

# A Conceptual Model of Participation Utility Under Uncertainty in Interactive Systems

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**Abstract**—This letter proposes a formalized conceptual model of participation utility in interactive systems operating under uncertainty. I define participation utility as the aggregation of short-term and long-term participation intention, structured by seven abstract factors: outcome payoff, total cost, temporal commitment, extrinsic motivation, intrinsic motivation, failure cost, and risk. Rather than optimizing predictive accuracy or fitting empirical data, this work aims to identify a complete, non-overlapping factor space that explains why participants choose to engage, persist, or withdraw under uncertain conditions. The model is intended as a theoretical foundation for future empirical validation, system diagnosis, and design analysis.

## I. PARTICIPATION INTENTION MODEL

I define participation utility  $U$  as the combined effect of short-term and long-term participation intention:

$$U = P_{\text{short}} + P_{\text{long}} \quad (1)$$

Short-term participation intention reflects the immediate willingness to engage with an activity or system. It is primarily influenced by perceived payoff and motivational states at the moment of decision:

$$P_{\text{short}} = f(O, M_e, M_i) \quad (2)$$

where  $f$  is generally assumed to be monotonically increasing with respect to all its arguments.

Long-term participation intention reflects the willingness to persist over time under uncertainty, accumulated pressure, and potential loss. It incorporates both motivational and structural constraints:

$$P_{\text{long}} = g(O, C, T, F, R, M_e, M_i) \quad (3)$$

The specific functional forms of  $f(\cdot)$  and  $g(\cdot)$  are intentionally left unspecified to maintain conceptual generality. This work focuses on identifying and structuring the factor space rather than committing to a particular optimization or weighting scheme. However, in most interactive contexts,  $O, M_e, M_i$  serve as driving forces, while  $C, T, F, R$  act as inhibitory pressures or costs.

### A. Outcome Payoff

Outcome payoff  $O$  represents the perceived value associated with successful participation:

$$O = \{O_d, O_x, O_s\} \quad (4)$$

where  $O_d$  denotes direct payoff,  $O_x$  denotes exclusivity or scarcity-based payoff, and  $O_s$  denotes social payoff derived from recognition or shared meaning.

### B. Total Cost

Total cost  $C$  represents all forms of expenditure required prior to or during participation, independent of outcome:

$$C = \{C_c, C_p, C_t, C_w, C_o\} \quad (5)$$

where  $C_c$  is cognitive cost,  $C_p$  is practice or skill acquisition cost,  $C_t$  is total time cost,  $C_w$  is waiting cost, and  $C_o$  is opportunity cost.

### C. Temporal Commitment

Temporal commitment  $T$  describes how participation pressure is distributed and accumulated over time:

$$T = \{T_s, T_w, T_f, T_h\} \quad (6)$$

where  $T_s$  denotes single-session duration,  $T_w$  denotes the proportion of waiting time,  $T_f$  denotes participation frequency, and  $T_h$  denotes the total time horizon required to reach a meaningful outcome.

### D. Extrinsic Motivation

Extrinsic motivation  $M_e$  represents externally induced drivers:

$$M_e = \{M_{e,s}, M_{e,v}, M_{e,p}, M_{e,st}\} \quad (7)$$

where components correspond to social, value-based, pressure-based, and stability-based motivation.

### E. Intrinsic Motivation

Intrinsic motivation  $M_i$  follows established self-determination theory:

$$M_i = \{M_{i,a}, M_{i,m}, M_{i,p}, M_{i,r}\} \quad (8)$$

corresponding to autonomy, mastery, purpose, and relatedness.

### F. Failure Cost

Failure cost  $F$  represents the additional loss incurred specifically upon unsuccessful participation:

$$F = \{F_s, F_o, F_a, F_r\} \quad (9)$$

where  $F_s$  is social cost,  $F_o$  is future exclusion cost,  $F_a$  is attribution cost, and  $F_r$  is recovery cost.

### G. Risk

Risk  $R$  captures uncertainty beyond individual failure:

$$R = \{R_p, R_a, R_d\} \quad (10)$$

where  $R_p$  is predictability,  $R_a$  is acceptability of loss, and  $R_d$  is dependency risk.

## REFERENCES

- [1] R. M. Ryan and E. L. Deci, "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being," *American Psychologist*, vol. 55, no. 1, pp. 68–78, 2000.  
DOI: 10.1037/0003-066X.55.1.68.