Participation in Information Markets Research: A New Conceptualization and Measurement

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Abstract

Participation is a fundamental concept in information systems research. It has been viewed to be a promising factor for the success of any IT system. However, its complex nature with respect to its conceptualization and measurement reported mix findings to the literature. In this paper, a literature review is conducted across many research disciplines to find a solid ground for proposing definition and new measures for assessing computer-recorded (e.g. online) participation. Specifically, this paper redefines traditional views on IS-related participation into a new conceptualization, and proposes methods for its operationalization to appropriately fit within recent technological contexts such as information markets.

Keywords: Participation, Information Markets, Influence measures, Effort measures, Frequency measures.

1. Introduction and Motivation

There are different methodologies for capturing different aspects of human behaviors. Surveys, questionnaires, and interviews are among the most popular research methods that are often retrospective self-report. However, with the rise of IT involvement, more directly observable and detailed data is available but has not been well exploited for investigation and analysis. Lucas et al. (1999) suggest that there is a need for studies to explore the nature of actual technology use and how to measure it. Prior research revealed that computer-recorded use was different from self-reported use (Straub et al., 1995; Collopy, 1996). Objective measures have many advantages over self-reported measures. They circumvent the reporting biases due to selective recall (Davis et al., 1992) and inaccurate estimation (Collopy, 1996). Moreover, using an objective measure avoids inherent methodological problems such as common-method bias, hypothesis guessing, and indistinguishable causation, associated with retrospective self-reported measures (Fichman, 1992; Straub et al., 1995; Szajna, 1996). Information markets (IMs) are among recent IT technologies with online recordable human activities where a group of individuals gets involved in predicting future events. While doing so, detailed data reflecting participants' behaviors can be captured and analyzed to increase our understanding about such behaviors. IMs, which use "the information content in market values to make predictions about specific future events" (Berg et al., 2003, pg. 79), are mechanisms that enable geographically dispersed participants to reach and continuously re-evaluate consensus about the value of alternative outcomes. This kind of distributed decision making has many applications, and IMs have been shown in some contexts to be better predictors of outcomes than traditional methods like polls and statistical methods (Jones et al., 2009). The challenge of finding objective direct methods stems from the lack of reliable measures to assess different computer-recorded trading activities (Fichman, 1992; Straub et al., 1995; Szajna, 1996, Lucas et al., 1999). This paper proposes computed and objective indicators/variables of trader participation in IMs context. By successfully identifying and defining such measures, it becomes reasonably logical to investigate future research venues that study the relationship between participation and other related concepts such as performance and system success. In an IM context, the process of engaging traders to participate is a promising factor for the success of IMs. In fact, there are many research studies that have found that high-level participation markets perform better than low-level participation markets (Barnes et al., 1986, Pennock et al., 2001). Bruggen et al. (2010) state that when markets attract broad participation, it is more likely that prices of outcomes encode more pieces of information about these outcomes; hence producing more accurate forecasts than markets with narrow participation. This could be especially important when the markets are small or thin, making any skews in the level of participation a concern (Alhayyan et al., 2011). If potential knowledgeable individuals do not participate or fail to maintain a certain level of participation the performance of the IM may suffer. How can decision makers in organizations identify precisely what objective measures to use for assessing different levels of participation and then understand how such level impacts the trader and market performance. Most recent research in IMs focuses on the effectiveness and efficiency of using such technology, or on the goodness of designing IMs mechanisms (Goel, 2010, Spann et al., 2009, Berg et al., 2008, Foutz et al., 2008, Elberse et al., 2007, Dahan et al., 2007, LaComb et al., 2007, Guo et al., 2006, Ostrover et al., 2005, Pennock et al., 2001). There is a research gaps motivating this study. In that, there is a need to define direct measures of computer-recorded activities performed by IM traders. Therefore, the central question of this line of research is:

Within the context of information markets, what direct and objective measures can be used for capturing trader participation?

The rest of this paper is organized as follows. Section 2 lists a summary of the conducted literature review. Participation definition is synthesized in section 3. Section 4 introduces

the three proposed measures of participation. The study is concluded in section 5.

2. Literature Review

In defining the concept of participation, we follow a definition approach proposed by MacKenzie et al. (2011) and Nunnally et al. (1994). They argue that writing good construct definitions requires clear conceptual thinking and organization. Therefore, we conduct a literature review across many research disciplines to find a solid basis for proposing definition and new measures for assessing computer-recorded participation. Participation has been studied in various disciplines such as MIS, finance, health care, management, and political science. The importance of participation stems from its impact on significant outcome constructs such as firm performance in management (Wagner, 1994), or system quality, user satisfaction, and system use in MIS (McKeen, 1994). In general, participation is a broad and complex construct (Yorkston et al., 2008b, Brakel et al., 2006, Rifkin et al., 1988, Robey et al., 1989, Doll et al., 1990, Barki et al., 1994, Butler et al., 1997, Cavaye, 1995, Shang et al., 2006). Table 1 summarizes the findings of 28 research studies on participation across different disciplines such as finance (5 studies), health care (3 studies), political science (2 studies), management (1 study), and MIS (17 studies), the theme of this paper. The table is organized into four columns: authors, referenced discipline, measured constructs, and method of measurement.

3. Proposed Definition of Participation

By synthesizing our understanding of the conducted literature review, we found that there has been a common consensus on the general meaning of participation with each discipline introducing its own definition in a different way. This consensus includes a reference to "taking part". For example:

- *Participation in MIS*: a set of behaviors or activities performed by users in the process of information system development (Barki et al., 1989, 1994).
- *Participation in finance*: a mix of definitions are introduced in context of financial stock market, among which are: cash level in a trader's portfolio (Allen et al., 1994), amount of asset holdings (Paiella, 2001), ratio of a trader's share volume to the total share volume (Madhavan et al., 1998), and whether or not a trader owns stocks and/or mutual funds (Rooij et al., 2007, Hong, 2004).
- *Participation in health care*: the level of involvement in life situations such as learning, communications, and self-care (Yorkston et al., 2008, Brakel et al., 2006).
- *Participation in management:* the involvement of managers and their subordinates in information processing, decision making, or problem solving endeavors (Wagner III, 1994).
- *Participation in political science*: the ratio of the number of actual voters to the total of registered citizens (Feddersen et al., 2006).

There is a general consensus in MIS on the distinction between participation and involvement in the process of information system development. Barki et al. (1989) suggest that the term *user participation* refers to "a set of activities performed by users in the process of system development" and the term *involvement* refers to "a subjective psychological state of the individual and is defined as the importance and personal relevance that users attach to a given system". While this distinction is important for developing acceptable conceptualization about trader participation, it is also important to clarify any ambiguity that may result from mixing the definitions of "participation" and "IS-use". IS-use refers to the set of behaviors individuals undertake concerning a specific task-technology-individual context (Barki et al., 2007). IS-use in IS literature is a widely utilized as dependent variable that has been examined extensively. In contrast, participation has been discussed as an important independent variable in the information system development literature. While IS-use (sometimes called system usage) is routinely assessed on the organizational level, participation is measured on the individual level, but it can be aggregated on many participants to test its impact on dependent variables such as system success. An exception is Barki et al. (2007) who employed IS-use on an individual level. Additionally, our review indicates that participation is conceptualized as a faithful/meaningful use of the IT with an ultimate goal in mind (e.g. to satisfy objectives such as system success or more accurate prediction). IS-use is implicitly viewed as random system usage with no specific objective to achieve (e.g. frequency of use or number of reports accessed or used). For this, DeLone et al. (1992) argue that "*simply saying that more use will yield more benefits without considering the nature of this use (and context) is clearly insufficient*". Generally speaking, an individual cannot participate without using technology, but could use technology with no participation. Finally, while both concepts, participation and IS-use, are conceptualized differently in IS, they are both measured using survey-based items. This important contrast becomes more critical to consider in contexts like IMs, since IMs offer an environment where participatory activities per trader (e.g. buying or selling alternative market contracts) play an important role in evaluating/re-evaluating consensus about the value of alternative market contracts. Buying shares of an IM contract raises its price (or valuation), while selling its shares reduces its price. Unless these activities are considered in quantifying a trader's participation level, the measure would not be accurate in identifying the extent to which a trader takes part in evaluating his/her own prediction in the first place, and then in forming the overall prediction on market contracts.

Table 1: Literature review summary on participation across different disciplines

Authors	Referenced discipline	Measured constructs	Method of measurement
Allen et al. (1994)	Finance	Stock market participation	Level of liquidity (cash) in a trader's portfolio is used as an indicator of participation.
Paiella (2001)	Finance	Financial market participation	Self-reported data on an individual's asset holdings in a past period is collected every three months. The level of participation is then computed by subtracting the changes occurred to the stocks over two consecutive periods.
Madhavan et al. (1998)	Finance	Trading specialist participation	Participation is the ratio of the specialist share volume to total share volume, a measure of overall dealer activity
Rooij et al. (2007)	Finance	Stock market participation	Rooij et al. investigated the impact of financial literacy on stock market participation, which is defined as owning individual stocks and/or mutual funds. Survey items (yes/no) are used to assess participation.
Hong et al. (2004)	Finance	Stock market participation	Hong et al. investigated the impact of social interaction on stock market participation. Participation is assessed using self-reported items asking whether a household owns stocks.
Yorkston et al. (2008b)	Health care	Participation	Yorkston et al. define participation according to ICF standards as involvement in life situations. They argue that participation is a complex construct, potentially composed of several dimensions. However, it is important to choose only key dimensions to reduce assessment burden, while still allowing for the collection of critical information. Therefore, they assess participation across 3 dimensions only: frequency, importance, and self-efficacy (confidence in ability to perform). 28 items are used to assess these 3 dimensions.
Brakel et al. (2006)	Health care	Participation	Brakel et al. developed a participation scale, an interview-based instrument, to measure client-perceived participation across 9 ICF-based dimensions: Learning and applying knowledge, General tasks and demands, Communication, Mobility, Self-care, Domestic life, Interpersonal interaction and relationships, Major life areas and community, Social, and Civic life.
Rifkin et al. (1988)	Health care	Participation in health care program.	Rifkin et al. define 5 factors that influence participation in health care programs. These factors are: needs assessment, leadership, organization, resource mobilization, and management. For each factor a continuum is developed with wide participation at one end and narrow participation at the other. The width of participation on the continuum of each of factor is used as an indicator for participation level in a health care program.
Feddersen et al. (2006)	Political Science	Participation in elections	Feddersen et al. define participation in elections as a ratio of the number of actual voters to the total of registered citizens.
Gibson et al. (2005)	Political Science	Online political participation	Gibson et al. investigated the internet effects on individual political participation using data from an NOP survey of UK adults. Findings support the idea that the internet is expanding the numbers of the politically active. Authors point that there is a need for a more sophisticated theoretical and empirical modeling of participation in the online environment.
Wagner III (1994)	Management	Participation, performance, and satisfaction	Wagner III (1994) conducted a meta-analytic reanalysis to investigate the relationship between the managerial participation and performance or satisfaction. The empirical findings reached suggest that there is an evidence of statistically significant but small relationships between participation and performance or satisfaction.
Dellarocas et al. (2004)	MIS	Buyer and seller participations	Participation is defined the number of comments received from a buyer or seller in an online environment.
Ives et al. (1984)	MIS	User participation and System success.	Ives et al. Investigated the link between user participation and system success. They noted one important methodological weakness of past participation measures, which were based on biased general opinions.
Cote et al. (1987)	MIS	Participation	Cote et al. showed that many participation measures were collected by asking respondents about their general opinions, which are less likely to be accurate.

To be continued

Authors	Referenced discipline	Measured constructs	Method of measurement
Franz et al. (1986)	MIS	User participation and perceived system usefulness	Franz et al. investigated the user involvement in information system development and the perceived system usefulness. Through using survey items, the findings showed that user involvement in design and implementation is related positively to users' perceptions of system usefulness.
Baroudi et al. (1986)	MIS	User participation, user satisfaction, and system usage	Baroudi et al. employed 94 survey items to assess user participation, user satisfaction, and system use. Findings demonstrate that user participation enhances both system usage and the user‘s satisfaction.
Robey et al. (1989)	MIS	Participation during project meetings	Robey et al. measured participation during project meetings using two different methods. A 3-item scale asked users to assess the amount of time they spent preparing for, the extent to which their opinion were consulted in, and the number of questions they asked during project meetings.
Barki et al. (1989)	MIS	User Participation and user involvement	Barki et al. suggested that user participation and user involvement present two distinct constructs. They provide a definition for each one of them (see paper text).
Doll et al. (1990)	MIS	End-user software involvement	Doll et al. propose an 8-item measure of end-user software involvement by asking users to assess the amount of time they spent in each of 8 development activities (e.g. project initiation, determining system objectives, user information needs, and developing input/output forms)
Alavi et al. (1992)	MIS	User participation	The development of a better measure of the user participation should mitigate the issues related to methodological weaknesses of past studies.
Barki et al. (1994)	MIS	User Participation , user involvement and user attitude	Barki et al. assess user participation using 20 items across three dimensions: user-IS relationship, responsibility, and hands-on activities, assess user involvement using 9-items across two dimensions: importance and personal relevance, and assess attitude using 4-items. User participation has long been considered a key variable in the successful development of ISs.
Jarvenpaa et al. (1991)	MIS	Executive participation, executive involvement, and IT use in firms	Jarvenpaa et al. proposed 3 alternative models to study the relationship between executive participation, executive involvement, and IT use in firms. While six items are used to assess participation, four are used to assess user involvement.
McKeen et al. (1994)	MIS	User Participation and user satisfaction	McKeen et al. investigated the relationship between user participation in the system development process and user satisfaction. Findings suggest that there is a direct relationship between the two constructs moderated by two factors: task complexity and system complexity.
Butler et al. (1997)	MIS	User Participation in the IS development process	Given the complexity of the user participation concept, mix findings were reported that explain the link between user participation and system success. Through employing a case-based study, Butler et al. found that high degree of user participation does not guarantee successful system use, but can instead, with other organizational factors, create a climate that is conductive to successful system use.
Cavaye (1995)	MIS	User Participation in IS development	Cavaye identifies various dimensions of user participation relating to the proportion of users who participate: formality, level of responsibility, influence on the development effort, the level of participation during different phases of development.
Markus et al. (2004)	MIS	User Participation in IS development	Markus et al. argue that there is a need to revisit the concept of user participation in light of the changing IS development environment.
McLeod et al. (2007)	MIS	User Participation in IS development	A survey of New Zealand organizations was undertaken in order to obtain an updated assessment of the actual practice of user participation in IS development projects from the perspective of IS management. The results suggest that user participation continues to be a dominant aspect of IS development for IS managers.
Shang et al. (2006)	MIS	Consumer participation and loyalty	Shang et al. used an online survey to test the impact of consumer participation in virtual communities on brand loyalty. Four items are used to assess consumer participation across two dimensions (time spent lurking on a virtual community per week and number of postings per month submitted to the virtual community).

This conceptualization about trader participation is in line with fulfilling the objective of IMs through harnessing the collective wisdom of crowd (Surowiecki, 2004), which is achieved as a result of all performed activities by traders during the use of the market. Following Mackenzie et al. (2011) and Nunnally et al. (1994) definition approach and synthesizing different bodies of research on participation and IS-use, trader participation in IMs contexts is defined here as "*the extent to which the trading-related activities, performed by an IM trader, influence the values (predictions) of alternative market outcomes*."

1. Proposed Measures of Participation

In defining measures for trader participation, it is critical to choose only key context-specific dimensions in order to reduce assessment burden, while still allowing for the collection of critical information (Yorkston et al., 2008b). However, finding a direct way to extract such dimensions is not a straightforward task, since most previous researchers do not state them directly. Our review indicates that no specific objective dimensions are defined for computer-recorded participation. For instance, Barki et al. (1994) developed three dimensions of user participation that are appropriate for the process of information system development: user responsibility, user-IS relationship, and hands-on activities, all of which are measured via survey-based items. In addition, the system use construct in the TAM model is usually determined by behavioral intention, consistent with the theory of reasoned action (Fishbein et al., 1975) from which TAM is derived. Intention is captured with retrospective self-reported measures. In fact, across all investigated disciplines, participation and its most related constructs, performance, were all consistently assessed using retrospective self-reports. Interestingly, Barki et al. (1994) argues that participation can be "viewed as frequency (i.e. the number of times one performs a given activity), effort (i.e. the time or energy invested in a given activity), or influence (i.e. the effect of a given activity), all of which have different meanings.

Table 2: Frequency measures

	Method	Equation
Frequency Measures	(1) Number of logins per trader	$= \boldsymbol{g_j}$, where $g_j \geq 0$ g_j - The total number of logins performed by trader *j*.
	(2) Count of buys per trader	$= \boldsymbol{b_j}$, where $b_j \geq 0$ b_j - The total number of buys performed by trader *j*.
	(3) Count of sells per trader	$= \boldsymbol{s_j}$, where $s_j \geq 0$ s_j - The total number sells performed by trader j.
	(4) Number of trades per trader	$= \boldsymbol{r_j = b_j + s_j}$, where $r_j \geq 0$ r_j - The total number of trades performed by trader *j*.
	(5) Number of exchanged comments per trader	$= \boldsymbol{c_j}$, where $c_j \geq 0$ c_j - The total number of exchanged comments between trader *j* and other traders.
Means for Frequency Measures	(1) Market mean of number of logins	$\boldsymbol{\bar{g} = (\sum_{i=1}^{m} g_j) / m}$, where $\bar{g} \geq 0$ $\bar{g}$ - The market mean of number of logins, g_j - The total number of logins performed by trader *j*, *m* - Total number of traders in a market.
	(2) Market mean of count of buys	$\boldsymbol{\bar{b} = (\sum_{i=1}^{m} b_j) / m}$, where $\bar{b} \geq 0$ $\bar{b}$ - The market mean of count of buys. b_j - The total number of buys performed by trader *j*, *m* - Total number of traders in a market.
	(3) Market mean of count of sells	$\boldsymbol{\bar{s} = (\sum_{i=1}^{m} s_j) / m}$, where $\bar{s} \geq 0$ $\bar{s}$ - The market mean of count of sells. s_j - The total number sells performed by trader j, *m* - Total number of traders in a market.
	(4) Market mean of number of trades	$\boldsymbol{\bar{t} = (\sum_{i=1}^{m} r_j) / m}$, where $\bar{t} \geq 0$ $\bar{t}$ - The market mean of number of trades, r_j - The total number of trades performed by trader *j*, *m* - Total number of traders in a market.
	(5) Market mean of number of exchanged comments	$\boldsymbol{\bar{c} = (\sum_{i=1}^{m} c_j) / m}$, where $\bar{c} \geq 0$ $\bar{c}$ - The market mean of number of exchanged comments, c_j - The total number of exchanged comments between trader *j* and other traders. *m* - Total number of traders in a market.

Each of these perspectives may provide a valid basis for the assessment of user participation." Scholars have consistently adopted these three perspectives in developing survey-based participation measures (Barki et al., 1994, Barki et al., 2001, Hartwick et al., 2001, Iivari, 2004, Markus et al., 2004, Ljung et al., 1999, Palanisamy, 2001). Drawing on this conceptualization, we introduce three sets of computer-recorded trader participation measures: frequency measures, effort measures, and influence measures. These measures are expected to provide quantitative evidence regarding the level of trader participation.

1.1 Frequency Measures

Frequency refers to the number of times an IM trader performs a given market activity. An activity can be: logging into the IMs, interconnecting with other traders to exchange information about traded outcomes, buying shares, and selling shares. Therefore, acceptable frequency measures per trader can be viewed as number of logins to the market, number of exchanged comments, count of buys, count of sells, or count of trades (the total number of buys and sells).Two points are noted on these measures. First, distinction among buys, sells, and trades is useful in situations when we want to track chosen trading strategies by traders during the use of the market. For instance, a trader may choose to buy shares in one trade, but he/she may sell them in more than one trade. Second, exchanged comments between traders are viewed as an information source that may motivate a trader to re-evaluate his/her opinion about market outcomes. The more of these exchanged comments, the more likely opinions about market outcomes get re-evaluated. The underlying idea of these quantitative measures is that "more is better". But, simply saying that the greater these measures are for a trader the more benefits they yield without considering other traders' measures is clearly insufficient. To determine the goodness or poorness of the frequency measure per trader, the market mean for each is computed to report how much each measure deviates from that market mean. Table 2 shows the equations representing frequency measures.

1.2 Effort measures

Effort refers to the time spent by an IM trader in performing given market activities. IMs are designed to run continuously within predetermined times and dates. However, a market session is marked with start and end time each time a trader chooses to login and logout from the market. Traders differ on how many times they login for the purpose of trading and on the duration of each market session. So, it seems reasonable to capture trader efforts through determining the total time spent on market sessions during the use of the market. The duration mean spent on all sessions per trader is calculated and reported for comparison purposes. In addition, the level of a trader effort is identified by assessing the degree and direction to which it deviates from the market mean of all traders' efforts in a market. Table 3 shows the equations representing effort measures.

Table 3: Effort measures

	Method	Equation
Effort Measures	(1) Trader effort - total time spent by a trader in all market sessions	$= \sum_{i=0}^{s} (\boldsymbol{ETij} - \boldsymbol{STij})$ *ETi* - The end time of market session *i* for trader *j*, *STi* - The start time of market session *i* for trader *j*, *i* - A market session where $i = 0,\ldots, s$ *s* - Total number of market sessions in which trader *j* participated.
	(2) Average time spent by a trader in market sessions	$= \sum_{i=1}^{s} (\boldsymbol{ETij} - \boldsymbol{STij}) / \boldsymbol{s}$
Market Mean of Effort Measures	Market mean of traders' Efforts	$= \frac{\sum_{j=1}^{m} \sum_{i=0}^{s} (\boldsymbol{ETij} - \boldsymbol{STij})}{\boldsymbol{m}}$ *j* - A market trader where $j = 1,\ldots, m$ *m* - Total number of traders in a market.

Table 4: Influence measure

Method	Equation
Trader influence on an outcome (*TIO*)	$TIO_{o_i \in O} = VOL(O_{ij}) \,/\, \sum_{j=1}^{m} VOL(O_{ij})$ *O* - Set of outcomes in the market, o_i - The i^{th} outcome in *O*, $VOL(O_{ij})$ - Total traded shares of outcome *i* traded by trader *j*, *j* - A market trader where $j = 1,\ldots, m$ *m* - Total number of traders in a market.
Trader influence on all market outcomes (*TIM*)	$TIM_{o_i \in O} = \sum_{i=1}^{n} VOL(O_{ij}) \,/\, \sum_{i=1}^{n}\sum_{j=1}^{m} VOL(O_{ij})$ *n* - Total number of market outcomes offered for trading.

1.1 Influence measures

Influence refers to the degree to which given activities, performed by a trader, impact the evaluations of market outcomes. The voice of the market is the price of the representative outcome shares (Jones et al., 2009). These prices should predict the true outcomes. So, there is a market voice on each outcome that is available for trading. However, the degree to which a trader influences the price on each outcome will certainly differ from one trader to another, since traders differ in which outcomes they prefer. While price can be used as a ranking indicator of which outcome voice comes first, volume (quantity of traded shares) on that outcome may be used to indicate how much impact a trader has on forming a price of an outcome. For instance, the influence of trader "A" on an outcome may be 3% while trader "B" influence can be 7%. Therefore, the influence measure on forming a price on an outcome is calculated as the ratio of total shares of that outcome that are traded (bought or sold) by a trader to the total shares of the same outcome traded by all traders in the market. Consequently, it is possible to infer a trader participation level in a market through computing the total influence a trader may have on all market outcomes. This aggregated influence is calculated as the ratio of total shares of all outcomes traded (bought or sold) by a trader to the total of shares of all outcomes traded by all traders. Table 4 shows the influence measure.

1.2 Which measure fits better in IMs context?

While it may seem convenient for a researcher to employ a single measure in assessing a multi-dimensional construct such as participation, most researchers assure on considering all related dimensions (hence all related measures) when assessing a construct to increase the level of validity. However, any study context as well as the construct definition will certainly determine which measure of many may fit better than the others. Participation is not an exception from this view. Scholars have noted that "true participation" involves the ability to make and influence decisions (Markus et al., 2004, Hunton et al., 1997, Saleem, 1996), which not all participation activities give equally. Considering this argument as well as the argument introduced by Barki et al. (1994), the measure of influence seems to be more fitting with the IM context and more consistent with the definition introduced to the concept of participation than the other two perspectives: frequency and effort. In spite of this, it is always recommended to provide quantifiable figures of frequency and effort for the purpose of shedding some light on the nature of relationship under investigation.

2. Conclusion

This paper contributes to the literature by defining and measuring the multi-dimensional construct of participation. Information markets context, as a recent technology, was employed to define and measure participation. Participation is defined as the extent to which the trading-related activities, performed by an IM trader, influence the values (predictions) of alternative market outcomes. Three sets of participation measures were also introduced: frequency measures, effort measures, and influence measures. Future research may consider examining these measures in a nomological network through testing the relationship of participation construct with other related construct such as performance. By adopting the introduced definition in other technological contexts, these measures can also be tested for quantifying different computer-recorded activities.

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