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Abstract

There is a critical need to better understand the nuances of decision making in today's global business environment. The quality of decisions is importantly influenced by the personality traits and knowledge of the decision makers. We analyze the effect of those factors on confidence and quality of decisions taken in the context of supply chain management. Personality traits are defined through the Big Five personality traits model which has recently gained widespread reception. The data was gathered via an experiment in which a group of participants played an online supply chain simulation game where several decisions needed to be made during a span of one week. The results show that confidence in decision positively affects decision quality. Neuroticism and agreeableness negatively affect confidence in decision, while self-reported knowledge positively affects confidence in decision. Further work includes running more experiments in order to gain more data for verification of results and testing of additional hypotheses which could not be tested on the current data sample.

Keywords: decision making, supply chain management, personality traits, decision confidence, decision quality, self-reported knowledge, objective knowledge, behavioral experiment.

1   Introduction

Supply chain management ('SCM') encompasses planning, implementing and controlling supply chain processes which often requires problem definition and proper decision making to solve those problems (Manuj and Sahin, 2011). Decision making in supply chains has been heavily studied and many methods in which to optimize certain parts of supply chains were developed. Thus, it is well known how companies make decisions on strategic and operational level (Steckel et al., 2004).

However, decision making/optimization in practice is not done by the companies but by individuals who use their own knowledge and utilize their available time to make each individual decision. The usual assumption in most optimization models is that individuals will follow the utility function of their organization; some behavioral elements (e.g. fatigue, preferences, maximizing personal benefits) were included in optimization models in the past (Bendoly et al., 2006, Croson et al., 2013). Still, human behavior in supply chain decision making is insufficiently explored, especially in complex decision situations (Brauner et al., 2013). There is a critical need to better understand the nuances of decision making (Knemeyer and Naylor, 2011).

The quality of these decisions is importantly influenced by the personality traits of the decision maker (Strohhecker and Größler, 2013). Although training can improve the orientation of supply chain personnel, recruiting employees who possess enduring personality traits that stimulate certain behavior will help a lot (Periatt et al., 2007). Thus, the purpose of this study is to investigate the influence of five basic dimensions of personality (extraversion, agreeableness, conscientiousness, neuroticism and openness personal traits) together with both self-reported and test-evaluated supply chain knowledge and time taken for each decision in structurally simple, yet dynamically complex SCM tasks. We analyze the effect of those factors on confidence and quality of decisions taken. This research-in-progress paper uses a behavioral experiment which represents a potentially valuable and currently underutilized approach for gaining insight into logistics and supply chain decision making that is commonly characterized by departures from rational thought (Knemeyer and Naylor, 2011). A laboratory situation identical for all participants allows controlling for factors otherwise beyond control, such as topicality and comparability of information (Strohhecker and Größler, 2013). We used an online simulation game environment to test our proposed structural equation model.

The structure of the paper is as follows. First the conceptual model is presented. Each of the hypotheses is theoretically grounded. The methodology of our research is presented and the details about how the game was executed are given. The hypotheses are statistically tested. Finally, the main findings are discussed and a clear path for our further research is outlined.

2   Conceptual model and hypotheses

We describe the variables used to build our structural model and provide a rationale for the pattern of relationships that is hypothesized to exist among these variables. We examine the impact of the five personality traits (extraversion, agreeableness, conscientiousness, neuroticism and openness), self-reported knowledge, measured knowledge and time taken on the confidence in the decision, which in turns, affect decision quality. Decision quality, time taken and confidence in decision are directly observed while the rest are all first-order exogenous variables.

Decision quality refers to both the process of decision making and the number of successful outcomes that may affect business. We focus on time taken to make the decision and confidence in the decision, both of which are considered gross surrogates to measure the process aspect of decision quality (Oz et al., 1993). Confidence in a decision is the level of belief of a decision maker about the desired outcome. It is the perception of an individual about the probability of success and acceptability of the decision. Several studies have tried to examine the relationship between confidence and decision quality. However, for supply chain domain this understanding is still limited (Knemeyer and Naylor,

2011). The impact of decisions in supply chain is substantial as a bad quality decision can even result in making a supplier bankrupt. This leads to our first hypothesis:

H1: Confidence in decision positively affects decision quality

2.1 Personality traits

The personality traits were defined via Big Five personality traits model which has recently gained widespread acceptance (Costa Jr and McCrae, 2013). The model defines five basic dimensions of personality: extraversion, agreeableness, conscientiousness, neuroticism and openness. The model was already successfully used in studies that were researching the correlation between personality traits and decision making styles (Rahaman, 2014, Riaz et al., 2012). In the next five subsections each of the five personality traits is briefly described together with the hypotheses.

2.1.1 Extraversion

Extraversion is defined as energetic, cheerful, and sociable, i.e. predisposed toward positive affect and preferring interpersonal interaction (Mooradian and Swan, 2006). Extraverts tend to be socially oriented such as outgoing and gregarious, but are also surging, such as dominant and ambitious, and active, such as adventuresome and assertive (Watson and Clark, 1997). Together with neuroticism and conscientiousness, extroversion appears to be most relevant to career success out of the big five personality traits (Judge et al., 1999). Extraversion is positively related to both rational and intuitive decision-making styles (Dalal and Brooks, 2013, Riaz et al., 2012). Extraversion is a direct predictor of self-confidence and is also a significant predictor of general confidence (Cheng and Furnham, 2002). Extroverts tend to perceive situations as more controllable and are therefore likely to be more proactive and aggressive in their decision making, which in turn leads to higher confidence in their actions (White et al., 2003). It is also important to note that interaction with others produces robust increases in decision confidence (Heath and Gonzalez, 1995). In addition to confidence, extraversion also significantly predicts overconfidence, which can be defined as a difference between confidence and accuracy (Schaefer et al., 2004). This leads to our second hypothesis:

H2   Extraversion positively affects confidence in decision

2.1.2 Agreeableness

Agreeableness is a prosocial trait which differentiates how people form interpersonal relationships and refers to humans that cooperate (John and Srivastava, 1999, John et al., 2008, Graziano and Tobin, 2009). It is shown via cooperation, sympathy, generosity, trust and modesty. Some opposite traits of agreeableness are cruelty and quarrelsome (Antoncic et al., 2014). People who are less agreeable tend to have interpersonal problems (John et al., 2008). Research has shown that people who are agreeable tend to perform better in teams (John et al., 2008). However, a trait of agreeableness is tender-mindedness (John et al., 2008). A person (decision maker in this case) who is tender minded tends to get influenced by other people and can doubt his/her own decisions. This tendency may lead to known decision biases and rationality shown by SC decision makers. Some examples of these decision biases are presentation, confirmation and availability cognition bias (Carter et al., 2007). All these biases can affect the rationality of the decision and may falter the confidence in the decision. Hence we propose our hypothesis:

H3   Agreeableness negatively affects confidence in decision

2.1.3 Conscientiousness

Conscientiousness describes socially prescribed impulse control that facilitates task and goal directed behavior, such as thinking before acting, delaying gratification, following norms (John et al., 2008). Conscientiousness people tend to be clean and tidy, work hard, follow the rules of society and social decorum, think before acting, and are organized (Jackson et al., 2010). Conscientiousness is

manifested in achievement orientation, dependability and orderliness. However, conscientiousness is not always good for well-being as even though that conscientious people tend to achieve more and have higher well-being, they also experience higher decrease in life satisfaction in the case of failure (Boyce et al., 2010). Research has also shown that conscientious managers will have harder time being promoted rather than their counterparts (Robertson et al., 2000). Conscientiousness greatly affects the decision accuracy, which is highest when both the leader and staff in a group are high on conscientiousness (LePine et al., 1997). Therefore our hypothesis is:

H4   Conscientiousness positively affects confidence in decision

2.1.4   Neuroticism

Neuroticism is the tendency to show poor emotional adjustment in the form of stress, anxiety, and depression (Judge and Ilies, 2002). In several studies, individuals high in neuroticism were more likely than those low in neuroticism to choose to increase their level of worry, as indicated by self-reported preferences and also by behavioral choices in experimental settings (Tamir, 2005). Presumably, people who are more neurotic may be more likely to avoid engaging in decision-making tasks because they doubt their abilities and feel vulnerable to stress (Wang et al., 2006). Risk taking overall was negatively associated with neuroticism (Lauriola and Levin, 2001, Nicholson et al., 2005). Individuals with high neuroticism are prone to experience negative affective states such as fear, anxiety, anger, guilt, and disgust (Denburg et al., 2009). Individuals who score highly on neuroticism may be afraid of the consequences of their decisions (Hirsh and Peterson, 2009). Those who report low levels of neuroticism tend to be emotionally stable, do not become preoccupied with minor perturbations, and feel self-assured (Denburg et al., 2009). Similar findings were reported in SCM settings: neuroticism consistently negatively predicts work-related performance to a comparatively large extent as shown by the inventory management study (Strohhecker and Größler, 2013) while another study (McMahon et al., 2013) found that inventory specialists score considerably higher on neuroticism than the general population. Again, these findings can be related to the type of work: e.g. neuroticism does not affect the performance of customer-oriented SCM personnel (Periatt et al., 2007). This leads to our next hypothesis:

H5   Neuroticism negatively affects confidence in decision

2.1.5   Openness

Openness assesses an individual's proactive seeking and appreciation of experience for its own sake, toleration for, and exploration of the unfamiliar. The higher scorers tend to be curious, creative, original, imaginative, and untraditional (Lin, 2010). Individuals who exhibit openness are considered innovative, adventurous and unusual in their ways. They show high levels of intellect and creativity and get bored of the same routine (John et al., 2008). Interestingly, Strohhecker et al. (2013), found negative effect of openness trait on inventory management performance mainly because a task related to inventory management might seem too boring or not challenging enough to such individuals. Openness to Experience is significantly correlated with risk-taking for gains (Lauriola and Levin, 2001). Further, people who take good business decisions (related to start-ups) score high on openness (Antoncic et al., 2014). People who are higher on openness to experience are posited to be better suited to adapt to the more dynamic environments and should be more flexible and adaptable as well as more creative and innovative (Colbert et al., 2014). This leads us to our next hypothesis:

H6   Openness positively affects confidence in decision

2.2   Supply chain knowledge

Four different components of knowledge are: knowledge of facts, knowledge of meaning, integration of knowledge, and application of knowledge (Hailikari et al., 2007). The first two components are declarative knowledge while the last two are procedural knowledge. Declarative knowledge is the accumulation of facts and concepts that come to the surface by recognition or reproduction (Dochy,

1992). Anderson (Anderson, 1990) defines declarative knowledge as "knowing that", and procedural knowledge as "knowing how". For the purposes of our research the measure of declarative knowledge was conducted since we needed to assess the factual and conceptual knowledge that the students had before playing the game.

We wanted to test how the declarative knowledge of supply chain topics affects the confidence in decisions and their quality. Supply chain knowledge is considered a tool for supply chain integration (Marra et al., 2012). Knowledge about a specific topic can create a cognitive bias towards over dependence on prior knowledge in arriving at decisions (Dietrich, 2010) and can therefore negatively affect the final outcome of the decision. In this context it is also important to distinguish between self-reported knowledge and test-based (objective) knowledge of the decision makers, since the two types of knowledge affect the entire decision process, from attribute selection through search to perceived decision outcomes, and are likely to have different effects on the decision process (Raju et al., 1995). Therefore we decided to separately test the objective and self-reported knowledge.

Since supply chain management is an interdisciplinary field the managers in supply chains should be experts in a wide variety of fields composed of general knowledge, supply chain related knowledge and knowledge related to competencies and skills (Mangan and Christopher, 2005), for example supply chain management, transportation and logistics, business ethics and production management (Murphy and Poist, 2007). There is a lack of relevant research in decision confidence related to prior knowledge in the field of SCM; therefore there is an urgent need to study the effect of self-reported and actual knowledge on performance.

When assessing specific knowledge or a specific body of information, a recognition measure such as a paper-and-pencil recognition test of topical knowledge is sufficient as opposed to an oral interview (Valencia et al., 1991). Dochy et al. (Dochy et al., 1999) identified six types of assessment methods that have been used in previous studies: multiple choice tests, open questions/completion tests, association tests, recognition tests, free recall and self-assessment. Multiple forms of assessment should be used in order to capture the phenomenon of prior knowledge more completely (Valencia et al., 1991).

Therefore we propose next two hypotheses:

H7   Self-reported SC knowledge positively affects confidence in decision

H8   Test-based SC knowledge positively affects confidence in decision

2.3   Time to make a decision

One of the important elements of each decision is also the time it takes for the decision to be made. The less time the decision maker has the more compromises they need to make. The compromises can be in a form of their performance which in most times gets worse with less time or decision strategy which is adapted to the limited time resource (Hwang, 1994). We decided not to limit the time for each of the decisions to allow for thorough reasoning (Strohhecker and Größler, 2013). Therefore our last hypothesis is:

H9   Time taken to make decision positively affects confidence in decision

3   Methodology: Game and Data

Behavioral experiments represent a potentially valuable and currently underutilized approach for gaining insight into logistics and SC decision-making (Knemeyer and Naylor, 2011). A deeper understanding of behavioral issues should enable firms to make better decisions and operate more efficiently (Croson et al., 2013). The participants in the experiment played the Supply Chain Game (Responsive Learning Technologies, 2015), which simulates the decision making in supply chain operations. The participants had to manage the supply chain for a company producing one product for the next two years. The game has four different parameters that participants could decide to change

(the game settings allow for these and no other parameters to be used): 1) capacity additions to the existing factory; 2) reorder point; 3) the factory's production batch size; and 4) type of transport. Five days before the start of the simulation the participants were provided with a detailed case that included the market analysis, information on operations of the company and two years of historical data (demand, satisfied demand, lost demand, all transportation activities, start/end of batch production, and capacity changes in factory). Participants started with a set amount of money. The simulation was accessible online via a web browser and ran for seven days without pause. The participants could change the parameters at any given time and any number of times. The participant with largest amount of money at the end won the game. A leaderboard was shown throughout the entire simulation so the participants could see their scores relative to others.

The experiment was run on a group of masters' students in an SCM course. Masters students are relatively easily accessible compared with working professionals, had course work in SCM and some of them had work experience. While a group of supply chain professionals would be preferable for such kind of an experiment, the described group of students is an adequate replacement (Knemeyer and Naylor, 2011). Participants were assumed to be appropriate approximation for real-world decision makers in terms of personality and education/knowledge except for experience that real-world managers have (following (Strohhecker and Größler, 2013)).

Qualitative and quantitative data from 29 participants (15 males, 14 females) comprising of 629 decisions were collected. 133 decisions had missing data or justifications and were excluded from further analysis. Thus, a total of 496 decisions were analyzed. As a first step, decisions were separated into two categories: 1) major decisions, which had a major impact on student results; and 2) minor decisions, which had low or no impact on participant results where 370 were major decisions and 125 were minor decisions. Only major decisions were included in the analysis. Reverses scored items were recoded before the analysis.

After the game the participants submitted their reports. The report included data description and timestamp (simulation day) of each decision; justification of each decision and possible alternatives (could be qualitative, quantitative or both); self-confidence in each decision on Likert scale from 1 to 5; time taken for each decision (in minutes); current position on the leader board.

Prior to the game, personality traits of participants were measured using the big five personality traits model (John et al., 2008). We used both the tests for direct assessment of knowledge and self-assessment tests. Participants reported their perception of SCM knowledge (self-reported SCM knowledge) using a 1-5 Likert scale with four questions. The participants also had to take an exam consisting of 10 questions, which were graded by their instructor. The students were tested for specific SCM knowledge that related directly to the contents of the game, such as: demand planning, Economic order quantity model, inventory costs, marginal costs, stock out and lead times. Scores from this exam were used to measure tested SCM knowledge construct.

During the game, three variables were measured: 1) confidence in decision, 2) decision quality, and 3) time taken by a participant to make the decision. To measure the decision quality on a scale of 1 to 5 three steps were carried out. As a second step, the quality of each decision was evaluated by the instructor (on a Likert scale of 1 to 5 with 1 being the lowest and 5 being the highest).

4   Hypothesis testing results

The data was analyzed using IBM SPSS v20 and AMOS. Firstly, reliability was assessed by the criterion of Cronbach's alpha being larger than 0.7 (Chin, 1998). Values of all variables have reliabilities that exceed 0.7, except for Conscientiousness. Several studies face issues with conscientiousness e.g. Judge and Ilies (Judge and Ilies, 2002) struggle with validity, while others (Strohhecker and Größler, 2013) report inconsistent effect sizes. In our case, conscientiousness had a reliability of 0.57 (minimum acceptable is 0.60 as per (Nunnally, 1978)).

Secondly, convergent validity was assessed by three-point criteria (Hair et al., 2006): (1) item loadings (lambda) greater than 0.5 at least and ideally greater than 0.7; (2) variance extracted on average (AVE) greater than 0.5; and (3) construct reliability exceeding 0.7. Next, discriminant validity was assessed by the criterion stating that the correlation of a construct with other constructs must be smaller than the square root of AVE (Fornell and Larcker, 1981). Further, factor analysis using principal component analysis was performed and each factor confirmed only one component extraction when checked individually except for openness. Several studies have reported that openness to experience (for example (Lev et al., 2008, Meyer and Purvanova)) lacks internal consistencies and is 'less robust' owing to its internal theoretical structure. This can explain why our measurement model of openness could not be verified. Both these factors were not retained for further analysis and thus, H4 and H6 could not be tested. The measurement and structural model were then run on AMOS and showed a good model fit. The tested model and path coefficients are shown in Figure 2.
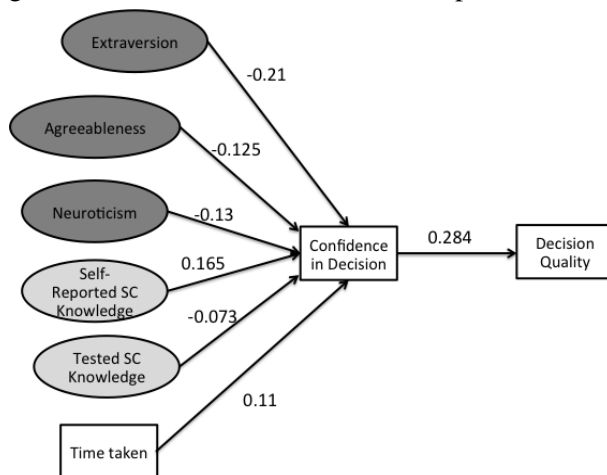

Figure 2.   Tested Model and Path Coefficients

Results are summarized in Table 1.

	Hypothesis		Results
H1	Confidence in decision positively affects decision quality	Accepted	Path Coefficient = 0.284; p value < 0.05
H2	*Extraversion positively affects confidence in decision*	*Rejected*	*Opposite sign than hypothesized; Path Coefficient = -0.21; p value < 0.05*
H3	Agreeableness negatively affects confidence in decision	Accepted	Path Coefficient = -0.125; p value < 0.05
H4	*Conscientiousness positively affects confidence in decision*	*Not Tested*	
H5	Neuroticism negatively affects confidence in decision	Accepted	Path Coefficient = -0.13; p value < 0.05
H6	*Openness positively affects confidence in decision*	*Not Tested*	
H7	Self-reported SC knowledge positively affects confidence in decision	Accepted	Path Coefficient = 0.165; p value < 0.05
H8	*Test-based SC knowledge positively affects confidence in decision*	*Rejected*	*Opposite sign than hypothesized; Path Coefficient = -0.073; p value < 0.05*
H9	Time taken to make decision positively affects confidence in decision	Accepted	Path Coefficient = 0.11; p value < 0.05

Table 1.   Hypothesis testing results.

5   Discussion and Conclusion

Several interesting implications can be derived from our initial results. More confidence from the decision maker positively affects the quality of decisions. For H2, interestingly, it seems that extroverts have lower confidence. This can be also attributed to the nature of the experiment (every student was working for him- or her-self, no cooperation allowed) which meant that the extroverts could not gain extra confidence level in their decision making process, because they need external confirmation (Heath and Gonzalez, 1995).

For H3, as expected, individuals who are agreeable in nature have less confidence in their decisions. Perhaps they get undecided and tend to doubt their decision, which makes them lose their decision confidence. For H5, neurotic individuals have less confidence. Our findings are contrary to the findings of (Periatt et al., 2007) that neuroticism does not affect the performance/confidence of customer-oriented SCM personnel. However, as hypothesized, this can be attributed to the mental state of stress, anxiety or depression that affects the quality of decisions by hampering the confidence in these decisions. Self-reported knowledge about the SCM helps in boosting the confidence of the decision maker. This makes sense as when a person perceives he/she has knowledge it helps them improve their confidence kind of like the mantra that if you 'believe' you know it, you 'feel' confident.

For H8, contrary to our hypothesis, results show that test-based knowledge negatively affects confidence. The more the participant 'really' knows about the SCM, the less confident he or she is. A possible explanation could be that more knowledge can possibly confuse the decision maker. To summarize H7 and H8 findings, the more one 'thinks' he or she knows, the more confident he or she is. However, the more he 'really' knows, the less confident he is. Finally, time taken to take the decision affects the confidence in the decision and hence a better decision. This also means that individuals who take more time to make a decision actually feel confident due to the reason that they believe they have evaluated each alternative in detail. Our work can make important contribution to the supply chain and decision making fields. We show that it is important to analyze the personality type of the candidates for SCM decision making positions as these traits can affect the confidence and hence the quality of the decisions. Extraverts do not seem to be good quality decision makers but this conclusion should be considered with caution due to the setup environment of our SCM game experiment. Future SCM game experiments should be carried with and without allowing individuals to talk to each other. Our case was a very particular case of decision making with individual decisions; in a company, many decisions are team-based. Extroverts may have an advantage there as it is easier for them to convince others albeit their decisions may not be really better (Cain, 2013).

Since neurotics have less confidence and make bad quality decisions, self-assured and less agreeable individuals who are not depressed are considered good candidates for decision making tasks. Enough time should be provided to the decision as hurried decisions may not good quality decisions.

Our work has several limitations: the sample has been small and included solely the masters' students. Our further work on this topic thus includes additional experiments with new groups of students. With new experiments we will gain more data in order to verify our initial findings. The way in which decisions are made in fictional (game) setting can be very different to real world since some of the participants might display slightly different personality traits compared to real life. In addition to the quantitative analysis, a qualitative analysis of results and student responses is also planned.

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