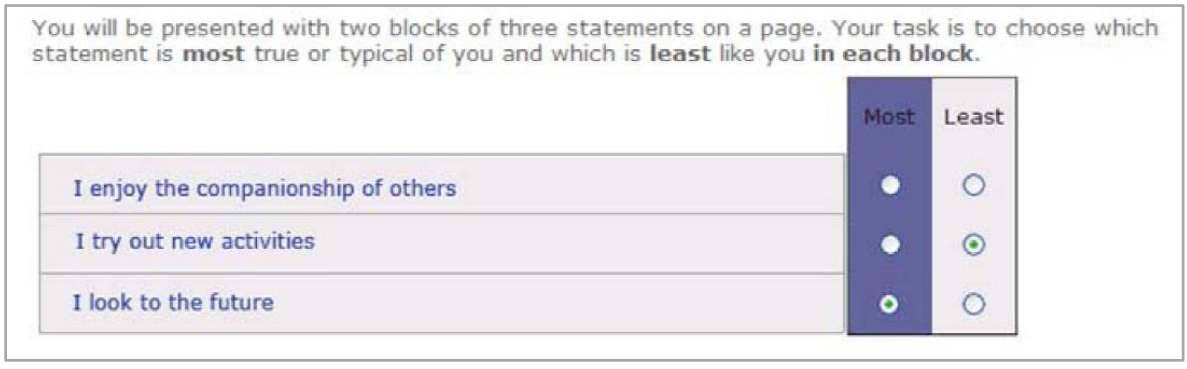


Figure 9. OPQ item example

iii. Reliability and validity

There have been numerous studies conducted on the internal reliability of the OPQ. The overall mean consistencies have been found to be in the range between 0.75 and 0.80 (Bartram et al, 2006). Over 90 independent validation studies have been conducted on the OPQ over a period of 25 years, across 20 countries and 40 industries, providing concrete evidence of its power to predict performance in the workplace (Bartram et al, 2006).

iv. Informed consent and confidentiality

Upon completing the OPQ online, any individual completing the assessment accepts the Data Protection Notice before proceeding with the assessment as follows shown in figure 10.

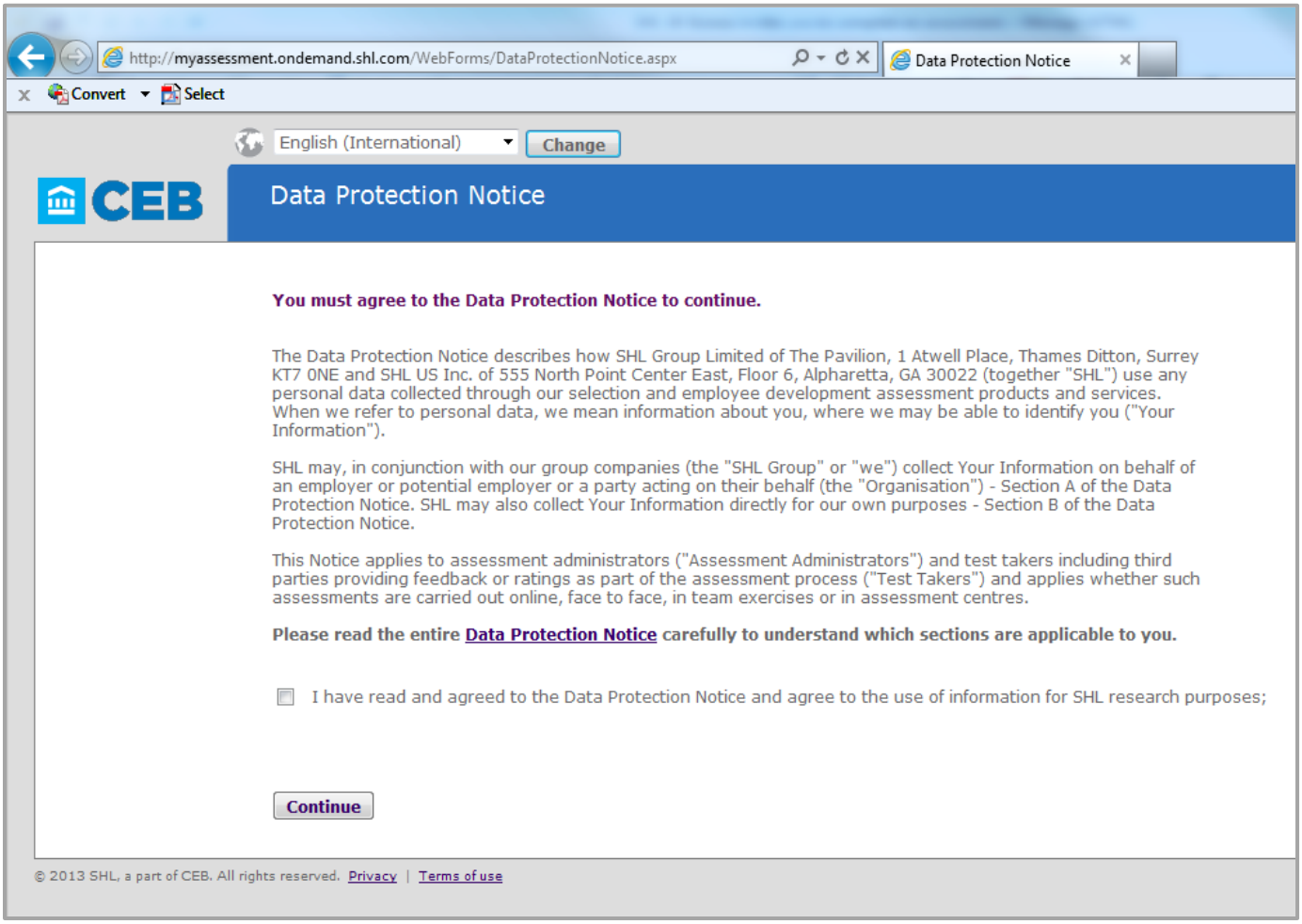


Figure 10. Data protection notice

The Data Protection Notice notes that the primary purpose for the data being collected is as stated by the data controller, generally the organisation. The notice also specifies that the SHL may also use the data gathered for their own research purposes within particular circumstances. Through this process the test taker is informed and gives consent for further studies as long as their individual results are not disclosed. In order to protect the identity of any individuals or organisations, any unique identifiers were removed from the data set. This included fields such as name, identity number, employee number, organisation name and so forth. The cleaned dataset only include a basic set of demographics with the two key fields of interest namely country and sector. It would therefore not be possible to trace the raw psychometric data back to any specific individual or organisation thereby fully protecting confidentiality.

v. Data agreement with SHL

In order to be able to access the dataset required to conduct the study proposed, a research agreement was concluded between the researcher and SHL. The signed research agreement allows the researcher access to the Occupational Personality Questionnaire (OPQ) dataset from the years 2009 to 2016. When applying a minimum threshold of at least 100 individuals per country, this dataset represents 3 066 905 individuals across 122 countries and 41 industries. A full copy of the signed research agreement is provided in appendix 3.

3.3 Research design sequence

The research design was primarily quantitative although the identification of key dimensions from the primary and secondary analysis was somewhat heuristic, therefore suggesting a mixed methods approach (Creswel, 2013). At a high level, the design is summarised in the steps in figure 11. This is followed by an explanatory section per step.

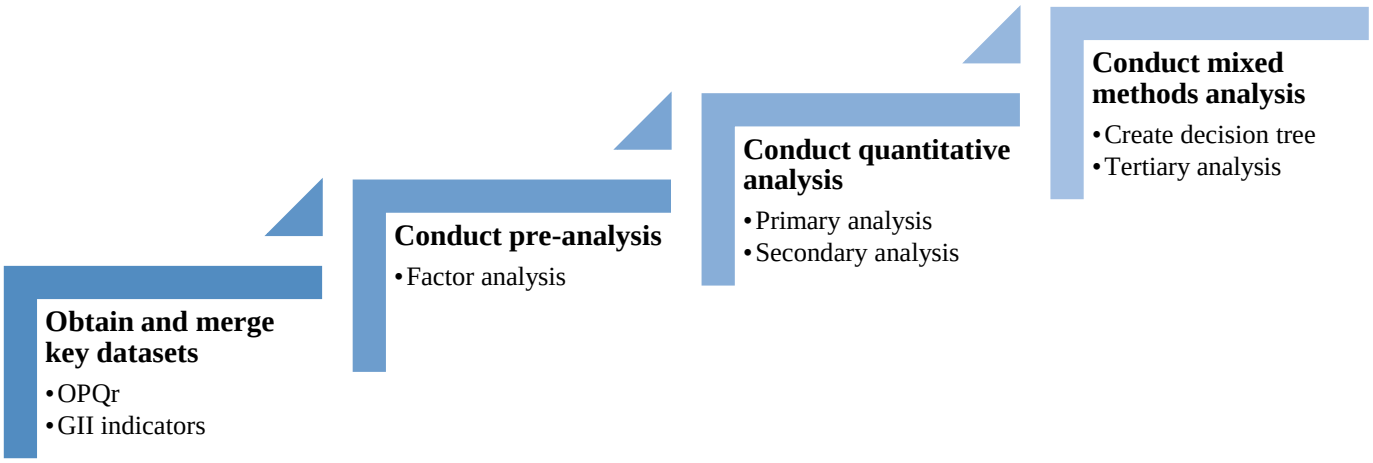


Figure 11. Research design sequence

i. Obtain and merge key data sets

The Occupational Personality Questionnaire (OPQ) data was obtained from SHL, for all individuals who had completed the ipsative version of the instrument in the period 2009 to 2016. Individuals who did not reported their country and individuals from countries with less than 100 respondents were excluded. After these exclusions, the total dataset represented **3 066 905 individuals**. Where individuals had reported their sector and industries were excluded with less than 100 individuals the total dataset included **4 168 210 individuals**. A second dataset was also requested for a panel view i.e. scores per year in order to conduct the secondary analysis. The following years were used: 2013 comprising 688 345 individuals, 2014 comprising 777 352 individuals and 2015 comprising 759 471 individuals. Descriptive statistics were requested solely for the purpose of reporting on the composition of the OPQ sample including number of respondents by country, sector, year, education level, age range and gender. This can be found in appendix 4.

The Global Innovation Index (GII) data was downloaded for the years 2013 to 2017. Each year had to be imported individually to ensure actual scores and not just ranks were obtained. These two datasets were then coded into one database. An important element was ensuring the exact match of country names. As a result of data gaps, each analysis has a slightly different number of countries inputted. There needed to be complete data for each variable for a particular country – any missing data would have excluded a country from analysis.

ii. Conduct pre-analysis

For the pre-analysis, factor analysis was conducted. The reason for this analysis was to attempt to cluster the personality variables inputted. The purpose was to ascertain if the 32 dimensions could be meaningfully condensed before being inputted into the analysis. Various methods were attempted including exploratory factor analysis, confirmatory factor analysis and variable clustering. This analysis was done on the panel OPQ data (2013, 2014 and 2015).

For the exploratory factors analysis, the MSA scores were so poor that this was abandoned. With the confirmatory factor analysis the fit was also reasonably poor – this was done in stages with only the factors that held up well. For example, for 2013 the confirmatory factor analysis had fit scores of Chi-square = 329.73 (DF = 84, p <.01); SRMR = .17; RMSEA = .19 (90%, CI = .17 - .22); CFI = .59; and NNFI = .49. Various possible model alterations were attempted, such as covering the errors, but this led to Heywood cases. In some, it does seem that the factor structure is not particularly tenable.

Finally variable clustering was undertaken, where variables were only allocated to one structure but this structure was not dictated. An example from 2013 is provided in table 3.

Table 3. 2013 Variable clustering example

2013 OPQ data, n = 76		**R-squared with**		***1-R**2 Ratio***
Cluster	**Variable**	**Own Cluster**	**Next Closest**	
Cluster 1	**Persuasive**	.73	.12	*.31*
	Controlling	.79	.06	*.22*
	Outspoken	.68	.04	*.33*
	Emotionally controlled (r)	.33	.13	*.77*
Cluster 2	**Outgoing**	.63	.05	*.40*
	Affiliative	.80	.09	*.22*
	Socially confident	.53	.29	*.67*
	Trusting	.61	.16	*.46*
Cluster 3	**Detail conscious**	.85	.06	*.16*
	Conscientious	.69	.26	*.41*
	Rule following	.52	.15	*.56*
Cluster 4	**Relaxed**	.68	.24	*.42*
	Worrying (r)	.66	.11	*.38*
	Tough minded	.46	.09	*.60*
	Optimistic	.48	.09	*.57*

Notes: (r) = Item is reversed

In order to be a good fit, the variable should have strong associations with its own cluster and weak with the next closest cluster. An ideal example is detail conscious with R^2 = .85 for cluster 3 and R^2 = .06 for the next closest structure. The total variation proportion explained was .63 for 2013; .63 for 2014; and .61 for 2015. Overall, there was enough evidence in some of the years but its success was debatable. It was therefore concluded to proceed to the analysis with both the clustered structure and the complete 32 dimensions.

iii. Conduct quantitative analysis

The results, which follow in chapter four, were obtained through three analytical focus areas. The primary analysis utilised the cross-sectional data, to maximise the sample size and assess associations. The secondary analysis utilised the panel data, which due to matching had a smaller sample size, to leverage a unique opportunity for longitudinal analysis at the national level. Both the primary and the secondary analyses were conducted using inferential statistical methods. As the analysis is primarily quantitative in nature, chapter four focuses on statistically significant findings as well as indicators of power. There will be reference made to various ad-hoc checks conducted to ensure the robustness of findings. This included, for example, the examination of residual plots following the regressions. The tertiary analysis used descriptive rather than inferential statistics, hence there is a qualitative component which is described in the next section.

A summary of the three groups of analyses in relation to the method, Occupational Personality Data (OPQ) data used, Global Innovation Index (GII) data used and subsequent sample size is presented in table 4 which follows.

Table 4. Statistical methods and input data summary

	Method	**OPQ Data used**	**GII Data Used**	**Representation**
Primary analysis	i. Partialled correlation matrix ii. Regression with stepwise variable selection	*CROSS-SECTIONAL* Aggregated OPQ data from 2009 to 2016, specifically split by country.	*CROSS-SECTIONAL* Averaged GII output country data from 2015 and 2016, with input data averages for inputs from 2013 to 2015. GII data used from different years to account for lag between inputs and outputs.	Minimum 104 countries Maximum 107 countries
Secondary analysis	i. Partialled correlation matrix ii. Regression with stepwise variable selection	*PANEL* Panel data for the OPQ by country for the years 2013, 2014 and 2015.	*PANEL* GII input data from same year with GII output data from the following year i.e. 2014, 2015 and 2016 to account for the lag between input and output.	74 countries across three time periods (in years)
Tertiary analysis	i. Descriptive statistics	*CROSS SECTIONAL* Aggregated OPQ data from 2009 to 2016, specifically split by sector.	N/A	41 industries n = 4 168 210

iv. Conduct mixed method analysis

The nature of the tertiary research questions, being illustrative and aiming to provide rich descriptive comparisons on fewer examples, required a mixed method approach (Creswell, 2013). This final component was dependent on the outcomes of the primary and the secondary analyses with a very high number of possible permutations. When conducting a research synthesis of this nature it was imperative to keep the area under study precise and well-bounded (Major & Savin-Baden, 2010). Therefore, a decision tree was created to force a prioritisation when considering personality dimensions by sector. The profiles of sectors, although based on data, do not empirically test the size or significance of differences or similarities. Rather these are discussed by identifying relative differences, linking themes and making various hypotheses – which is the qualitative component (Creswell, 2013).

3.4 Limitations of the study

In terms of the statistical analysis, an all-encompassing model of innovation may be unrealistically utopian due to the many factors that result in the differences between countries. There are three key limitations to note in this regard. Next, in relation to the methodology chosen, the limitations of the qualitative component will be discussed.

Firstly, personality is a complex construct. A common analogy used to describe personality is an *iceberg* where much is hidden and only a small proportion is actually experienced or observable. Although the instrument proposed measures typical ways of thinking, feeling and behaving (below the surface); this does not by any means perfectly predict the manifestation in terms of observable behaviours (above the surface). Therefore the contribution of personality to a predictive model may be small, relatively speaking. This may be further aggravated by a small sample size, a problem inherent in a country level analysis where there are a limited number of countries in total and complete datasets do not exist for all countries.

Secondly, there is no universally agreed standard or measure for innovation inputs and outcomes at a national level. While there are generally accepted proxies and far more advanced datasets than ever before, these are by no means exhaustive and each measure has its own set of limitations. The Global Innovation Index (GII) has been selected as most appropriate and the detail of its robust composition provided, however the study is reliant on its accuracy in reporting to the public.

Thirdly and most importantly the study is not designed to ascertain causal relationships. As this is a field-based study, it lacks the control conditions necessary to make causal deductions (Booth, Colomb & Williams, 2003). It is important to caveat, however, that any knowledge that assists in accounting for even a small portion of associations with innovation outcomes can make a difference (Mairesse & Mohnen, 2002).

In terms of the descriptive component, this study aims only to identify key covariates to link to existing literature narratives. However the study does not endeavour to empirically test any of these narratives and will only provide a cursory analysis of the current, available body of research. It is noted that it is likely to be an intensive follow-up endeavour to this particular study to explore all the trends as well as to truly test the rigour and accuracy of current sectoral narratives. It is important to note in conclusion that there are several cautions when combining quantitative and qualitative data with the mixed methods approach proposed for this study (Morse, 1991). These include:

- difficulty of merging quantitative and qualitative data
- interpretation when the two data set have seemingly different results
- merging of concepts
- managing the weighting of both types
- separating the relative value of each

In this study the broad based quantitative analysis will allow for narrow focus to be applied in the post-hoc linkages to the literature and proposed hypotheses. In this way the methods will be complementary rather than competing for contribution to the study. Significant attention will need to be devoted to synthesis as this will be key in ensuring that the data can be merged seamlessly and result in a cohesive narrative.

3.5 Ethical considerations

A key consideration is the protection of the psychometric data that is seminal to the study. The Health Professions Council of South Africa (HPCSA) sets best practice standards for the use of psychometrics within the South African context. According to the Health Professions Act (Act 56 of 1974) tests, measures, questionnaires, instruments, etc. that tap psychological constructs must be used, interpreted, and controlled by psychologists (Foxcroft, Paterson, Le Roux & Herbst, 2004). The control of tests relates to:

- Selecting tests;
- Administering tests;
- Scoring tests and selecting norms;
- Interpreting tests and setting cut-off scores;
- Reporting on results - including the provision of feedback; and
- The ethical rules of conduct in relation to the above actions (Foxcroft et al, 2004).

It was therefore incumbent upon the researcher, as a registered psychologist, to ensure the proper ethical standards were upheld in the use of the results. Specific to this study was ensuring that correct interpretations were applied and participants were protected from any potential harm. The principles of *informed consent* and *protection of confidentiality* as already outlined were cornerstone in upholding these standards.

3.6 Summary

To conclude, it should be noted that the research design sought to make the most of the unique position of accessing a proprietary, global database of personality data (the Occupational Personality Questionnaire) which was representative of major industries and numerous countries. With the consolidation into the Global Innovation Index, this presented a wholly unique dataset for analysis. The study could was thereby enabled to focus on adding to three under-represented areas in the current literature namely:

1. Limited analysis at a macro level in general (Anderson et al, 2004; Anderson et al, 2014)
2. Markedly limited macro information outside of traditional Western contexts (Albuquerque et al, 2015)
3. Over-reliance on aggregated personality data e.g. Five Factor Model (Obschonka et al, 2015)

Despite the noted, few inherent limitations of a macro study of this nature; there is unique relevance of this study to practitioners in the academic, national and organisational spheres. A more nuanced understanding of the dimensions of personality that associate with a wider range of innovation outcomes can better inform current understanding of what constitutes *innovativeness* at the macro-level. The findings that will now be presented, begin to tap into the potential of the dataset, but it will also be made clear that further analysis is possible which the bounds of this study did not allow.

Chapter four: Presentation of findings and data

4.1 Introduction

The presentation of findings is divided chiefly into the outcomes of the primary, secondary and tertiary analysis. These findings will be summarised further in relation to the specific research question posed in chapter five.

4.2 Primary analysis

The primary analysis employed a cross-sectional view to better understand the association between personality dimension, as well as factors, when controlling for innovation inputs. The primary analysis is divided into the following three sections:

i. Cross sectional data descriptive statistics and correlations
ii. Regression with complete 32 personality dimensions
iii. Regression with factors

i. Cross sectional data descriptive statistics and correlations

A partialled correlation was conducted where the 15 Global Innovation Index (GII) input factors were partialled out, this was to remove their influence on the association between the personality variables and the innovation outputs. The results of this as well as the mean and standard deviation for each variable are shown in table 5.

Table 5 demonstrates that there are significant associations between numerous personality factors and innovation outcomes at the national level. One of the clusters, namely *sociability*, as well as eight of the personality dimensions, for example *affiliative*, have significant associations across all GII output factors. The strength of these significant associations range between $.16 \leq \beta \leq .52$ with certain dimensions showing a consistently inverse association, for example *data rationa*.

Table 5. Descriptive statistics and correlations for cross sectional data

	M	***SD***	**I.O.**	**6.**	**6.1**	**6.2**	**6.3**	**7.**	**7.1**	**7.2**	**7.3**
GII Output factors											
I.O. Innovation output	*30.19*	*10.13*	1.00								
6. Knowledge and technology	*27.33*	*10.33*	.91***	1.00							
6.1 Knowledge creation	*19.07*	*15.48*	.79***	.88***	1.00						
6.2 Knowledge impact	*33.69*	*10.53*	.67***	.74***	.47***	1.00					
6.3 Knowledge diffusion	*29.24*	*11.79*	.75***	.82***	.57***	.45***	1.00				
7. Creative outputs	*32.62*	*10.65*	.92***	.77***	.69***	.54***	.65***	1.00			
7.1 Intangible assets	*43.91*	*10.28*	.69***	.56***	.55***	.34***	.48***	.83***	1.00		
7.2. Creative goods and services	*20.16*	*11.05*	.80***	.71***	.63***	.49***	.60***	.85***	.59***	1.00	
7.3 Online creativity	*23.73*	*16.89*	.86***	.76***	.68***	.53***	.64***	.88***	.58***	.72***	1.00
OPQ Personality clusters											
Influence	*0.56*	*0.16*	-.18*	-.28***	-.26***	-.30***	-.15	-.16*	-.07	-.24**	-.16
Sociability	*0.19*	*0.13*	.35***	.43***	.46***	.21**	.37***	.42***	.31***	.39***	.47***
Structure	*0.36*	*0.12*	-.18*	-.29***	-.27***	-.23**	-.24**	-.11	-.09	-.16	-.14
Emotions	*0.38*	*0.10*	.14	.19*	.25**	.04	.13	.22**	.12	.23**	.25**

	M	*SD*	I.O.	6.	6.1	6.2	6.3	7.	7.1	7.2	7.3
OPQ 32 Dimensions											
Achieving	*0.61*	*0.19*	-.15	-.21**	-.14	-.25**	-.18*	-.12	-.08	-.22**	-.08
Adaptable	*-0.01*	*0.26*	.15	.25**	.21**	.17*	.24**	.05	-.01	.13	.05
Affiliative	*-0.07*	*0.19*	.42***	.48***	.48***	.30***	.41***	.52***	.38***	.47***	.53***
Behavioural	*-0.09*	*0.17*	.34***	.43***	.41***	.28***	.39***	.36***	.26***	.32***	.38***
Caring	*-0.14*	*0.15*	.25**	.36***	.36***	.24**	.27***	.26***	.13	.28***	.27***
Competitive	*0.20*	*0.21*	-.15	-.24**	-.26***	-.17*	-.16*	-.26***	-.18*	-.32***	-.25**
Conceptual	*0.17*	*0.14*	.11	.13	.14	.07	.10	.04	.03	-.06	.07
Conscientious	*0.37*	*0.13*	.12	.09	.10	.05	.06	.21**	.21**	.10	.16
Controlling	*0.74*	*0.17*	-.15	-.23**	-.21**	-.25**	-.14	-.14	-.06	-.24**	-.12
Conventional	*-0.05*	*0.21*	-.05	-.12	-.20**	.07	-.14	-.02	-.03	.03	-.09
Data rational	*0.76*	*0.19*	-.37***	-.50***	-.46***	-.42***	-.37***	-.40***	-.23**	-.47***	-.43***
Decisive	*0.61*	*0.22*	-.03	-.07	-.07	-.15	.05	.07	.14	.01	.07
Democratic	*0.35*	*0.21*	.02	.07	.11	.02	.02	.06	-.00	.12	.04
Detail conscious	*0.45*	*0.13*	-.15	-.21**	-.16	-.18*	-.19**	-.10	-.03	-.15	-.16
Emotionally controlled	*-0.35*	*0.13*	.02	.00	.03	-.03	.01	-.07	-.17*	.01	-.04
Evaluative	*0.54*	*0.16*	.07	.05	.12	-.03	.02	.18*	.21**	.06	.16
Forward thinking	*0.42*	*0.16*	-.26***	-.25**	-.21**	-.18*	-.25**	-.35***	-.35***	-.27***	-.32***
Independent minded	*-0.29*	*0.17*	.20**	.27***	.30***	.17*	.20**	.11	.04	.17*	.14
Innovative	*0.65*	*0.18*	-.15	-.23**	-.19**	-.27***	-.14	-.15	-.10	-.25**	-.15
Modest	*-0.23*	*0.12*	.03	.01	-.03	-.00	.08	.01	-.07	.07	-.01
Optimistic	*0.41*	*0.15*	-.14	-.09	-.04	-.08	-.13	-.13	-.15	-.07	-.06
Outgoing	*0.11*	*0.13*	.32***	.41***	.41***	.26***	.33***	.33***	.24**	.35***	.39***
Outspoken	*0.26*	*0.17*	-.22**	-.34***	-.35***	-.26***	-.23**	-.18*	-.09	-.23**	-.19**
Persuasive	*0.66*	*0.21*	-.09	-.15	-.11	-.25**	-.04	-.11	-.04	-.15	-.10
Relaxed	*0.20*	*0.13*	.12	.15	.26***	-.04	.09	.18*	.07	.22**	.20**
Rule following	*0.26*	*0.20*	-.30***	-.45***	-.44***	-.34***	-.35***	-.27***	-.27***	-.25**	-.25***
Socially confident	*0.54*	*0.14*	.10	.16	.24**	-.05	.16*	.16	.13	.11	.22**
Tough minded	*0.24*	*0.11*	.29***	.33***	.38***	.22**	.19*	.35***	.19*	.33***	.38***
Trusting	*0.39*	*0.20*	.20**	.28***	.28***	.13	.29***	.27***	.21**	.27***	.29***
Variety seeking	*-0.11*	*0.17*	.10	.09	.13	-.08	.16	.18*	.13	.17*	.18*
Vigorous	*0.51*	*0.17*	.12	.13	.20**	-.01	.11	.27***	.19**	.22**	.32***
Worrying	*-0.68*	*0.18*	-.09	-.06	-.11	.05	-.05	-.12	-.00	-.16	-.12

Notes: M = Variable mean, SD = standard deviation, *** = p < .01, ** = p < .05, * = p < .10

ii. Regression with complete 32 personality dimensions

The results for the regression, using the cross-sectional data, are summarised in the three tables that follow. The first considers the overall innovation measure as well as its two components. The next two tables provide the three sub-indices nested in each component.

Table 6. Innovation output: broad measures

	Innovation Output: Broad Measures		
	Overall output	**Knowledge & Technology**	**Creative outputs**
Intercept	*.00****	*.00****	*.00****
Political environment	.38***	-	.22**
Tertiary education	-	-	-.30***
Research & development	-	.19***	-
ICTs	-	-	.24**
Knowledge workers	.18*	-	-
Knowledge absorption	-	.30***	.29***
Achieving	-	-.33***	-
Affiliative	.39***	.20***	.32***
Behavioural	-	-	.19*
Caring	-	-	-.25***
Competitive	.27***	.20**	-
Conceptual	.23***	.29***	.17**
Conscientious	-	.44***	.33***
Controlling	-	.28**	.16*
Data Rational	-.24**	-.23**	-.25**
Detail Conscious	-	-.17*	-
Evaluative	-	-	-.20*
Independent Minded	-	.17**	-
Optimistic	-	-.15**	-.23***
Outspoken	-	-.26***	-
Persuasive	-.21**	-.23***	-.26***
Tough Minded	-	.23***	.27***
F	***18.89******	***18.11******	***13.68***
R²	***.57***	***.75***	***.70***
Adj R²	***.54***	***.71***	***.65***

*Notes. *** = p < .01, ** = p < .05, * = p < .1. GII input factors. OPQ 32.*

Overall comment

The table above contains only those variables that proved to have a significant association with overall innovation output or either of its two components through the stepwise regression. The data sets could be matched for 107 countries for innovation output overall with 105 for its two components namely knowledge and technology as well as creative outputs.

R^2 is a measure of how much of the variability in innovation outputs are accounted for by the inputs. 57% of the variability in innovation output overall is accounted for by the input factors - both from the GII and the OPQ. For each of the two pillars an even higher percentage, 75% and 70% respectively, was found. There were significant associations found with six GII inputs (out of 20 possible) and the sixteen dimensions of personality of the OPQ (out of 32 possible). The adjusted R^2 gives some idea of how well the model generalises and should ideally be the same value, or very close to the R^2. If the ratio of variables to observations is quite high, which is the case here, this will also impact the adjusted R^2. In this case, the difference between the two is small so no cause for concern is noted.

Specific considerations

Affiliative, *conceptual*, *data rational* (inverse) and *persuasive* (inverse) are the only four input factors that are significant across the overall output and its two components. The range of effect size is $.15 \leq \beta \leq .44$.

In terms of the GII input factors *political* has the highest $\beta = .44$. *Knowledge absorption*, had the strongest association with both components of output, with $\beta = .30$ for *knowledge and technology* as well as $\beta = .29$ for *creative inputs*. In terms of the personality dimensions an inverse relationship was found with *caring*, *data rational*, *detail conscious*, *evaluative*, *optimistic*, *outspoken* and *persuasive*. A particular dimension of interest is *affiliative* with $.20 \leq \beta \leq .39$ across. *Conscientiousness* showed the highest association for just the two components; $\beta = .44$ and $\beta = .33$.

Table 7. Innovation Outputs: Knowledge & Technology sub-Indices

	Innovation Outputs: Knowledge & Technology sub-Indices		
	Knowledge creation	**Knowledge impact**	**Knowledge diffusion**
Intercept	*.00*	*.00***	*.00***
Political environment	-	.28***	-
Research and development	.23**	-	-
Ecological sustainability	-.19**	-	-
Innovation linkages	-	-	.22***
Knowledge absorption	.20***	-	.28***
Affiliative	.22***	.32***	-
Behavioural	-	-	.20*
Comp	-	-	.33***
Conceptual	.18***	.17**	.30***
Conscientious	.31***	.36***	.17*
Conventional	-	-	.16
Data rational	-	-.27***	-.46***
Decisive	-	-	.27**
Detail conscious	-.17*	-.23*	-
Independent minded	.26***	-	-
Modest	-	-	.31***
Outspoken	-.28***	-	-
Relaxed	-	-.26**	-
Rule following	-	-.29***	-.24**
Socially confident	-	-.34***	-
Tough minded	.29***	-	-
Variety seeking	-	-.35***	-
Worrying	-	-.24**	-
F	***17.09****	***10.28****	***9.63***
R^2	***.71***	***.55***	***.54***
Adj R^2	***.67***	***.50***	***.48***

Notes. *** = $p < .01$, ** = $p < .05$, * = $p < .1$. *GII input factors. OPQ 32.*

For the three sub-indices of *knowledge and technology* there are interesting associations across a broad spectrum of personality dimensions, more numerous than the GII inputs. In addition, the degree of the associations with outputs for the GII inputs and the personality dimensions respectively are comparable, being generally modest. The total variability is explained by the input factors ranges from 48% to 67%.

Conceptual and *conscientious* are the only two input factors with associations across all three sub-indices. *Data rational* has the strongest association, notably negative, which borders on large in effect size at $\beta = -.46$.

Table 8. Innovation Outputs: Creative output sub-indices

	Innovation Outputs: Creative output sub-indices		
	Intangibles	**Creative goods**	**Online**
Intercept	*.00***	*.00***	*.00***
Political environment	-	.23*	.41***
Regulatory environment	.23*	-	-
Tertiary education	-.39***	-	-
Research and development	.27**	-	-
Credit	-.22*	-.27***	-
Knowledge workers	-	.23**	-
Knowledge absorption	.40***	.17*	-
Affiliative	-	.27***	.53***
Conceptual	-	-	.15**
Conscientious	.25***	-	-
Data rational	-	-.14	-
Democratic	-	-	-.22***
Emotionally controlled	-	-	.14**
Forward thinking	-.26***	-	-
Modest	-	.17**	-
Optimistic	-.14	-	-
Outgoing	-	.15	-
Persuasive	-.22***	-.17*	-.20***
Rule following	-.20**	-	-
Tough minded	.22***	.23***	.24***
F	***8.99***	***12.33***	***22.59***
R^2	***.52***	***.57***	***.62***
Adj R^2	***.46***	***.52***	***.59***

*Notes. *** = p < .01, ** = p < .05, * = p < .1. GII input factors. OPQ 32.*

The overall variability explained by the input factors for the creative output sub-indices ranges from 46% to 59%. *Persuasive* and *tough minded* shows significant associations across all sub-indices. There is a moderate, bordering on large association, β = .50, between *affiliative* and *online creativity*.

iii. Regression with factors

The results for the regression using the factors rather than the complete 32 dimensions, using the cross-sectional data, are summarised in the three tables that follow. The first considers the overall innovation measure as well as its two components. The next two tables provide the three sub-indices nested in each component.

Table 9. Innovation Outputs: Broad Measures

	Innovation Outputs: Broad Measures		
	Overall outputs	**Knowledge & Technology**	**Creative outputs**
Intercept	*0***	*0****	*0****
Political environment	.38***	.20*	.30**
Tertiary education	-	-	-.36***
Research & development	-	.16*	-
ICTs	-	-	.35***
Knowledge absorption	.20**	-	.16*
Influence	-	-.22**	-.25***
Sociability	-	.18**	.39***
Behavioural	.25***	.24***	-
Competitive	.29***	.22***	-
Conceptual	.19***	.21***	.19***
Conventional	.25**	-	.33***
Data rational	-.41***	-.35***	-
Evaluative	.26**	-	-
Forward thinking	-	-	-.16**
Variety seeking	-	-	.35***
F	***13.17****	***19.96****	***13.92****
R^2	***.58***	***.65***	***.60***
Adj R^2	***.53***	***.62***	***.55***

*Notes. *** = p < .01, ** = p < .05, * = p < .1. GII input factors. Personality factors. OPQ 32.*

The regression with the factors demonstrates a comparable proportion of variability explained in terms of overall outputs. However, in terms of the two components, there is 10% less variability explained for each. This may suggest the model with the complete 32 is a better fit, however, all sub-indices should be considered.

Neither of the personality factors associate across all, however they do both associate significantly with the two components. *Influence* has a modest association with *creative outputs* with β = .39. The strongest association is between *data rational* (inverse) and *overall outputs*, β = -.41.

Table 10. Innovation Outputs: Knowledge & Technology sub-Indices

	Innovation Outputs: Knowledge & Technology sub-Indices		
	Knowledge creation	**Knowledge impact**	**Knowledge diffusion**
Intercept	*0*	*0****	*0****
Political environment	.20*	.41***	-
Business environment		-.35**	-
ICTs		.26*	-
Ecological sustainability	-.19**	-	-
Knowledge workers	.33***	-	-
Innovation linkages	-	-	.21**
Innovation absorption	-	-	.32***
Influence	-.28***	-	-
Sociability	.39***	-	-
Achieving	.17*	-	-
Behavioural	-	.24**	.31***
Competitive	-	.18*	.27***
Conceptual	.22***	-	.26***
Data rational	-.21**	-.54***	-.42***
Independent minded	.16**	-	-
Decisive	-	-.20**	.18*
Democratic	-	-.17*	-
Evaluative	-	.37***	-
Variety seeking	-	-.33***	-
Vigorous	-	-.18**	-
Modest	-	-	.25***
F	***17.72****	***8.28****	***11.92****
R²	***.63***	***.49***	***.50***
Adj R²	***.59***	***.44***	***.46***

*Notes. *** = p < .01, ** = p < .05, * = p < .1. GII input factors. Personality factors. OPQ 32.*

When considering the sub-indices for *knowledge and technology*, there are only associations between two of the factors, *influence* (β = -.28) and *sociability* (β = .39), with *knowledge creation*.

This model, in relation to the complete 32, does boost the association of *data rational* with *knowledge impact* to β = -.54 which is one of the strongest effect sizes noted in either model when considering the associations between personality and innovation output. This is also the only factors with associations across all *knowledge and technology* sub-index.

Table 11. Innovation Outputs: Creative output sub-indices

	Innovation Outputs: Creative output sub-indices		
	Intangibles	**Creative Goods**	**Online**
Intercept	*0****	*0****	*0*
Political environment	-	-	.43***
Tertiary education	-.36***	-	-
General infrastructure	.27***	-	-
Knowledge workers	.34***	.26***	-
Knowledge absorption	.32***	.19**	-
Sociability	-	.25**	.35***
Influence	-.22**	-	-
Caring	-	-	-.16*
Evaluative	.30***	-	-
Forward thinking	-.30***	-	-
Behavioural	-	.21**	-
Conceptual	-	-	.24***
Conventional	-	.56***	-
Data rational	-	-.21**	-.32***
Modest	-	.18**	-
Variety seeking	-	.37***	-
Vigorous	-	-	.17**
F	***10.15****	***13.45****	***21.94****
R^2	***.46***	***.56***	***.57***
Adj R^2	***.41***	***.52***	***.55***

*Notes. *** = p < .01, ** = p < .05, * = p < .1. GII input factors. Personality factors. OPQ 32.*

The factors of *sociability* and *influence* show associations with the creative output sub-indices. These are of a modest (β = .25 and β = -.22) and moderate (β = .35) effect size.

Notably, in all cases it is only these two factors which are significant. The remaining factors of *structure* and *emotions* showed no significant associations with any output index or sub-index.

The strongest association is between *conventional* and *creative goods*, β = .56 which is the largest effect size noted in the study between personality and innovation output.

4.3 Secondary analysis

The secondary analysis uses panel data and longitudinal analysis methods to better understand the association between personality dimension, as well as factors, over time when controlling for innovation inputs. The secondary analysis is divided into same three sections as the primary analysis:

i. Panel descriptive statistics and correlations
ii. Regression with complete 32 personality dimensions
iii. Regression with factors

i. Panel data descriptive statistics and correlations

A partialled correlation was conducted where the 15 Global Innovation Index (GII) input factors were partialled out, this was to remove their influence on the association between the personality variables and the innovation outputs. The results of this as well as the mean and standard deviation for each variable are shown in table 12.

Table 12 demonstrates that there are significant associations between numerous personality factors and innovation outcomes at the national level, even when taking a panel view. In comparison to the cross sectional view, none of the factors are significant across all output dimensions. However all of the clusters as well as eighteen of the personality dimensions have significant associations across some of the GII output factors. The strength of these significant associations range between $.22 \leq \beta \leq .53$ with certain dimensions showing a consistently inverse association, for example *data rational*.

Table 12. Descriptive statistics and correlations for panel data

	M	*SD*	I.O.	6.	6.1	6.2	6.3	7.	7.1	7.2	7.3
GII Output factors											
I.O. Innovation output	*36.58*	*11.84*	1.00								
6. Knowledge and technology	*33.62*	*13.41*	.78***	1.00							
6.1 Knowledge creation	*24.5*	*20.24*	.61***	.74***	1.00						
6.2 Knowledge impact	*39.96*	*12.00*	.23*	.42***	.19	1.00					
6.3 Knowledge diffusion	*36.39*	*16.24*	.57***	.70***	.22	-.14	1.00				
7. Creative outputs	*39.54*	*12.04*	.81***	.27**	.26*	-.03	.23*	1.00			
7.1 Intangible assets	*48.92*	*9.56*	.54***	.11**	.07*	-.18	.23*	.73***	1.00		
7.2. Creative goods and services	*25.96*	*13.42*	.48***	.19	.16	.00	.15	.56***	.06	1.00	
7.3 Online creativity	*34.34*	*25.00*	.67***	.29**	.32**	.15	.09	.77***	.25*	.37***	1.00
OPQ Personality clusters											
Influence	*.57*	*.16*	-.05	-.11	-.14	-.31**	.15	.03	.13	-.21	.05
Sociability	*.24*	*.13*	.22	.10	.15	-.16	.13	.24*	.08	.09	.34**
Structure	*.36*	*.13*	-.05	-.23*	-.14	-.19	-.13	.14	.16	-.10	.16
Emotions	*.34*	*.11*	.22*	.09	.09	.11	-.00	.25*	.12	.00	.36***
OPQ 32 Dimensions											
Achieving	*.64*	*.19*	.09	.02	-.03	-.27**	.22*	.12	0.12	-.11	.19
Adaptable	*.00*	*.29*	.08	.21	.16	-.01	.21	-.07	-0.11	.16	-.13
Affiliative	*.00*	*.19*	.31**	.07	.13	-.07	.05	.41***	0.14	.22*	.52***
Behavioural	*-.03*	*.17*	.04	.03	.06	-.11	.08	.03	-0.05	.08	.06
Caring	*-.10*	*.15*	.08	-.02	.00	-.19	.09	.13	0.13	.01	.11
Competitive	*.17*	*.22*	-.07	.11	-.01	-.12	.25*	-.20	-0.01	-.33**	-.17
Conceptual	*.17*	*.16*	-.08	-.10	-.04	-.23*	.02	-.03	0.19	-.27**	-.09
Conscientious	*.39*	*.13*	.01	-.08	-.03	-.14	-.00	.09	0.15	-.14	.09
Controlling	*.76*	*.17*	-.04	-.02	-.10	-.23*	.19	-.04	0.02	-.19	.03
Conventional	*-.09*	*.21*	-.21	-.26**	-.23*	.20	-.35***	-.08	-0.11	.10	-.10
Data rational	*.78*	*.2*	-.14	-.11	-.21	-.27**	.17	-.11	0.07	-.22	-.15
Decisive	*.65*	*.21*	-.07	-.15	-.03	-.26*	-.05	.04	0.03	-.14	.14
Democratic	*.34*	*.2*	.17	.06	.01	.22	-.06	.20	0.12	.20	.14
Detail conscious	*.45*	*.14*	-.00	-.03	.02	-.08	-.02	.02	0.07	-.06	.00
Emotionally controlled	*-.39*	*.13*	.24*	.24*	.20	.05	.18	.15	0.02	.35***	.03
Evaluative	*.57*	*.16*	.10	.01	.08	-.14	.04	.15	0.05	-.03	.26**
Forward thinking	*.42*	*.15*	.01	.18	.07	.19	.10	-.16	-0.25*	.12	-.11
Independent minded	*-.28*	*.19*	.29**	.43***	.37***	.03	.34***	.06	-0.06	.20	.05
Innovative	*.66*	*.18*	.01	-.01	.05	-.25*	.10	.02	0.04	-.11	.08

	M	*SD*	I.O.	6.	6.1	6.2	6.3	7.	7.1	7.2	7.3
Modest	*-.25*	*.12*	-.02	-.06	-.07	-.17	.08	.02	-0.05	.28**	-.10
Optimistic	*.43*	*.15*	.18	.16	.06	.16	.09	.13	0.04	-.04	.23*
Outgoing	*.15*	*.13*	.05	.13	.18	-.07	.10	-.04	-0.13	.03	.03
Outspoken	*.25*	*.2*	-.07	-.21	-.18	-.27**	-.02	.09	0.18	-.20	.10
Persuasive	*.70*	*.18*	-.00	-.03	-.07	-.31**	.22	.02	0.13	-.16	-.00
Relaxed	*.20*	*.15*	.26*	.05	.20	.01	-.08	.34***	0.17	.14	.40***
Rule following	*.22*	*.21*	-.10	-.39***	-.28**	-.22*	-.23*	.20	0.17	-.05	.24*
Socially confident	*.57*	*.17*	.12	.04	.06	-.22	.15	.15	0.13	-.06	.18
Tough minded	*.27*	*.11*	.01	-.04	.04	.04	-.11	.05	-0.07	.06	.15
Trusting	*.45*	*.21*	.13	.05	-.02	.08	.04	.15	0.14	-.09	.21
Variety seeking	*-.10*	*.18*	.16	.11	.08	-.15	.20	.14	0.00	.13	.19
Vigorous	*.51*	*.2*	.28**	.11	.19	-.14	.11	.33**	0.15	.15	.38***
Worrying	*-.70*	*.2*	-.24*	-.12	-.13	.14	-.17	-.26*	-0.10	-.17	-.28**

*Notes: M = Variable mean, SD = standard deviation, *** = p < .01, ** = p < .05, * = p < .10*

ii. Panel regression with complete 32 personality dimensions

The results for the regression, using the panel data, are summarised in the three tables that follow. The first considers the overall innovation measure as well as its two components. The next two tables provide the three sub-indices nested in each component. Important to note that the estimate is not standardised as was the case for the primary analysis.

Table 13. Panel: Innovation Outputs: Broad Measures

	Panel: Innovation Outputs: Broad Measures		
	Overall outputs	**Knowledge & Technology**	**Creative outputs**
Intercept	*.19**	*.07*	*.14*
Institutions	.28***	-	-
Political environment	-	.14**	-
Regulatory environment	-	-	.16**
Business environment	-.17**	-	-
Human capital and research	-12.1*	-	-13.58***
Education	3.71**	-	4.19***
Tertiary education	4.49**	-	5.00***
Research and development	6.61**	.48***	7.37***
Infrastructure	-	-.36***	-
ICTs	-	-	-
General infrastructure	.10***	.14**	-
Ecological sustainability	-	.24***	-
Market sophistication	0.24*	-	.26***
Credit	-.20**	-	-
Investment	-.15**	-	-.08*
Business sophistication	.22***	.40***	-
Knowledge workers	-	-.14*	-
Innovation linkages	-	-.11**	-
Achieving	-	-	-07*
Affiliative	.17***	-	.13***
Behavioural	-	-	-.10**
Caring	-.15***	-	-
Competitive	-	.16***	-
Conceptual	-	-	.09**
Controlling	-.08*	-.14**	-
Conventional	-.15**	-	-
Data rational	-.10**	-	-
Detail conscious	.09*	-	-
Evaluative	-	.08*	-
Independent minded	-	.10**	-
Outspoken	-	-.11*	-.10**
Persuasive	-	-	.10***
Rule following	-	-	-13***
Trusting	.13**	.17***	-
Variety seeking	-.11*	-	-
SSE	***4.55***	***8.54***	***7.89***
MSE	***.02***	***.04***	***.04***
R^2	***.57***	***.55***	***.50***

Notes. *** = $p < .01$, ** = $p < .05$, * = $p < .1$. *GII input factors. OPQ 32.*

Overall

It is important to preface that there are likely to be differences between the panel model and the cross-sectional model due to the nature of the data under analysis. The panel view, can in some respects, be considered a more precise view and it is less likely to import the effects of averaging. It is for this reason, for example the sub-indices headers, such as *institutions*, are emerging as significant which did not appear at all in the cross-sectional results. In the panel analyses these would have been averages of averages, restricting range and making significant results less likely.

Overall the panel model explains 20% less variance than the cross-sectional model. However the R^2 is still encouraging ranging between .55 and .57.

Specific considerations

The GII factors across the panel regressions are somewhat more subjective to interpret due to the measures not being fully standardised. Interestingly to note however, that when taking a year on year view, rather than cross-sectional the GII input and output factors do associate to a higher degree generally.

The personality factors range from $\beta = .08$ to $\beta = .17$. These are predominantly small effect sizes with a few bordering on moderate.

Table 14. Panel: Innovation Outputs: Knowledge & Technology sub-Indices

	Panel: Innovation Outputs: Knowledge and Technology sub-Indices		
	Knowledge creation	**Knowledge impact**	**Knowledge diffusion**
Intercept	*.14*	*.1*	*.06*
Institutions	-	-	.57***
Regulatory environment	.16**	-	-
Business environment	-	-	-.30**
Human capital and research	-13.58***	-	.71**
Education	4.19***	-	-.26**
Tertiary education	5.00***	-	-.26**
Research and development	7.37***	-	-
Infrastructure	-	.16*	-20.74*
ICTs	-	-	11.26*
General infrastructure	-	-	6.53*
Ecological sustainability	-	-	7.30*
Market sophistication	.26***	-	-.39**
Credit	-	-	-
Investment	-.08*	-	.40***
Business sophistication	-	.32***	74.00***
Knowledge workers	-	-.17**	-.44***
Innovation linkages	-	-	-.32***
Achieving	-07*	-	-
Affiliative	.13***	-	-
Behavioural	-.10**	-	-
Competitive	-	.20***	-
Conceptual	.09**	-	-
Conscientious	-	.21***	-
Controlling	-	-.16**	-
Data rational	-	-.20***	-
Innovative	-	-.22**	-
Modest	-	-.18***	-
Outspoken	-.10**	-	-
Persuasive	.10***	-	-
Rule following	-13***	-	-
Tough minded	-	.15***	-
Trusting	-	.20***	-
Vigorous	-	-.21***	-
SSE	***2.57***	***14.00***	***23.89***
MSE	***.01***	***.07***	***.12***
R^2	***.44***	***.34***	***.31***

Notes. *** = $p < .01$, ** = $p < .05$, * = $p < .1$. *GII input factors. OPQ 32.*

In this model, *knowledge diffusion* has no associations with any of the 32 personality factors. The effect sizes for *knowledge creation* for the seven significant personality factors are small. Only *knowledge impact* appears to have modest association across nine of the personality factors.

Table 15. Panel: Innovation Outputs: Creative output sub-indices

	Panel: Innovation Outputs: Creative output sub-indices		
	Intangibles	**Creative goods**	**Online**
Intercept	*.01*	*.09*	*.16*
Institutions	-	-	-.70***
Political environment	-	-	.26***
Regulatory environment	-	-	.50***
Human capital and research	-.55***	-	-9.56*
Education	-	-	3.01*
Tertiary education	.20*	-	3.63*
Research and development	-	.23**	5.28*
Infrastructure	.52***	-	-9.34**
ICTs	-	-	5.21**
General infrastructure	-	-	2.87**
Ecological sustainability	-.26**	-	3.23**
Market sophistication	33.47**	-	.28**
Credit	-17.65**	.14*	-.18**
Investment	-15.84**	-	-.17**
Trade, competition and market scale	-7.04**	.08*	-
Business sophistication	93.00***	-	-
Knowledge workers	-.29**	-	.11***
Knowledge absorption	-.39***	-	-
Achieving	-.15*	-	.18***
Adaptable	-	-	-.13*
Affiliative	-	-	.22***
Behavioural	-	.17***	-
Conceptual	.14*	-.19***	-.07*
Conscientious	-	-	-.22***
Controlling	-	-.30***	-
Data rational	-	-	-.19***
Democratic	-	-	-.23***
Evaluative	-	.16**	.27***
Independent minded	-	.13**	-
Modest	-	-	.11**
Optimistic	-	-	.17***
Outspoken	-	-	-.14**
Socially confident	-	.16**	-.09*
Variety seeking	-	-	-.1**
Vigorous	.23**	-	-
SSE	***42.94***	***19.64***	***3.09***
MSE	***.21***	***.09***	***.02***
R^2	***.29***	***.37***	***.49***

Notes. *** = $p < .01$, ** = $p < .05$, * = $p < .1$. *GII input factors. OPQ 32.*

Intangibles has small associations with only three personality dimensions. *Creative goods* significantly associates with six of the personality dimensions, generally small associations with a noteworthy moderate association, β = -.3, with *controlling*. Online shows associations with the most number of personality dimensions across all output factors. Of the thirteen personality dimensions associated, nine are small and four are modest.

iii. Panel regression with factors

The results for the regression using the factors rather than complete 32 dimensions, using the panel data, are summarised in the three tables that follow. The first considers the overall innovation measure as well as its two components. The next two tables provide the three sub-indices nested in each component.

Table 16. Panel: Innovation Outputs: Broad Measures

	Panel: Innovation Outputs: Broad Measures		
	Outputs	**Knowledge and Technology**	**Creative Inputs**
Intercept	*.21**	*.07*	*.06*
Institutions	.33***	-	-
Political environment	-	.17**	-
Business environment	-.18***	-	-
Human capital and research	-14.1**	-	-
Education	4.35**	-	-
Tertiary education	5.22**	-	-
Research and development	7.68**	.53***	.16*
Infrastructure	-	-.28**	-
ICTs	-	-	.18***
General infrastructure	.07**	.13**	.16***
Ecological sustainability	-	.21***	-
Market sophistication	.37***	-	11.45*
Credit	-.30***	-	-6.05*
Investment	-.20***	-	-5.46*
Trade, competition and market scale	-	-	-2.35*
Business sophistication	-	.38***	.34
Knowledge workers	.12***	-.15**	-
Innovation linkages	.09**	-.13**	-
Knowledge absorption	-	-	-.15***
Influence	-.11**	-.13**	-.10*
Sociability	.24***	-	.17**
Emotions	-	.13**	-
Caring	-.10**	-	-.09*
Competitive	-	.15***	-
Vigorous	-	-	.16***
SSE	4.42	8.33	8.38
MSE	.02	.04	.04
R-Square	.46	.49	.48

*Notes. *** = p < .01, ** = p < .05, * = p < .1. GII input factors. Personality factors. OPQ 32.*

The overall model is slightly weaker than the panel model with all 32 dimensions. The personality factors show small to modest effect sizes of $.10 \leq \beta \leq 24$. The dimensions have small effect sizes of $.10 \leq \beta \leq .16$.

Table 17. Panel: Innovation Outputs: Knowledge & Technology sub-Indices

	Panel: Innovation Outputs: Knowledge & Technology sub-Indices		
	Knowledge Creation	**Knowledge Impact**	**Knowledge Diffusion**
Intercept	*.14*	*.10*	*.06*
Institutions	-	-	.57***
Regulatory environment	.15**	-	-
Business environment	-	-	-.30**
Human capital and research	-13.3***	-	.71**
Education	4.1***	-	-.26**
Tertiary education	4.89***	-	-.26**
Research and development	7.26***	-	-
Infrastructure	-	.26***	-2.74*
ICTs	-	-	11.26*
General infrastructure	-	-	6.53*
Ecological sustainability	-	-	7.30*
Market sophistication	.28***	-	-.39**
Credit	-	-	-
Investment	-.11**	-	.40***
Business sophistication	-	.22***	.74***
Knowledge workers	-	-	-.44***
Innovation linkages	-	-	-.32***
Influence	-	-.25***	-
Sociability	.13***	-	-
Emotions	-	.17**	-
Structure	-.07*	-	-
Caring	-.06*	-	-
Competitive	-	.16**	-
Conceptual	-	-.12**	-
Conventional	-	.14*	-
Data rational	-	-.16**	-
Evaluative	-	.16**	-
Modest	-	-.17***	-
Vigorous	-	-.22***	-
SSE	2.70	15.5	23.89
MSE	.01	.07	.12
R-Square	.36	.33	.31

Notes. *** = $p < .01$, ** = $p < .05$, * = $p < .1$. *GII input factors. Personality factors. OPQ 32.*

The overall model is slightly weaker than the panel model with all 32 dimensions. The personality factors show small to modest effect sizes of $.07 \leq \beta \leq 25$. The dimensions have small effect sizes of $.06 \leq \beta \leq .22$. *Knowledge diffusion* shows no association with any factors or dimensions. *Knowledge creation* associated with two factors and one dimension. *Knowledge impact* associates with two factors and seven dimensions. The relatively strongest associations, although still only modest, are *influence* ($\beta = .25$) and *vigorous* ($\beta = -.22$) with *knowledge impact*.

Table 18. Panel: Innovation Outputs: Creative output sub-indices

	Panel: Innovation Outputs: Creative output sub-indices		
	Intangibles	**Creative Goods**	**Online**
Intercept	*.01*	*.09*	*.07*
Institutions	-	-	-.72***
Political environment	-	-	.36
Regulatory environment	-	-	.51***
Human capital and research	-.54***	-	-
Education	-	.12**	-
Tertiary education	.20*	-	.12***
Research and development	-	.23***	.37
Infrastructure	.48***	-	-
Ecological sustainability	-.24**	-	-
Market sophistication	33.39**	-	-
Credit	-17.59**	-	-
Investment	-15.8**	-	-
Trade, competition and market scale	-7.03**	.10**	-
Business sophistication	.42**	-	-
Knowledge workers	-	-	.10**
Innovation linkages	.20*	-	-
Knowledge absorption	-.20**	-	-
Influence	-	-.26***	-
Sociability	-	.28***	-
Emotions	-	-	.24
Structure	.30**	-	-
Achieving	-.26**	-	-
Competitive	-	-	.16***
Conceptual	.17**	-.12**	-
Conventional	-.26**	-	-
Data rational	-	-	-.15***
Evaluative	-.18*	.14**	.10**
Modest	-	-	.10**
Vigorous	.22**	-	-
SSE	39.74	2.91	3.80
MSE	.20	.10	.02
R-Square	.31	.38	.38

Notes. *** = $p < .01$, ** = $p < .05$, * = $p < .1$. *GII input factors. Personality factors. OPQ 32.*

The overall model is slightly weaker than the panel model with all 32 dimensions. The personality factors show modest to moderate effect sizes of $.24 \leq \beta \leq 30$. The dimensions have small, moderate and modest effect sizes of $.10 \leq \beta \leq .26$.

Before concluding the presentation of the primary and secondary analyses, it is briefly noted that a range of post hoc checks were conducted for example residual plots, multicollinearity indicators and so forth.

4.4 Primary and secondary analysis summary

The previous sections have provided detailed statistical analyses that have been conducted with both the cross-sectional data and the panel data. These results will be summarised, linked backed the research question in chapter five then discussed in terms of implication in chapter six.

In the interim, a pictorial summary is provided in figure 12 which follows. This summary takes the form of a decision tree, the purpose of which is to create a prioritisation for the consideration of dimensions, given than 32 is a large number to interpret. A count is provided for the number of significant associations noted in the cross-sectional analysis then a count is then applied for the number of significant association in the panel analysis. Where the relationship was noted to be consistently inverse – the dimension is displayed in *italics*.

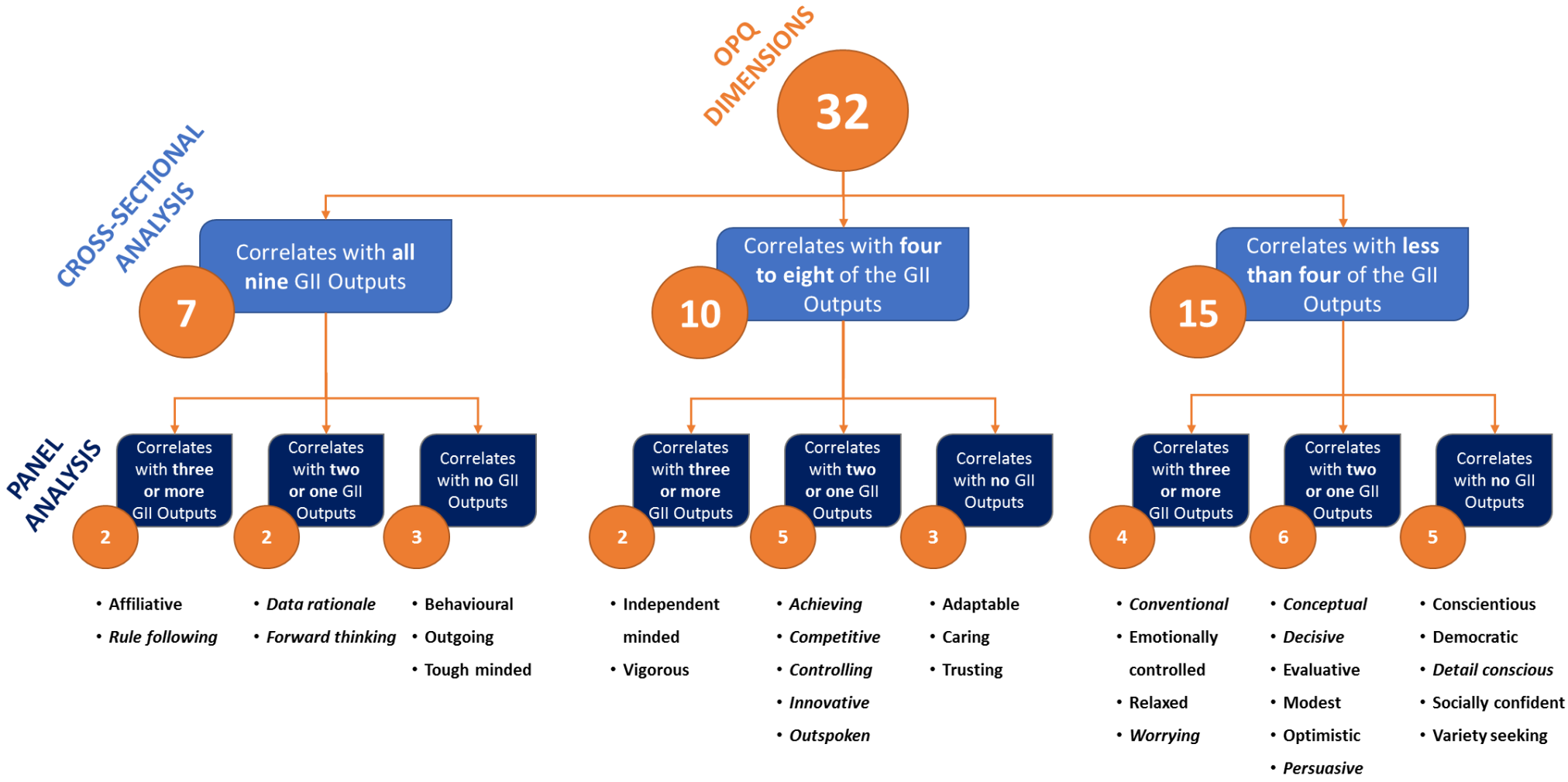


Figure 12. Decision tree summary of primary and secondary analysis

4.5 Tertiary analysis

The tertiary analysis, due to the extensive possible permutations and cautions for mixed methods approaches, is first bounded. A dimension analysis is then completed for *affiliative* followed by *rule following*. The outcomes of these rankings are briefly summarised before in depth sector comparisons commence. The first comparison pair presented is p*harmaceuticals & biotechnology* and *mining*. The second comparison pair presented is *media* and *banking*. The chapter concludes with thoughts on the sector comparisons.

i. Bounding the tertiary analysis

In order to complete the tertiary analysis the entire Occupational Personality (OPQ) dataset from the period 2009 to 2016 was utilised and theta scores were averaged by dimension per 41 reported sectors based on the responses of 4 168 210 individuals. The average number of individuals assessed by sector was 101 664 individuals with a range of 650 (*nonequity investment instruments*) to 869 552 (*financial services*). A summary of this dataset can be found in appendix 4 and a description of the sub-sectors represented by each sector tag applied can be found in appendix 5.

There are a substantial number of permutations and comparisons that are possible across sectors given the results presented in the primary and secondary analysis. The decision tree has been used as a starting point, to identify the dimensions that were most prominent in both the cross-sectional and panel analyses. Thus the tertiary analysis begins with a stack rank of results per sector for *affiliative* and *rule following* to illustrate the comparisons possible.

To provide an alternative perspective, two key industries – noted for both their prominence in the analysis and in the literature – are then compared side by side. This analysis is of the entire composite profile across all 32 dimensions to provide an illustration of the richness of context to be gleaned.

ii. Dimension analysis: affiliative

A key covariate with innovation outcomes which has emerged from the primary and secondary analysis is *affiliative*. A higher preference suggests an individual who enjoys others' company, likes to be around people and can miss the company of others. A lower preference suggests an individual who is comfortable spending time away from people, values time spent alone and seldom misses the company of others. In figure 13 below the scores on the affiliative dimension across various sectors are compared relative to each other.

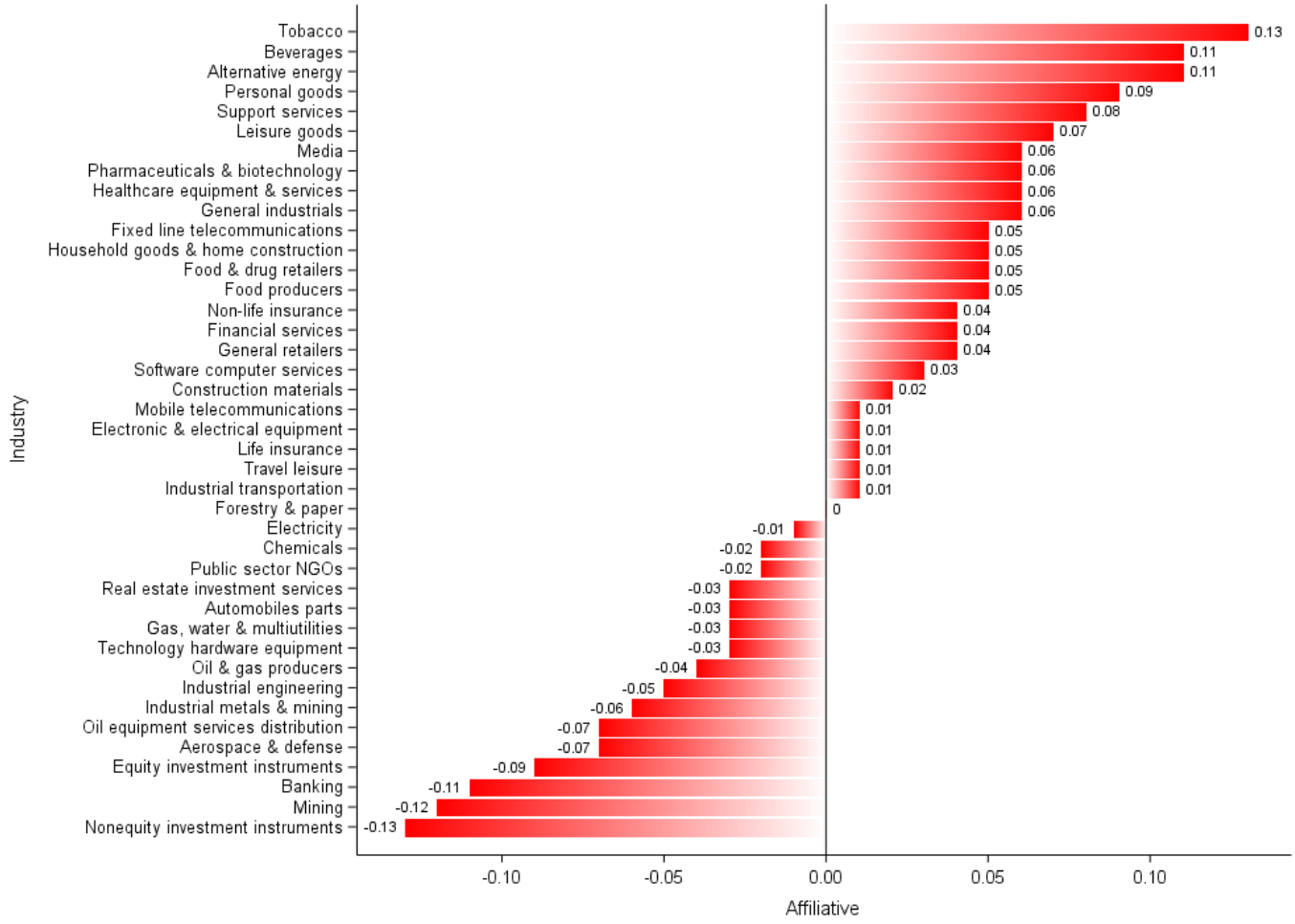


Figure 13. Affiliative scores by sector[7]

[7] The affiliative axis is the average Theta score for the sector from the cross-sectional OPQ data. A summary of the sample size (n) per sector as well as demographic breakdown can be found in appendix 4. Definitions of the industries, as well as sub-sectors included, can be found in appendix 5.

What this suggests is that sectors such as *tobacco*, *beverages* and *alterative energies* are likely to be comprised of individuals who prefer the company of others – through this increased seeking of connection – these individuals could be hypothesised to be more likely to both generate and disseminate ideas.

On the opposite extreme, industries such as *non-equity investments*, *mining* and *banking* are more likely to be comprised of individuals who value time spent alone. This may result in missed opportunities for collective creativity and the spread of new ideas.

iii. Dimension analysis: rule following

The second key covariate which emerged from the primary and secondary analyses is *rule following*. It is important to note that this is an inverse relationship. Essentially, a lower preference for rule following is associated with higher innovation outcomes. Individuals with a lower preference on this dimension can be described as not restricted by rules and procedures; prepared to break rules; with a tendency to dislike bureaucracy. In figure 14 the scores on the rule following dimension across various sectors are compared relative to each other.

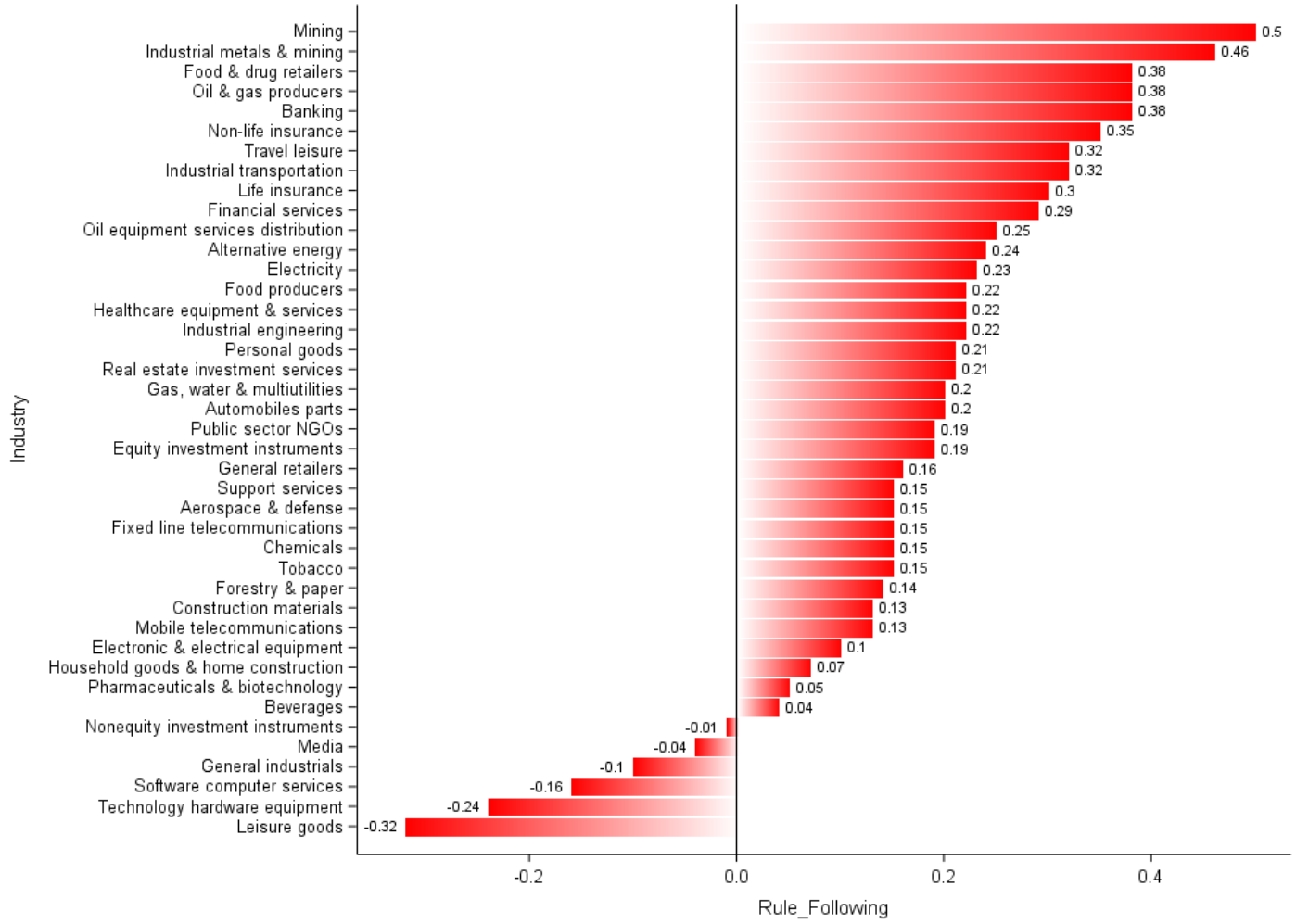


Figure 14. Rule following score by sector [8]

This ranking suggests that *mining*, *industrial metals & mining* as well as *food & drug retailers* comprises of individuals who are followers of rules and regulations, who prefer clear guidelines and who would find it difficult to break rules. This propensity towards rule following is negatively correlated with innovation factors suggesting that this may be a less ideal when attempting to achieve innovation outcomes.

[8] The rule following axis is the average Theta score for the sector from the cross-sectional OPQ data. A summary of the sample size (n) per sector as well as demographic breakdown can be found in appendix 4. Definitions of the industries, as well as sub-sectors included, can be found in appendix 5.

On the opposite extreme industries such as *leisure goods*, *technology hardware equipment* and *software computer services* are comprised of those reporting a lower preference for *rule following*. It could be posited that this profile could be posited to be more ideal due to its positive covariance with innovation outcomes.

iv. Summary of dimension comparison across sectors

Based on the outputs of the primary and secondary analysis is could be posited that an ideal personality composite profile for a sector should consist of a higher preference for *affiliative* and a lower preference for *rule following*. To illustrate the implications, the sectors which overlap as being in both the top ten for *affiliative* and bottom ten for *rule following* were identified.

Those sectors displaying the 'ideal' profile for solely these two dimensions associated with higher innovation outputs include:

- **Pharmaceuticals and biotechnology (*n* = 61 930)**
- Beverages (*n* = 51 142)
- **Media (*n* = 111 422)**
- General industrials (*n* = 4 637)
- Leisure goods (*n* = 31 695)

Those sectors that are least likely to benefit from the posited ideal composite profile include:

- **Mining (*n* = 48 303)**
- Industrial metals and mining (*n* = 50 822)
- Oi and gas producers (*n* = 43 717)
- **Banking (*n* = 707 310)**

It is clear that there is significant potential for further comparisons outside the precise bounds of this study – the extensive opportunities for further analysis will be discussed in chapter six. The section which follows compares two pairs of sectors (indicated in **bold**) to deepen the illustration of the inferences to be made from comparing the hypothesised 'ideal' and 'less ideal' profiles.

v. Sector comparison: pharmaceuticals and biotechnology versus mining

Comparing all sectors on select dimensions that appear to be strong covariates is one way in which they can be compared. However, the results from the primary and secondary analyses also suggest a complex relationship between personality dimensions and innovation outcomes for some of the following key reasons:

- Some personality dimensions may co-vary with certain innovation outcomes but not others.
- Some personality dimensions have positive relationships while others have inverse relationships.
- Some personality dimensions have stronger associations while others have weaker associations.
- Some personality dimensions have stronger associations in the cross-sectional analysis while others have stronger relationships in the panel analysis.

As such, an alternative way in which sectors could be compared would be to consider their entire composite personality profiles side-by-side. The purpose would be to identify dimensions where the profiles seem disparate and then relate this back to possible explanations in relation to their *innovativeness*. The illustrations that follow build on the previous examples by considering in more depth two pairs of sectors that were highlighted in relation to the 'ideal' versus 'less ideal profile'. These have also been selected as the literature has focused on both of these industries in relation to their *innovativeness* or lack thereof.

Mining and *pharmaceuticals & biotechnology* are both mature sectors however the former has struggled with massive downturns and persistent instability while the latter continues to grow at rates which outpace most established sectors (Gassmann et al, 2013; Mikesell & Whitney, 2017). *Mining* has been widely critiqued for lacking agility due to the massive infrastructures and longer term investment prerequisite whereas *pharmaceutical & biotechnology* continues to be a highly research and development intensive sector with budgets for these efforts rising year on year (Fan et al, 2017; Gassmann et al, 2013).

The two graphs that follow in figure 15 compare the average theta scores across all 32 dimensions for both sectors to allow for comparisons and contrasts to be inferred.

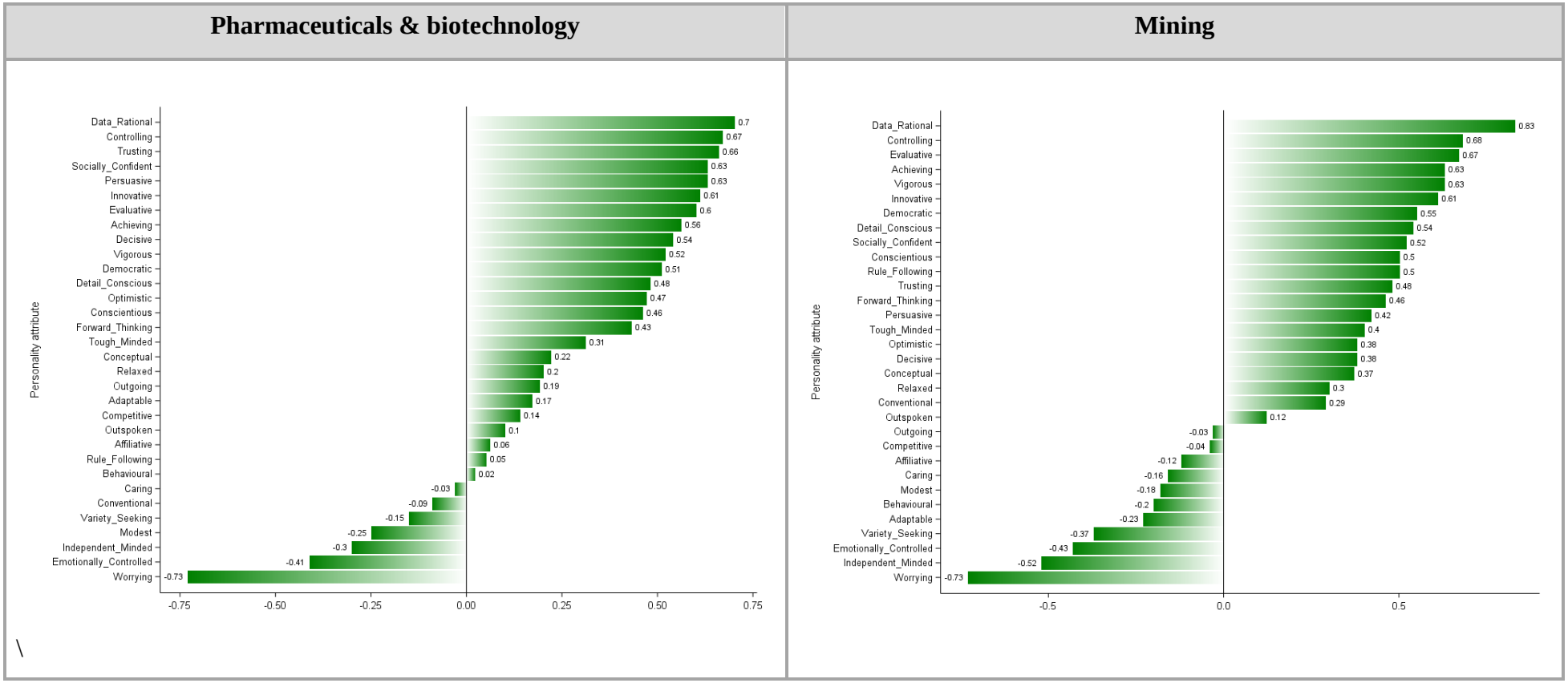


Figure 15. Comparing the OPQ 32 dimensions between *pharmaceuticals & biotechnology* and *mining*

In order to compare these industries, the decision tree was followed, and any interesting patterns are now highlighted. As *affiliative* and *rule following* were used to select these industries for this analysis – the differences and impact have already been discussed and will not be repeated.

Interestingly there does appear to be a wider gap on the *behavioural* dimension which correlated positively across all nine GII outputs in the cross-sectional analysis. Overall, individuals employed in *pharmaceuticals & biotechnology* report more often trying to understand motives and behaviours. As these individuals enjoy analysing people, it may be hypothesized that they are more able to identify opportunities for innovation that can meet *hidden needs*[9]. They may also gain buy-in more easily by understanding the individual drivers behind adoption versus rejection.

Independent minded also had quite a wide gap in terms of comparative averages. This was a dimension that positively correlated across six and four elements in the Global Innovation Index (GII) outputs structure for the cross-sectional and panel analyses respectively. *Mining* reported a lower average suggesting an acceptance of majority decisions whereas *pharmaceuticals & biotechnology* indicated a preference for following their own approach and a preparedness for disregarding majority decisions.

Therefore it could be hypothesised that these key dimensions have some role to play in the relative innovativeness of p*harmaceuticals & biotechnology* versus *mining*:

- Affiliative (.06 versus -.12)
- *Rule following (.05 versus .5)
- Behavioural (.02 versus -.2)
- Independent minded (-.3 versus -.52)

** inverse relationship*

[9] Hidden needs are defined by Goffin, Lemke & Koners (2010, p. 8) as "issues and problems that customers face but have not yet realised" which "many customers recognize as important in the final product but do not or are not able to articulate in advance."

vi. Sector comparison: media and banking

The second pair chosen for the purposes of a deepened illustration is the *media* and *banking* sectors. Both sectors have long-lasting histories but their evolution, range of innovation achievements as well as relative sensitivity to disruptors makes for an interesting comparison. While the *media* sector has a long history, it can be said that the nature of the sector has truly transformed over recent years due to technological advances, deregulation and the confluence of numerous capabilities such as digital, media and entertainment.

The *media* sector boasts examples of innovations across product, marketing, process and organisation. From a product perspective the examples are numerous – while in its early days heavily reliant on a few core products such as newspapers or television broadcasting, the *media* sector now offers a staggering array of products which include, for example video-on-demand; content streaming; as well as hyper-targeted content and advertising (Van Kranenburg, 2017; Deloitte Centre for Technology, Media & Telecommunications, 2018). From a process perspective the means in which this sector delivers to and engages its customers has also shifted to be more heavily reliant on technology in the back-end. This ranges from being at the forefront of planning for 5G as well as pioneering augmented and virtual reality (Deloitte Centre for Technology, Media & Telecommunications, 2018, 2018). From a marketing perspective, *media* sector firms are now more likely to have a direct relationship with the customer i.e. evolving from B2B to B2C (Deloitte Centre for Technology, Media & Telecommunications, 2018, 2018). In terms of organisational innovation, this is a sector rife with mergers and acquisitions where new capabilities are absorbed or divested (Deloitte Centre for Technology, Media & Telecommunications, 2018, 2018). *Media* has been particularly sensitive to the effects of disruptors as barriers to entry are relatively low and investment has flooded into media related start-ups (Van Kranenburg, 2017).

The *banking* sector, by comparison, displays a more limited range in terms of innovation achievements across product, process, marketing and organisation. Partially this can be attributed to high start-up costs and stringent regulations which tend to act as automatic barriers to entry thus the sector is overall less sensitive to a plethora of disruptors. There are of course notable exceptions such as technologically-driven service augmentations, such as online banking, or cutting edge

cyber risk practices (Deloitte Centre for Financial Services, 2018). While services innovations are certainly desirable and often represent untapped potential, there is a degree of risk as these can often be more easily replicated by competitors (Goffin & Mitchell, 2005). This can be readily noted in the *banking* sector where for example, if one bank builds an app the rest tend to follow suit relatively quickly.

Yet, despite some innovative progress, the sector is still critiqued for being removed from the *voice of the customer*[10], lacking agility and being burdened with legacy – including inherited hodgepodges of processes, systems, redundant skills and archaic attitudes (Deloitte Centre for Financial Services, 2018; Sarel & Marmorstein, 2003). In a recent review of the sector by Deloitte Centre for Financial Services (2018, p. 3) it was quite bluntly summarised.

> "Although banking has undoubtedly improved in many ways in the last couple of decades, most organisations have not gone through the customer-centric transformation that other industries have undergone. With widespread digital disruption, banks may even risk losing control over customer experience."

In figure 16 the profiles of the *media* and *banking* sectors are compared side by side across all 32 dimensions of personality as measured by the OPQ. Following this is a discussion of noteworthy differences; the discussion of dimensions is ordered in line with the decision tree.

[10] Listening to the *voice of the customer* is an in-depth exercise of identifying, structuring and prioritising a detailed set of customer needs as well as wants (Sarel & Marmorstein, 2003).

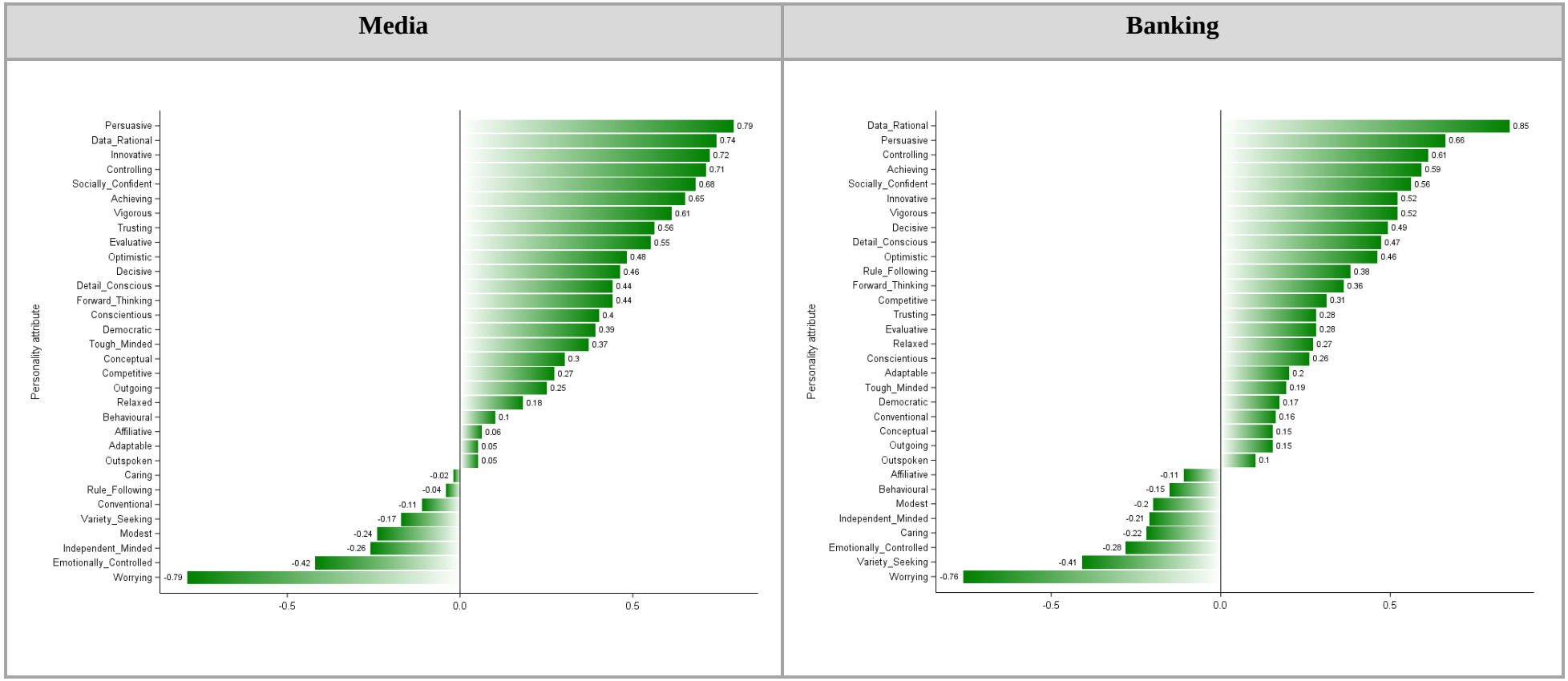


Figure 16. Comparing the OPQ 32 dimensions between *media* and *banking*

These are the top ten noteworthy relative differences, these are listed in the order derived from the decision tree rather than size of difference.

- Affiliative (.06 versus -.11)
- *Rule following (-.04 versus .38)
- *Data rational (.74 versus .85)
- Behavioural (.1 versus -.15)
- Outgoing (.25 versus .15)
- Tough minded (.37 versus .19)
- Vigorous (.61 versus .52)
- *Controlling (.71 versus .61)
- *Conventional (-.11 versus .16)
- Emotionally controlled (-.42 versus -.28)

**inverse relationship*

As *affiliative* and *rule following* were used to select these industries for this analysis – the differences and proposed explanation have already been discussed and will be mentioned but not explored in depth.

The *media* sector is more likely to report a preference for dealing with opinions and feelings rather than facts and figures (**data rational*). This is reinforced with an interest in understanding the motives, drivers and needs of others (*behavioural*). The *banking* sector reports in comparison a higher preference for telling others what to do, a more directive approach, and is much less likely to ever bend internal rules or processes to meet a need (*controlling* / *rule following*). When weaving these four dimensions together it could be hypothesised that the *media* sector, relative to *banking* is innately more astute, to the voice of the customer.

In terms of the typical ways of thinking, *media* reports a higher likelihood to reject established methods, rather preferring new approaches (**conventional*). The *banking* sector seems to report a higher preference for conventional approaches, this may go some way in explaining the critique of being inflexible and slow to adopt more agile ways of working (Deloitte Centre for Financial Services, 2018).

The two sectors report differences in their typical ways of feeling with *media* individuals reporting to be more expressive, sensitive and hurt by criticism (*emotionally controlled* / *tough minded*). *Banking* reports a preference for personal distance and is more prepared to ignore insults or criticism. It could be hypothesised that the greater receptiveness to negative feedback and the free flow of emotions has been enabling for the *media* sector. It could be hypothesised that an openness to difficult or negative feedback from customers may assist progression through the adoption lifecycle curve, particularly when it the type of innovation that requires a new social habit which could engender resistance (Goffin & Mitchell, 2005).

Finally, the *media* sector reports thriving on activity, being quite lively in groups and preferring the company of others (*vigorous* / *outgoing* / *affiliative*). This is in comparison to *banking* individuals who - overall and relatively speaking - would prefer a steadier pace, are more reserved and may actively seek out time alone. When attempting to cross the chasm, factors such as *observability* and *triability* come into play, these are opportunities for users to perceive the benefits and try out the innovation (Goffin & Mitchell, 2005). In *media* the higher rates of connection and engagement amongst individuals may mean increased ‘face time’ for *triability* and *observability* such that innovations are quicker to diffuse and are more likely to be adopted.

vii. Sector comparison summary

The preceding section attempted to illustrate the depth of comparison possible when considering a pair of sectors side by side. Current narratives in the literature can be related back to reported patterns of typical ways of thinking, feeling and behaving that lead a range of interesting hypothesises in terms of how personality may be linking to innovation outcomes.

The two pairs selected are a minute representation of the possible further applications. In order to ascertain the number of unique sector pairs the following equation is useful:

$$n\,(n\text{-}1) / 2$$

$$= 41\,(41\text{-}1) / 2$$

$$= \mathbf{820}$$

So, 820 comparisons of pairs are possible and this does not include the opportunities presented by comparing triplets or quadruplets. The possibilities for future research, based not only on the number of permutations possible but also the various alternate methods of modelling will be explored further in chapter six when possibilities for future research are described.

4.6 Summary

Chapter four has presented findings divided into those related to the primary, secondary and tertiary analyses as follows:

- **Primary analysis**
    - Cross-sectional data descriptive statistics and correlations
    - Regression with complete 32 personality dimensions
    - Regression with factors
- **Secondary analysis**
    - Panel data descriptive statistics and correlations
    - Panel regression with complete 32 personality dimensions
    - Panel regression with factors
- Primary and secondary analysis summary
- **Tertiary analysis**
    - Bounding the tertiary analysis
    - Dimension analysis: affiliative
    - Dimension analysis: rule following
    - Summary of dimension comparison across sectors
    - Sector comparison: pharmaceuticals and biotechnology versus mining
    - Sector comparison: media and banking
    - Sector comparison summary

Chapter five will consolidate the findings from each of these three analyses and present these back in relation to the research questions proposed at the end of chapter two.

Chapter five: Analysis of the research findings

5.1 Introduction

The next chapter draws together the research findings from chapter four in relation to the specific research questions that the study set out to address. It is divided into three sections addressing two sub-questions in each section. Thus it is ordered by primary analysis, secondary analysis and tertiary analysis.

5.2 Primary analysis

Primary research question: How do innovation inputs and personality dimensions associate with innovation outcomes?

I. *When controlling for GII inputs, how do personality dimensions associate with innovation outcomes?*

The correlations, which partialled out the Global Innovation Index (GII) inputs, suggested significant relationships between numerous personality dimensions and GII outputs at the national level. Certain dimensions consistently had associations across multiple output factors, whereas others did not seem to have any association whatsoever. Useful reference is table 5 for the section that follows. Specific dimensions and their associations will now be discussed with hypotheses on how this relationship may have manifested at the national level.

Affiliative, *behavioural* and *caring* are all significantly correlated with nearly all GII outputs with small to bordering on large effect sizes. When considered together these dimensions suggest most individuals reported to enjoy the company of others; enjoy analysing the motives of others as well prefer to be sympathetic and considerate with a tendency to get involved in other's problems. It could be hypothesised that these types of characteristics drive problem solving as individuals seek

out connection and to ease the strife of others. This desire to understand and help, may facilitate ideation while, in addition, the diffusion of useful ideas through society happens more easily as individuals prefer to remain connected rather than being isolated.

There were noteworthy relationships with GII outputs and personality dimensions, including *achieving* (inverse), *competitive* (inverse), *outgoing* and *outspoken (*inverse*).* This suggests a collection of individuals who are not driven by personal progression and the desire to win. Rather this suggests individuals with inclusive styles that prefer to strive for achievable targets for the collective gain. In line with the findings above, this would also be a collective who would seek out connections with others and be comfortable in groups, preferring to hold back from criticising others. It seems that the suppression of individual gains for the collective, or the good of the 'other' is an immediately emergent theme. Secondarily the characteristics associated with individuals being meaningfully connected are consistently coming to the fore.

Interestingly *data rational* and *forward thinking* were also found to consistently have a significant, inverse association with GII outputs. This at first appears to contradict popular logic that suggests innovativeness requires a penchant for data analysis and a preference for taking a longer term, strategic view. It is important to note that while aspects of this may hold true in the ideation phase at the individual level, this study considers outputs achieved (i.e. successful diffusion) at a national level. An explanation may be that in order to successfully adopt and diffuse, a nation should not be prone to analysis paralysis and should also be readily open to serving shorter term goals, rather than being fixated on longer time horizons.

The final collection to consider is the relationship between *rule following* (inverse), *tough minded* and *trusting* with GII outputs. These dimensions in combination suggest individuals who tend to dislike bureaucracy, are not easily offended and see others as honest. This is interesting, when considered in combination with the GII input *political,* concerned with political stability and safety as well as government effectiveness, which emerges as a consistently strong covariate across all

regression analyses. It could be hypothesised that those nations where bureaucracy is non-restrictive and there is a general atmosphere of greater trust, are more likely to foster innovation.

II. *When fitted into a model, which dimensions or inputs explain the most variance in the innovation output factors?*

When inputted into the regression model, there are certain factors which emerge in line with the findings above, as well as a few new entrants. Tables 6, 7 and 8 can be referenced for detailed results.

Affiliative maintains consistent associations across all Global Innovation Index (GII) outputs while *behavioural* and *caring* emerge as significant only against the sub-indices of *creative outputs and knowledge diffusion*. *Conscientiousness*, which suggests persistence until the job is done, also emerges as a dimension of interest.

Achieving (inverse), *outgoing* and *outspoken* each have associations with one or two of the GII outputs. Interestingly, *competitive* which has an inverse relationship in the correlations with all outputs showed a positive relationship with *knowledge diffusion* and its supra-categories. New factors emerging around this theme include *persuasive* (inverse) and *modest* which suggests individuals less likely to pressure others into changing their views or boast about achievements.

Data rational and *forward thinking* maintain an inverse relationship with continued strong associations across most outputs. *Detail conscious* (inverse) emerges as significant for two of the outputs and its overall index. This reinforces the possible hypothesis that an overall predisposition less preoccupied with detail may be an enabler of innovation. A new, interesting dimension comes to the fore - *conceptual* - which explains variation across all overall innovation outputs, both indices and four sub-indices. This is in line with this theme as it suggests a group of individuals interested in discussing theories and abstract concepts. Perhaps this shows that nations should be

interested in, and connect around, *what* innovation can theoretically achieve even if they are less preoccupied with exactly *how* it is to be achieved.

Tough minded significantly explains variance across four outputs and two indices. *Rule following* (inverse) has maintains a significant association across three factors. Trusting does not enter the model, although it was a noted covariate. These two dimensions along with *data rational* (inverse) and *affiliative* emerge most consistently in the analysis of the cross-sectional data.

5.3 Secondary analysis

Secondary research question: How do innovation inputs and personality dimensions associate with innovation outcomes year on year?

I. *When controlling for GII inputs, how do personality dimensions associate with innovation outcomes in a longitudinal analysis?*

When considering the panel analysis in relation to the cross-sectional analysis, there are two considerations to bear in mind. Firstly, the panel analysis is more precise – particularly in the relations between Global Innovation Index (GII) inputs and outputs, which are more variable year on year than the personality make-up. Secondly, the panel analysis was subject to a slightly smaller sample size as it was more challenging to match data in this manner. Table 12 can be referenced for the section that follows.

Overall, there are still significant associations between numerous personality dimensions and GII outputs. *Affiliative* and *rule following* (inverse) emerge across both the panel and cross-sectional models as explaining significant variance across multiple outputs. There is also some overlap with *achieving* (inverse), *competitive* (inverse), *outspoken* (inverse) and *forward thinking* (inverse).

Factors which emerge more strongly in the panel analysis than the cross-sectional analysis include *conventional* (inverse), *emotionally controlled*, *independent minded*, *relaxed*, *vigorous* and *worrying* (inverse).

Conventional (inverse) and *independent minded* can be related to the findings around a profile averse to bureaucracy. Specifically, this suggests a nation willing to try out new methods and being willing to think for themselves. Adding to this *vigorous*, suggest thriving on activity and being busy.

Emotionally controlled, *relaxed*, and *worrying* (inverse) suggests a new theme emerging around a general national profile which is resilient. This means less likely to have outbursts and less likely to experience both state and trait anxiety. This marries well with the cross sectional analysis that identified *tough minded* as a key dimension.

II. *When fitted into a model, which dimensions or inputs explain the most variance in the innovation output factors in a longitudinal analysis?*

It is important to note that the amount of variance explained does decrease somewhat for the personality factors in the panel analysis in relation to the cross-sectional analysis. Tables 13, 14 and 15 can be referenced for detailed results. This may be, in part, explained by less year on year variance in personality data as well as the smaller sample size.

However, there are still a few noteworthy associations. *Affiliative*, *behavioural*, *data rational* (inverse) and *trusting* emerge once again even if more sparsely. Interestingly in some cases *behavioural* shows an inverse relationship in contradiction to cross-sectional findings. However these effect sizes are small so it may not be worth over-extrapolating.

Controlling (inverse) emerges as having associations across two outputs and two supra-indices. It, interestingly has the strongest effect size for a dimension within the panel regression of β = -.30 with *creative goods*. This suggest there is an association between nations which report to prefer to let others take the lead and dislike telling others what to do with the production of creative goods and services. This begins to demonstrate the nuances in the relationships between the various dimensions and specific outputs.

Achieving mostly maintains a negative relationship although with very small effect sizes. There is one exception which is the β = .18 with *online*. While this is also a small effect size, it is interesting to note as it demonstrates the nuances of the findings. Whereas, over time on a national level *achieving* (inverse) seems to be preferred for an innovative atmosphere, for the creation of online content in the shorter term – wanting personal accolade does have a small part to play. This is similar to the finding for *conscientiousness* which seems useful to drive all innovation output over time but which has β = -.22 for *online*. It could be suggested that the speed of the online mechanism appeals to those who do not tend to persist in tasks preferring to get things done in a more flexible, expedited manner. There is also an association with *democratic* (inverse), β = -.22 & -.23 for cross-sectional and panel respectively, suggesting those less prone to consult with others perhaps prefer to disseminate ideas online. This is the only notable pattern in relation to this dimension. Finally, *optimistic, β* = .17, is inverse in other appearances. In general, the input factors for *online* seemed to be quite different for those associated with all other outputs.

*Innovative (*inverse*)*, makes an appearance in the panel regression and correlation with β = .22 and β= -.25 respectively with *knowledge impact*. Interestingly, it also has significant inverse associations with three outputs in the cross-sectional data – even though not appearing in the regression models. While all effect sizes are modest, it is interesting in that it contradicts popular logic. It suggests that nations with greater innovation output do not necessarily report themselves, as a collective, to be radically original or creative. Perhaps it can be proposed that only a small number of idea generators are required but that widespread diffusion is driven by quite different dimensions. This would be congruent with the diffusion of innovations model (DIM) which suggests the adoption or rejection of an idea in a complex system is driven by many factors

(Rogers, 2004). It is not solely the innovativeness of the idea but also other prior conditions such as norms of the social system (Rogers, 2004). Even with certain preconditions met, there is no guarantee of progressing through the five proposed stages of adoption, as each has its own set of determinants (Rogers, 2004).

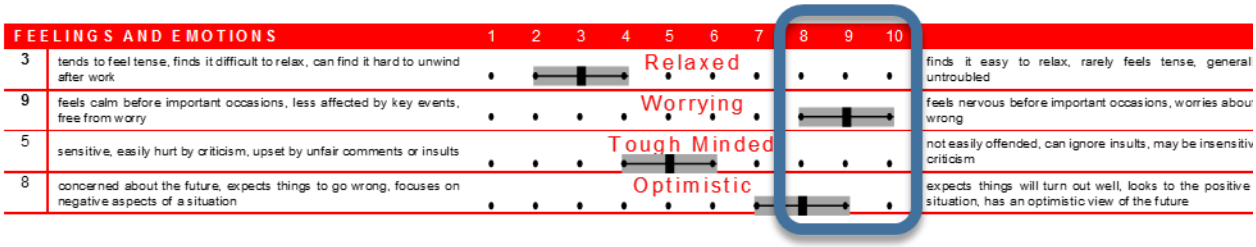
A last interesting dimension to highlight for its highly nuanced associations is *evaluative*:

- Cross sectional correlations: *Creative output*, β = .18 and *intangible assets*, β = .21.
- Cross sectional regression: *7. Creative output* β = -.20
- Cross sectional regression with factors: *Overall outputs*, β = .26; *knowledge impact*, β =.37; *intangibles*, β = .30;
- Panel correlations: *Online*, β = .26
- Panel regressions: *Knowledge and technology*, β = .08; *creative goods*, β = 1.6; *online*, β = .27
- Panel regressions with factors: *knowledge impact*, β = .16; *intangibles*, β = -.18; *creative goods*, β - .14 and *online*, β 0.10.

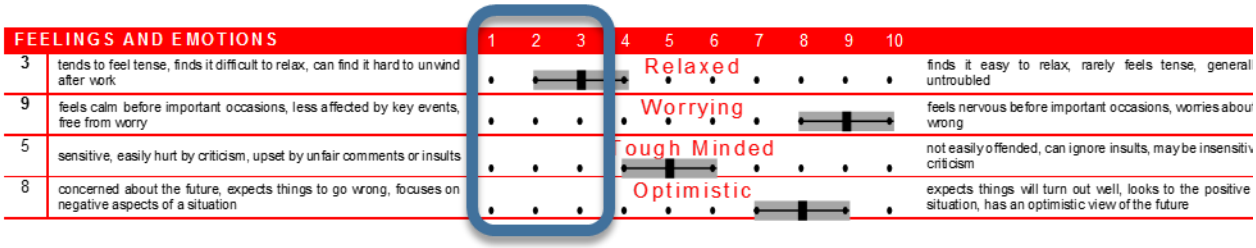
While the effect sizes are small to modest, this is interesting to note as both the strength and direction of association seem to be highly nuanced. This is when compared to a factor such as affiliative which appears to have more stable associations across all analyses.

Further analyses, not presented as part of this study, suggested that certain dimensions behave differently i.e. not in a linear fashion. For example rather than it being desirable to be at one pole or the other, it is desirable simply to be at a pole and not middling or vice versa. This is demonstrated in figure 17. The study presented has only explored the possible relationships depicted in A and B. Those depicted in C and D may go some way in exploring contradictory findings or factors which have not emerged that may on face value seem important. These considerations will inform the suggestions for future research in the concluding chapter.

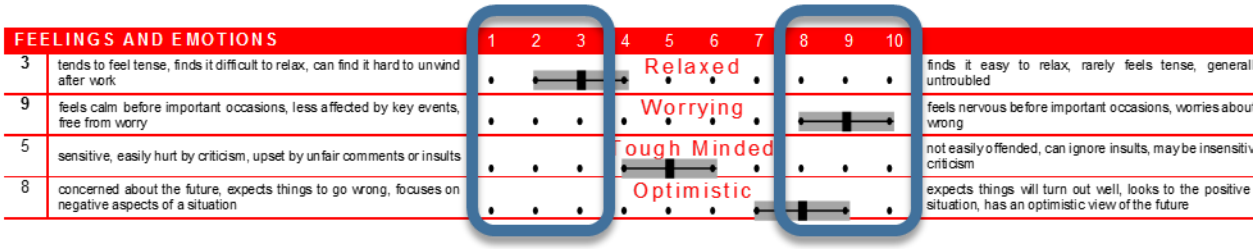
A. Preferred score zone for positive association



B. Preferred score zone for an inverse association



C. Preferred score zone for extremes



D. Preferred score zone for middling

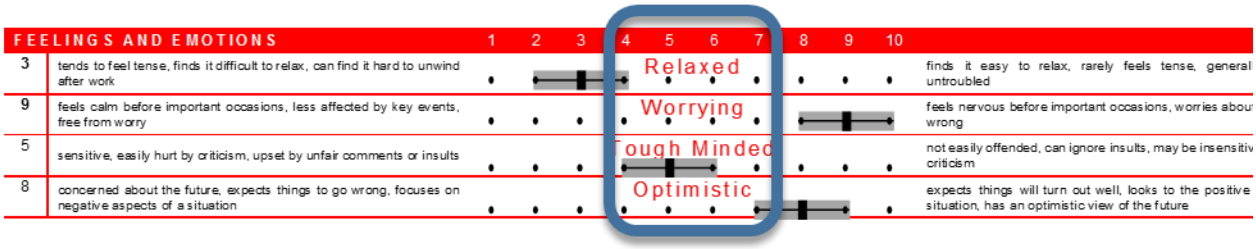


Figure 17. Illustration of possible desirable scoring patterns

5.4 Tertiary analysis

Tertiary: How could the *innovativeness* of sectors be compared?

I. *How do sectors 'stack up' relative to one another when significantly associated personality dimensions are considered?*

The primary and secondary analysis outcomes were summarised in the decision tree depicted in figure 12. This decision tree used the counts of significant findings, both in the cross-sectional and panel analysis, to prioritise the consideration of personality dimensions. Using this decision tree the Occupational Personality Questionnaire (OPQ) dimensions most note-worthy for further exploration were identified to be *affiliative* and *rule following (inverse).* A descriptor of the preferences that would typify an 'ideal profile' associated with higher innovation outcomes in relation to a 'less ideal profile' which would be associated with lower innovation outcomes is summarised in table 19 which follows.

Table 19. Descriptors for affiliative and rule following

	Ideal profile	Less ideal profile
Affiliative	A collection of individuals who report to enjoy others' company. These individuals like to be around people and can miss the company of others.	A collection of individuals who are comfortable spending time away from people. These individuals value time spent alone and seldom miss the company of others.
Rule following	A collection of individuals who report to not be restricted by rules and procedures. These individuals are more prepared to break rules and tend to dislike bureaucracy.	A collection of individuals who report to be most likely to follow rules and regulations. These individuals prefer clear guidelines and find it difficult to break rules

It was hypothesised that a greater preference on the *affiliative* dimension may enable innovation due to the higher degree of interconnectedness of individuals within the sector as well as with their customers. It was suggested that this may enable greater opportunity to gain insight into the *voice of the customer* as well as allow for faster *diffusion*.

It was hypothesised that showing less of a preference for *rule following* may also enable innovation as the individual, or collection of individuals, may be more likely to challenge or disrupt the status quo as they feel less restricted by rules or procedures. When considering the Innovation Pentathlon, this may support in less ideas being rejected in the *prioritisation phase* due to their clashes with current rulesets. This may also speed up *implementations phase* as this would be a collection of individuals more willing to bend rules or flex current processes to bring an idea to fruition.

As a closing exercise, noteworthy results were extracted from the presented stack rank of all 41 sectors, refer to figure 13 and figure 14, in relation to their reported preference for *affiliation* as well as *rule following*. Those sectors displaying the 'ideal' profile for solely these two dimensions associated with higher innovation outputs included:

- **Pharmaceuticals and biotechnology (*n* = 61 930)**
- Beverages (*n* = 51 142)
- **Media (*n* = 111 422)**
- General industrials (*n* = 4 637)
- Leisure goods (*n* = 31 695)

Those sectors that are least likely to benefit from the posited ideal composite profile included:

- **Mining (*n* = 48 303)**
- Industrial metals and mining (*n* = 50 822)
- Oi and gas producers (*n* = 43 717)
- **Banking (*n* = 707 310)**

Those sectors indicated in bold were identified as useful comparison pairs to address the final research question. The entire profiles of each of these four sectors were then extracted, with pairs compared side by side to address the final research question.

II. *How could particular sectors be explored, or compared, in greater depth when linking their personality profiles to innovation outcomes?*

Research to date has struggled to truly describe in a consistent manner the relationship between personality and innovation outcomes at the macro level. The findings in this study suggest that there is a complexity in these relationships that is not well accounted for when simply relying on gross aggregated measures and linear relationships. In order to demonstrate the richness of comparative context that can be gleaned, a nuanced view of 32 dimensions of personality, was compared across two pairs of sectors.

In order to bound the analysis, where the comparison of all 41 sectors across all 32 dimensions can quickly become unmanageable, two considerations were made. The first was which sectors were highlighted from the primary and secondary analyses as having a more or less ideal profile in relation to the key dimensions of *affiliative* and *rule following* identified. The second was to order the review of apparent differences in dimensions in relation to the decision tree, in figure 12, in order to provide greater focus on those dimensions with the strongest demonstrated associations in the cross-sectional, as well as panel analysis, with innovation outcomes.

This study compared the *pharmaceuticals & biotechnology* sector to the *mining* sector (refer to figure 15). In summary, it was hypothesised that the *pharmaceuticals & biotechnology sector* is more astute to hidden needs and also gaining buy by better grasping the drivers behind adoption versus rejection. *Mining* comparatively reported to be less interested in analysing people or better understanding their motives and needs. It was further hypothesised that innovation in *mining* may be constrained by a typical preference for simply accepting majority decisions. This was as

compared to *pharmaceuticals & biotechnology* were individuals reported to be more prepared to think independently and follow their own approaches.

The second comparison presented was between the *media* sector and the *banking* sector (refer to figure 16). It was hypothesised that the *media* sector, relative to *banking*, is more astute to the voice of the customer. Not only due to a reported greater interest in their drivers and motives but also due to higher receptiveness to feedback. It was also hypothesised that the *media* sectors' personality preferences may be more enabling for agile ways of working whereas *banking* reported a preference for established methods. Finally, it was hypothesised that for the *media* sector the reported higher energy levels and enthusiasm for spending time with others may enable faster diffusion. This was compared to *mining* where, relatively speaking, individuals reported less of a preference for connecting with others and an inclination for a steadier pace.

5.5 Summary

Each of the research questions proposed at the end of chapter two have been addressed in this chapter with reference to the detailed findings that are presented in chapter four. Chapter six now follows which summarises the major findings, highlights the relevance to key stakeholders and then finally suggests direction for future research.

Chapter six: Conclusions and recommendations

6.1 Introduction

The findings and analysis which have preceded this concluding chapter have highlighted at several junctures the complexity of the associations between personality and innovation outcomes. In order to bring together the literature as well as key outcomes from this study, reflections are presented in relation to key themes including defining *innovativeness*; *innovativeness* over time; comparing the *innovativeness* of sectors; then finally *innovativeness* in relation to the Big Five. The relevance is then related back to key stakeholders identified in chapter one. In closing, suggestions for future research are advanced.

6.2 Major findings

i. Reflections on defining *innovativeness*

Simply assuming that accepted definitions of *innovativeness* at an individual level will hold at a macro-level of analysis seems to be misguided. Those dimensions which typify highly creative or research driven individuals such as *conceptual* or *data rational* respectively did not consistently associate with innovation output at a national level. Significant associations noted across both latitudinal and longitudinal analyses suggest *affiliative* and *rule following* (inverse) as key covariates to consider. This can be extrapolated to suggest that in a domain - be this a nation or sector - where individuals seek out connection and invest energy to maintain their networks, ideas may be more readily diffused and enable tangible innovation outcomes. Furthermore, it may be postulated that innovation outcomes are further enabled in contexts where individuals feel free to push the boundaries of rules, flex processes and work in more agile ways.

ii. Reflections on *innovativeness* over time

Another aspect of interesting reflection is the differences in the dimensions coming to the fore in the cross-sectional analysis versus the panel analysis. There is a portion of this that could possibly be attributed to the nature of the analysis, specifically the use of averages vs. precision measures, stable vs. more stable constructs, and different sample sizes. Despite this cautionary note, a unique set of dimensions does emerge which associate significantly in a panel view of the data. In some cases, there is overlap, in others new dimensions emerge. Overall, driving innovation output over time, i.e. persistently year on year, seems to be a unique set of dimensions that are not necessarily the same as those that associate with shorter term rises or dips in innovation output.

iii. Reflections on comparing the *innovativeness* of sectors

Both in defining *innovativeness* and considering its impacts over time, it becomes apparent that the relationships under study are highly complex in nature. Therefore, it could be strongly recommended that in order to truly be able to contextualise the *innovativeness* of domain, a complete and nuanced personality profile would be of the greatest utility. In the limited examples, that the bounds of this study could explore, it became apparent that relative rankings assigned were congruent to literature describing certain sectors. A particularly powerful illustration was the comparison of the *media* and *banking* sector which set forth a number of testable hypotheses on the basis of relative differences in profiles on dimensions that have been highlighted to co-vary with innovation outcomes.

iv. Reflections on *innovativeness* in relation to the Big Five

As a brief recap of key findings noted in chapters one and two. The literature most consistently associated *openness to experience* with innovation. *Agreeableness* has also been identified in a number of studies as a covariate, however there is some disagreement in terms of its strength and direction which has been hypothesised to suggest stronger association with diffusion than idea generation. *Conscientiousness* has contradictory findings – most often no or negative associations with innovation. *Extraversion* and *emotional stability* are least reported for their relationship with innovation.

In order to most effectively summarise the findings from this study in relation to the Big Five, a colour coded version of the decision tree is presented in figure 18. The mapping between the OPQ and the Big Five is the most up to date and is based on a 2016 statistical investigation of the overlap between these two models of personality. A summary of this can be found in appendix 6. As an ancillary note, it was found to be a good fit with the original mapping proposed in the technical manual by Bartram et al (2006). Each of the OPQ 32 factors barring one were found to be a good fit within the five factor model, barring the single dimension *adaptable*.

For the two instances where a factor has a relationship with two of the Big Five, the colour code indicates reflects the stronger relationship. All inverse relationships are indicated with an asterisk (*) and all *italicised* dimensions were most consistency inverse associations with innovation outputs, after controlling for innovation inputs. While this illustration goes some way to demonstrate why there have been limited, and at times even contradictory findings to date in relation to the Big Five model – expanded upon in the suggestions for future research – it is not a specific focus of this research.

When considering the Big Five factor *emotional stability* these results seem to corroborate findings to date of limited relationships. In the cross-sectional analysis *tough minded* had some significant relationships but these did not hold in the panel analysis. While *worrying*, *relaxed* and *optimistic* showed some associations in the panel analysis, this did not hold well in the cross sectional analysis.

When considering the Big Five Factor *openness to experience* these results somewhat corroborate findings though suggest the relationship may not be as linear as sometimes posited. For example certain factors such as lower *rule following* and *independent minded* are well aligned with findings to date. Other facets of this Big Five Factor may be hold less association such as *variety seeking*.

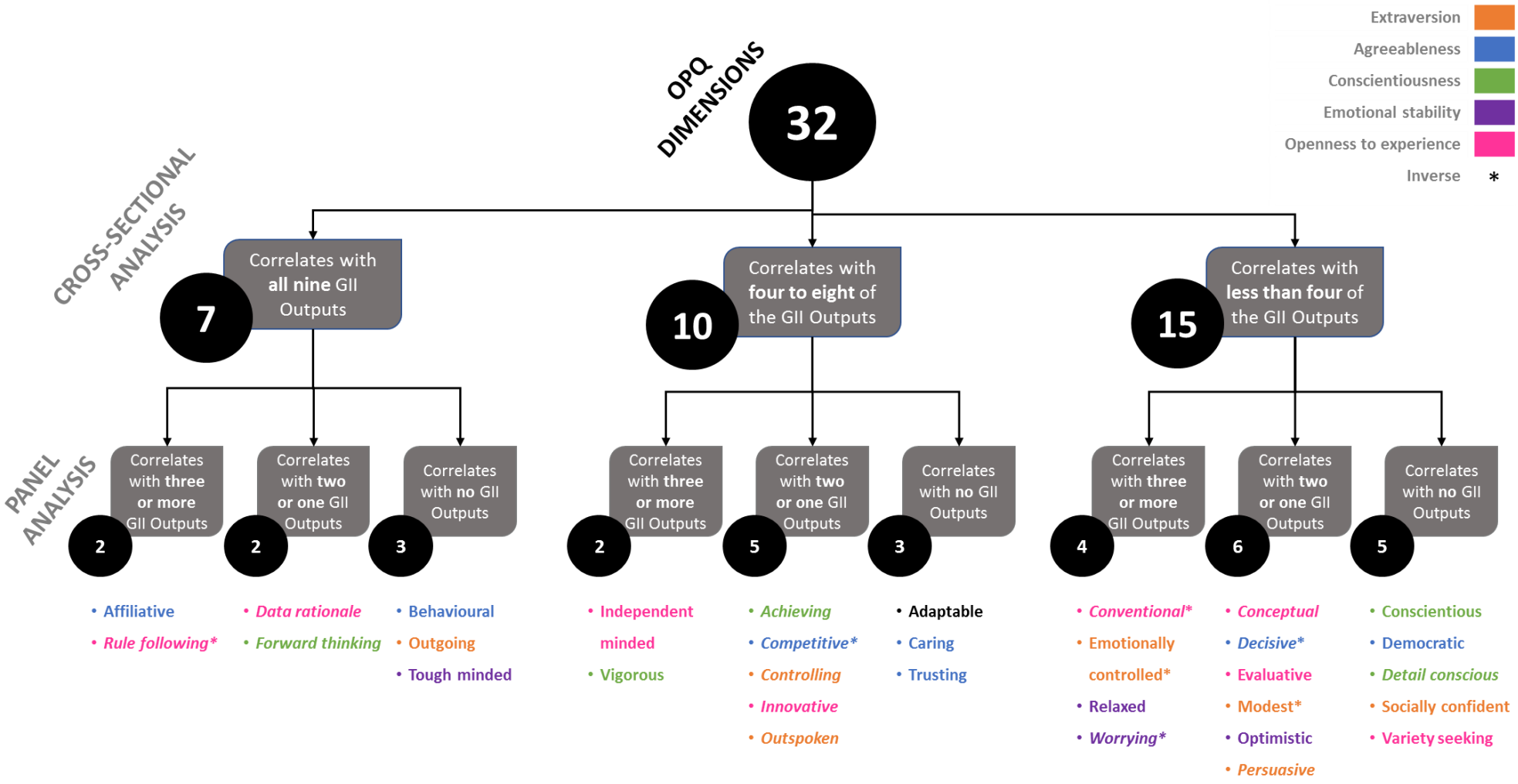


Figure 18. Primary and secondary results coded to the Five Factor mode

6.3 Relevance and Recommendations

i. Implications for academia

In order to more accurately define *innovativeness* there are a number of recommendations that emanate from these findings which would be relevant in deepening the current understanding of this construct.

- That which is *innovativeness* at the individual level may not be that which is *innovativeness* at the national or sectoral level.
- That which is *innovativeness* in the short term my not be that which is *innovativeness* in the longer term.
- That which is *innovativeness* in one domain may not be that which is *innovativeness* in another domain.

In summary, *innovativeness* is not a singular concept but rather a unique combination of many dimensions which are may be enabling or constraining depending domain, time horizon as well as level of analysis.

ii. Implications for leaders of nations and policy makers

The influence of the so-called cultural element is one which remains a research-practice gap for policy makers looking to drive innovation outcomes at a national level (Anderson et al, 2014). Indicators, such as the Global Innovation Index (GII), are able to tangibly measure innovation inputs such as institutions; human capital and research; infrastructure[11]; market sophistication and business sophistication. However these do little to create comparable platforms for better understanding some of the softer measures.

[11] Note that this input pillar consists of Education, Tertiary education and Research and development (R&D) subcomponents.

In this study, 57% of the total variability in innovation outputs was accounted for by input factors (both from the GII and the OPQ) in the cross-sectional and panel regressions. For each of the respective pillars being *knowledge and technology outputs* (75% for cross-sectional and 55% for panel) and *creative outputs* (70% for cross sectional and 50% for panel) the results were striking. For both the cross-sectional and panel regressions, multiple personality dimensions emerged as significant, contributing at times comparable or higher degrees of explanation for the variability in innovation outputs than innovation inputs. This is further ratified in the correlations, where innovation inputs were partialled out and yet a range of noteworthy correlations between overall outputs, pillars as well as specific outputs were noted.

In summary, while the focus on collating tangible measure at the national level has progressed significantly, there are still softer measures, which appear to relate in a noteworthy manner to innovation outcomes that may remain hidden to policy makers. A better understanding of the 'profile' of the national collective of *intrapreneurs* and *entrepreneurs* may go some way in understanding if an enabling or disabling culture for innovation seems pervasive.

iii. Implications for leaders of industry and organisational practitioners

Current organisational practices often devote significant time and effort to 'selecting in' for *innovativeness*. Particularly when organisational strategies are underpinned by innovation and current incumbents are not perceived embrace this agenda. The results of this study challenge these practices on three fronts. Firstly, the actual dimensions or facets of *innovativeness* may not be well understood, secondly focusing only on research and development (R&D) or leadership roles may be somewhat short-sighted and then finally the applications beyond recruitment may be underleveraged.

Firstly, current organisational practices claim to be able to identify 'out of the box' thinkers who are heralded as saviours to drive organisational innovation. While this study certainly does not suggest that these selecting these individuals is unimportant, it does suggest that there may be an overemphasis on selecting in for 'creativity' so specifically. The range of characteristics that are

truly needed to achieve broad based innovation outcomes are perhaps considerably wider and more complexly intertwined than commonly thought. Furthermore, depending on the type of innovation outcome an organisation is trying to drive (e.g. *online creativity* versus *knowledge diffusion*) the set of dimensions may vary. The period over which these achievements must be sustained should also be clear in order to truly identify the dimensions of *innovativeness*. Ultimately, more precisely defining the type of innovation output required as well at the time horizons for attainment may go a long way in progressing from a generic mould versus a tailored ideal profile.

Secondly, the results of the study suggest that when trying to drive innovation outcomes at scale, a very precise balance of dimensions seem to be of relevance for a large number of individuals. So, if an organisation's objective is to drive systemic innovation, the key it is not just the small number of individuals in research and development (R&D) departments or isolated think-tanks. It is also not just as simple as selecting a leadership team that is 'open to new ideas'. In order to truly achieve tangible innovation outcomes, at scale, there is a much larger number of people who need to work together and who, when possessing certain characteristics, seem to enable innovation output. Thus, there is a strong challenge against a narrow focus on specific roles.

Finally, it was noted in chapter one that the current application of this study and similar studies tend to be isolated to selection practices at the individual level. There are occasionally instances of profiles being leveraged for audit or development purposes; and there are also, even if less commonly, examples at the group level. There is unrealised potential in specifically focusing on dimensions of personality, which are known to drive certain innovation outcome at scale including *knowledge creation*, *knowledge impact*; *knowledge diffusion*; *intangible assets*; *creative goods and services* as well as *online creativity*. If an organisation has a clear strategic imperative to drive certain innovation outcomes then it would be invaluable to be able to gain an understanding of the profile of its teams, departments, its entire organisation or its domain. In this way ideal or less ideal sets of typical ways of thinking, feeling and behaving can be understood. Not only may this be able to better inform selection process, but it may go some way in better understanding internal and contextual barriers to idea generation, idea prioritisation and idea implementation.

6.4 Suggestions for Future Research

i. Further exploring non-linear relationships

This study begins to illustrate the degree of nuance in the relationships between personality dimensions and innovation outcomes, when controlling for other innovation inputs. While certain dimensions were demonstrated to co-vary across a number of outputs, others fell by the wayside in the focus of this study as there were few weak, or no demonstrated significant associations. That should not automatically lead to these dimensions being discredited as possible co-variates. It may be possible that the relationships between these dimensions and innovation outcomes are simply not linear. In preliminary analysis, not presented in this study, a few dimensions became significant when it was dictated in the statistical analysis for the dimensions to be ideal when either extreme in nature (regardless of pole) or middling in nature. This type of relationship would be interesting to explore further as it may suggest that for certain dimensions of personality, a u-shaped relationship may hold as illustrated in figure 19.

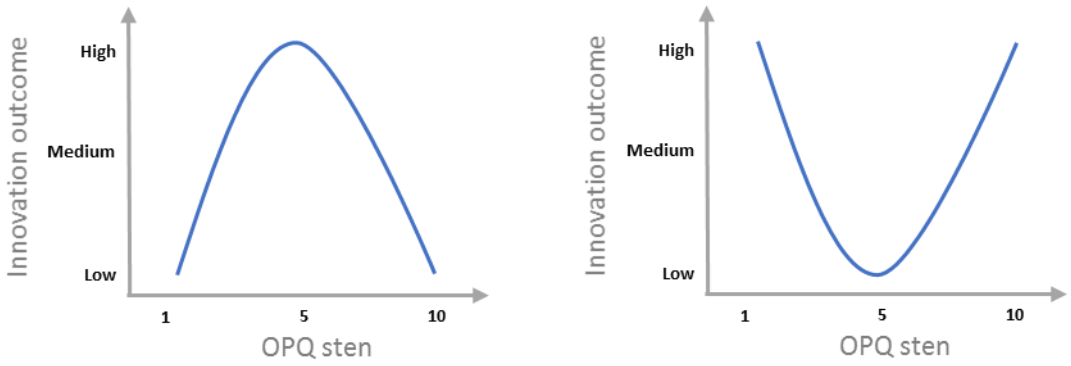


Figure 19. U-shaped relationships illustrated

ii. Further evaluations of the coherence with Big Five findings

Earlier in this chapter, a brief overview of current findings in relation to the Big Five Factor Model at the macro level were provided. An illustration was provided for reference of the relationship between this dominant model of personality and the 32 OPQ dimension model. The implications are briefly discussed but a more in depth review of all findings relating personality to innovation outcomes at the macro level would be useful in progressing the current body of research more coherently.

iii. Further industry analysis and modelling

As noted in the tertiary analysis, the results presented in this study represent only a small fraction of the possible comparisons possible. With the current dataset the following additional possibilities exist:

- Comparisons of all sectors on each of the 32 dimensions (only two presented in this study)
- Comparisons of all 820 possible sector pairs (only two presented in this study)
- Comparisons of sector triplets or quadruplets

It could also be further investigated if innovation output measures for industries or sectors (an equivalent of a GII type database) are available. If so, then the modelling completed in the primary and secondary analyses could be replicated for industries or sectors.

iv. Country clustering

It could be further investigated if countries could be divided into meaningful clusters to compare country groupings rather than individual nations. These may be regional blocs or clusters based on their innovation status i.e. ‘leading’; demonstrating strong efforts at ‘catching up’ versus those that are seen as ‘lagging’.

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Appendix 1: Measures of the GII

The following table provides a complete breakdown of the measures used in the GII.

	Sub-indices	Input measures
1 Institutions	1.1 Political environment	1.1.1 Political stability and safety* 1.1.2 Government effectiveness*
	1.2 Regulatory environment	1.2.1 Regulatory quality*[a] 1.2.2 Rule of law*[a] 1.2.3 Cost of redundancy dismissal, salary weeks[b]
	1.3 Business environment	1.3.1 Ease of starting a business* 1.3.2 Ease of resolving insolvency* 1.3.3 Ease of paying taxes*
2 Human capital and research	2.1 Education	2.1.1 Expenditure on education, % GDP 2.1.2 Govt expend. on edu./pupil, secondary[1] 2.1.3 School life expectancy, years 2.1.4 PISA scales in reading, maths & science[a] 2.1.5 Pupil-teacher ratio, secondary[a,b]
	2.2 Tertiary education	2.2.1 Tertiary enrolment, % gross[a] 2.2.2 Graduates in science & engineering, % 2.2.3 Tertiary inbound mobility, %[a]
	2.3 Research and development (R&D)	2.3.1 Researchers, FTE/mn pop 2.3.2 Gross expenditure on R&D, % GDP 2.3.3 Global R&D firms, avg. exp. top 3, mn $US 2.3.4 QS university ranking, average score top 3*

3 Infrastructure	3.1 Information and communication technologies (ICTs)	3.1.1 ICT access* 3.1.2 ICT use* 3.1.3 Governments online service* 3.1.4 E-participation*
	3.2 General infrastructure	3.2.1 Electricity output, kWh/cap[a] 3.2.2 Logistics performance*[a] 3.2.3 Gross capital formation, % GDP
	3.3 Ecological sustainability	3.3.1 GDP/unit of energy use, 2010 PPP$/kg oil eq 3.3.2 Environmental performance* 3.3.3 ISO 14001 environ. certificates/bn PPP$ GDP[a]
4 Market sophistication	4.1 Credit	4.1.1 Ease of getting credit* 4.1.2 Domestic credit to private sector, % GDP 4.1.3 Microfinance gross loans, % GDP
	4.2 Investment	4.2.1 Ease of protecting minority investors* 4.2.2 Market capitalization, % GDP[a] 4.2.3 Venture capital deals/bn PPP$ GDP[a]
	4.3 Trade, competition, and market scale	4.3.1 Applied tariff rate, weighted mean, %[a,b] 4.3.2 Intensity of local competition[†] 4.3.3 Domestic market scale, bn PPP$
5 Business sophistication	5.1 Knowledge workers	5.1.1 Knowledge-intensive employment, % 5.1.2 Firms offering formal training, % firms 5.1.3 GERD performed by business, % GDP[a] 5.1.4 GERD financed by business, %[a] 5.1.5 Females emp. w/adv. degrees, % tot. emp.[a]
	5.2 Innovation linkages	5.2.1 University/industry research collaboration†[a] 5.2.2 State of cluster development† 5.2.3 GERD financed by abroad, % 5.2.4 JV-strategic alliance deals/bn PPP$ GDP[a] 5.2.5 Patent families filed in 2+ offices/bn PPP$ GDP[a]

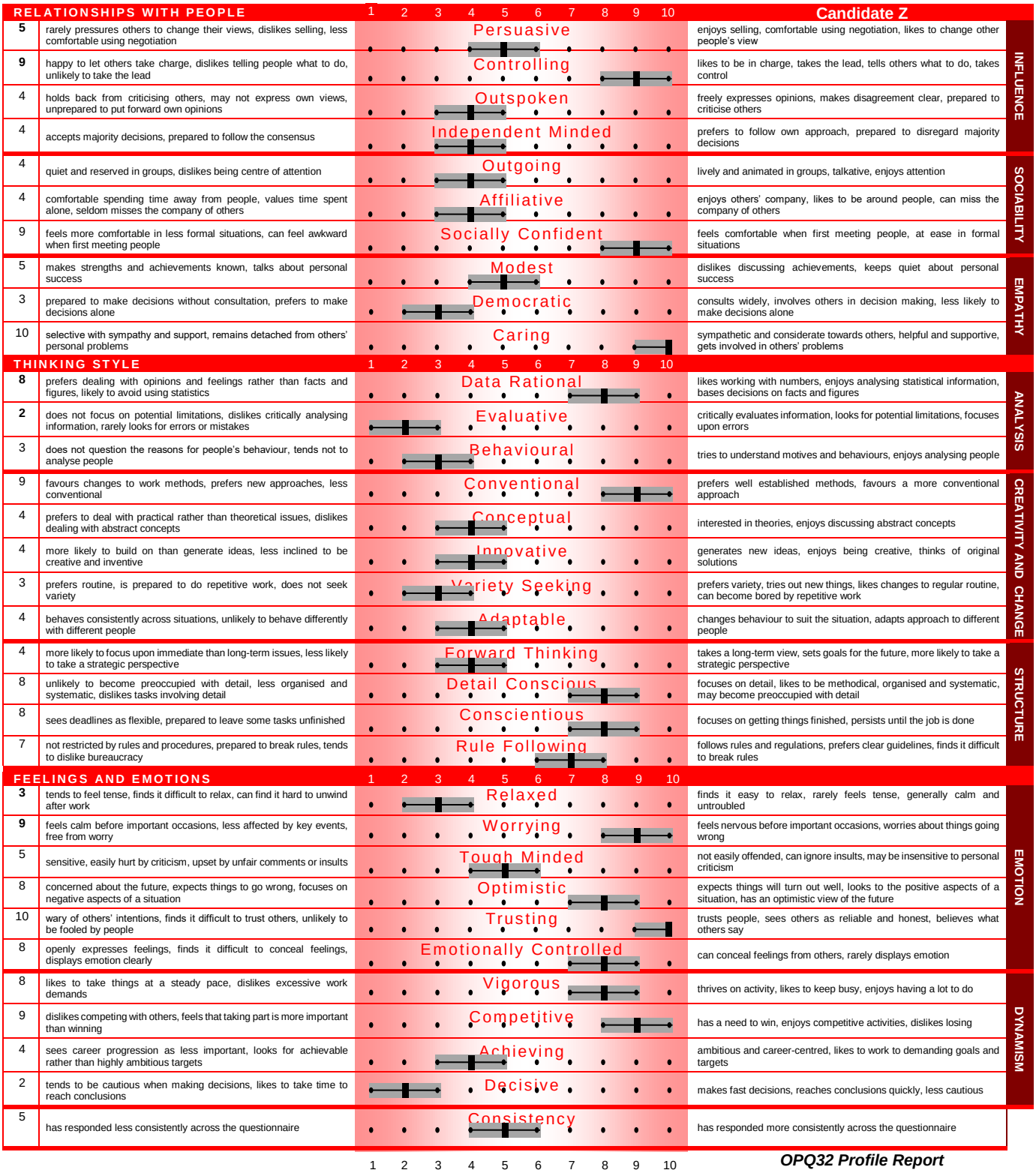
	5.3 Knowledge absorption	5.3.1 Intellectual property payments, % total trade[a] 5.3.2 High-tech imports less re-imports, % total trade 5.3.3 ICT services imports, % total trade 5.3.4 FDI net inflows, % GDP 5.3.5 Research talent, % in business enterprise
6 Knowledge and technology outputs	6.1 Knowledge creation	6.1.1 Patents by origin/bn PPP$ GDP[a] 6.1.2 PCT patent applications/bn PPP$ GDP[a] 6.1.3 Utility models by origin/bn PPP$ GDP 6.1.4 Scientific & technical articles/bn PPP$ GDP[a] 6.1.5 Citable documents H index*[a]
	6.2 Knowledge impact	6.2.1 Growth rate of PPP$ GDP/worker, % 6.2.2 New businesses/th pop. 15–64[a] 6.2.3 Computer software spending, % GDP[a] 6.2.4 ISO 9001 quality certificates/bn PPP$ GDP[a] 6.2.5 High- & medium-high-tech manufactures, %[a]
	6.3 Knowledge diffusion	6.3.1 Intellectual property receipts, % total trade[a] 6.3.2 High-tech exports less re-exports, % total trade[a] 6.3.3 ICT services exports, % total trade[a] 6.3.4 FDI net outflows, % GDP
7 Creative outputs	7.1 Intangible assets	7.1.1 Trademarks by origin/bn PPP$ GDP 7.1.2 Industrial designs by origin/bn PPP$ GDP[a] 7.1.3 ICTs & business model creation† 7.1.4 ICTs & organizational model creation†
	7.2 Creative goods and services	7.2.1 Cultural & creative services exp., % total trade[a] 7.2.2 National feature films/mn pop. 15–69[a] 7.2.3 Global ent. & media market/th pop. 15–69[a] 7.2.4 Printing & publishing manufactures, % 7.2.5 Creative goods exports, % total trade

	7.3 Online creativity	7.3.1 Generic TLDs/th pop. 15–69 7.3.2 Country-code TLDs/th pop. 15–69 7.3.3 Wikipedia yearly edits/mn pop. 15–69 7.3.4 Video uploads on YouTube/pop. 15–69

Notes. (*) index, (†) survey question, (a) half weight, (b) higher values indicate worse outcomes.

Source: Global Innovation Index Report 2016 (9th Edition) (Cornell INSEAD WIPO, 2016)

Appendix 2: The 32 Scales of the OPQ



Source: OPQ 32 technical manual (CEB, 2016)

Appendix 3: Research agreement

CEB
WHAT THE BEST COMPANIES DO

SHL Group Limited
The Pavilion
1 Atwell Place
Thames Ditton
Surrey, KT7 0NE
United Kingdom
Tel: +44-(0)-208-335-8000
Fax: +44-(0)-208-335-7000

9 November 2017

Lauren Huntington

15 Villa Roseto, Katumba Road
Sunninghill, Johannesburg
Gauteng
South Africa

Dear Lauren:

Research Agreement ("Agreement")

The purpose of this Agreement is to allow SHL Group Limited ("SHL"), a wholly-owned subsidiary of CEB Inc. ("CEB") or CEB affiliates, to discuss with you the possibility of supporting you or providing you with materials to carry out a "**Research Project**" as further defined in Schedule A, and to disclose Confidential Information to you.

1. DEFINITIONS

In this Agreement, unless the context otherwise requires:

"**Confidential Information**" means any and all information in whatever form disclosed by one party to the other whether provided orally, in writing or in any other manner, which is designated in writing as being confidential or which by its nature is intended to be confidential including, but not limited to, the terms and conditions of this Agreement, the existence and content of the discussions between the parties, trade secrets, any information relating to a Disclosing Party's plans, designs, ideas, concepts, costs, prices, finances, marketing plans, business opportunities, customers, clients, personnel, products (including software and hardware products), research, development, know-how, any agreement or commercial negotiations concerning the Disclosing Party's products and any other technical or business information of the Disclosing Party but excluding the Excluded Information;

"**Disclosing Party**" means the party disclosing Confidential Information;

"**Receiving Party**" means the party receiving the Confidential Information.

2. <u>The Research Project</u>

In collaboration on the Research Project SHL shall provide you with access to Confidential Information, and as further set out in Schedule A ("SHL Materials"). You shall use SHL Materials only to collect data in relation to the Research Project and for the purposes of completing the Research Project. As the case may be, SHL will retrieve and own all data collected in relation to the Research Project using SHL Materials and give a copy of such data to you, and/or you will retrieve and send to SHL a copy of all data collected in relation to the Research Project using SHL Materials or any other materials as soon as reasonably practicable upon completion of the data collection.

In return for authorising you to use SHL Materials for the Research Project, you shall (i) authorise SHL to keep a copy of all data collected (regardless of source) in relation to the Research Project for SHL's own purposes; (ii) appropriately cite SHL Materials and/or SHL in your research findings; (iii) send SHL a report that outlines the research findings before it is published to allow SHL to review the papers for inaccurate insertions, incorrect conclusions, misleading statements or other errors. You agree that prior to publishing such a report, all the aforementioned will be either corrected at SHL's direction, or qualified in a manner acceptable to SHL.

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SHL further undertakes not to publish the data collected in relation to the Research Project using materials other than SHL Materials or any research findings using such data without your prior consent and only to use such data for SHL own internal researches.

3. Disclosure and Use

3.1. You shall, at all times, treat all SHL Materials disclosed to you as secret and confidential.

3.2. You shall not reproduce, or use any SHL Materials in any other way other than for the purposes of the proper performance of this Agreement or with our prior written consent.

3.3. You shall not disclose any SHL Materials to any other party without our prior written consent. Where such consent is given, you shall ensure that the third-party Receiving Party is subject to a confidentiality agreement in the form of that set out in Schedule B and you agree to provide SHL with a copy of the signed and executed Confidentiality Agreement so that SHL may countersign.

4. Exceptions

The restrictions on use and disclosure set out above shall not apply to any SHL Materials which:-

4.1. are disclosed to you, without any obligation of confidence, after the date of this Agreement by a third party who has not derived it directly or indirectly from us;

4.2. are in or come into the public domain other than as a result of a breach of this Agreement;

4.3. you disclose pursuant to a legal obligation, providing you first consult with us as to the nature of this obligation and the SHL Materials which you believe must be disclosed pursuant to it so that an appropriate course of action may be agreed; or

4.4. you can prove, by documentary evidence produced to us within 28 days of the date of disclosure of SHL Materials to you, is or was already in your possession and at your free disposal before such disclosure.

5. Legal Compulsion to Disclose

In the event that the Receiving Party, its officers, employees, agents or advisers or anyone to whom that party transmits any Confidential Information becomes (or it is reasonably likely that it or they shall become) compelled to disclose any Confidential Information disclosed by the Disclosing Party by reason of law or government direction or request, prompt notice of such fact shall be given to the Disclosing Party at the above address so that the Disclosing Party may seek an appropriate remedy to prevent such disclosure or waive compliance with the provisions of this agreement preventing such disclosure and the Receiving Party will comply with the reasonable directions of the Disclosing Party regarding the manner, timing and content of such disclosure and will fully cooperate with the Disclosing Party in the event that the Disclosing Party elects to challenge the validity of such requirement.

6. Confidentiality Measures

In order to ensure the secrecy and confidentiality of SHL Materials, you agree:-

6.1. to keep separate all SHL Materials (and any copies thereof) and all information which you will generate based thereon, from all other documents and records held by you;

6.2. not to use, produce, transform or store any of SHL Materials in any externally accessible computer or electronic information retrieval system or transmit it in any form or by any means whatsoever outside your usual place of business unless strictly necessary for the purpose of this Agreement in which case you will use your best endeavours to maintain the secrecy and confidentiality of SHL Materials; and

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6.3. to notify us promptly of the date of, and the circumstances involved in, the loss of or unauthorised disclosure, if any, of any documents, data, drawings, descriptions, writings or information comprised in, containing or relating to SHL Materials; and

6.4 to refrain from reverse engineering, decompiling or disassembling any software code and/or pre-release hardware devices disclosed by Disclosing Party to Receiving Party under the terms of this Agreement, except as expressly permitted by applicable law; and

6.5 to make copies of the Confidential Information only to the extent that it is strictly necessary.

7. Intellectual Property Rights

7.1. You acknowledge that all intellectual property and other property rights existing and created during the course of the Research Project, in all SHL Materials, including but not limited to copyright, trademarks, service marks, design right, software and patents are and remain or shall become our sole ownership and *that no rights of such nature are granted to you under this Agreement.*

7.2. We hereby grant you a non-exclusive, non-transferable, revocable licence to use the SHL Materials for your non-commercial personal research purposes only. Such licence shall automatically terminate on expiry or termination of this Agreement unless otherwise agreed by SHL.

7.3. You agree not to cause or permit anything that may damage our intellectual property rights in the SHL Materials and to provide due accreditation and acknowledgement where SHL Materials have been used in your work.

8. Term and Termination

8.1. This Agreement shall commence on the date we receive your signed acceptance and shall continue until the earliest occurrence of any of the following events: (i) either party decides not to proceed with the Research Project, (ii) pursuant to clause 8.2 below, or (iii) the completion of the Research Project.

8.2. Without prejudice to any rights or remedies available to us, we may immediately terminate this Agreement by notice in writing to you if you commit a material breach of this Agreement, which breach is not capable of remedy or if remediable, has not been remedied within 30 days of being required to do so in writing.

8.3. Upon termination or expiry of this Agreement, you will return to us promptly all SHL Materials and all documents containing SHL Materials together with any copies (whether in electronic or other formats) of the same unless otherwise agreed in writing by SHL.

8.4. Any provision which expressly or by implication is intended to come into or remain in force on or after termination shall continue in full force and effect.

9. Indemnity

9.1. You shall keep us fully indemnified against all costs, claims, actions, expenses, losses or liabilities (including without limitation, economic loss, and loss of profit (direct or indirect), indirect or consequential loss) resulting directly or indirectly from your failure to comply with this Agreement.

9.2. Each party excludes all liability to the other party (except in respect of death or personal injury due to that party's negligence or in respect of any fraudulent misrepresentation) for any loss or damage (whether arising under contract, in tort or otherwise) suffered or incurred by the other party as a result of the supply to that party or the use by that party of the Confidential Information, in particular as a result of any errors or inaccuracies in the Confidential Information whether such losses arise directly or indirectly. In respect of all such computer software and/or hardware forming part of the Confidential Information, such material is provided "AS IS" without warranty of any kind, and the Receiving Party agrees that neither the Disclosing Party nor its suppliers shall be liable for any damages whatsoever arising from or relating to Receiving Party's use or inability to use such software and/or hardware.

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9.3. Each party agrees to comply with all applicable international and national laws that apply to any Confidential Information (including any applicable data protection regulations).

9.4. Notwithstanding and without prejudice to the other terms of this Agreement, you hereby consent and agree that any breach of the terms of this Agreement could cause irreparable damage to SHL and in addition to all other remedies SHL shall be entitled to seek injunctive or other interim or equitable relief, including damages (or their equivalent in any jurisdiction), which may be appropriate in the event of any breach or anticipatory breach by you of the terms of this Agreement. Nothing contained in this Agreement shall be construed as prohibiting SHL from pursuing any other remedies available to it either at law or in equity for such breach or anticipatory breach including specific performance and recovery of damages. If you are in breach of this Agreement, you shall be liable to pay SHL's reasonable legal fees in enforcing its rights arising out of or relating to this Agreement.

10. General

10.1. Any notice given under this Agreement shall be in writing and delivered by registered post, fax or email to the address of the party indicated in this Agreement or such other address as notified to the other party from time to time and in the case of notices sent by fax or email, a confirmation copy shall be sent by registered post as set out in this paragraph.

10.2. Nothing in this Agreement shall be regarded as creating a partnership or a relationship of employer and employee, or principal and agent between the parties.

10.3. This Agreement complemented by any specific non-disclosure agreement entered into between the parties, constitutes the entire agreement and understanding between the parties with respect to its subject matter and supersedes any prior agreement, understanding or arrangement between the parties, whether oral or in writing.

10.4. No variation of this Agreement shall bind any party unless made in writing and signed by all parties hereto.

10.5. The invalidity or unenforceability of any term or any right arising pursuant to this Agreement shall not adversely affect the validity or enforceability of the remaining terms and rights.

10.6. You may sub-contract performance of the services (or part thereof) to any person only with the prior written consent of SHL provided that you shall remain responsible to us for the performance of such services in accordance with the terms of this Agreement.

10.7. This Agreement shall not be assigned by you without our prior written consent. For the purposes of the Contracts (Rights of Third Parties) Act 1999, the provisions of this Agreement is not intended to, and does not, give any person who is not a party to it any right to enforce any of its provisions.

10.8. Any waiver of any breach of this Agreement shall be in writing. The waiver by either party of any breach of this Agreement shall not prevent the subsequent enforcement of that provision and shall not be deemed to be a waiver of any subsequent breach of that or any other provision.

10.9. This Agreement and any dispute or claim arising out of or in connection with it will be governed by and construed in accordance with the laws of England. All disputes or claims arising out of or relating to this Agreement shall be subject to the exclusive jurisdiction of the English Courts to which both parties irrevocably submit.

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I should be grateful if you would sign the enclosed duplicate letter and return it to me to confirm your acceptance of the terms and conditions set out above.

Yours sincerely

Paul DeKoekkoek

for and on behalf of SHL Group Limited

I hereby confirm my acceptance of the terms and conditions set out above.

Lauren Huntington

Managing Consultant, CEB

Dated: 9 November 2017

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Schedule A

1. **Purpose of Research Project ("Research Project")**

In an increasingly complex and competitive world, innovation is a key differentiator. While innovativeness, in either a nation or an industry, has been identified as a relevant precondition for idea generation as well as ultimate commercialisation; the quantification of this variable has proven to be a more complex endeavour.

The availability of large psychological datasets, specifically the global OPQ dataset, provides researchers with a major opportunity to empirically test the relationship of the macro-psychological make-up of geographies or industries - loosely termed innovation DNA in this study - against their achieved outcomes.

The purpose of the proposed study is twofold – to both create a cohesive narrative describing current patterns across nations and industries in innovation DNA as well as to empirically test its correlation with innovation outcomes.

2. **SHL Research Materials**

The OPQr 2009-2015 dataset will be used. There are a maximum of 3 360 295 datapoints across 230 countries. In order for a particular country or industry analysis to be considered viable it will need to meet all of the minimum criteria of a sample size greater than 100. When this minimum filter is applied this reduces the dataset to be used to 3 342 347 relating to 136 countries.

Kristin Allen, Senior Research Scientist, has been assigned to assist with ensuring the integrity and protection of this data.

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Schedule B

Non-Disclosure Agreement

THIS Non-Disclosure Agreement is entered as of the 01 April 2017 (**"Effective Date"**), by and between Lauren Huntington of 15 Villa Roseto, Katumba Road, Sunninghill, Johannesburg, South Africa and SHL Group Limited, a subsidiary of CEB Inc. (CEB), with registered offices at The Pavilion, 1 Atwell Place, Thames Ditton, Surrey KT7 0NE (**"SHL"**).

1. DEFINITIONS

1.1 In this Agreement, unless the context otherwise requires:

"Confidential Information" means any and all information in whatever form disclosed by one party to the other whether provided orally, in writing or in any other manner, which is designated in writing as being confidential or which by its nature is intended to be confidential including, but not limited to, the terms and conditions of this Agreement, the existence and content of the discussions between the parties, trade secrets, any information relating to a Disclosing Party's plans, designs, ideas, concepts, costs, prices, finances, marketing plans, business opportunities, customers, clients, personnel, products (including software and hardware products), research, development, know-how, any agreement or commercial negotiations concerning the Disclosing Party's products and any other technical or business information of the Disclosing Party but excluding the Excluded Information;

"Disclosing Party" means the party disclosing Confidential Information;

"Excluded Information" means any Confidential Information which:

1.1.1 is in or comes into the public domain other than as a result of a breach of this Agreement or any undertaking given the Disclosing Party;

1.1.2 is disclosed to the Receiving Party, without any obligation of confidence, after the date of this Agreement by a third party who has not derived the Information directly or indirectly from the Disclosing Party;

1.1.3 is independently developed by the Receiving Party without the use of any Confidential Information of the Disclosing Party as evidenced by written documentation;

1.1.4 the Receiving Party can prove, by documentary evidence produced to the Disclosing Party within 28 days of the date of disclosure of the Information, was already in its possession and at its free disposal before such disclosure provided that the source of such information is not subject to any agreement or other duties relating to confidentiality in respect thereof; or

1.1.5 the Receiving Party is required to disclose pursuant to a legal obligation, providing the Receiving Party first consults with the Disclosing Party to agree an appropriate course of action.

"Purpose" means for evaluating the possibility of creating a business relationship between the parties and/or subsequently entering in to such a business relationship; and

"Receiving Party" means the party receiving the Confidential Information.

2. DISCLOSURE AND USE

2.1 Each party shall keep strictly private and confidential in accordance with this Agreement:

2.1.1 the Purpose and the existence of discussions or negotiations taking place between the parties; and

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2.1.2 all Confidential Information and not to disclose it to any other person whatsoever except those who are a party's representatives or advisers and who need to know such information for the Purpose.

2.2 Each party agrees to use the Confidential Information only for the Purpose and for no other purpose. Each party agrees not to make any use of any Confidential Information disclosed by the other party with a view to its commercial exploitation either by itself or in conjunction with any other person or entity of whatsoever nature.

3. CONFIDENTIALITY MEASURES

3.1 To secure the confidentiality attaching to the Confidential Information, the Receiving Party shall:

3.1.1 refrain from disclosing any Confidential Information of the Disclosing Party to third parties for *five (5) years following the date that Disclosing Party first discloses such Confidential Information to Receiving* Party except as expressly permitted in this Agreement;

3.1.2 apply to the Confidential Information no lesser security measures and degree of care than those which the Receiving Party applies to its own Confidential Information and which the Receiving Party warrants as providing adequate protection from unauthorised disclosure, copying or use;

3.1.3 refrain from disclosing, reproducing, summarizing and/or distributing Confidential Information of the Disclosing Party except in pursuance of Receiving Party's business relationship with Disclosing Party, and only as otherwise provided hereunder;

3.1.4 refrain from reverse engineering, decompiling or disassembling any software code and/or pre-release hardware devices disclosed by Disclosing Party to Receiving Party under the terms of this Agreement, except as expressly permitted by applicable law;

3.1.5 allow access to the Confidential Information exclusively to those of its employees who have a need to see and use it for the Purpose and inform each of the said employees of the confidential nature of the Confidential Information and of the obligations on that party in respect thereof and shall take such steps as may be reasonably desirable to enforce such obligations;

3.1.6 make copies of the Confidential Information only to the extent that it is strictly necessary;

3.1.7 notify the Disclosing Party immediately upon discovery of any unauthorized use or disclosure of Confidential Information or any other breach of this Agreement by Receiving Party and its employees and consultants, and will cooperate with Disclosing Party in every reasonable way to help Disclosing Party regain possession of the Confidential Information and prevent its further unauthorized use or disclosure.

4. LEGAL COMPULSION TO DISCLOSE

4.1 In the event that the Receiving Party, its officers, employees, agents or advisers or anyone to whom that party transmits any Confidential Information becomes (or it is reasonably likely that it or they shall become) compelled to disclose any Confidential Information disclosed by the Disclosing Party by reason of law or government direction or request, prompt notice of such fact shall be given to the Disclosing Party at the above address so that the Disclosing Party may seek an appropriate remedy to prevent such disclosure or waive compliance with the provisions of this agreement preventing such disclosure and the Receiving Party will comply with the reasonable directions of the Disclosing Party regarding the manner, timing and content of such disclosure and will fully cooperate with the Disclosing Party in the event that the Disclosing Party elects to challenge the validity of such requirement.

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5. MUTUAL RIGHTS AND OBLIGATIONS

5.1 **No representation**: The Receiving Party acknowledges that it shall be solely responsible for making its own judgement and decisions on all Confidential Information disclosed to it and except as may be otherwise agreed in writing by the Disclosing Party, the Disclosing Party shall not accept any responsibility for or make any representation, express or implied, with respect to the accuracy or completeness of the Confidential Information (whether written or oral) supplied.

5.2 **Liability**: Each party excludes all liability to the other party (except in respect of death or personal injury due to that party's negligence or in respect of any fraudulent misrepresentation) for any loss or damage (whether arising under contract, in tort or otherwise) suffered or incurred by the other party as a result of the supply to that party or the use by that party of the Confidential Information, in particular as a result of any errors or inaccuracies in the Confidential Information whether such losses arise directly or indirectly. In respect of all such computer software and/or hardware forming part of the Confidential Information, such material is provided "AS IS" without warranty of any kind, and the Receiving Party agrees that neither Disclosing Party nor its suppliers shall be liable for any damages whatsoever arising from or relating to Receiving Party's use or inability to use such software and/or hardware.

5.3 **Legal Compliance**: Each party agrees to comply with all applicable international and national laws that apply to any Confidential Information (including any applicable data protection regulations).

5.4 **No Obligation**: Each party agrees that the other party will be under no obligation to accept any offer or proposal which may be made in the course of any negotiations and that each party reserves the right in its sole and absolute discretion to terminate discussions and negotiations with the other party at any time. Each party is under no obligation to reimburse any costs or expenses which the other party may incur in connection with any discussions between the parties concerning the Purpose. Each party shall be entitled at any time to decline to provide or to continue to provide any Confidential Information to the other party.

5.5 **Deliver Up**: Each party shall immediately upon receipt by it of a written request from the other party to do so, deliver up to the other party or to its order all written Confidential Information which had been disclosed by that party (including any copies, analyses, memoranda or other notes made by either party or in either party's possession or under their custody and control) or at the other party's option, certify the destruction of the same and so far as it is practicable to do so, expunge any such Confidential Information from any computer, word processor or other device in its possession or under its custody and control containing Confidential Information.

5.6 **Additional Remedies**: Notwithstanding and without prejudice to the other terms of this Agreement, each party hereby consents and agrees that any breach of the terms of this Agreement could cause irreparable damage to the other party and in addition to all other remedies each party shall be entitled to seek injunctive or other interim or equitable relief, including damages (or their equivalent in any jurisdiction), which may be appropriate in the event of any breach or anticipatory breach by the other party of the terms of this Agreement. Nothing contained in this Agreement shall be construed as prohibiting either party from pursuing any other remedies available to it either at law or in equity for such breach or anticipatory breach including specific performance and recovery of damages. If the Receiving Party is in breach of this Agreement, it shall be liable to pay the Disclosing Party's reasonable legal fees in enforcing its rights arising out of or relating to this Agreement.

5.7 **Intellectual Property**: All proprietary rights in the Confidential Information (including any copyright, patent, database right, moral right, registered design, trade mark, service mark, domain name, know-how, utility model, unregistered design or where relevant, any application for any such right and all other industrial rights or rights of an intellectual property nature) shall continue to belong solely to the Disclosing Party. This Agreement shall not be construed as a grant by the Disclosing Party to the Receiving Party of any licence of

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rights or other rights relating to any Confidential Information whether before or after the date of this Agreement.

6. GENERAL

6.1 **Notice**: Any notice given under this Agreement shall be in writing and delivered by registered post to the registered address of the party, or such other address as is notified to the other party from time to time.

6.2 **Void provisions**: If at any time any part of this Agreement is held to be or becomes void or otherwise unenforceable for any reason under any applicable law, the same shall be deemed omitted from this Agreement and the validity and/or enforceability of the remaining provisions of this Agreement shall not in any way be affected or impaired as a result of that omission.

6.3 **Waiver**: Any waiver of any breach of this Agreement shall be in writing. The waiver by either party of any breach of this Agreement shall not prevent the subsequent enforcement of that provision and shall not be deemed to be a waiver of any subsequent breach of that or any other provision.

6.4 **Assignment**: This Agreement is personal to both parties. Neither party shall assign or otherwise transfer the rights and responsibilities under this Agreement to any other party. A person who is not a party to this Agreement shall not have the right to enforce any term of this Agreement without the express prior written agreement of the parties which agreement must refer to this clause.

6.5 **Entire Agreement**: This Agreement sets out the entire agreement between the parties relating to its subject matter and overrides any prior agreement or representations. No purported alteration or variation of this Agreement shall be effective unless it is in writing and is duly executed by the parties to this Agreement. All warranties and conditions not set out in this Agreement whether implied by statute or otherwise are excluded to the fullest extent permitted by law. This Agreement remains in effect for a period of five (5) years from the Effective Date.

6.6 **Law/Jurisdiction**: This Agreement shall be governed by the laws of the state of New York if the SHL entity is a US entity with the parties agreeing to the jurisdiction of New York federal court in New York city; or England and Wales for any other SHL entity entering this Agreement, with the parties agreeing to the jurisdiction of English courts.

In consideration of the mutual covenants and undertakings contained in this Agreement, THE PARTIES AGREE to the terms and conditions of this Agreement.

Lauren Huntington:	**SHL:**
By: _____	By: _____
Name:	Name: Paul DeKoekkoek
Title:	Title: Research Leader
Date: 9/11/2017	Date: 11/30/2017

Appendix 4: OPQ data composition

Table 20. Number of individuals assessed on the OPQr per country

#	Country	n
1	Afghanistan	163
2	Albania	367
3	Algeria	566
4	Angola	1 718
5	Argentina	1 927
6	Australia	299 763
7	Austria	3 233
8	Azerbaijan	130
9	Bahrain	571
10	Bangladesh	416
11	Belarus	177
12	Belgium	99 909
13	Bermuda	112
14	Botswana	3 108
15	Brazil	21 237
16	Brunei	202
17	Bulgaria	782
18	Burundi	118
19	Cameroon	174
20	Canada	26 080
21	Cape Verde	205
22	Chad	378
23	Chile	5 285
24	China	179 224
25	Colombia	6 873
26	Costa Rica	1 487
27	Croatia	460

#	Country	n
28	Cyprus	436
29	Czech Republic	2 917
30	Denmark	50 809
31	Dominican Republic	214
32	Ecuador	388
33	Egypt	12 204
34	El Salvador	4 735
35	Estonia	1 501
36	Ethiopia	156
37	Fiji	338
38	Finland	45 862
39	France	59 157
40	Georgia	169
41	Germany	28 276
42	Ghana	2 383
43	Greece	2 964
44	Guadeloupe	159
45	Guam	102
46	Guatemala	635
47	Guernsey	120
48	Honduras	2 144
49	Hungary	4 221
50	Iceland	2 807
51	India	423 536
52	Indonesia	31 804
53	Ireland	13 374
54	Man, Isle of	119
55	Israel	508
56	Italy	64 644
57	Japan	5 909
58	Jersey	203
59	Jordan	635

#	Country	n
60	Kazakhstan	263
61	Kenya	7 325
62	Kuwait	2 154
63	Latvia	1 029
64	Lebanon	1 075
65	Lesotho	426
66	Lithuania	1 063
67	Luxembourg	2 414
68	Malawi	300
69	Malaysia	14 327
70	Malta	208
71	Mauritania	248
72	Mauritius	965
73	Mexico	6 665
74	Morocco	853
75	Mozambique	1 066
76	Namibia	5 046
77	Nepal	169
78	Netherlands	82 436
79	New Caledonia	174
80	New Zealand	49 464
81	Nicaragua	422
82	Nigeria	5 696
83	Norway	53 397
84	Oman	650
85	Pakistan	4 729
86	Panama	404
87	Papua New Guinea	263
88	Paraguay	824
89	Peru	2 541
90	Philippines	15 039
91	Poland	14 824

#	Country	n
92	Portugal	12 174
93	Puerto Rico	811
94	Qatar	1 547
95	Romania	5 165
96	Russia	6 802
97	Rwanda	259
98	Saudi Arabia	26 149
99	Senegal	1 140
100	Serbia and Montenegro	875
101	Singapore	23 415
102	Slovakia	1 496
103	Slovenia	275
104	South Africa	188 260
105	Spain	17 711
106	Sri Lanka	1 354
107	Swaziland	353
108	Sweden	105 559
109	Switzerland	14 032
110	Thailand	11 433
111	Trinidad and Tobago	104
112	Tunisia	301
113	Turkey	10 459
114	Turkmenistan	408
115	Uganda	915
116	Ukraine	1 147
117	United Arab Emirates	14 781
118	UK (incl. Scotland, Wales)	544 876
119	US	377 864
120	Uzbekistan	122
121	Zambia	1497
122	Zimbabwe	1068

Table 21. Number of individuals assessed on the OPQr by industry

Industry	n
Oil & gas producers	4 3717
Oil equipment services & distribution	2897
Alternative energy	1 8123
Chemicals	44 239
Forestry & paper	9 916
Industrial metals & mining	50 822
Mining	48 303
Construction materials	67 083
Aerospace & defense	13 511
General industrials	4 637
Electronic & electrical equipment	25 093
Industrial engineering	65 867
Industrial transportation	70 257
Support services	388 254
Automobiles parts	81 335
Beverages	51 142
Food producers	78 591
Household goods & home construction	39 249
Leisure goods	31 695
Personal goods	96 081
Tobacco	6 312
Healthcare equipment & services	78 575
Pharmaceuticals & biotechnology	61 930
Food & drug retailers	58 832
General retailers	74 226
Media	111 422
Travel leisure	116 444
Fixed line telecommunications	44 393
Mobile telecommunications	99 433
Electricity	33 361

Gas, water & multiutilities	15 813
Banking	707 310
Non-life insurance	161 095
Life insurance	102 284
Real estate investment services	21 224
Financial services	869 552
Equity investment instruments	6 130
Nonequity investment instruments	650
Software computer services	191 425
Technology hardware equipment	69 827
Public sector NGOs	107 160

Table 22. Number of individuals assessed on the OPQr per year

Year	n
2009	262
2010	68 914
2011	311 615
2012	474 156
2013	702 017
2014	794 660
2015	776 557
2016	632 025

Table 23. Education level of OPQr respondents

Qualification	n
Other / prefer not to answer	11 511
No formal qualification	5 691
High school completion / equivalent	141 194
Vocational qualification	26 243
Degree	274 143
Advanced Degree	214 276

Table 24. Age of OPQr respondents

Age range	n
Under 18	1 623
18 to 20	28 931
21 to 24	334 467
25 to 29	344 460
30 to 34	319 570
35 to 39	267 091
40 to 44	225 289
45 to 49	171 444
50 to 54	96 439
55 to 59	39 492
60 to 64	8 220
65 +	1 246
Declined to Respond	86

Table 25. Gender of OPQr respondents

Gender	n
Male	1 873 837
Female	1 052 919
Other/Prefer Not To Answer	53

Appendix 5: Industry classification

INDUSTRY	SUPERSECTOR	SECTOR	SUBSECTOR	DEFINITION
0001 Oil & Gas	0500 Oil & Gas	0530 Oil & Gas Producers	0533 Exploration & Production	Companies engaged in the exploration for and drilling, production,refining and supply of oil and gas products.
			0537 Integrated Oil & Gas	Integrated oil and gas companies engaged in the exploration for anddrilling, production, refining, distribution and retail sales of oil and gasproducts.
		0570 Oil Equipment, Services & Distribution	0573 Oil Equipment & Services	Suppliers of equipment and services to oil fields and offshore platforms, such as drilling, exploration, seismic-information servicesand platform construction.
			0577 Pipelines	Operators of pipelines carrying oil, gas or other forms of fuel. Excludes pipeline operators that derive the majority of their revenues from direct sales to end users, which are classified under Gas Distribution.
		0580 Alternative Energy	0583 Renewable Energy Equipment	Companies that develop or manufacture renewable energy equipmentutilizing sources such as solar, wind, tidal, geothermal, hydro and waves.
			0587 Alternative Fuels	Companies that produce alternative fuels such as ethanol, methanol,hydrogen and bio-fuels that are mainly used to power vehicles, andcompanies that are involved in the production of vehicle fuel cells and/or the development of alternative fuelling infrastructure.
1000 Basic Materials	1300 Chemicals	1350 Chemicals	1353 Commodity Chemicals	Producers and distributors of simple chemical products that are primarily used to formulate more complex chemicals or products,including plastics and rubber in their raw form, fiberglass and synthetic fibers.
			1357 Specialty Chemicals	Producers and distributors of finished chemicals for industries or end users, including dyes, cellular polymers, coatings, special plastics andother chemicals for specialized applications. Includes makers of colorings, flavors and fragrances, fertilizers, pesticides, chemicals used to make drugs, paint in its pigment form and glass in its unfinished form. Excludes producers of paint and glass products used for construction, which are classified under Building Materials & Fixtures.
	1700 Basic Resources	1730 Forestry & Paper	1733 Forestry	Owners and operators of timber tracts, forest tree nurseries andsawmills. Excludes providers of finished wood products such aswooden beams, which are classified under Building Materials & Fixtures.
			1737 Paper	Producers, converters, merchants and distributors of all grades of paper. Excludes makers of printed forms, which are classified under Business Support Services, and manufacturers of paper items such as cups and napkins, which are classified under Nondurable Household Products.
		1750 Industrial Metals & Mining	1753 Aluminum	Companies that mine or process bauxite or manufacture and distributealuminum bars, rods and other products for use by other industries. Excludes manufacturers of finished aluminum products, such as siding, which are categorized according to the type of end product.
			1755 Nonferrous Metals	Producers and traders of metals and primary metal products other than iron, aluminum and steel. Excludes companies that make finished products, which are categorized according to the type of end product.
			1757 Iron & Steel	Manufacturers and stockholders of primary iron and steel products such as pipes, wires, sheets and bars, encompassing all processes from smelting in blast furnaces to rolling mills and foundries. Includescompanies that primarily mine iron ores.

INDUSTRY	SUPERSECTOR	SECTOR	SUBSECTOR	DEFINITION
2000 Industrials		1770 Mining	1771 Coal	Companies engaged in the exploration for or mining of coal.
			1773 Diamonds & Gemstones	Companies engaged in the exploration for and production of diamonds and other gemstones.
			1775 General Mining	Companies engaged in the exploration, extraction or refining of minerals not defined elsewhere within the Mining sector.
			1777 Gold Mining	Prospectors for and extractors or refiners of gold-bearing ores.
			1779 Platinum & Precious Metals	Companies engaged in the exploration for and production of platinum, silver and other precious metals not defined elsewhere.
	2300 Construction & Materials	2350 Construction & Materials	2353 Building Materials & Fixtures	Producers of materials used in the construction and refurbishment of buildings and structures, including cement and other aggregates, wooden beams and frames, paint, glass, roofing and flooring materials other than carpets. Includes producers of bathroom and kitchen fixtures, plumbing supplies and central air-conditioning and heating equipment. Excludes producers of raw lumber, which are classified under Forestry.
			2357 Heavy Construction	Companies engaged in the construction of commercial buildings, infrastructure such as roads and bridges, residential apartment buildings, and providers of services to construction companies, such as architects, masons, plumbers and electrical contractors.
	2700 Industrial Goods & Services	2710 Aerospace & Defense	2713 Aerospace	Manufacturers, assemblers and distributors of aircraft and aircraft parts primarily used in commercial or private air transport. Excludes manufacturers of communications satellites, which are classified under Telecommunications Equipment.
			2717 Defense	Producers of components and equipment for the defense industry, including military aircraft, radar equipment and weapons.
		2720 General Industrials	2723 Containers & Packaging	Makers and distributors of cardboard, bags, boxes, cans, drums, bottles and jars and glass used for packaging.
			2727 Diversified Industrials	Industrial companies engaged in three or more classes of business within the Industrial industry that differ substantially from each other.
		2730 Electronic & Electrical Equipment	2733 Electrical Components & Equipment	Makers and distributors of electrical parts for finished products, such as printed circuit boards for radios, televisions and other consumer electronics. Includes makers of cables, wires, ceramics, transistors, electric adapters and security cameras.
			2737 Electronic Equipment	Manufacturers and distributors of electronic products used in different industries. Includes makers of lasers, smart cards, bar scanners, fingerprinting equipment and other electronic factory equipment.
		2750 Industrial Engineering	2753 Commercial Vehicles & Trucks	Manufacturers and distributors of commercial vehicles and heavy agricultural and construction machinery, including rail cars, tractors, bulldozers, cranes, buses and industrial lawn mowers. Includes nonmilitary shipbuilders, such as builders of cruise ships and ferries.
			2757 Industrial Machinery	Designers, manufacturers, distributors and installers of industrial machinery and factory equipment, such as machine tools, lathes, presses and assembly line equipment. Includes makers of pollution control equipment, castings, pressings, welded shapes, structural steelwork, compressors, pumps, bearings, elevators and escalators.
		2770 Industrial Transportation	2771 Delivery Services	Operators of mail and package delivery services for commercial and consumer use. Includes courier and logistic services primarily involving air transportation.
			2773 Marine Transportation	Providers of on-water transportation for commercial markets, such as container shipping. Excludes ports, which are classified under Transportation Services, and shipbuilders, which are classified under Commercial Vehicles & Trucks.
			2775 Railroads	Providers of industrial railway transportation and railway lines. Excludes passenger railway companies, which are classified under

INDUSTRY	SUPERSECTOR	SECTOR	SUBSECTOR	DEFINITION
				Travel & Tourism, and manufacturers of rail cars, which are classifiedunder Commercial Vehicles & Trucks.
			2777 Transportation Services	Companies providing services to the Industrial Transportation sector,including companies that manage airports, train depots, roads, bridges, tunnels, ports, and providers of logistic services to shippers of goods. Includes companies that provide aircraft and vehicle maintenance services.
			2779 Trucking	Companies that provide commercial trucking services. Excludes road and tunnel operators, which are classified under Transportation Services, and vehicle rental and taxi companies, which are classified under Travel & Tourism.
		2790 Support Services	2791 Business Support Services	Providers of nonfinancial services to a wide range of industrial enterprises and governments. Includes providers of printing services,management consultants, office cleaning services, and companiesthat install, service and monitor alarm and security systems.
			2793 Business Training & Employment Agencies	Providers of business or management training courses and employment services.
			2795 Financial Administration	Providers of computerized transaction processing, datacommunication and information services, including payroll, bill payment and employee benefit services.
			2797 Industrial Suppliers	Distributors and wholesalers of diversified products and equipmentprimarily used in the commercial and industrial sectors. Includesbuilders merchants.
			2799 Waste & Disposal Services	Providers of pollution control and environmental services for the management, recovery and disposal of solid and hazardous waste materials, such as landfills and recycling centers. Excludes manufacturers of industrial air and water filtration equipment, whichare classified under Industrial Machinery.
3000 Consumer Goods	3300 Automobiles & Parts	3350 Automobiles & Parts	3353 Automobiles	Makers of motorcycles and passenger vehicles, including cars, sportutility vehicles (SUVs) and light trucks. Excludes makers of heavytrucks, which are classified under Commercial Vehicles & Trucks, and makers of recreational vehicles (RVs and ATVs), which are classified under RecreationalProducts.
			3355 Auto Parts	Manufacturers and distributors of new and replacement parts for motorcycles and automobiles, such as engines, carburetors andbatteries. Excludes producers of tires, which are classified under Tires.
			3357 Tires	Manufacturers, distributors and retreaders of automobile, truck andmotorcycle tires.
	3500 Food & Beverage	3530 Beverages	3533 Brewers	Manufacturers and shippers of cider or malt products such as beer, ale and stout.
			3535 Distillers & Vintners	Producers, distillers, vintners, blenders and shippers of wineand spirits such as whisky, brandy, rum, gin orliqueurs.
			3537 Soft Drinks	Manufacturers, bottlers and distributors of nonalcoholic beverages,such as soda, fruit juices, tea, coffee and bottled water.
		3570 Food Producers	3573 Farming & Fishing	Companies that grow crops or raise livestock, operate fisheries or ownnontobacco plantations. Includes manufacturers of livestock feeds andseeds and other agricultural products but excludes manufacturers offertilizers or pesticides, which are classified under Specialty Chemicals.
			3577 Food Products	Food producers, including meatpacking, snacks, fruits, vegetables,dairy products and frozen seafood. Includes producers of pet food and manufacturers of dietary supplements, vitamins and related items. Excludes producers of fruit juices, tea, coffee, bottled water and othernonalcoholic beverages, which are classified under Soft Drinks.
	3700 Personal & Household Goods	3720 Household Goods & Home Construction	3722 Durable Household Products	Manufacturers and distributors of domestic appliances, lighting, handtools and power tools, hardware, cutlery, tableware, garden equipment, luggage, towels and linens.

INDUSTRY	SUPERSECTOR	SECTOR	SUBSECTOR	DEFINITION
			3724 Nondurable Household Products	Producers and distributors of pens, paper goods, batteries, light bulbs, tissues, toilet paper and cleaning products such as soaps and polishes.
			3726 Furnishings	Manufacturers and distributors of furniture, including chairs, tables, desks, carpeting, wallpaper and office furniture.
			3728 Home Construction	Constructors of residential homes, including manufacturers of mobile and prefabricated homes intended for use in one place.
		3740 Leisure Goods	3743 Consumer Electronics	Manufacturers and distributors of consumer electronics, such as TVs, VCRs, DVD players, audio equipment, cable boxes, calculators and camcorders.
			3745 Recreational Products	Manufacturers and distributors of recreational equipment. Includes musical instruments, photographic equipment and supplies, RVs, ATVs and marine recreational vehicles such as yachts, dinghies and speedboats.
			3747 Toys	Manufacturers and distributors of toys and video/computer games, including such toys and games as playing cards, board games, stuffed animals and dolls.
		3760 Personal Goods	3763 Clothing & Accessories	Manufacturers and distributors of all types of clothing, jewelry, watches or textiles. Includes sportswear, sunglasses, eyeglass frames, leather clothing and goods, and processors of hides and skins.
			3765 Footwear	Manufacturers and distributors of shoes, boots, sandals, sneakers and other types of footwear.
			3767 Personal Products	Makers and distributors of cosmetics, toiletries and personal-care and hygiene products, including deodorants, soaps, toothpaste, perfumes, diapers, shampoos, razors and feminine-hygiene products. Includes makers of contraceptives other than oral contraceptives, which are classified under Pharmaceuticals.
		3780 Tobacco	3785 Tobacco	Manufacturers and distributors of cigarettes, cigars and other tobacco products. Includes tobacco plantations.
4000 Health Care	4500 Health Care	4530 Health Care Equipment & Services	4533 Health Care Providers	Owners and operators of health maintenance organizations, hospitals, clinics, dentists, opticians, nursing homes, rehabilitation and retirement centers. Excludes veterinary services, which are classified under Specialized Consumer Services.
			4535 Medical Equipment	Manufacturers and distributors of medical devices such as MRI scanners, prosthetics, pacemakers, X-ray machines and other nondisposable medical devices.
			4537 Medical Supplies	Manufacturers and distributors of medical supplies used by health care providers and the general public. Includes makers of contact lenses, eyeglass lenses, bandages and other disposable medical supplies.
		4570 Pharmaceuticals & Biotechnology	4573 Biotechnology	Companies engaged in research into and development of biological substances for the purposes of drug discovery and diagnostic development, and which derive the majority of their revenue from either the sale or licensing of these drugs and diagnostic tools.
			4577 Pharmaceuticals	Manufacturers of prescription or over-the-counter drugs, such as aspirin, cold remedies and birth control pills. Includes vaccine producers but excludes vitamin producers, which are classified under Food Products.
5000 Consumer Services	5300 Retail	5330 Food & Drug Retailers	5333 Drug Retailers	Operators of pharmacies, including wholesalers and distributors catering to these businesses.
			5337 Food Retailers & Wholesalers	Supermarkets, food-oriented convenience stores and other food retailers and distributors. Includes retailers of dietary supplements and vitamins.
		5370 General Retailers	5371 Apparel Retailers	Retailers and wholesalers specializing mainly in clothing, shoes, jewelry, sunglasses and other accessories.
			5373 Broadline Retailers	Retail outlets and wholesalers offering a wide variety of products including both hard goods and soft goods.

INDUSTRY	SUPERSECTOR	SECTOR	SUBSECTOR	DEFINITION
			5375 Home Improvement Retailers	Retailers and wholesalers concentrating on the sale of home improvement products, including garden equipment, carpets, wallpaper, paint, home furniture, blinds and curtains, and building materials.
			5377 Specialized Consumer Services	Providers of consumer services such as auction houses, day-care centers, dry cleaners, schools, consumer rental companies, veterinary clinics, hair salons and providers of funeral, lawn-maintenance, consumer-storage, heating and cooling installation and plumbing services.
			5379 Specialty Retailers	Retailers and wholesalers concentrating on a single class of goods, such as electronics, books, automotive parts or closeouts. Includes automobile dealerships, video rental stores, dollar stores, duty-free shops and automotive fuel stations not owned by oil companies.
	5500 Media	5550 Media	5553 Broadcasting & Entertainment	Producers, operators and broadcasters of radio, television, music and filmed entertainment. Excludes movie theaters, which are classified under Recreational Services.
			5555 Media Agencies	Companies providing advertising, public relations and marketing services. Includes billboard providers and telemarketers.
			5557 Publishing	Publishers of information via printed or electronic media.
	5700 Travel & Leisure	5750 Travel & Leisure	5751 Airlines	Companies providing primarily passenger air transport. Excludes airports, which are classified under Transportation Services.
			5752 Gambling	Providers of gambling and casino facilities. Includes online casinos, racetracks and the manufacturers of pachinko machines and casino and lottery equipment.
			5753 Hotels	Operators and managers of hotels, motels, lodges, resorts, spas and campgrounds.
			5755 Recreational Services	Providers of leisure facilities and services, including fitness centers, cruise lines, movie theaters and sports teams.
			5757 Restaurants & Bars	Operators of restaurants, fast-food facilities, coffee shops and bars. Includes integrated brewery companies and catering companies.
			5759 Travel & Tourism	Companies providing travel and tourism related services, including travel agents, online travel reservation services, automobile rental firms and companies that primarily provide passenger transportation, such as buses, taxis, passenger rail and ferry companies.
	6500 Telecommunications	6530 Fixed Line Telecommunications	6535 Fixed Line Telecommunications	Providers of fixed-line telephone services, including regional and long-distance. Includes companies that primarily provide telephone services through the internet. Excludes companies whose primary business is Internet access, which are classified under Internet.
6000 Telecommunications		6570 Mobile Telecommunications	6575 Mobile Telecommunications	Providers of mobile telephone services, including cellular, satellite and paging services. Includes wireless tower companies that own, operate and lease mobile site towers to multiple wireless service providers.
	7500 Utilities	7530 Electricity	7535 Conventional Electricity	Companies generating and distributing electricity through the burning of fossil fuels such as coal, petroleum and natural gas, and through nuclear energy.
			7537 Alternative Electricity	Companies generating and distributing electricity from a renewable source. Includes companies that produce solar, water, wind and geothermal electricity.
7000 Utilities		7570 Gas, Water & Multiutilities	7573 Gas Distribution	Distributors of gas to end users. Excludes providers of natural gas as a commodity, which are classified under the Oil & Gas industry.
			7575 Multiutilities	Utility companies with significant presence in more than one utility.
			7577 Water	Companies providing water to end users, including water treatment plants.
	8300 Banks	8350 Banks	8355 Banks	Banks providing a broad range of financial services, including retail banking, loans and money transmissions.

INDUSTRY	SUPERSECTOR	SECTOR	SUBSECTOR	DEFINITION
	8500 Insurance	8530 Nonlife Insurance	8532 Full Line Insurance	Insurance companies with life, health, property & casualty andreinsurance interests, no one of which predominates.
			8534 Insurance Brokers	Insurance brokers and agencies.
			8536 Property & Casualty Insurance	Companies engaged principally in accident, fire, automotive, marine,malpractice and other classes of nonlife insurance.
			8538 Reinsurance	Companies engaged principally in reinsurance.
		8570 Life Insurance	8575 Life Insurance	Companies engaged principally in life and health insurance.
	8600 Real Estate	8630 Real Estate Investment & Services	8633 Real Estate Holding & Development	Companies that invest directly or indirectly in real estate through development, investment or ownership. Excludes real estateinvestment trusts and similar entities, which are classified as Real Estate Investment Trusts.
			8637 Real Estate Services	Companies that provide services to real estate companies but do notown the properties themselves. Includes agencies, brokers, leasing companies, management companies and advisory services. Excludes real estate investment trusts and similar entities, which are classifiedas Real Estate Investment Trusts.
		8670 Real Estate Investment Trusts	8671 Industrial & Office REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that primarily invest in office, industrial and flex properties.
			8672 Retail REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that primarily invest in retail properties. Includes malls,shopping centers, strip centers and factory outlets.
			8673 Residential REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that primarily invest in residential home properties. Includes apartment buildings and residential communities.
			8674 Diversified REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that invest in a variety of property types without a concentration on any single type.
			8675 Specialty REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that invest in self storage properties, properties in thehealth care industry such as hospitals, assisted living facilities and health care laboratories, and other specialized properties such as auto dealership facilities, timber properties and net lease properties.
			8676 Mortgage REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that are directly involved in lending money to real estateowners and operators or indirectly through the purchase of mortgagesor mortgage backed securities.
			8677 Hotel & Lodging REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that primarily invest in hotels or lodging properties.
	8700 Financial Services	8770 Financial Services	8771 Asset Managers	Companies that provide custodial, trustee and other related fiduciaryservices. Includes mutual fund managementcompanies.
			8773 Consumer Finance	Credit card companies and providers of personal finance services such as personal loans and check cashing companies.
			8775 Specialty Finance	Companies engaged in financial activities not specified elsewhere. Includes companies not classified under Equity Investment Instrumentsor Nonequity Investment Instruments engaged primarily in owning stakes in a diversified range ofcompanies.
			8777 Investment Services	Companies providing a range of specialized financial services,including securities brokers and dealers, online brokers and security orcommodityexchanges.
			8779 Mortgage Finance	Companies that provide mortgages, mortgage insurance and other related services.

INDUSTRY	SUPERSECTOR	SECTOR	SUBSECTOR	DEFINITION
		8980 Equity Investment Instruments	8985 Equity Investment Instruments	Corporate closed-ended investment entities identified under distinguishing legislation, such as investment trusts and venture capital trusts.
		8990 Nonequity Investment Instruments	8995 Nonequity Investment Instruments	Noncorporate, open-ended investment instruments such as open-ended investment companies and funds, unit trusts, ETFs and currency funds and split capital trusts.
9000 Technology	9500 Technology	9530 Software & Computer Services	9533 Computer Services	Companies that provide consulting services to other businesses relating to information technology. Includes providers of computer-system design, systems integration, network and systems operations, data management and storage, repair services and technical support.
			9535 Internet	Companies providing Internet-related services, such as Internet access providers and search engines and providers of Web site design, Web hosting, domain-name registration and e-mail services.
			9537 Software	Publishers and distributors of computer software for home or corporate use. Excludes computer game producers, which are classified under Toys.
		9570 Technology Hardware & Equipment	9572 Computer Hardware	Manufacturers and distributors of computers, servers, mainframes, workstations and other computer hardware and subsystems, such as mass-storage drives, mice, keyboards and printers.
			9574 Electronic Office Equipment	Manufacturers and distributors of electronic office equipment, including photocopiers and fax machines.
			9576 Semiconductors	Producers and distributors of semiconductors and other integrated chips, including other products related to the semiconductor industry, such as semiconductor capital equipment and motherboards. Excludes makers of printed circuit boards, which are classified under Electrical Components & Equipment.
			9578 Telecommunications Equipment	Makers and distributors of high-technology communication products, including satellites, mobile telephones, fiber optics, switching devices, local and wide-area networks, teleconferencing equipment and connectivity devices for computers, including hubs and routers.

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Appendix 6: Big Five Factor loadings to the OPQ 32

Principal component analysis loadings above +/- 0.4 for three datasets. Only loadings found in at least two of the samples are included in the table.

Big Five factor	OPQ32 scales	OPQ32r Calibration sample (Sample 3, N=518)	Training delegates sample (Sample 7, N=551)	Online high-stakes sample (Sample 8, N=18,423)
Extraversion	Outgoing	0.81	0.67	0.71
	Emotionally Controlled	-0.70	-0.73	-0.70
	Outspoken	0.58	0.71	0.65
	Modest	-0.73	-0.72	-0.61
	Affiliative	0.57		0.45
	Socially Confident	0.57		0.41
	Controlling	0.44	0.50	
	Persuasive	0.41	0.52	
Agreeableness	Caring	0.72	0.75	0.73
	Democratic	0.73	0.71	0.72
	Behavioural	0.59	0.67	0.61
	Competitive	-0.51	-0.51	-0.41
	Trusting	0.46	0.52	0.52
	Decisive	-0.46	-0.44	
	Affiliative	0.44	0.52	0.46
	Independent Minded	-0.43	-0.40	-0.45
Conscientiousness	Conscientious	0.76	0.80	0.75
	Detail Conscious	0.69	0.65	0.66
	Vigorous	0.70	0.74	0.78
	Forward Thinking	0.71		
	Achieving	0.72	0.48	
Emotional Stability	Relaxed	0.80	0.80	0.77
	Worrying	-0.69	-0.75	-0.70
	Tough Minded	0.70	0.71	0.72
	Optimistic	0.55	0.65	0.41
	Socially Confident	0.48	0.63	0.51
Openness (unconventionality)	Conventional	-0.79	-0.85	-0.77
	Variety Seeking	0.72	0.8	0.77
	Rule Following	-0.69	-0.69	-0.69
	Innovative	0.61	0.61	0.42
	Independent Minded	0.49		0.55
Openness (critical thinking)	Evaluative	0.68	0.79	0.77
	Data Rational	0.64	0.56	0.50
	Conceptual	0.59	0.67	0.67

Congruence between the data sets is clear, with the majority of scales showing consistently strong loadings on the factors. It can be seen that the scales loading on each of the FFM factors correspond well with the hypotheses developed from the expert mapping of the OPQ32 onto the FFM (described in the OPQ32 Technical Manual, chapter 7; CEB, 2006). Overall, the results support the construct validity of the OPQ32r as an instrument that may be applied to measure the FFM.

Source: OPQ technical manual (CEB, 2016, p. 41)