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Chapter 2

Partners Behavior in Virtual Organization Breeding Environments

This chapter contains the material of the following paper, which has won the best PhD student award:

- Shadi, M. and Afsarmanesh, H. (2011). Addressing behavior in collaborative networks. In *Adaptation and Value Creating Collaborative Networks, 12th IFIP WG 5.5 Working Conference on Virtual Enterprises (PRO-VE)* (pp. 263-270). Springer.

2.1 Introduction

In the light of advances in telecommunication and information technology, nowadays, organizations can interact and communicate with each other, and co-work with no customary time or location limitation. Collaborative networks, such as global supply chains, aid industries in manufacturing and delivering products to markets with proper quality and efficiency. A Collaborative Network (CN) is composed of a variety of independent entities, organizations and individuals, with geographical distribution, and heterogeneity in their working environment, culture, social capital, and objectives, which are supported by computer network, and cooperate and interact to effectively attain common or compatible goals [22].

With respect to the collaboration and the network features as well as considering the intricacy of CNs, the ARCON (A Reference model for Collaborative Networks) modeling framework is developed in [20], within which the CN's characteristic are divided into two subsets of the internal elements characteristics of CNs, namely "Endogenous Elements (Endo-E)", and the external interactions characteristics, namely "Exogenous Interaction (Exo-I)". The Endo-E subset is taken into account from four perspectives, i.e. structural, componential, functional and behavioral. Among these, the behavioral perspective has been rarely studied in the CNs-related literature, however if it becomes possible to analyze,

model, and predict the organizations' behaviors, many conflicts and difficulties in CNs could have been resolved and ultimate productivity of organizations/individuals at the CNs would have been drastically improved [80]. Due to the impressive number of both human and organizational behavioral factors found in analyzed reports, an assumption can be made that probably most partnership failures and successes are strongly related to, if not caused by, the behavioral factors of the involved partners. A number of behavioral factors are identified as strongly influencing the success of partnerships, including: good communication, decision making by consensus, encouraging creativity, fairness, flexibility, best use of interests, knowledge sharing, creating joy in working together, visible leadership, collaboration readiness, open and honest participation, promoting willingness to commit resources and capabilities, development of social skills, transparency in provision of information, etc. Moreover, partners' behavioral factors have a vital influence on establishing the needed trust relationship with other partners, while individual collaborative behavior can be motivated through creation of some incentives and rewarding models and mechanisms as a part of the CN's governance model [80].

Modeling and predicting the behavior of CN's members are necessary factors for measuring the success and failure potential of CNs. Obviously, the purpose of modeling and analyzing the individual behavior may target other specific objectives. These objectives may include identification or prediction of conflicts, selecting the best-fit members to create a new VO, better role and right assignment in CNs, and effective membership structure management, among others.

There are some personality models introduced to describe the relationship among humans' personality, and their traits (see [31] and [67]). Based on and adapting some information extracted from these models, we have proposed a new approach to model and estimate the organizations' behavior in a VBE. In other words, the individual organization's collaborative behavior is defined based on its personality and compared with others' behavior who are involved in a VBE. For measuring an organization's behavior within the VBE, four specific quality-behavioral dimensions are considered, including: integrity, courage, agreeableness, and openness, which are then each modeled through a set of its traits. A quantitative causal approach is then defined to inter-relate some known factors from the environment with the traits of these four behavioral dimensions. The results are further used to measure each organization's level of Individual Collaborative Behavior (ICB) within the VBE, in comparison to all others. Formulas are derived from these quantitative causal relationships, for computing the collaborative behavior degree for each organization. This measure constitutes one criterion in our proposed approach for evaluating collaborative trustworthiness of the organization (see Chapter 3), as needed to be measured during the VO operation phase.

This Chapter is organized as follows: in Section 2 some works related to behavior capturing and personality models are presented. Section 3 addresses

how we model, and measure the individual collaborative behavior of organizations in the VBE, and finally in Section 4 some conclusive remarks are drawn.

2.2 Related Work

2.2.1 Behavior Capturing

The behavior intuitively implies the actions exposed by a human or animal. However, this definition is changed based on the field to which it is applied. In business area, it is defined as a reaction of an individual or a group to an action, an environment, or a person [17], while in psychology, it is characterized based on the personality profile of a person [34]. In our research, we adopt the personality-based definition for organization's behavior, i.e. an organization's behavior in a CN is characterized by its personality profile. Based on the literature, two kinds of behavior, proactive and reactive can be observed [34]. Although, the internal states of a human mind, such as emotions, and feelings can trigger a behavior, these states themselves are not considered as behavior.

The intentions behind the behavior modeling determine which approach is more suitable to be followed. For example, in CNs, the organization behavior model is essential for controlling, supervising, performing assignments, following regulations, or predicting the future action/reaction. This means that a specific model of behavior is needed for each of these intentions. In [59], some approaches for behavior modeling, like probabilistic models, roles assignments, rules-based models, qualitative modeling, and neural networks are discussed.

Suitable approaches for comparing the behavior of organizations involved in VOs are rarely studied. However, in [80], the collaboration readiness of organizations are assessed based on hard and soft competencies. To assess the level of soft competencies, the observed level of several organizations' traits as well as recommendations from trustworthy advisers about those organizations' traits are taken into account. The organization's traits are rooted in Chun's model [31]. In the model introduced in [80], the hard and soft competencies measured for an organization is compared with the hard and soft competencies required for a new opportunity, for which a VO is formed.

We define the organization's personality as the total of its qualities and traits, and propose a new approach defining the causal relationships among the organization's personality, some behavioral dimensions, and their related traits. A central perspective behind this research is behavior prediction and estimation, which can be associated either to the repetition of behavioral patterns, or to the repetitive occurrence of behavioral traits in an organization's behavior. In other words, when some traits are regularly repeated, it is foreseen that they may persist in the future as well. With this rule, predicting the behavior of an entity, whether it is a human, animal or even an inanimate object would be possible.

On the other hand, each behavioral pattern is specified by its related characteristics, which in turn correspond to the behavioral dimensions of the personality models addressed later in more details. Behavior prediction can be performed using personality profile; in other words, when consider knowing an organization's personality in a CN, it is possible to predict its behavior in the future.

2.2.2 Personality Models

The focus of our approach is on the concept of personality. At its origin, this corresponds to the totality of a person's behavioral traits, history, reputation in community, and values [34]. The most relevant psychological theory is the Traits Theory in which a set of psychological traits explains the individual personality. Based on this theory, the future behavior prediction for an individual is possible, using its personality profile [82]. Personality models reviewed in the literature are composed of some dimensions, where each dimension contains several traits. A number of personality models are introduced in the literature, such as:

- Big-Five model - composed of Openness, Conscientiousness, Extraversion, Agreeableness, and Emotional stability [66].
- MBTI (Myers-Briggs Type Indicator) model - that includes Extraversion/Introversion; Sensing/Intuition, Thinking/Feeling; and Judging/Perceiving [71].
- OCI (Organizational Character Index) model - composed of similar dimensions to MBTI, but they are applied to organizations [16].
- Chun's ethical character scale of organizations - that includes Integrity, Empathy, Courage, Warmth, Zeal, and Conscientiousness [31].

Each of the factors in Big-Five model displays a mass of traits correlated together [67], as Table 2.1 shows. The big-five is not intrinsically a theory of personality, rather it is a model of personality based on nearly a half-century of research. Although it is not a theory in itself, the model has generated several trait theories.

Similar to human behavior modeling, the organization's personality can also be specified as the aggregation of several behavioral dimensions, such as openness, conscientiousness, etc. A behavioral dimension in fact, is defined as a super trait. The reason of sorting the traits into dimensions is the fact that some traits are correlated with each other together composing a more intangible behavioral characteristic. For example, there are correlations among creativity, curiosity, being insightful, and being intellectual, which bundles them together and being referred to as the openness super trait (behavioral dimension) [67]. Based on [31], organization's personality profile is aligned with behavioral dimensions, including Integrity, Empathy, Courage, Warmth, Zeal, and Conscientiousness (see Table 2.1).

Personality Model	Behavioral Dimension
Big-five	Conscientiousness
	Extroversion
	Agreeableness
	Emotional Stability
	Openness to experience
Chun's model	Integrity
	Empathy
	Courage
	Warmth
	Zeal
	Conscientiousness

Table 2.1: Behavioral dimensions of big-five model [67], and Chun's model [31].

We propose a new hierarchical model for estimation of Individual Collaborative Behavior (ICB) of each organization in the VBE, in which integrity and courage from Chun's model, and openness and agreeableness from [67] are adopted as the behavioral dimensions.

2.3 Behavior Modeling

For modeling of organizations' behavior, we intend to define the behavior of an organization as an entity in a VO. In general, each organization (or person) involved in a VO interacts with other VO partners to achieve common or compatible goals. Several reactions, proactive actions, and traits are observed during organization's interaction with the environment and the other partners of the VO. We define the totality of an organization's qualities and traits as its Individual Collaborative Behavior (ICB). This definition is similar to personality's definition for humans discussed in [17].

Based on the literature related to the personality models, there is a relationship between humans/organizations' personality, and their traits. Traits of an organization are its tendencies to act in a particular way. Traits can be determined as a pre-specified set, which are related to the representation of behavioral patterns appeared regularly or repeatedly [31]. Reliability, adaptability, empathy, and creativity are examples of such traits. It is critical to differentiate behavioral patterns from traits. A behavioral pattern indicates concealed characteristics perceived in the organizations' behaviors, while a trait is related to the display of habitual behavioral patterns. The former is used to distinguish different behaviors, while the latter is used to distinguish different organizations, which is the main goal of our work [80].

We propose a new approach to estimate the organization's behavior in the VBE, which consists of two steps. The **first step** is to identify, define and inter-

relate all elements that have vital roles in organization's behavior modeling and behavior prediction. The interrelation arrangement that we propose is done based on the measuring level of each element. As Figure 2.1 illustrates, our structured hierarchy to estimate the individual collaborative behavior of an organization in VBE, consists of five levels:

- **Targets** are the reasons for which ICB of an organization is estimated. Two targets are considered in this thesis. The first target is to use ICB of an organization as a criterion in evaluation of its behavioral trustworthiness. The second target is to use ICB of organizations in selection of the best-partner from the VBE to reassign some currently at risk tasks, which is only when there is no capable partner in the current VO to take over and perform the task. Each target is then characterized by a set of behavioral dimensions.
- **Behavioral dimensions** are defined as super traits for organizations involved in the VO. We determine four specific behavioral dimensions, i.e. **integrity**, **courage**, **agreeableness**, and **openness to new experience**. Each behavioral dimension is characterized further by some traits.
- **Traits** are tendencies of an organization to act in a particular way, such as honesty, cooperativeness, pro-activity, etc. Each trait is characterized by a set of known factors.
- **Known factors** include some sub-traits and actions related to the organizations in the VBE, as shown in details in Table 2.2. Each known factor, such as truthfulness, problem avoidance, etc. is then attributed to a number of measurable metrics.
- **Metrics** are measurable scales for known factors, as exemplified in Table 2.2.

In the hierarchy shown in Figure 2.1, the leaves (Metrics) are measurable, while the root is highly abstract.

The **second step** is to analyze the impact of changes in the values of measurable elements on the organization's behavior as a whole. We propose that the behavior of an organization can be evaluated through four behavioral dimensions that we defined in the first step, i.e. **integrity**, **courage**, **openness**, and **agreeableness**, which are adopted from [31] and [67]. We have investigated into the literature to specify the traits that influence these behavioral dimensions, however, in [31] and [67], some correlated traits are introduced for each behavioral dimension. We also specify known factors that influence these traits, while their metrics are determined using the suggestions of experts in Virtual Organization management (see Table 2.2). Causal analysis is applied to analyze influence of inter-relationships between different factors in an environment. Keywords such

Known factors	Metrics
Business Success (BS)	The number of successful years in business with the VBE (# of years)
Capability (CP)	The number of offered services by an organization (# of services)
Communication Rate (CMR)	The ratio of successful contacts established with other partners ($0 \leq \# \leq 1$)
Conflict Resolution (CR)	The number of situations in which constructive suggestions are offered by an organization to solve problems in the VBE (# of situations)
Current Responsibility (CB)	The number of responsibilities currently accepted by an organization in the VBE (# of responsibilities)
Employee Size (ES)	The number of employees of an organization (# of employees)
Fairness (FA)	The number of times an organization agrees with certain benefits distribution, which also complies with consortium majority (# of times)
Flexibility ability (FT)	The ratio of accepted adaptations to new required plans ($0 \leq \# \leq 1$)
Intolerance to Stress (IS)	The number of past responsibilities that an organization pulled out before performing them (# of responsibilities)
Inventiveness (II)	The number of patents/awards in the last five years (# of patents)
Leadership Ability (LA)	The ratio of successful administrative and management roles ($0 \leq \# \leq 1$)
Not Fulfilling (NF)	The number of an organization's past responsibilities, which were not fulfilled (# of responsibilities)
Others' fault Compensation (FC)	The number of times that an organization (which has delayed providing its commitment on time) compensates another organization for the caused damages (# of times)
Past Responsibilities (PR)	The number of an accepted organization's past responsibilities to perform tasks (# of responsibilities)
Pro-activity ability (PT)	The number of new opportunities brought into the VBE by the organization (# of opportunities)
Problem Avoidance (PA)	The number of critical situations in which the provided reaction time by an organization is below the threshold (# of situations)
Punctuality (PN)	The average number of times that an organization does not have delay in its product delivery, or in fulfilling its responsibilities ($0 \leq \# \leq 1$)
Resource Size (RS)	The number of resources that is shared by an organization (# of resources)
Truthfulness (TR)	The ratio of true claims made by an organization about other organizations' services or behavior ($0 \leq \# \leq 1$)
Volunteering (VE)	The number of situations in which a responsibility is voluntarily committed & fulfilled by an organization, to assist with handling exceptions that rise in the VBE (# of situations)

Table 2.2: Examples of known factors and their related metrics about organizations in VOs.

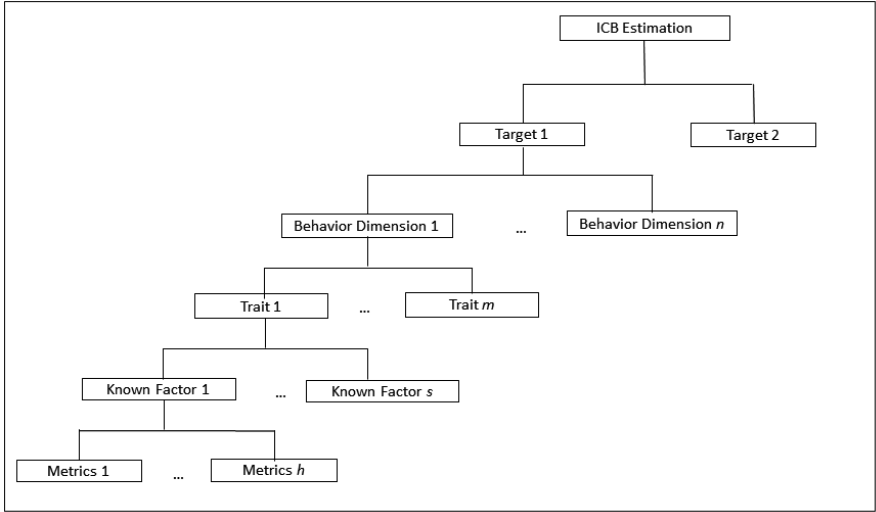


Figure 2.1: The proposed model for organization’s individual collaborative behavior (ICB).

as *leads to*, *influences*, and *if-then*, etc. implies causal relationships between two elements [52]. For example, in [73], it is mentioned that being fair leads to being honest. Table 2.3 shows the definitions of behavioral dimensions and its related traits in our proposed model.

Based on the defined causal relationships, some formulas are derived for measuring the scores of behavioral dimensions, and then the comparative score of ICB is measured for each organization member in the VBE, based on its scores for the four planned behavioral dimensions, as discussed later in Section 2.3.2.

But clearly, the behavior of an organization cannot be represented by an absolute value. Rather, in our approach, we can compare one organization’s personality, and collaborative behavior against another. In other words, to assess the organizations’ ICB(s), we compute the relative score for each behavioral dimension for each organization through comparing the measured value of the applied behavioral dimension against the optimal value of that dimension among all participated organizations. It means that when a partner leaves the VO, then the optimal value for each behavioral dimension may change. The same situation is also the case when a new partner joins the collaboration. This shows that the levels assigned to each organization’s behavior depend on the group of currently involved organization at the time of computation.

Behavioral Dimension	Super Trait Description	Traits	Trait Description	known factors
Integrity	"It is defined as a reputation for trustfulness and honesty of the trusted person" [18].	Honesty	Honesty means the quality of being fair and truthful ¹ .	Truthfulness Others' Fault Compen- sation Fairness
		Trustworthiness	Trustworthiness is the quality of a person or a thing that inspires reliability ¹ .	Past Responsibilities Not Fulfilling Communication's Rate Punctuality
Courage	"It is defined as success in achieving the desired outcome and effort by the agent" [51]. Leading, and competent are positively related to courage [31].	Leading Rate	Leading means providing direction or guidance ¹ .	Leadership Ability Current Responsibility Business Success
		Competence	Competence means having the necessary ability or skills to do something well ¹ .	Capability Employee Size Resource Size
Agreeableness	Being warm and supportive indicates the person's agreeableness [67]. Being compassionate and cooperative are also related to agreeableness [95].	Cooperativeness	This is marked as a willingness and ability to work with others, and motivating colleagues ¹ .	Past Responsibilities Not Fulfilling Intolerance to stress Others' Fault Compen- sation Fairness
		Supportive	Supportive means providing additional help, and information to others ¹ .	Problem Avoidance Volunteering Conflict Resolution
Openness to experience	Those jobs that need creativity and flexibility require high openness [67]. One would expect openness to experience to relate positively to pro-activity [12].	Flexibility	Flexible means easily changed or able to change, or to do different things ¹ .	Flexibility Ability
		Pro-activity	"Pro-active personality describes the differences between individuals in the extent to which they identify opportunities" [12].	Pro-activity Ability
		Creativity	Being creative means having or showing an ability to make new things or think of new ideas ¹ .	Inventiveness

Table 2.3: The elements of proposed model for individual collaborative behavior.

2.3.1 Causal Analysis

A causal diagram is composed of some nodes and links, which relate the nodes together. These causal links (arrows) are accompanied by a sign either positive or negative (+ or -). The positive causal link from A to B shows that a change in A leads to a change in B in the same direction, while the negative causal link from A to B means that a change in A generates a change in B in the opposite direction.

To visualize a system's structure and behavior, causal diagrams can be employed. Causal diagrams can be converted into a stock and flow diagram, for quantitative analysis. In other words, analyzing a system in a quantitative way is done in our approach through the stock and flow model in system dynamics modeling [60].

Any entity that accumulates or diminishes over time is considered as a stock, while the rate of change in a stock represents a flow. Typically, the flows are assumed to be continuous, however many relations /processes cannot be built upon the assumption of continuous flow. The reason behind an assumption is that it will produce fairly precise results, and also in this way the development and solution of the model is substantially simplified. Additionally based on our experience, even when the quantities under consideration are small, it is adequate for practical analysis to treat them as being continuous.

There are two kinds of flows in a system dynamics stock and flow structure: an inflow and an outflow. The quantity of a stock at time t equals to the initial value of the stock at time $t = 0$, plus the integral of flows into the stock, minus the flows out of the stock [60].

2.3.2 Measurement Development

The score of a behavioral dimension at time t is calculated from the sum of the integrals of its flows, i.e. its traits. The equations for traits are derived from the causal relations among them and some known factors mentioned in Table 2.2. Based on the rules of system dynamics [60], the plus sign (+) in the causal links between known factors and traits (flows) corresponds to either addition or multiplication, while the minus sign (-) corresponds to either subtraction or division. The semantics of traits and the metrics of the known factors, shown in Table 2.2 determine which operation (e.g. between the addition and multiplication) should be conducted for each of the signs [60]. The details of formulas, for the four behavioral dimensions in our approach, are discussed in the following paragraphs, which show how we can find a comparative value for an organization's individual collaborative behavior.

¹Merriam-Webster Dictionary

Agreeableness (AG)

Being warm, friendly and tactful indicates the person's agreeableness. Being compassionate and cooperative are also related to agreeableness. In jobs that need patience and friendly behavior with people, like in sales, having high agreeableness is an advantage [67]. Applying this behavioral dimension to organizations, in Figure 2.2, we have specified two traits (see also Table 2.3) that have causal relationship with agreeableness, i.e. cooperativeness and proactively supportive. Furthermore, a set of known factors are defined for each of these traits. The metrics of these defined known factors are shown in Table 2.2. The relations among agreeableness as a behavioral dimension, its traits and known factors are shown in Figure 2.2.

The equation relating VE (volunteering), PA (problem avoidance), and CR (conflict resolution) to SP (proactively supportive) is derived from their causal relationships as follows. Notice that all the signs for SP in the causal diagram are positive and based on the Table 2.2, the units of these known factors are the same, so the addition operator is selected:

$$SP = VE + PA + CR \quad (2.1)$$

Similarly, the equation relating PR (past responsibility), NF (not fulfilling), IS (intolerance to stress), FA (fairness), and FC (others' faults compensations) to CO (cooperativeness), derived from the causal relationships is as follows (see Table 2.2 for units of known factors and see the related signs in Figure 2.2):

$$CO = (PR - NF - IS) * (FA + FC) \quad (2.2)$$

Considering Figure 2.2, proactively supportive and cooperativeness are inflows for the agreeableness as a stock. Therefore, the accumulation of values of flows (traits) over time for the stock (behavioral dimension) is captured based on the integral calculus [60]. This integration process measures the accumulation of the behavioral dimension from time t_1 to t_2 , as shown below for "agreeableness":

$$\begin{aligned} \frac{d}{dt}AG &= SP + CO \\ \int_{t_1}^{t_2} d AG &= \int_{t_1}^{t_2} SP dt + \int_{t_1}^{t_2} CO dt \\ AG(t_2) &= \int_{t_1}^{t_2} (VE + PA + CR) dt + \int_{t_1}^{t_2} (PR - NF - IS) * (FA + FC) dt + AG(t_1) \end{aligned} \quad (2.3)$$

It should be noticed that SP and CO are continuous in respect to time.

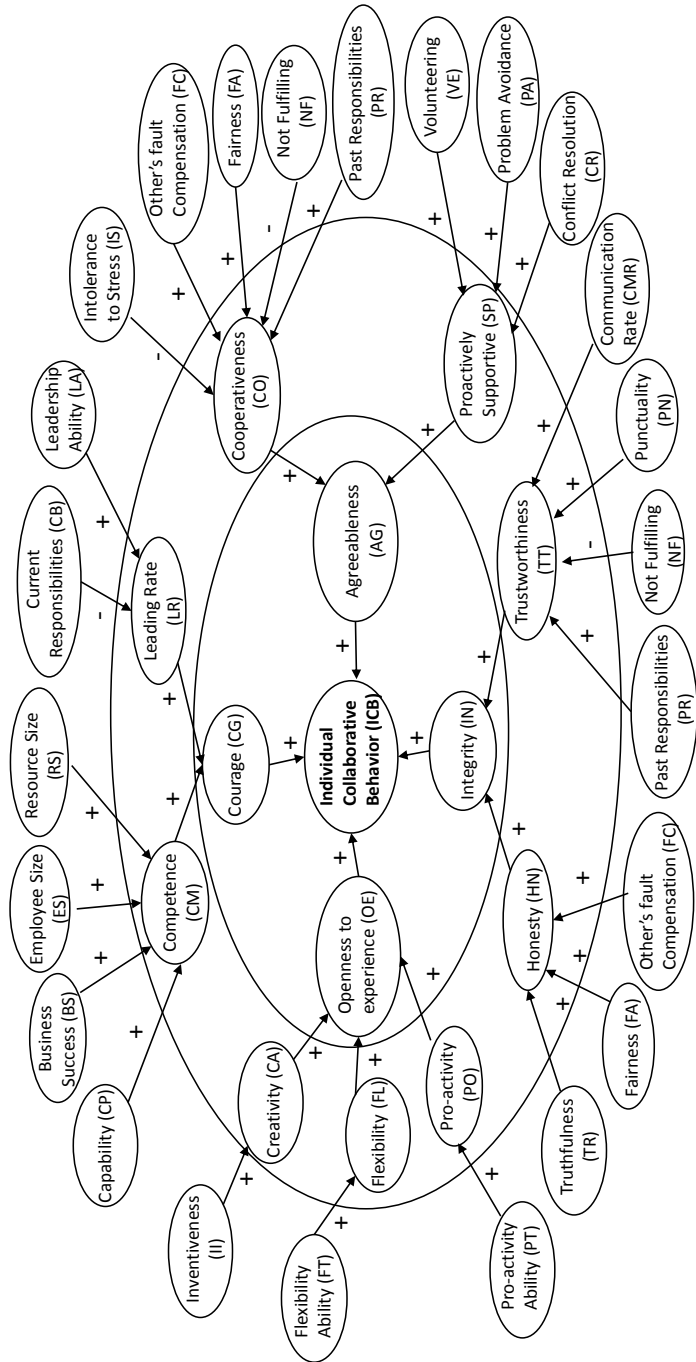


Figure 2.2: The proposed causal diagram for modeling individual collaborative behavior in VBEs.

Integrity (IN)

Recently one frequently cited ethical term is integrity [18], which is not a single observable entity but a term referred to a composite number of virtues. Integrity is primarily related to honesty, and trust [31]. Applying this to organizations, the causal relationships based on which we develop an equation for integrity, is illustrated in Figure 2.2. Considering the Figure 2.2, the equation relating FA (fairness), FC (Others' fault Compensation) and TR (truthfulness), to HN (honesty), as well as the equation relating CMR (communication rate), PR (past responsibility), NF (not fulfilling) and PN (punctuality) to TT (Trustworthiness) are as follows:

$$\begin{aligned} HN &= (FA + FC) * TR \\ TT &= (PR - NF) * (PN + CMR) \end{aligned} \quad (2.4)$$

Honesty (HN) and trustworthiness (TT) are inflows for Integrity as a stock. Therefore, based on the discussion in [60], the accumulation of values of flows (HN and TT) over time for the stock (IN) is captured based on the integral calculus. In other words, the integration process measures the accumulation of IN from time t_1 to t_2 , as shown below:

$$\begin{aligned} \frac{d}{dt} IN &= HN + TT \\ \int_{t_1}^{t_2} d IN &= \int_{t_1}^{t_2} HN dt + \int_{t_1}^{t_2} TT dt \\ IN(t_2) &= \int_{t_1}^{t_2} (FA + FC) * TR dt + \int_{t_1}^{t_2} ((PR - NF) * (PN + CMR)) dt + IN(t_1) \end{aligned} \quad (2.5)$$

Courage (CG)

Research in [31] shows that one important trait of a successful manager is still courage, however its meaning in the organization needs some modification. The definition of courage in the business world is presented by Harris as "success in achieving the desired outcome and effort by the agent" [31]. Since Courage is a very important trait in personal behavior, in relation to organizations, we keep this trait, while it primarily refers to the Lead Potential of the organization and not being daring, as it might represent for personal behavior. The causal diagram shown in Figure 2.2 represents the relations of Courage as a behavioral dimension for an organization with Competence (CM) and Leading Rate (LR) and some given known factors (i.e. Capability (CP), Business Success (BS), Resource Size (RS), Employee Size (ES), Current Responsibility (CB), and Leadership Ability (LA)). Based on the information shown in Figure 2.2, the equation of CM , and

LR are as follows:

$$\begin{aligned} CM &= CP * BS * RS * ES \\ LR &= \frac{LA}{CB} \end{aligned} \quad (2.6)$$

Competence (CM) and leading rate (LR) are inflows for courage as a stock. Therefore, the accumulation of values of flows (CM and LR) over time for the stock (CG) is captured below. The integration process measures the accumulation of CG from time t_1 to t_2 , as follows:

$$\begin{aligned} \frac{d}{dt}CG &= CM + LR \\ \int_{t_1}^{t_2} d CG &= \int_{t_1}^{t_2} CM dt + \int_{t_1}^{t_2} LR dt \\ CG(t_2) &= \int_{t_1}^{t_2} (CP * BS * RS * ES) dt + \int_{t_1}^{t_2} \left(\frac{LA}{CB}\right) dt + CG(t_1) \end{aligned} \quad (2.7)$$

Openness to New Experience (OE)

Being curious, broad minded and trying new ideas are the features of an individual who is highly open to new experiences. Those jobs that need creativity and flexibility, like advertising and research require high openness [67]. The causal diagram shown in Figure 2.2 represents the proposed relation of Openness to New Experiences as a behavioral dimension with traits and known factors as we have specified. Creativity (CA), flexibility (FL), and pro-activity (PO) are inflows for openness to new experience (OE) which is a stock. Therefore, based on the discussion in [60], the accumulation of values of flows (CA, FL and PO) over time for the stock (OE) is captured based on the integral calculus. It should be mentioned that Inventiveness (II), flexibility ability (FT), and pro-activity ability (PT) are the known factors defined for creativity, flexibility and pro-activity, respectively. In other words, the integration process measures the accumulation of OE from time t_1 to t_2 , as shown below:

$$\begin{aligned} \frac{d}{dt}OE &= CA + FL + PO \\ OE(t_2) &= \int_{t_1}^{t_2} II dt + \int_{t_1}^{t_2} FT dt + \int_{t_1}^{t_2} PT dt + OE(t_1) \end{aligned} \quad (2.8)$$

Finally, for organization O_1 , its score for ICB, called ICB_{O_1} , is calculated through weighted averaging of the scores obtained by the organization in its four different behavioral dimensions, i.e. Agreeableness (AG), Courage (CG), Integrity (IN), Openness to new experiences (OE). With the assumption of independence but complementarity of these four behavioral dimensions, the general equation for

calculation of the level of ICB_{O_1} , is as follows:

$$ICB_{O_1}(t) = \text{Average} \left(w_{AG} * \frac{AG(t)}{Max_{AG}(t)} , w_{CG} * \frac{CG(t)}{Max_{CG}(t)} , \right. \\ \left. w_{IN} * \frac{IN(t)}{Max_{IN}(t)} , w_{OE} * \frac{OE(t)}{Max_{OE}(t)} \right) \quad (2.9)$$

where, $Max_{AG}(t)$, $Max_{CG}(t)$, $Max_{IN}(t)$, and $Max_{OE}(t)$ are the maximum value of Agreeableness, Courage, Integrity, and Openness to new experiences among all involved partners in the VO. The weights $(w_{AG}, w_{CG}, w_{IN}, w_{OE})$ shall be defined by experts in the field related to the specific VBE, and depending on the specific type of VO and its related works. For example, the type of job performed by the VO determines whether the organization needs to have a high or low value for agreeableness dimension, and therefore different weights will be considered in different situations. Like agreeableness, the type of job also determines whether high or low openness to experience is an advantage [67]. These weights should belong to the $[0,1]$ interval and the sum of all these weights should be equal to 1. Since the value of each behavioral dimension for an organization is divided by the maximum value for that among all organizations, the value of ICB_{O_1} is in an interval $[0,1]$. Finally, since we calculate the score for each member organization in the VBE, when a VO planner decides to select the most suitable member, she/he can compare how these aspects rate against each other. It should be noticed that the amount of all four behavioral dimensions at time t_0 is set to 0.5. Relevant information related to the known factors for each partner are periodically recorded and the degree of ICB for each partner is calculated.

2.4 Conclusion

Quantitative causal modeling is a powerful aid to better understanding a system and enabling to make practical decisions about what might be the best action to take under a certain circumstance. In this approach, we measure the comparative individual collaborative behavior (ICB) of an organization by using quantitative causal modeling. In order to assess each individual organization behavior, causal relations among four behavioral dimensions, including: agreeableness, openness to experience, courage, and integrity as well as their related traits and known factors are specified. Based on the derived formulations from causal relationships, the score of ICB is measured for each organization. According to ICB scores, the behavior of VBE members could be compared with each other, and they will be informed that enhancing their individual behavior will result in more success in their collaboration with other organizations. The scores of ICB for VO partners are also used both for their trustworthiness level assessment as well as for suitable partner selection when it is needed to reassign some risky tasks. Our proposed

causal model of organizational behavior is enhanced and validated in collaboration with expert members from the SOCOLNET community of researchers in collaborative networks ².

²<https://sites.google.com/a/uninova.pt/socolnet/>