Assessing team members' interpersonal competencies in new product development e-projects

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Abstract: Choosing team members for e-business New Product Development (NPD) projects can be difficult because the online context requires strong interpersonal skills, and geographically dispersed specialists often have diverse cultural backgrounds. This study identified instruments from the literature and then surveyed 1358 NPD team members in different e-business projects, within eight corporations spanning eight countries. The goal was to measure how positive and negative interpersonal competencies in NPD e-business teams affected their project performance. Self-report bias and exaggeration were controlled by incorporating social desirability markers. Demographics such as education, experience, age and gender were included for individual control. Project attributes such as team size, duration and industry were added for group control. Organisational-level controls consisted of size, region, manager age, NPD characteristics and sales force automation software. The instruments were validated and a multivariate model was proposed to help select effective NPD e-business team members.

Keywords: e-business project management; new product development; NPD; NPD teams; interpersonal competencies.

Reference to this paper should be made as follows: Strang, K.D. (2009) 'Assessing team members' interpersonal competencies in new product development e-projects', *Int. J. Project Organisation and Management*, Vol. 1, No. 4, pp.335–357.

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1 Introduction

Project managers and leaders have already been extensively analysed in the literature, especially in terms of explaining how leadership competencies impact team performance (Mumford *et al.*, 2002; Strang, 2005; Strack and Werth, 2007). This study instead examines team members, to assess how their interpersonal competencies impact New Product Development (NPD) project performance.

NPD has been improved by the availability of electronic business (e-business) software, which integrates data and processes across business units (Zahra, 1999; Zhuang and Lederer, 2006). E-business networks interconnect customers and suppliers from around the world using the internet (Chang and Cho, 2008). The same can be implied for staff working on geographically-dispersed NPD projects: e-business software (including knowledge sharing and project management tools), improves the ability of team members to electronically share ideas, collaborate and perform (Kyriakopoulos and deRuyter, 2004; Ngai *et al.*, 2008). Organisational culture impacts team performance, especially when people with diverse norms are brought together (Hofstede, 2001; McCrae and Terracciano, 2005; Hayagreeva and Simona, 2006).

It is well-documented in the literature that the competencies of team members (as well as leaders and supervisors), are key criteria in building effective NPD teams (Ancona and Caldwell, 1987; Belout and Gauvreau, 2004; Chen and Kanfer, 2006). The strategic advantage of identifying and measuring interpersonal competencies is they can be used in employee screening (McCrae and Costa, 1997; Houghton, 2000; Robbins and Judge, 2009). In particular, qualitative competencies can be used to identify effective leadership and team member interpersonal skills (Sherman *et al.*, 2005; Mullen and Donnelly, 2006; Strang, 2007).

Interpersonal soft skills are critical competencies for participants of e-business projects, due to the multicultural team composition, and virtual communication context which lacks face-to-face tactical feedback (Ashwin and Sanjay, 2004; Ngai *et al.*, 2008). Theories such as Myers Briggs Type Indicator (MBTI) can explain interpersonal behaviour (Myers and McCaulley, 1998). However, most interpersonal trait tests were designed and validated for the face-to-face team context, in USA or UK (Capraro and Capraro, 2002), with only a few applied internationally (Butcher *et al.*, 2003). Additionally, the requisite competencies for NPD team performance are hard to articulate (Yu *et al.*, 2005; Duarte and Reis, 2006), while the interpersonal skills are difficult to truthfully capture (Donaldson and Grant-Vallone, 2002). Furthermore, NPD performance can be hard to quantify "because of the difficulty of obtaining objective financial data" (Chang and Cho, 2008, p.17). Thus, the challenge in this study was to find relevant reliable instruments that could assess interpersonal competencies and measure team performance.

To investigate the above, formal research methodologies were used, and the positivist ideology was applied (seeking evidence to explain *a priori* theory). First a conceptual model was drawn from a literature review, producing hypotheses. Survey instruments were chosen, issued to a large sample, and then validated using factor analysis tools. The hypotheses were tested using several techniques, including best subsets regression, fit analysis, and multivariate regression.

2 Literature review

The literature review first discusses NPD, then e-business management theories, as they relate to team member competencies and performance. Following that, e-business management theories are briefly explored to identify relevant competency standards. This section closes with a synthesis of how team member interpersonal skills can be assessed in NPD e-business projects.

2.1 New product development in e-business

Advanced e-business technology has not changed that NPD is a critical business function which requires good teamwork skills for attaining competitive advantage and sustaining growth (Zahra, 1999; Koen *et al.*, 2002). Organisations have used e-business software to improve the ability of staff to collaborate and generate innovative ideas in NPD projects, but the competitors have done likewise (Zhuang and Lederer, 2006; Gordon *et al.*, 2008).

Although the core NPD functions of research, ideation, innovation, design, development, and test-marketing have not disappeared, their methods have evolved to include more electronic (online) collaboration and knowledge sharing by leveraging e-business software (Sherman *et al.*, 2005; Ettlie and Elsenbach, 2007). NPD e-business teams often span physical boundaries, creating an increased need for cross-cultural interpersonal skills that facilitate knowledge sharing and problem solving within and across the virtual spaces (Lynn *et al.*, 2000; Kyriakopoulos and deRuyter, 2004; Hegde and Shapira, 2007; Chang and Cho, 2008).

Good NPD performance requires effective NPD teams. One of the difficulties in building effective NPD teams is that they require complex interactions across organisational business functions and external entities, which is further exasperated when multiple countries, cultures and time zones are involved (Chang and Cho, 2008; Tan *et al.*, 2008). Additionally, NPD projects often interface with other e-business teams and systems, such as marketing, client relationship management, supply chain logistics, enterprise resource planning, and selling chain development (Sherman *et al.*, 2005). However, the management science theories may have not yet caught up with the contemporary needs and emergent practices for creating effective NPD teams in e-business (Sherman *et al.*, 2005; King and Burgess, 2006; Mullen and Donnelly, 2006; Ngai *et al.*, 2008). Mainly what seems to be lacking (as mentioned earlier), are criteria for selecting NPD e-business team members, such that the candidates could be pre-selected to ensure they could effectively collaborate with staff across business functions, countries and cultures.

2.2 Interpersonal competencies in e-business projects

E-business and NPD teams have benefited from leveraging the world-wide best-practices in professional disciplines like accounting, construction, electrical engineering, human resource management, project management, and so on. Desired NPD team member skills often correlate to the best-practice functions of creativity, experience with idea generation techniques, client relationship management, yet less research has been done to examine the individual interpersonal competencies such as ability to work well and communicate in a team.

2.3 Empirical studies of NPD project teams

One of the most relevant empirical studies of team work in NPD projects was the study of 169 Korean manufacturing firms by Chang and Cho (2008). They measured the effects of numerous project and organisational factors, including knowledge sharing, innovativeness, team size, and company structure on perceived benefits of NPD. They used multivariate regression to show that perceived NPD performance could be predicted by organisational memory (knowledge sharing), use of external information, use of formal procedures, and innovativeness. Their unit of analysis was organisation, and their dependent variables were subjective, yet it was noteworthy they included numerous factors for control.

One of the most relevant statistically-credible studies was the NPD organisational culture research of Belassi *et al.* (2007). They surveyed 95 US-based manufacturing companies (from a sample frame of 500), employing factor analysis to extract three significant organisational culture components with six items each (all loadings >0.5): Positive work environment ($\alpha = 0.706$), management leadership ($\alpha = 0.758$), and results oriented ($\alpha = 0.533$), (Belassi *et al.*, 2007, p.17). They used multivariate regression to show these factors predicted three outcomes of commercial success ($r^2 = 0.249$, adjusted $r^2 = 0.197$), technical success ($r^2 = 0.155$, adjusted $r^2 = 0.098$) and customer satisfaction ($r^2 = 0.102$, adjusted $r^2 = 0.041$), (Belassi *et al.*, 2007, p.19).

Given that "86.3% of the sample have a high degree of technical success, and 75.8% have a high degree of customer satisfaction" (Belassi *et al.*, 2007, p.19), it is possible the low factor regression effect on these dependant variables (0.197, 0.098, 0.041) were due in part to the subjectivity and difficulty in having stakeholders estimate longer-term NPD outcomes for shorter-term projects (the latter having specific scope and fixed duration). For example, to create the three dependent variables, they "asked top management to rate the commercial and technical success of their products on a scale of 0 to 100%, and to what extent customers accepted the developed products" (Belassi *et al.*, 2007, p.18). Despite one low factor reliability for 'results oriented' and low regression effects for 'technical' and especially 'customer satisfaction', the 'commercial success' NPD factor achieved a level (≥ 0.20) that is considered a small significant effect in social science research (Cohen, 1992; Keppel and Wickens, 2004). What is interesting and relevant in the NPD study by Belassi and colleagues (Belassi *et al.*, 2007) was their interdisciplinary approach to building a model and survey instrument by integrating theories from culture (Hofstede, 2001), project management, strategic management and human resource management. Notwithstanding this feat, the level of analysis was organisation, not individual.

2.4 Theories and studies of interpersonal competencies in e-business

Interpersonal theories used in e-business and NPD empirical studies are usually grounded in the Organisational Behavior (OB) literature (study of human behaviour and performance in organisations). OB is derived from an interdisciplinary combination of (Robbins and Judge, 2009): Social psychology (study of humans in society), individual psychology (study of the individual and their behaviour), anthropology (evolution and culture) and social psychology (study of group behaviour and interaction). An empirical study like this cannot cite all theories, so the most relevant alternatives are noted while the selected model is explained in more detail later.

Several instruments have been applied for assessing team member interpersonal competencies, namely the Apter (2001) Motivational Style Profile (MSP), Honey and Mumford (2000) Learning Style Questionnaire (LSQ), the Jackson (2002) Learning Style Profiler (LSP), and the Belbin Team Roles (BTR) (Belbin *et al.*, 1976). All of these are based on the MBTI personality theories, they are very similar, and all of them have been criticised for not being statistically proven (Coffield *et al.*, 2004). The MSP applies (MBTI) personality and reversal theories using an Apter Team Contribution System survey – which is reported to have good internal reliability and validity, but it has not been replicated by other researchers (Apter *et al.*, 1998; Coffield *et al.*, 2004). The LSQ was found to be invalid and not reliable in several empirical studies (Swailes and Senior, 1999; Duff and Duffy, 2002; Price and Richardson, 2003). The LSP is considered the strongest of the three but it has not been replicated sufficiently to validate the factors (Coffield *et al.*, 2004). Nevertheless it can be observed from the author's data (Jackson *et al.*, 2000; Jackson, 2002) that there was at least one high (undesirable) correlation (+ 0.38) between the 'analyst' and 'reasoner' interpersonal factors.

The BTW was derived from the MTBI factors and it is sometimes used for assessing project team member emotional (interpersonal) competence (Belbin *et al.*, 1976). BTW (unlike MBTI) has been criticised for its lack of factor relevance (Costea and Crump, 1999) and lack of reliability (Costea and Crump, 1999; Dulewicz and Higgs, 1999). For example, in a study of 201 European managers (65% based in UK), problems were cited with its reliability, 13/20 intercorrelations between the seven factors were above + 0.30 and some above + 0.50 (Dulewicz and Higgs, 1999, p.246). These intercorrelations are too high to achieve a valid replication of an *a priori* instrument with this moderately large sample size (Keppel and Wickens, 2004). Furthermore, most PM and NPD studies (such as those cited earlier including: Dulewicz and Higgs, 1999) employ a self-report survey with no measure or control for social desirability and self-perception bias. Only a few of these studies (cited previously) have tested for the casual effect of team member interpersonal competencies on performance, namely by authors: (Fisher and Katz, 2000; Kline *et al.*, 2000; Donaldson and Grant-Vallone, 2002).

2.5 Interdisciplinary measures of interpersonal competencies in NPD

In NPD, several researchers have taken an interdisciplinary approach to measure interpersonal competency effect on performance by adapting the 'Five Factor Model' (FFM) from individual psychology while also controlling for many of the confounding factors and bias (such as: Liao and Chuang, 2004; Buchanan *et al.*, 2005; Kankanhalli *et al.*, 2005; Cabrera *et al.*, 2006; Landers and Lounsbury, 2006; Taylor, 2006; Wang and Lai, 2006; Wasko and Faraj, 2006).

FFM (sometimes called Big Five or NEO5) measures variability in normal personality along five dimensions:

1 neuroticism

2 extraversion

3 openness to experience (openness)

4 agreeableness

5 conscientiousness.

'NEO5' is a common acronym referring to the first letter of the first three factors ('N', 'E', 'O') plus the '5' meaning there are five factors in this model. FFM is reliable as evidenced in numerous empirical studies, notably the 45-year longitudinal research of Soldz and Vaillant (Soldz and Vaillant, 1999). FFM instruments have been validated within 55 different countries (McCrae and Terracciano, 2005), and translated from English to Spanish, German, Chinese and Estonian languages (Yang and Bond, 1990; McCrae and Costa, 1997; Barrick and Mount, 1999; Del Barrio *et al.*, 2004).

The FFM items are clearly related to NPD team interpersonal competency expectations. For example, conscientiousness includes the facets competence, order, dutifulness, achievement striving, self-discipline, and deliberation. Cabrera *et al.* (2006) found business team performance was related to conscientiousness traits of reliability, dependability, industriousness, organisation and achievement orientation. In a similar study conscientious individuals were dependable, responsible, hardworking, and achievement-oriented (Landers and Lounsbury, 2006). Conscientious team members tend do to what is expected of them (Liao and Chuang, 2004). In a similar fashion, extraversion indicators of sociability and talkativeness might suggest team members would make friends with others and tap into new knowledge sources.

Agreeable people (with respect to FFM principles) are cooperative, cheerful, and supportive of others, thereby motivating team members as well as accepting feedback. Openness has been linked to valuable NPD traits such as divergent thinking and creativity (McCrae and Costa, 1987), and by comparison: "closed individuals are not necessarily defensive, but they are more comfortable with the familiar and have little incentive to try the new" (p.1259). Furthermore, openness has been found related to imagination, curiosity, artistic sensitivity, and originality (Cabrera *et al.*, 2006), which are desired traits for NPD staff. Neuroticism is associated with anxiety, hostility, depression, self consciousness, impulsivity, or vulnerability (McCrae and Costa, 1987), which are less preferred NPD e-business team traits.

2.6 Strengths and weaknesses of popular interpersonal theory instruments

MBTI was emphasised because it is better-known in business and NPD plus it has been found to be more reliable and valid in comparison to most interpersonal competency alternatives (cited earlier). However it is argued here that FFM has a number of advantages over MTBI. First, MTBI (and their inherited models) are rooted in older US-based cultural norms from Jung's theory of human personality. Jung's original theory attempted to model useful behaviour during the 1940–1960 era. Secondly, although FFM was modelled after MTBI, a fifth dimension 'neuroticism' was added and it was extensively validated outside the USA (McCrae and Costa, 1987). Thirdly, FFM was empirically derived using observations, while MTBI is a theory-based model grounded on ideal (good) interpersonal traits. For example, it is possible that at least some NPD team members could have negative traits (in the neuroticism dimension), but it is clear MTBI cannot capture this. On the other hand, there are fewer comparative studies in the literature that can explain neuroticism as a statistically significant (negative) factor within business teams.

A common weakness of most interpersonal self-rated instruments is the potential bias for exaggeration (Fisher and Katz, 2000). A related phenomenon that exists in e-business is the "espoused versus reality perception gap" (Donaldson and Grant-Vallone, 2002). What respondents believe and report can be subjective and quite different from objective

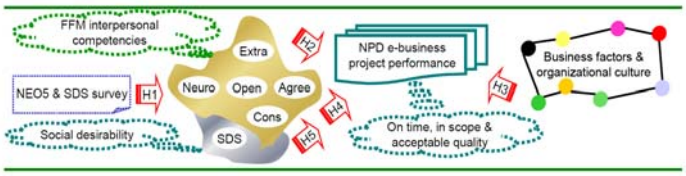
fact as most others would view it from a normative perspective (Strang, 2003). It is common to see a 'social desirability tendency' of team members wanting to 'look good' and often they want their peers and/or superiors to also 'look good' (or sometimes they purposefully rate their superiors/peers badly). These are psychological drawbacks that exist and they need to be controlled during research in order to produce accurate results. None of the studies cited thus far have controlled for this.

2.7 Conceptual model and hypotheses

The most relevant principles for assessing interpersonal competencies of NPD e-business team members can be synthesised from this literature review into a theoretical model. Figure 1 presents a diagram to sketch the conceptual research framework.

The arrows labelled as 'H1' through 'H5', refer to the hypotheses being statistically significant ($\alpha = 0.05$). H1 posits the FFM theory and instrument can reliably assess the interpersonal competencies of these NPD e-business team members. It is expected that individual FFM and social desirability factors will be significant predictors of NPD team performance (H2) when also including the available macro environment data for control, such as team size, age, gender, experience, region, and so on (H3 tests the control factors). The remaining hypotheses were established to test the predictive effect of FFM and SDS factors on NPD performance. H3 also seeks to find an overall 'model' effect (the one in Figure 1), while H4 isolates the FFM factors as compared with SDS factors (H5).

Figure 1 Hypothetical model (see online version for colours)



3 Methods

The research philosophy was positivist, while the strategy was deductively focused on examining an integrated *a priori* model, using a multi-method approach to test the hypotheses (Creswell, 2003; Keppel and Wickens, 2004). The level of analysis is the NPD project team, while the unit of analysis is the interpersonal competency effect on NPD team performance. First, an *a priori* survey was issued to intact groups and project performance data was available from the participating organisations (all results were quantitative data). The sample data was examined to verify performance ratios and to remove outliers such as those with high social desirability scale items (explained later). Secondly, the construct (integrated SDS and FFM) was validated by confirmatory ordinal factor analysis (since the items were binomial), and model invariance analysis was applied to demonstrate split sample validity (Creswell, 2003; Keppel and Wickens, 2004; Strang, 2009). Best-subsets multiple regression, experimental lack of fit analysis, and multivariate regression were the techniques used to test the remaining hypotheses (Browne and Cudeck, 1993; Keppel and Wickens, 2004; Levine *et al.*, 2005).

3.1 Subjects and demographics

Eight medium-to-large corporations (each with at least 500 employees), in the marketing research, residential telecommunications, multi-line insurance and financial-superannuation management industries, voluntarily participated. All companies operated either their head office or a business unit in Australia. Seven of these corporations were multinationals with project offices in at least two of the following countries: Australia, South Africa, UK, USA, New Zealand, Singapore, Japan and India.

In this study, the final sample size was 1358 team members, from eight medium-to-large organisations across eight countries. All subjects worked in the English language (many spoke other languages and were born in different countries as compared to their work site), plus all had recently graduated from English-speaking universities. Demographics and descriptive statistics are summarised in Table 1 to help readers understand the composition of the sample teams. The projects typically encompassed early NPD phases (needs analysis, ideation, and/or conceptual design), so the 0.8 years mean duration is lower than the 2.0 years benchmark from the Product Development Management Association best practices survey (Barczak *et al.*, 2009, p.7).

Table 1 Demographic and descriptive statistics

Key demographic measures			*Industry*	*%*	*Project office*	*%*
Mean age: 41.6	Standard deviation: 6.78		Telecommunication	0.27	Australia	0.21
Mean team size: 3.3	Standard deviation: 1.77		Marketing	0.26	UK	0.16
Mean duration (years): 0.8	Standard deviation: 0.19		Insurance	0.24	USA	0.15
Mean team projects: 2.2	Standard deviation: 1.18		Financial	0.23	India	0.15
Gender: Male 61%	Female 39%				Japan	0.10
Languages spoken: English+ 54%	English only 46%				Singapore	0.08
Highest degree: Bachelor* 81%	Masters** 19%	Other 0%			South Africa	0.08
					New Zealand	0.07

Notes: * Many claimed a masters in-progress.
** Includes one team member with a PhD.

3.2 Instruments and measures

There are several versions of the FFM instrument, with the most popular being the NEO-PI-R form (McCrae and Costa, 1997). The FFM survey used here contained 240 items with a five-point Likert response scale (1 = strongly disagree to 5 = strongly agree). Since the sample contained people from countries that may not totally understand certain terms, additional explanations were added to assist multicultural team members that may be using English as a foreign language so as to avoid changing the instrument and its *a priori* status (Strang, 2008b).

The short form of the Social Desirability Scale (SDS) survey was also included to control for self-report bias (Crowne and Marlowe, 1960). SDS includes 13 items on a seven-point Likert scale (1 = strongly disagree to 7 = strongly agree), with questions such as: “no matter who I am talking to, I am always a good listener; it is sometimes hard for me to go on with my work if I am not encouraged; I am sometimes irritated by people who ask favors of me” (Reynolds, 1982, pp.352–353). The SDS is arranged

in a way to measure the degree to which a respondent is answering in an espoused 'socially desirable' manner. The SDS was used to detect outliers with extreme high means for the first factor and extreme low means on the last two factors (Reynolds, 1982; Fisher and Katz, 2000) – five records were deleted early on using this criterion (n = 1358). The mean scores from the FFM (and somewhat from the SDS) became the independent factors.

Two objective dependent variables were taken from the data supplied by the participating organisations to measure NPD outcomes. NPD success is often measured by sales, market share, Return-on-Investment (ROI), and profit relative to targets. However, due to the difficulty of gaining accurate financial data, which would also be directly linked to immediate team performance, most researchers instead ask for estimates or perceptions (Ashwin and Sanjay, 2004; Belassi *et al.*, 2007; Chang and Cho, 2008). Furthermore, the survey was anonymous and employee performance data was not available (some organisations were reluctant to provide salary, cost figures for earned value or competitive product design information). Subsequently, two variables were calculated from the project data to measure time, scope and quality performance (as explained below).

Time Performance Index (TPI) is a ratio calculated using this formula (specified as SPIt in: Strang, 2008a): planned effort days/actual effort days (where divide by zero is zero). Although TPI can be interpreted much like Schedule Performance Index (SPI) as specified in the PMBOK, it is fundamentally different. TPI is mainly an 'end-of-project' performance ratio used in e-business NPD program management to benchmark time performance. SPI is an earned value ratio used 'during' projects to benchmark schedule efficiency (calculated by the formula: "EV [earned value]/PV [planned value]"), whereby an "SPI greater than 1.0 indicates the project is ahead of its planned schedule" (PMI, 2008, section 7.3.2.1). The problem in using CPI and SPI for benchmarking projects is they become 1.0 at completion (even if the project completed late and over budget). Additionally, SPI is not reflective of time performance 'during' the later stages of a project since a project can be very late but still produce a high SPI. Misleading SPI can result from its formula which assesses direct and indirect costs, potentially including expensive project assets, but not team effort days. For example, if expensive consultants were heavily loaded on project tasks in the first half of the critical path, and if these had already completed and/or expensive project assets had been acquired on schedule (such as software, land/buildings or intellectual property), then this could inflate the SPI on a project that was severely impaired or make a project look successful that was (or had completed) drastically behind schedule.

Other researchers concur and have developed alternatives to the SPI (Jacob and Kane, 2004; Lipke, 2004; Book, 2006; Bower, 2007; Corovic, 2007), but those variations cannot accurately benchmark a late project in the circumstances described above. A creative SPI variation is the:

> "Phase Schedule Performance Index (SPIp) […] the ratio of the Planned Duration (PD) to the Actual Duration (AD), both counted from the Project Start Date (PSD) calendar date to the end of the last completed phase calendar date when work 100% complete…expressed as calendar days." (Bower, 2007, pp.9–10)

SPIp is an improvement over SPI for benchmarking schedule performance either during or after project completion, except that it must instead use effort days (which is what TPI does), because task dependencies (feeding buffers, gaps and lags) as well as resource/asset costing, preclude using duration as a performance metric. As an example, TPI will accurately measure time performance regardless of whether expensive or economical resources are used (*e.g.*, expensive subject matter experts or trainees), and/or when fixed assets (or liabilities) are tracked in the NPD e-business project earned value database.

The Scope Defects Index (SDI) is an end-of-project benchmark ratio calculated using this formula (Strang, 2008a): 1 / (WD * e + SCR) + 1). The 'WD' refers to total Work Defects, e = 2.718 is a mathematical constant in the expected value calculated from Poisson or exponential statistical distributions (Aliaga and Gunderson, 2003), and 'SCR' means Scope Change Requests. Work defects were deliverable non-conformances (insufficient quality) that required additional re-work. SCR were 'official changes' (due to external factors or the wishes of the stakeholders) raised to the project sponsor and approved. The effect of this formula is to penalise work defects more so than scope changes (the latter of which are officially sanctioned by the sponsor yet a high SCR does imply poor project owner planning). SDI is usually improved by NPD team experience and effective project management, but decreased by factors such as poor research, uncooperative team work, new legislation, inadequate client relationship management, defective work, sponsor scope changes, and so on. It is desirable to have a high value of one for SDI, indicating good scope and quality management.

4 Results

First, the sample normality was examined, which was necessary for satisfying the assumptions of the statistical techniques such as factor analysis and casual regression (Keppel and Wickens, 2004; Levine *et al.*, 2005). Next, the interpersonal competency instrument was validated using ordinal factor analysis since the data types are binary (Jöreskog and Moustaki, 2006; Strang, 2009). Finally this was followed by a discussion of NPD cause-effect performance hypotheses testing (as specified earlier and shown in the hypothetical model of Figure 1).

4.1 Exploratory sample data analysis

The exploratory data analysis of the independent factors, as well as the dependent variables, indicated the sample was suitable for applying the chosen statistical techniques (the summary statistics were included in Table 1).

4.2 Interpersonal competency factor validity

The FFM and SDS constructs were confirmed for validity using Ordinal Formal Inference Maximum Likelihood (ORFIML) in LInear Structural RELations (LISREL) software – since all the variables were ordinals (Jöreskog and Moustaki, 2006; Strang, 2009). At the lowest level of factor analysis, item-to-item correlations were less than ±0.20, and item-to-total correlations for FFM responses loaded on the proper subscales, across the five dimensions (Neuro, Extra, Open, Agree, Cons). As summarised in

Table 5 of the Appendix (showing the promax oblique rotation solution), all dominate factor loadings met the 15% variance captured for internal consistency threshold of +0.3 (Kline *et al.*, 2000). Most loadings were above +0.5 on the *a priori* factor, without significant cross-loading on others, albeit a few loaded somewhat (+0.2 to +0.3) on multiple factors (*e.g.*, activity, dutifulness, fantasy, modesty).

At the next higher level of analysis, the internal reliabilities for the FFM dimensions were: 0.62 (N), 0.76 (E), 0.72 (O), 0.89 (A), 0.77 (C), which are a bit lower than the span of 0.86 to 0.92 reported in the US normative sample (Costa and McCrae, 1992). The neuroticism reliability scale was the lowest at .62 which is likely due to minor problems with the instrument, in particular, many dimension items contained negative loadings on several of the other factors. This cross-loading was not likely due to self-report bias since outliers were screened earlier using the SDS construct. The internal reliability benchmarks for validating *a priori* instruments vary by authority, such as ≥ 0.80 (Davis, 1995), ≥ 0.70 (Nunnaly, 1978), ≥ 0.65 (DeVellis, 1991) and ≥ 0.5 for new attitude/perception studies (Tuckman, 1999). The internal reliabilities (ranging from 0.62 to 0.89) were statistically significant, so the construct was examined using the fit indexes. The chi-square Goodness-of-Fit (GF) and Likelihood-Ratio (LR) indexes are most relevant to show the instrument supports the FFM theory when fitted with the data. The key benchmark sought was that the univariate and bivariate GF and LR indexes would roughly equal one another (Jöreskog and Moustaki, 2006), and this was the finding here. The univariate LR was close to the GF (210.46 vs. 212.88), while the bivariate LR also was close to the GF (269.62 vs. 272.10).

Finally, to ensure the FFM could demonstrate external validity in this type of research, a confirmatory factor analysis was replicated in LISREL with the covariance matrix, using a split sample. The replication variance difference indicated the model was consistent across the split samples (LR $X^2 = 1.49$, $p > 0.05$). In addition, SDS invariance was similarly compared, with an insignificant difference between groups. Subsequently, the first hypothesis H1 was accepted.

4.3 Interpersonal competency effect on performance

Given that instrument reliability was established, attention was focused on testing the impact of the FFM interpersonal competency dimensions on NPD performance. The backward elimination strategy was employed (Keppel and Wickens, 2004) starting with a 'fully saturated' model that included business, team and demographics as control, plus FFM and SDS, regressed on the dependent variables (TPI and SDI). The team, individual and business factors were: Projects completed with current members, team size, gender, age, NPD experience, region, sales force automation availability, sales orders, clients surveyed, NPD assets investment, CEO age, and completed products (additional business factors were available from the organisations but they were statistically insignificant in all models).

Multivariate Two-Stage Least Squares regression (TSLS) was used to test FFM, SDS, and all these 'organisational factors' from the dataset, on TPI and SDI. Repeat team 'projects' was the only organisational factor that greatly impacted NPD performance (along with the hypothesised factors in FFM and SDS), although Sales Force Automation (SFA) technology and individual team member experience had 'some' predictive effect in certain combinations. Table 2 lists these best model combinations (with better models

toward the bottom), showing the adjusted r^2 captured on TPI, then SDI, with each row indicating the factor(s) selected for regressing dependent variables (TPI coded P, SDI coded D). It should be noted there is ambiguity in the literature on benchmarks for assessing best-subsets regression, with a popular method being to select predictors when 'k-1 number of factors' is close to C-p statistic (Levine *et al.*, 2005). Instead the criteria employed here was to rely on adjusted r^2 since this is precise (Levine *et al.*, 2005) yet it still considers the number of factors plus standard error. Censored regression was applied for the continuous data type factors but yielded the same result as TSLS.

Table 2 Best subsets multivariate regression

Performance		*Team*		*Individual*			*Interpersonal competencies*						*Business unit program factors*						
TPI r^2*adj*	*SDI* r^2*adj*	*Projects*	*Team size*	*Gender*	*Age*	*Experience*	*Neuro*	*Agree*	*Extra*	*Open*	*Cons*	*SDS*	*Region*	*SFA*	*Sales*	*Clients*	*NPD assets*	*CEO age*	*Products*
.441	.386								P		D								
.804	.778	PD																	
.826	.789	PD						P		D									
.826	.788	PD						P	PD										
.842	.797	PD						D	P	P	PD								
.848	.798	PD							D	PD	P								
.856	.801	PD					P	D	D	D	P	P							
.859	.802	PD						PD	P		D	P							
.863	.802	PD					P	PD	D	P	P	PD		P					
.865	.803	PD					P	PD	D	P	PD	P							
.865	.805	PD					D	D	PD	PD	P	D							
.866	.806	PD					PD	D	D	P	P	P		P					
.866	.807	PD				D	PD	PD	PD	PD	PD	P		P					
.867	.808	PD					P	P	PD	PD	PD	D			P				
.868	.809	PD					PD	PD	PD	PD	PD	PD							

Notes: P = selected in model as TPI predictor ($p < 0.05$).
D = selected in model as SDI predictor ($p < 0.05$).
H2 & H3 accepted.

A second 'condensed' multivariate regression model was created, including only FFM, SDS and 'projects', as predictors. The first 'fully saturated' model captured 87.4% of variance on TPI (adj. $r^2 = 0.872$, ss = 18.6336, se = 0.04476, f = 516.61, df = [18, 1357], $p < 0.001$); and 81.7% of variance on SDI (adj. $r^2 = 0.814$, ss = 14.36142, se = 0.04903, f = 331.83, df = [18, 1357], $p < 0.001$). The second 'condensed' model (FFM + SDS + projects) captured 86.9% of variance on TPI (adj. $r^2 = 0.868$, ss = 18.5231, se = 0.04549, f = 1278.72, df = [7, 1357], $p < 0.001$); and 81.0% of variance on SDI (adj. $r^2 = 0.809$, ss = 14.2344, se = 0.04979, f = 820.30, df = [7, 1357], $p < 0.001$). Results from the best subsets regression on each NPD dependent variable supported the retention of only the FFM dimensions, SDS, and

'projects', as predictors. *F*-tests were used to compare the 'fully saturated' versus 'condensed' regression models (Keppel and Wickens, 2004), which confirmed the latter was more effective ($f = 415.83$, $df = [18, 1357]$, $p < 0.001$ versus $f = 1028.861$, $df = [7, 1357]$, $p < 0.001$).

The remaining hypotheses were tested using un-weighted least squares regression to measure the effect of the factors on each performance outcome separately (avoiding multivariate dependent variable interaction). A statistically significant model was produced that supported the hypotheses, with the key results synthesised in Table 3 (for TPI) and Table 4 (for SDI). The standardised beta coefficients reported in the tables, reveal the true effect size of FFM and SDS on TPI and SDI to be small (but statistically significant), with 'projects' capturing a large impact.

Table 3 NPD time performance index regression

UWLS	*X = FFM, SDS, Projects; Y = TPI*				H_0: $F < F_{crit}$ H_1: $F \geq F_{crit}$ $\alpha = 0.05$			*Hypotheses*
Model r^2	0.869			*Model fit tests*			*Result*	
Adjusted r^2	0.868			Durbin-watson D statistic			0.18	H3 accepted
SE	0.04549			*Mahalanobis distance invariance*			$p > 0.05$	H3 accepted
Sample size	1358							
ANOVA	*DF*	*SS*	*MS*	*F*	*P*		*Effect*	
Regression	7	18.5231	2.6462	1278.72	1.381E-07		0.8689	H3 accepted
Residual	1350	2.7937	0.0021					
Total	1357	21.3167						
Predictor	*Beta*	*SeqSS*	*T*	*P*	*VIF*	*Lack-of-fit*	*Effect*	
Constant	0.50219		47.30	0.000				
Projects	0.068119	17.1412	38.62	0.000	2.8	$p > 0.05$	0.8041	Un-hypothesised
Neuro	–0.016167	0.4623	–10.70	0.000	1.4	$p > 0.05$	0.0217	H4 accepted
Agree	0.009057	0.0192	4.69	0.000	1.5	$p > 0.05$	0.0009	H4 accepted
Open	0.020397	0.4995	11.87	0.000	1.6	$p > 0.05$	0.0234	H4 accepted
Extra	0.005447	0.0097	3.00	0.003	1.6	$p > 0.05$	0.0005	H4 accepted
Cons	0.021926	0.2527	10.48	0.000	1.7	$p > 0.05$	0.0119	H4 accepted
SDS	0.009581	0.1386	8.18	0.000	1.0	$p > 0.05$	0.0065	H5 accepted

Albeit the sample size of over 1000 was large enough to inflate regression, the factor-to-variate ratio was acceptable (Levine *et al.*, 2005) at 7:2 (projects, FFM and SDS on TPI and SDI). As a precaution, an 'experimental lack-of-fit-test' was conducted using ANOVA *f*-tests and *t*-tests to systematically check multicollinarity, interactions and error residual patterns, on a model and factor basis. This was accomplished by partitioning the sample into high and low groups based on the Mahalanobis distance centroid (this used the SDI median value to split the sample into two approximately equal sized groups). The sample data was fitted to the regression equation, capturing invariance and error residuals for each predictor between test models (using *f*-tests). A Bonferroni adjusted *p*-value was calculated for each predictor as well as for the overall model (in this test significant *p*-values suggest a poor fit). The Bonferroni calculation is similar to the

standard *p*-value hypothesis testing but it also considers common error and the number of independent factors used in the regression model to predict the dependent variable (Lesaffre and Verbeke, 2005), whereby a parsimonious model uses as few factors as necessary. For similar applications of the above statistical techniques see (Williamson *et al.*, 2002). Independent variable multicollinearity and auto regression were also checked to ensure the standardised residuals met the appropriate benchmarks: $t \leq \pm 2$ (Jöreskog *et al.*, 2006), Variance Inflation Factor (VIF) ≤ 3 (Carlson *et al.*, 2004) or ≤ 5 (Snee, 1973), and Durbin-Watson d ≤ 2 (Levine *et al.*, 2005). These experimental lack-of-fit checks are reflected in Table 3 and Table 4 (as the right-most column indicates, the hypotheses were accepted).

Table 4 NPD scope defect index regression

UWLS	*X = FFM, SDS, Projects; Y = SDI*				H_0: $F < F_{crit}$ H_1: $F \geq F_{cri}$ $\alpha = 0.05$			*Hypotheses*
Model r^2	0.810			*Model fit tests*			*Result*	
Adjusted r^2	0.809			Durbin-watson D statistic			0.11	H3 accepted
SE	0.04979			*Mahalanobis distance invariance*			$p > 0.05$	H3 accepted
Sample size	1358							
ANOVA	*DF*	*SS*	*MS*	*F*	*P*		*Effect*	
Regression	7	14.2344	2.6462	820.30	2.182E-05		0.8097	H3 accepted
Residual	1350	3.3466	0.0025					
Total	1357	17.5809						
Predictor	*Beta*	*SeqSS*	*T*	*P*	*VIF*	*Lack-of-fit*	*Effect*	
Constant	0.50963		43.85	0.000				
Projects	0.066856	13.6825	34.63	0.000	2.9	$p > 0.05$	0.7783	Un-hypothesised
Neuro	–0.002220	0.0611	–2.34	0.018	1.6	$p > 0.05$	0.0035	H4 accepted
Agree	0.009042	0.0307	4.28	0.000	1.7	$p > 0.05$	0.0017	H4 accepted
Open	0.009395	0.1749	5.10	0.000	1.7	$p > 0.05$	0.0099	H4 accepted
Extra	0.008591	0.0342	4.33	0.000	1.7	$p > 0.05$	0.0019	H4 accepted
Cons	0.018014	0.1695	7.86	0.000	1.8	$p > 0.05$	0.0096	H4 accepted
SDS	0.007353	0.0816	5.74	0.000	1.1	$p > 0.05$	0.0046	H5 accepted

5 Discussion and limitations

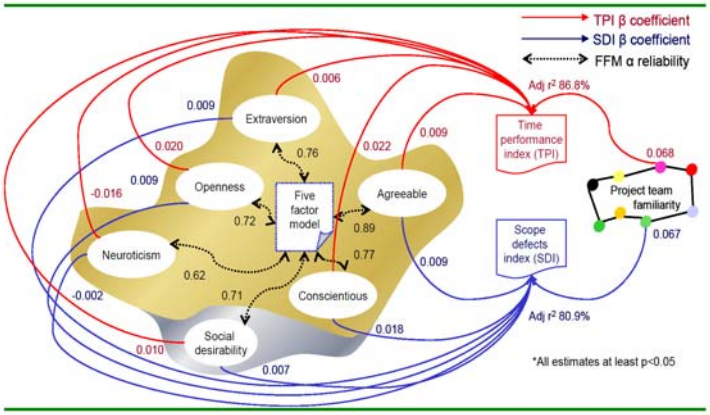
These results support all hypotheses, and the FFM replication is consistent with other studies (such as: Landers and Lounsbury, 2006). In total there were seven statistically significant factors: five FFM dimensions, SDS and 'projects'. The model is depicted in the cause-effect diagram of Figure 2, showing how the validated FFM and SDS (along with the 'projects' factor), strongly impact the two NPD e-business outcomes of time performance index (86.8%), and scope defects index (80.9%). In Figure 2, the interpersonal competency construct is shown at the center, with the statistically significant alpha reliabilities (ranging from 0.62 to 0.89), pointing to each FFM dimensions and SDS. The interpersonal competency marker items for the FFM dimensions in Figure 2 are most easily cross-referenced by looking at Table 5 (see the Appendix).

The multivariate regression generated two standardised beta estimates (one for each factor impact on TPI and SDI), ranging from –0.002 to 0.022 for the FFM dimensions, and 0.067 to 0.068 for the 'projects' factor. Betas estimate the 'standardised' change in one unit of a predictor (factor) for a change in one unit of the dependent variable. Only two negative betas were estimated for the model, referring to neuroticism impacting TPI and SDI. This means that slightly lower levels of neuroticism (lower anxiety, low hostility, no depression, minor self consciousness, lack of impulsivity, and not vulnerable), will favourably impact both team performance variables. The opposite goes for the other four FFM dimensions, meaning that higher levels of the interpersonal competencies in extraversion, openness, agreeableness, and conscientiousness, will improve both NPD e-business performance indexes. From these results, it can be interpreted that higher levels of the following interpersonal competencies will generally improve NPD e-business performance: warmth, gregariousness, assertiveness, activity/action, excitement seeking, positive emotions, fantasy, aesthetics (beauty), kind feelings/empathy, ideas, ethical values, agreeableness, straight-forwardness, altruism, compliance, and modesty.

In a comparative sense, most FFM dimensions produced more or less equal betas (statistically significant), except that as mentioned and expected from theory, neuroticism had negative levels, while SDS was about the same. The two exceptions were conscientiousness and projects.

Conscientiousness had at least twice the standardised beta as compared with the interpersonal competency dimensions, suggesting that competence, order, dutifulness, achievement striving, self discipline, and deliberation, were preferred traits of team members that obtained better NPD time performance and scope quality compliance. Finally, 'projects' generated positive betas twice the size of the largest FFM dimension (conscientiousness) on both performance variables (TPI 0.068, SDI 0.067). The interpretation of this high 'projects' is twofold. First, since this measures team familiarity between current individuals (how many projects they worked on together before this one), it suggests that working repeatedly together (in same team), when interpersonal competencies are 'normative', will successively improve performance. Secondly, this factor is strongly related to the FFM itself, and may be indirectly capturing some of the interpersonal competency effect on NPD team performance.

Figure 2 Interpersonal competency effect on NPD performance (see online version for colours)



Researchers may not often wish to report un-hypothesised results (Wacker, 1998), yet it was important to discover that the 'projects' factor (project team familiarity) captured the most effect on NPD performance. Although 'projects' is capturing different effects on TPI and SDI than the FFM + SDS predictors in this model, it is probable there is a latent (unobserved) relationship between these factors. Upon examining the residuals from the Mahalanobis lack-of-fit tests, as well as the high VIF for the 'projects' factor (TPI 2.8, SDI 2.9), this confirms interaction and multicollinearity of 'projects' with the FFM dimensions. This makes theoretical sense when considering the definition of these factors. In this study, 'projects' represents the number of times the subject stated they worked with their existing team members, on any project, in any organisation (not just the current one), without a time limit. These team members may have worked together recently and/or earlier in their career.

The theory underlying FFM is that personality traits are stable over time, while social desirability could vary slightly depending on national and/or organisational culture. Given the complex disconnected virtual context of NPD projects in e-business, it was argued that good interpersonal competencies are essential, as many of these people seldom work face-to-face. Thus, individuals with good 'normative' interpersonal competencies would likely work well together (effectively and efficiently), and wish to again work with one another, each time achieving adequate or slightly better performance on average (over a longitudinal period). Therefore, the latent effect would represent the fact that good interpersonal competencies actually improve e-business team relationships and workmanship, thereby improving results, while also increasing the likelihood these same individuals would choose to work together again on future NPD projects (or they may be appointed as a team again by management).

5.1 Limitations

The main limitation with intact sample groups is that this statistically significant model (for measuring interpersonal skills to select good NPD candidates) may not generalise to other e-business contexts. The current model is valid only for this sample, which reflects successfully completed projects (encompassing the first three phases of the NPD process), across the eight countries represented, in the telecommunications, marketing research, multi-line insurance or pension management industries. The mean team size of 3.3 was smaller than other NPD studies, such as a recent sample ($n = 64$, mean team size = 9) of Korean e-businesses (Park *et al.*, 2009). Additionally, other popular indicators of NPD performance were not analysed (as they were not available in the data), namely: Number of creative ideas and remuneration level (some staff may have received large salaries and/or performance bonuses that could have motivated creativity).

Furthermore, if a random sample were drawn from other industries, and/or if failed projects were included, it might produce different results. The sample data was captured before the 2008 global financial crises, which was such a significant event it could change the interpersonal competencies needed for future NPD e-business projects. For example, while the SDS was used to control for extreme levels of social desirability, and lower levels of neuroticism were found, future NPD e-business teams may need more of these traits. Additionally, project management methodology was not specifically controlled for nor was staff cognitive ability.

The final limitation is the 'projects' factor (repeat team experience) appears to latently 'interact' with the interpersonal competencies by capturing some of the performance effect. It is possible this latent factor captures cognitive ability and other critical dimensions noted above.

6 Conclusions and implications

The study commenced with the assertion that 'good' interpersonal competencies of team members collaborating on NPD in different e-business projects across several countries would predict 'good' performance. An interdisciplinary approach was taken to overcome the difficulties cited in the empirical literature for measuring these 'good' indicators and outcomes. The differences in this research, as compared to the typical empirical NPD e-business project management studies reviewed herein, amounted to focusing on the team members (instead of leaders), and capturing objective quantitative outcomes (not perceptions). Furthermore, the exaggeration (lying) on personality surveys was adequately screened using the SDS construct. Finally, a balanced macro-economic perspective was taken in measuring the effect – project level variables were chosen to assess interpersonal competency, but team as well as business unit data (plus individual demographics) were all thrown into the regression analysis – to serve as control.

Two *a priori* personality trait instruments were integrated to measure the team member interpersonal competencies, namely the Big Five (FFM) and Social Desirability Scale (SDS). Intact groups of NPD e-business teams were surveyed with the help of eight organisations that spanned eight countries (n = 1358). NEO5 and SDS instruments were validated using rigorous confirmatory ordinal factor analysis – which itself is an accomplishment worth reporting. The alpha reliabilities were significant for all five FFM dimensions and the SDS, but with slightly lower estimates than the US normative baseline, yet in line with other comparative international NPD and e-business studies. The interpersonal dimensions (neuroticism, extraversion, openness, agreeableness, and conscientiousness), plus social desirability (wanting to be normal), were able to predict the NPD performance variables of time performance index (adjusted $r^2 = 86.8\%$), and scope defects index (adjusted $r^2 = 80.9\%$). Numerous environment factors were included in the model analysis to ensure they were not confounding the impact, and deviations from hypotheses were explained. Care was taken to use NDP and team-related variables as a direct measure of performance. The result was that positive team work of 'repeat project experience' surfaced as the most significant predictor in the entire model – leading to the innoduction that team members having prominent agreeable, open, extraverted and conscientious interpersonal competencies will likely continue collaborating, and improve NPD e-business performance on future projects.

6.1 Implications

Business managers, sponsors and boards, are encouraged to leverage this research, and use instruments such as NEO5 (available in the literature), for selecting or auditing NPD team members. At least this study suggested the interpersonal competencies model worked well for predicting NPD e-business project time and quality performance, and the sample involved multicultural respondents from eight well-known countries.

This theoretical implication is intended to be innoductive reasoning (Creswell, 2003), which means the logic is from 'general factors' to 'general dependencies'. The rational ideology is stochastic (problematic), as compared to deterministic, because the proposed model includes unknown randomness (not every 'real world' factor is represented – such as staff cognitive or creative ability). This differs from the three other common research implications: Abductive interpolation (one-to-one detailed factor-variable patterns), deductive casual models or inductive sample-population inferences.

In answer to the rhetorical question of why did not someone do this before – personality instruments have been used, but in NPD e-business, project-level metrics are required to more accurately measure performance (and bias control is needed) – other studies have not done that. This project-level assessment makes sense as it is economically unlikely a specific new product ROI could be measured at the completion of the project cycle, as it would likely take years to see the portfolio or program level break-even point. Furthermore, it would be unfair to hold project leaders and NPD teams responsible for longer term business portfolio or program performance since the latter is the accountability of the board of directors and departmental management. Finally it is possible that NPD team members will exaggerate self-rated survey item responses so proper instruments and procedures are needed to identify and control bias.

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Appendix

Table 5 Confirmatory ordinal factor analysis

FFM	*Sub-scaled factors**	*Neuroticism*	*Extraversion*	*Openness*	*Agreeableness*	*Conscientiousness*
Neuroticism	Anxiety	*.69*	–.06	–.08	.03	–.03
	Angry hostility	*.30*	–.43	–.36	–.46	–.09
	Depression	*.48*	–.20	–.02	–.03	–.4
	Self consciousness	*.68*	–.20	–.15	.05	–.21
	Impulsivity	*.61*	.12	.14	–.21	–.21
	Vulnerability	*.43*	–.09	–.19	.02	–.20
Extraversion	Warmth	–.23	*.64*	.18	.22	.13
	Gregariousness	–.16	*.54*	–.07	.24	.01
	Assertiveness	–.42	*.58*	.13	–.31	.22
	Activity	–.17	*.55*	.08	–.23	.25
	Excitement seeking	–.13	*.62*	.21	–.03	–.02
	Positive emotions	–.26	*.72*	.20	.17	.14
Openness	Fantasy	.07	.25	*.72*	.00	–.10
	Aesthetics	.07	.16	*.73*	.09	.10
	Feelings	.10	.21	*.45*	–.01	–.01
	Actions	–.12	.21	*.70*	–.06	–.02
	Ideas	–.20	.06	*.77*	–.03	.18
	Values	–.22	.03	*.68*	.07	.00
Agreeableness	Agreeableness	–.15	.22	.15	*.63*	.09
	Straightforwardness	.03	–.15	–.11	*.65*	.07
	Altruism	–.10	.20	.20	*.57*	.22
	Compliance	–.03	–.02	–.25	*.63*	–.04
	Modesty	.24	–.21	–.07	*.48*	–.24
	Tender mindedness	.12	.19	.13	*.36*	.13
Conscientious	Competence	–.38	.17	.22	.07	*.73*
	Order	–.01	.01	–.12	–.13	*.77*
	Dutifulness	–.15	–.02	.23	.26	*.64*
	Achievement striving	–.13	.22	.09	–.09	*.72*
	Self discipline	–.32	.13	–.02	.02	*.75*
	Deliberation	–.24	–.09	.05	–.22	*.62*
Alpha reliability (this study)		0.62**	0.76**	0.72**	0.89**	0.77**
NEO5 Costa and McCrae (1992)		0.86	0.92	0.91	0.87	0.89
Social desirability reliability		0.71*** (this study)				
Representative benchmarks		0.77 (Sosik, 2005); 0.72 (Sarros *et al.*, 2005); 0.88 (Crowne and Marlowe, 1960)				

Notes: * $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

H1 accepted.