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An Inductive Ethnographic Study in Elderly Woman Technology Adoption and the Role of her Children

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Abstract--**Elderly woman strives to have a streamlined life surrounded by ease and familiarity. As she is aging, her desire for simplicity grows, her self-efficacy weakens, her prudency intensifies and her overall inclination toward status quo strengthens. As a result, she delays, or refuses, making any decision that might bring complexity and disrupt the continuity in her life, particularly new and unfamiliar technologies (which often bring complexity, before providing ease). Consequently, her technology adoption has a much lower rate than that of other demographics.**

To open the black box of elderly woman technology adoption process, this study focuses on the role of the most significant population of "gatekeeping" group, children, to examine how this potential influence plays out in the elderly women adoption process of technology. Using grounded theory approach and case study, it investigates how the process of technology adoption by elderly woman develops and what is the role of the "gatekeeping" children in the adoption. This qualitative research using ethnographic interview and fuzzy cognitive mapping in addition to the traditional qualitative analysis coding. It validates the current technology adoption theories, particularly Unified Theory of Acceptance and Use of Technology (UTAUT), in the context of elderly technology adoption. However, it shows the importance of expanding such theories and unpacking the abstract constructs in the context studied to facilitate the emergence of empirical insight that can lead to implementable strategies.

There are two key findings emerged from this research: 1) Domestication is a key process in the successful adoption as it allows the elderly woman to try and become familiar and hence find the technology easy to use and then useful. 2) Caregiving children play a critical role in influencing the elderly woman technology adoption. This critical role is materialized in suggesting, modeling, providing facilitating condition and Intervening in the adoption.

I. INTRODUCTION

Technology Adoption in general and Health technology adoption in particular, constitutes a big practical problem among elderly women that needs to be resolved [1]–[3]. The global elderly population, mostly women, is growing at a rapid rate [4], [5] and even more so in the developed countries [6] and solutions for ensuring their health and well-being are becoming an urgent need [6] [7].

The process of technology adoption is known to be complex and is not only impacted by the elderly themselves but also the elderly's caregivers (primarily their children [8]–[11]), who have critical influence because they serve as gatekeepers [10], [12]–[14]. The majority of both of these populations of elderly and caregivers are women [7] which makes the study of elderly women health technology adoption a compelling issue demanding close attention. The staggering rate of health technology adoption among elderly (and particularly elderly women) has been the subject of different streams of research. Over four decades of research in technology adoption has resulted in abundance of sound theories that present the most influential high level adoption factors and their interrelations in the organizational settings [15]. While such theories still applies to the elderly health technology adoption, their general abstract nature falls short to explain the intricacies involved in the elderly health paradigm. To successfully increase adoption, there is a need to understand the complex paradigm of the elderly health technology adoption in the intersection of adverse effect of aging, multi-stakeholder nature of healthcare settings and the difficulty of technology adoption. To do such, this study researches a retrospective case of technology adoption of a smartphone which is increasingly transforming as a healthcare delivery technology to the elderly.

II. METHODOLOGY

Adopting the grounded theory and case study approach and leveraging it with Fuzzy cognitive mapping (FCM), this study is able to both validate and extend the priori theoretical knowledge in the challenged context of technology adoption among elderly women. Here, the priori specification of key constructs, known to be important in technology adoption, are valuable and create sensitivity to the triangulated measures [16]. This study retrospectively studies the process of a past adoption of smartphone by an elderly woman and the role of her daughter in this adoption. This in-depth case study results in the findings that are strongly triangulated by the gerontology and technology adoption literatures.

III. DATA INQUIRY GUIDELINES

The interview guideline is developed based on steps laid out by Jetter et al. [17] for extracting knowledge from experts as follows:

1) **Identification of experts:** As per objective of the proposed research, the ideal expert group consists of an elderly woman who has adopted technology, and her technology gatekeeping daughter. A pair fitting the requirements of this research was identified and recruited from the circle of local friends.
2) **Knowledge activation and capture:** Each interview session starts with a brief information on the process of the interview followed by a short training on FCM mapping, as well as conducting an exercise on a familiar

subject to get the participant comfortable and ready for drawing her own mental model throughout the course of interview. From there, the recorded ethnographic interview is conducted. In each session, the participant is given the common prepared set of relevant concept cards (previously created based on previously conducted literature review) to help her with capturing the knowledge content. She is asked open probing questions to retrospectively remember different aspects of the adoption process and is invited to brainstorm. During the brainstorming, she is requested to identify as many key concepts, influencing her adoption decision, as possible (either from the existing concept cards or create new ones). To capture the knowledge structure, she is helped with moving the cards until she is satisfied with their structure, followed by drawing the cognitive map, using the identified concepts and adding their links. She then assigns weights (such as Likert Scale [18]) to the links and discusses the expecting behavior of the map [19].

3) **Interpretation and documentation:** This step is described in the following sections, including transcription, ontology building and the iterative analysis and verification.

The interview questions are designed to maximize acquired knowledge by involving different parts of memory based on evidence showing that learning happens in divided processes each stored in a different section of the memory [20]. Recent cognitive and social psychology discoveries have shown that different categories of questions activate and result in different types of answers [21]. Here, to optimize the knowledge elicitation, LaFrance's "Knowledge Acquisition Grid" [22] has been utilized in designing interview questions to create the six distinct types of questions aimed at different aspects of expert knowledge. Once the ethnographic interview starts all, some, or none, of these open-ended questions may be asked based on dynamic of the interview [23]. Although not in the same order, the conducted interviews addressed all the questions designed.

IV. DATA INQUIRY AND ANALYSIS

After a brief reiteration on the research objectives, the recruited pair of elderly woman and her daughter were given a short FCM training followed by an exercise to draw a causal map of a topic. From there, the ethnographic interview was conducted and video recorded.

This qualitative study of the elderly woman smartphone adoption paves the path for either developing and testing a new theoretical process model, or confirming an existing one. The research follows Eisenhardt's advantageous case study approach [16] as it utilizes and extends the existing frameworks of Yin [25], Miles and Huberman, and Strauss and Corbin [26], for building process theory.

There are varieties of grounded theory methodologies available today, ranging from the oldest and most rigorous by its founders Glaser and Strauss (1967), to the modern less structured versions, like Charmaz's approach [28]. This study stayed close to the Straussian's framework. , but evaluate, compare and learn various techniques, two close (for coherency), yet different techniques have been followed for data analysis. Adopter data analysis follows the classical technique laid out by Strauss [26]. This variation organizes the axial and selective coding steps of the analysis in the form of: Causal condition, phenomenon, action/interactions and consequences. Gatekeeper's data analysis, including the constant comparison, follows the less structured, 18 years later, variation [23]. Here, the axial and selective coding are intertwined and conducted through iterative memo writings. Overall, as it becomes evident in the result of this study, while the two analyses look slightly different in writing, they produce similar results.

The process of data analysis started before the first interview was completed. This was in part possible by the FCM mapping process that forced experts to conceptualize their thoughts around abstract terms (whether from the ontology list or creating their own), which helped with both open and axial coding. During each interview, while zooming in and providing details of the events, the experts had to also force themselves to zoom out and conceptualize their mental model by analyzing the process at the macro level. Right from the beginning, this facilitated breaking the artificial distinction between micro level data and macro level concepts [23], which became instrumental across all coding attempts of the analysis. Upon receiving, verifying and correcting minor typos in the transcripts, they were each imported to Atlas-Ti software as the Computer Assisted/Aided Qualitative Data Analysis Software used for this research. Open coding was conducted immediately after each data collection interview and then the gatekeeper's open coding. As recommended [23], and to obtain maximum detailed coding, line-by-line coding was utilized (based on the granularity of the information sometimes per sentence and sometime couple of sentences. The intention was to stay very close to micro level data. However, in the first attempt, due to jumping too soon to generalization, many codes were merged (resulting in 29 codes from the initial 100 codes). This was relatively an inexpensive failure, as it happened very early. Nonetheless, redoing of the open coding became necessary, as much of the variations in the codes and dimensions of the concepts were lost. As a result, great care was taken during the second attempt to open coding. This time the line-by-line coding and many in-vivo codes (in total 78 codes) were created and kept to capture as much nuances of the story, and to better identify all the concepts and their dimensions, which paved the path to creation of the categories.

After open coding of the adopter's transcription, to capture all the concepts and their relations making up the process, the adopter's network diagram was prepared. This was done by importing all the codes and connecting the interrelated ones based on studying and comparing the interview transcript and FCM map. It's important to note that

there are fundamental differences between a network diagram in Atlas.ti and a FCM map. The key difference is that the network diagram nodes (open codes) represent the action, or detail about the relationship among the concepts (similar to the links in a FCM map), whereas the FCM map nodes represent the concepts involved. However, they complement each other as FCM map provides one more data point for constant comparison, and the combination provides a synergic view for axial coding.

Reviewing the videos and checking the concurrent process of storytelling and FCM map building provide a great way for eliminating any confusion around the concepts and their relations during the open coding and remaining analysis, leading to clustering of concepts and formation of categories. As these categories emerge from the codes, their individual network diagrams are created to analyze their properties and variations, as well as finding their action/reaction connections, in relation to other categories. In general, once a category was surfaced, subsequently, its dimensions, context, intervening condition, action/interaction strategies and consequences were analyzed and interconnected. At times, when more detailed properties or variations were needed, the microanalysis mandated going back to redoing the open coding, to look for more detail, regarding the category under study.

This process was conducted for all the identified categories in 11 phases and resulted in the emergence of 4 major categories, relating the stories, as:

- Strong elderly woman's resistance to new technology
- Adoption Intervention as a salient factor in elderly woman technology adoption
- Innovation Domestication as a vital process for elderly woman technology adoption
- Gatekeeper influence as a critical facilitator of the adoption process, with dimensions of suggesting, modeling, providing facilitating condition and Intervening in the adoption.

The analysis of elderly woman technology adoption suggests that gatekeeper plays a vital role in this process, as elderly repeatedly mentioned that if it weren't for her daughter's push, she would not have adopted smartphone. It's also understood that elderly's resistance to technology was stronger than usual, which signifies the role of adoption intervention that initiates the process in which elderly can experience technology and gradually become familiar with, experience, learn, like and finally enjoy it. The key is facilitating elderly's use of the technology, to learn (overcoming technology anxiety and building self-efficacy) and to become familiar with, and perceive it as easy to use. Once this is achieved, elderly is willing to use and explore additional benefits which leads to perceiving it as useful, and consequently accepting and adopting the technology. Used extensively by Miles and Huberman [25], conceptualizing the findings by graphical diagrams are recommended as the best way to present conceptual frameworks depicting the entire information in one page, dividing and relating all the variables of a phenomena [25].

The analysis of the data collected from gatekeeping daughter shed more light on the adoption process. Having done iterations of open and axial coding on the adopter's collected data prior to that of gatekeeper, increased theoretical sensitivity that leveraged gatekeeper's analysis; and experiencing the danger of rushing the analysis, extra time and care was allocated to the open coding. This breaking data apart stage delineated more properties and dimensions of the concepts which led to going back to the adopter's open and axial coding step, making regular modification and recoding. This facilitated divergence of the dimensions, and then better regrouping of the concepts into interrelating categories. The constant comparison [27] between the data in the units of analysis (information provided by adopter and gatekeeper) highlighted many similarities and differences in the process of adoption. This constant questioning and comparison further revealed the underlying categories of elderly's resistance causing drivers, and how they were addressed as the prerequisites for acceptance of the technology. It was through the within-case analysis and going back and forth through the collected data and triangulating it with variety of literature sources (here gerontology and gerontechnology) that led to discovery of the underlying categories that make up elderly's paradigm of: 'need', 'familiarity', 'prudence' and 'self-efficacy'. This analysis involved gathering, differentiating and combining the data and reflecting on the information obtained [25]. This recurring process led to these emerging categories, which in turn, necessitated going back, analyzing and grouping apparent inhibiting factors as the dimensions and properties of these underlying drivers. Apparently, the effect of aging has driven elderly to further seek simplicity in life and combined with prudence, lack of self-efficacy and status quo bias led to resisting technology change and its perceived involved complexity. As recommended [23], the theoretical scheme was validated with the raw data (e.g. the in-vivo codes such as: "when it comes to technology, status quo is fine with me'), confirming the findings. Additionally, these categories were verified with the elderly, in a verification session, as a recommended step in grounded theory [23]; and elderly acknowledged the emerged underlying drivers and stated that aging is intensifying them.

As the memo writing is the pivotal intermediary between data collection and theoretical integration [28], the memos become the running log [23] for the axial and selective coding. Corbin [23] posits: "writing memo makes you "chew" on, "digest" it, and "feel" the data". And as such, the back and forth through the memos, during categories analysis, led to the discovery of the core category of this case, which surfaced as 'Innovation Domestication'. The two categories of 'ease of use' and 'usefulness' were the two vivid ones, grounded in data, and surfacing right away by overwhelming support of open codes and FCM map concepts. From there, the influence of the gatekeeper was

another shining category that surfaced clearly, during the analysis, with many dimensions and interconnected with other categories in other memos. During and after development of the categories, the process of their interconnection (i.e. axial coding) as studied in the memos became the heart of the analysis. For example, the interplay between gatekeeper's modeling and elderly adopter's self-efficacy shows how this dimension of gatekeeper influence strengthens elderly's, much needed, self-efficacy as a prerequisite for what later emerge as domestication process.

As suggested in grounded theory techniques [23], and recommend in case study approach as an essential feature of theory building process [16], literature not only made the analytic juices flowing [23], but also triangulated and verified the findings. In this research, progressive literature search from various fields (Psychology, sociology, technology adoption, gerontology and gerontechnology) was undertaken concurrent to axial coding. This external source of data brought internal validity during the analysis, and helped with generalization of the findings and ultimately building theoretical propositions. The emergence of adoption intervention and particularly facilitating condition, as two of the main categories, captured the immense influence of the gatekeeping daughter; however, the findings of the innovation domestication as the core category became the highlight of the analysis. The excitement of what appeared at first as a groundbreaking discovery was soon vanished by the finding that this phenomenon (called Domestication) had been conceptualized in early 90's [29], and later signified as a key process in the innovation life cycle [14]. After reviewing the scheme for internal consistency, strengthening the categories, validating and trimming their excess data [23], the theoretical scheme was conceptualized in the integrative diagram in Figure 2.

During the analysis, some discrepancies amongst the two units of the case studied surfaced. This variance demanded microanalysis and potentially modification of the FCM maps, which was checked and verified during the theoretical verification meeting [23] with the experts. This fruitful step led to the finalization of the integrated and augmented combined FCM map depicted in Figure 1.

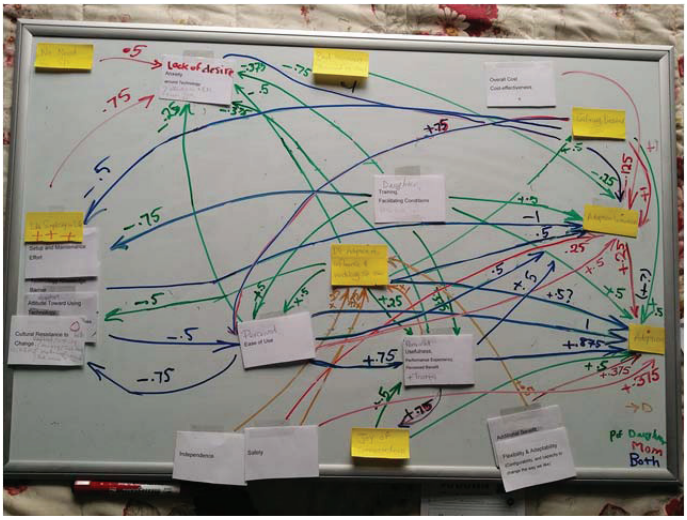

Figure 1 - Verified Integrated FCM

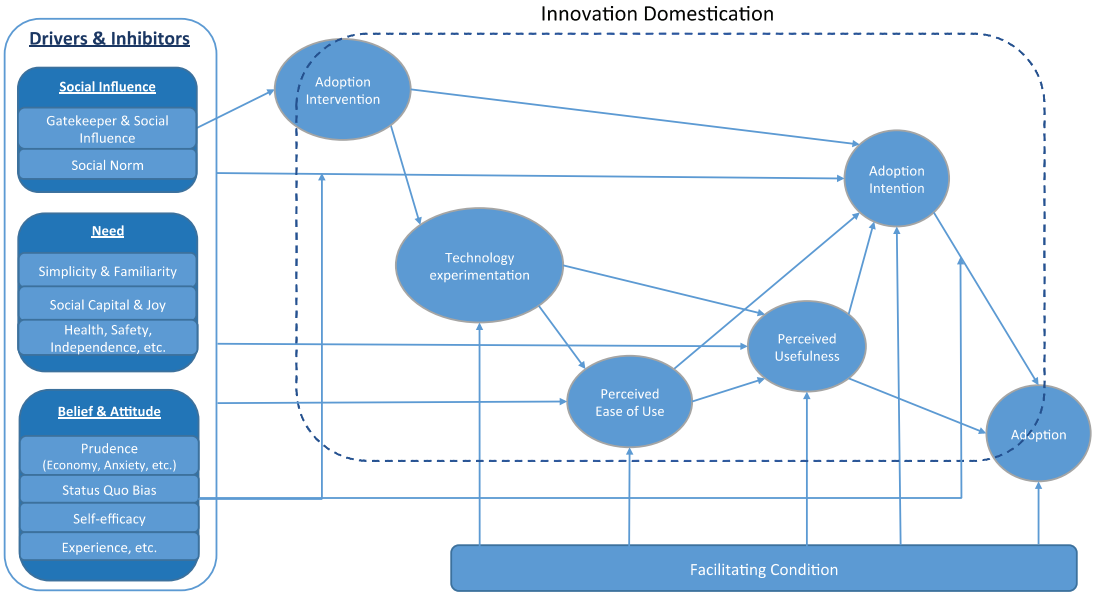

Figure 2 - Elderly Woman Technology Adoption Process Model (EWTA)

TABLE 1 - ELDERLY WOMAN TECHNOLOGY ADOPTION SIMULATION

Scenario	Simulation Result
1) No gatekeeper influence (i.e. no suggestion and modeling, no facilitating condition and no intervention)	Neither intending (-0.98) nor adopting (-0.91) the technology
2) There is facilitating condition, but no (other) gatekeeper influence, and no intervention	Neither intending (-0.35) nor adopting (-0.23) the technology (with less intensity)
3) There are gatekeeper influence and facilitating condition, but no intervention	This leads to elderly's adoption (both intending (0.99) and adopting (1.00))
4) Full dimensions of gatekeeper influence are present (Influence effects, facilitating condition and intervention)	This leads to elderly's adoption (both intending (0.99) and adopting (1.00))
5) There are some effects of gatekeeper influence and intervention, but no facilitating condition	Neither intending (-0.95) nor adopting (-0.44) the technology

In the process of theoretical comparison, integration and prioritization, FCM simulation capability became instrumental, as its quantitative capacity provided evidences that otherwise were not clear [16]. The resulting FCM adjacency matrix of the integrated FCM map was created and 5 most probable scenarios were designed and simulated to quantitatively measure the degree of impacts of the key emerged categories. Using binary squashing function in excel, for each simulation, the input vectors (representing elderly's paradigm) were initialized and then the resultant adoption and adoption intention concepts were measured as depicted in Table 1 below. The elderly condition is represented by: 'Lack of Simplicity & Familiarity', no perceived 'Need', and general 'Prudence' toward the technology, and initially not liking the bad manners displayed by other users.

These simulations measure the value of the gatekeeper's facilitating condition as the most significant dimension of the gatekeeper's influence in making the elderly adoption a success. Simulation result of scenario 1 highlights the importance of gatekeeper's influence in general, without which the possibility of adoption and intention to do so are the absolute minimum. In scenario 2, while there is facilitating condition, there are no other dimensions of gatekeeper influence (this could represent a conventional support system, such as phone support or Genius bar in Apple store); in this scenario while the two indicators of the adoption are less negative (adoption is -0.23, intention is -0.35), they still lead to no adoption. Both scenarios 3 and 4, lead to adoption rendering the key role of gatekeeper influence in its entirety; however simulation result of the scenario 3 suggest that gatekeeper influence and training even without intervention lead to the eventual adoption. This could be due to the fact that the elderly woman, studied in this case, did not have too much concern about the overall cost of the technology (with the effect of -0.13 on intention. Scenario 5 is designed to test the finding of the analysis (as proposed in **Error! Reference source not found.**) that emphasizes on the importance of availability of facilitating condition in elderly woman adoption.

Simulation result of the 5th scenario strengthens the theoretical proposition of 4th hypothesis, emphasizing on the colossal importance of the facilitating condition aspect of the gatekeeper influence. While regular facilitating condition (often effective for other demographics) without the gatekeeper's influence (tailoring to elderly's need) is not sufficient for elderly woman adoption (scenario 2), its combination with gatekeeper's influence lead to adoption (scenario 3 and 4), even without intervention (scenario 3, i.e. the technology is not given to the elderly). In addition, without this gatekeeper's facilitating condition (gatekeeper influence + facilitating condition) adoption is unlikely to succeed (scenario 5). These findings strongly support **Error! Reference source not found.** and **Error! Reference source not found.**).

Throughout the selective coding, further and more abstract conceptualization of the emerged categories, particularly with innovation domestication process as the core category, led to the delineation of the story of adoption process. Integrating the memos, the key constructs are summarized and the entire process is conceptualized in the integrated theoretical scheme of Figure 2. One of the products of the entire analysis is **Error! Reference source not found.** which theorizes the main dimensions of the gatekeeper's influence to: suggesting, modeling, facilitating condition and intervening.

V. DISCUSSION AND LITERATURE TRIANGULATION

A. Comparing hypotheses to the existing literature:

Hypothesis 1 - Elderly's Adoption Rate: ***The rate of technology adoption among elderly woman is lower than that of others.***

There is an abundance of evidence in the literature suggesting that elderly woman's technology adoption is in fact lagging behind. Morrison et al. study [30] of gender and age difference in technology usage suggest that gender effects in technology adoption and usage rate differed based on age. This finding suggests that while technology adoption rate is emerging as a unisex pattern among younger generations (and

in some cases higher adoption rate among women in the younger generations [31], the effect of gender on technology adoption rate is more pronounced among elderly as the technology usage were found lower among older women. Venkatesh and Morris (2000) research on gender difference in technology adoption also confirms the findings of this case, and also suggest that elderly women have strong desire for ease of use, simplicity and familiarity. Their research showed that elderly women's strongest driver for technology adoption is ease of use, along with social norm.

There is also a major body of literature highlighting the negative effect of lack of self-efficacy on technology adoption among elderly [33], which worsens by further aging [10], and most particularly in older women [34] .

The weak self-efficacy among both elderly [33] and women [35] were also appeared as a major factor causing a range of negative attitudes toward technology [34]. These researchers found similar dimensions of attitudes like those observed in this study, including anxiety [36], resistance to technology change [34] and satisfaction with mediocre, but old, familiar, technologies [37][38] that challenged technology adoption.

Additionally, the effect of biological aging on cognitive decline such as loss of visual and auditory acuity gradually weakens elderly's ability to recognize and use typical modern innovations, which more than often rely on subtle cues to present information [2]. Additionally, elderly's need and desire for simplicity and familiarity in their environment is well recognized in gerontology [39]–[43] and is becoming an important usability factor in gerontechnology product design [44], [45]. It appears that the study of technology adoption is lagging behind in recognizing these important effects of aging and its important negative influence on adoption behavior.

Overall, the existing literature confirms that range of obstacles, are more severe among females, and combined with challenges introduced by health and cognitive decline [46] Intensify the barriers to, and negatively affect the rate of, technology adoption [48].

Hypothesis 2 – Innovation Domestication: ***The process of 'innovation domestication' is the essential component of elderly woman technology adoption as it paves the path toward adoption by the four steps of:***

1) Experimentation,

2) Building perception of ease of use,

3) Building perception of usefulness, and

4) Acceptance and adoption of technology.

Despite finding sufficient support in literature for the first hypothesis, the second one was not greatly recognized by technology adoption literature. Broadening the search resulted in finding a similar theme: 'domestication', which has been studied in the lucrative industry of gerontechnology design and development. The concept was first emerged from the studies of Silverstone in early 90's [49], [50] and later it was further explored for studying information and communication technology design and domestication [14]. Silverstone and Haddon [14] considered domestication as an important component in completing innovation life cycle. They emphasize on commodification in the sense of establishing interrelation between design and domestication, as the two sides of the innovation coin. They posit: "Domestication is anticipated in design and design is completed in domestication" [14]. Domestication is emphasized as the critical process in which consumers define their own relationship with the innovation. Silverstone and Haddon categorize the process of domestication of technology as: 1) Appropriation (obtaining), 2) Objectification (exploring), 3) Incorporation (experimenting), and 4) Conversion (consumption) [14]. This echoes the process that this case's elderly adopter went through during her lengthy journey toward adoption:

1) Adoption intervention by gatekeeper giving the technology to elderly (Appropriation),
2) Elderly exploring the technology with gatekeeper's help and finding it easy to use (Objectification),
3) Elderly experimenting technology's different functionalities and finding it useful (Incorporation),
4) Elderly intending, and starting the consumption (Conversion).

Compagna and Kohlbacher [44] posit that the most suitable method of new assistive technology design, for older people, is direct interaction between technology and elderly dominated by rapid prototyping; and that the early process of domestication offers a lot about elderly's needs, preferences and attitudes, to be addressed. The outmost important role of what is coined here as: "Innovation Domestication" is giving elderly the chance and time to build the most important driver in her technology acceptance: 'perceived ease of use'. The importance of Ease of use among elderly women is well known and supported by literature [2], [51]–[54] and is a primal factor in much of technology adoption theories. The emphasis on this effect is due to elderly's strong desire for ease, and familiarity in her surrounding life [38]. It's also through perceived ease of use that the elderly is willing (boosting self-efficacy) to experiment and learn, for herself, about the technology usefulness, which is also a vital factor in the elderly's adoption [9], [55]. Here, the development of these perceptions becomes the important product of innovation domestication, which leads to technology acceptance and use.

Innovation Domestication in a way resonates with what Rogers called 'triability' as one of the five factors (along with Relative advantage, compatibility, complexity and observability) of his technology adoption theory: 'Diffusion of Innovations' [56]. In this theory, the rate of innovation adoption correlates with triability representing the degree in which the innovation can be tried out and experimented.

The importance of domestication in the context of elderly technology adoption is also discovered in Lee and Renaud and Biljon [13] studies. Lee's research (2007) found the four

dimensions of the domestication an applicable analytical process in the context of elderly technology adoption, and for understanding their experiences and needs. Similarly, Renaud and Biljon [13], who studied and proposed 'Senior Technology Acceptance & Adoption model for Mobile technology (STAM)', found Silverstone's and Haddon's [14] process of domestication significant in the case of elderly and adapted it for the conceptualization of their elderly mobile adoption model.

Hypothesis 3 - Elderly's Adoption as a Process: ***Technology Adoption among elderly woman is rather a long process. The allocation of extended time in this process is more important than that of other demographics' technology adoption.***

The adoption model emerged from this case study is the process model depicted in Figure 2.

The emerged process model is a dynamic sequence and phases of action and interaction, by the individual, in her process of adoption decision-making. In variance theories, the relationship between the causes and effects are invariant, and the antecedent cause is considered as both necessary and sufficient condition, resulting in effect. However, in process theory, similar to what surfaced here, the focus is the development of the outcome over time; and the antecedent, while being required, is not necessarily sufficient to result in the effect [57].

Haddon [58] stresses on the adoption as a process rather than an event. And Molar [59] calls for increased use of process model as a better alternative to variance models, for more stable research that can theoretically explain phenomena. Roger's Innovation Diffusion theory [56], among the most cited adoption models, proposes a five stage process (1) introduction, 2) persuasion, 3) purchase, 4) implementation, and 5) confirmation), in which the innovation is adopted. While technologists predominantly focus on variance theories, sociologists favor researching adoption, as a process [58], which signifies the concept of time in the interplay of factors and events leading to adoption or rejection of technology [13]. The recognition of time as the important facilitator for overcoming elderly woman barriers (including self-efficacy and lack of familiarity), and building essential drivers (Ease of Use and Usefulness), can only be captured through process model like the one proposed here. Renaud's and Biljon's model (2008) of 'Senior Technology Acceptance & Adoption model for Mobile technology (STAM)' is also a process model as depicted here, describing both acceptance and rejection.

Elderly woman experiences many challenges echoed by literature. These range from attitudinal [2], [33], [34], [60]–[62], informational [61], [62], perceptual [33], [39], [42] and cognitive [39]–[43] barriers in her process of technology adoption that often remain unaddressed and lead to technology rejection [30], [54]. Beating this stumbling rate, and overcoming the effect of these inhibiting forces, necessitate investing major time and energy [63]. Additionally, many research findings emphasize on the importance of providing extra time to accommodate elderlies' needs as they tend to be slower learners [64], [65]. Studies also show that older people are often out of practice of learning, and that makes their learning even harder [66]. Kubeck et al. [46] examination of 6,610 workers on whether job-related training performance decline with age, found poorer training performance, less mastery of the learnt material and slower completion of final training task among older workers. Furthermore, Conci et al. [67] suggest that due to sensory, cognitive, and motor challenges, older people need more time for learning and require more steps for operating a system.

The fast rate of emerging innovative products can be very daunting. Loe's research [68] emphasizes that elderlies have often taken decades to fully domesticate technologies (such as telephones or kitchen tools). Domestication process of those technologies necessitated extended time to allow elderly a chance to find a sense of familiarity and utility. The process of domestication is not unique to elderly woman as Pedersen and Ling stress its societal consequences as a process, in which the use of technology becomes integrated into people's everyday life [69]. However, domestication period is much shorter for younger generations (if not instant) and given its longevity for elderly, and their much needed support during this process, the concept of time becomes very important. It's through this recognition that extended time can be allocated, and appropriately strategized to pave the path to successful adoption [63], [64].

Hypothesis 4 – Facilitating Condition: ***The role of continuous facilitating condition, in enabling elderly woman technology adoption, is crucial and much more important than that of typical*** technology adoption.

The in-depth analysis of the conducted case study, as intertwined and augmented by the FCM mapping and its simulation capacity, identified gatekeeper's facilitating condition as the critical factor in materializing elderly woman technology adoption. The flexibility, continuity, availability, convenience, persistence and patience in the delivery of facilitation condition, deliverable by gatekeeper, has been the key to successful:

1) Training of the elderly woman throughout the process of innovation domestication,
2) Facilitation and formation of positive adoption intention, and
3) Continuous support that resulted in, and maintained, technology adoption.

The process of elderly technology adoption in this research reveals the importance of facilitating condition not just as the antecedent, but also throughout and even beyond the adoption process. This key role is reflected in the proposed model in Figure 2, as facilitating condition strengthens every key factor toward adoption (including maintaining the adoption itself). Literature provides a strong

body of evidence to the necessity of continuous facilitating condition in elderly technology adoption and usage [60], [64], [67], [70]–[72]. While facilitating condition has been a recognized and important component, in enabling technology adoption across industries and for all ages [54], [64], [72], effective training and support are found to be even more important as a crucial factor in alleviating elderlies' barriers to technology adoption [2]. These barriers, from perceptual and cognitive, to attitudinal, as observed in the case studied, reduce aging people's confidence and perception of fitness for learning new technologies [73]. As it's known in gerontology, perception is a complex psychological process, which aging erodes both its speed and amplitude [52]. Elderly also tend to be slower learners [65]. These effects debilitate elderlies' own initiation of learning new technology, making their training and support needs even more important.

The recognition of the elderlies' pressing need for adequate facilitating condition enables designing and delivering appropriate training and support, for addressing these challenges. For example, in the study of computer usage among elderly, it is found that the adequate support that suites elderly needs should not only be jargon free and patient, but also continually accessible and available for long-term [70]; and offered at more convenient locations [60]. The study of internet use among Chinese elderly also stresses on the key role of elderly having access to easy, accessible, and long-term, facilitating condition [71], exactly what this case's elderly woman had access to.

Morris and Venkatesh [2] and Morris et al. [30], likewise, recognized the necessity of facilitating condition particularly for elderly, and due to the differences in the salience of adoption factors among younger and older workers. In their study, they identified that the younger groups are driven by instrumentality vs. older groups, who are primarily influenced by social influence and lack of self-efficacy. This indicates that, when training, technology's ease of use should be promoted to get "buy-in" from the older groups, who tend to be more skeptical. Also leveraging on significance of social influence for older workers, it's important to cultivate positive reaction from the opinion leaders, who can have immense influence on older workers' adoption intention. The role of facilitating condition in elderly's technology usage remains important beyond domestication and initial adoption, as research suggests that the need for technology support persist years after initial adoption, since older people tend to keep a distance from technology, and not go beyond familiar functionalities [67].

Hypothesis 5 – Gatekeeper Influence: ***Elderly's children (here the daughter) as the main gatekeeper(s) can influence adoption in different forms including forming elderly's adoption intention through suggestion and encouragement, and intervening in her adoption (by expediting adoption or breaking adoption deadlock).***

Literature confirms the immense influence of elderly's children, as gatekeepers, on their technology adoption [8]–[11]. Interestingly, research findings also suggest that they frequently intervene in the process of adoption, by providing the technology to the elderly [10], [12]–[14]. The role of these children, both as the gatekeepers, as well as the reason for technology usage (for example, in the case of communication technologies, used for connecting with them), appears to be crucial. They influence elderly, by suggesting and encouraging building adoption intention (Morrell et al., 2004). Many cases of initiating the usage of technology, by elderly, were based on the combination of the gatekeeper influence, and the desire to stay connected with them [8], [9], [70], [74].

Similarly, Conci et al. [67] research findings emphasized on the strong influence of children in promoting the utilitarian values of the use of technology. Renaud and Biljon research [13], to conceptualize elderly adoption, observed that the appropriation phase of domestication process is often skipped (identical to the case studied here), as older people seldom made the decision to buy the technology, since their first phone was often given to, or bought for them. Mallenius et al. [10] research for Nokia also informed marketers and policy makers about the fact that younger family members acting as the technology gatekeepers not only influence, but also, more than often, make the purchasing decision for their elderlies. Carpenter and Buday [70] found many elderlies receive computer from their children (similar to this research), for emailing them, and then further used it for surfing web or storing recipes. And Davis's research (1995) reported the trend of giving cellular telephones as an appropriate gift by family members, to ensure elderlies' safety.

Overall, literature fully supports this hypothesis, by showing that children are elderlies' opinion leaders, and play the critical role in, both initiating and accelerating, the diffusion process [76], as they have the greatest impact on the elderlies' adoption [10]. They not only planting the seed of intention in the older people's minds, but also starting the innovation domestication by gifting the technology [13].

Hypothesis 6 – Gatekeeper as the best Facilitating Condition Agent: ***Children, as primary gatekeepers, have the unique ability to provide the most effective facilitating condition, through convenience, continuity, accessibility and availability, essential to elderly's adoption during and beyond Innovation Domestication.*** (This hypothesis is an extension of hypothesis 4, emphasizing on gatekeeper's unique fitness for providing the appropriate facilitating condition that elderly woman needs).

As captured earlier in triangulation of hypothesis 4, research overwhelmingly supports the instrumentality of convenient and continuous facilitating condition in making elderly's adoption possible. The availability (physical or virtual), persistence, and attention of children, as primary

gatekeepers, provide them the advantageous ability to deliver the best tailored, and appropriate, training and support, as needed by elderly. As discussed in length, elderly, who, among other barriers, suffer from low self-efficacy, is strongly influenced by perceived difficulty of technology [77] and hence, crucially need the time and support, for domesticating the technology [51], [54].

Pan and Jordan-Marsh [71] while stressing on the importance of access to easy, accessible and long-term support, underline the critical role that elderlies' children play in providing those support. Additionally, Compagna and Kohlbacher [44] emphasize on the importance of instrumentality of gatekeepers as technophiles. Morrell et al. [11] point out that social capital drives technology usage among elderly, who are not only encouraged by, but more importantly, trained by their surrounding people.

Many research findings while signify the gatekeepers' role in initiating the technology adoption (by both influencing and intervening), find that their role is even more crucial in maintaining the adoption, by providing continuous training and support. This strengthens elderlies' self-efficacy and knowledge on how to keep using the technology and benefiting from it. Studies show that lack of this continuous support leads to technology abandonment (due to unaddressed usability challenges), as some elderly gave the idle technology to grandchildren [14], and some other deserted them [10]. The effect of gatekeeper's training is even more salient on elderly women, as Lee's research (2007) found that female users more than anything rely on the help of surrounding people, to learn technology (as opposed to male users who often try it first).

Overall, research stresses on the necessity of the education and training that can address older adults' concerns, wishes, and challenges [70]. It also emphasizes that the elderlies' children are not only most knowledgeable about those barriers, but also, as gatekeepers, are most influential in addressing them [9].

VI. CONFIRMING EXTANT THEORIES

All the constructs emerged from the conducted grounded theory study appear to be fully supported by the existing theories and or gerontechnology studies.

TABLE 2 - EXTANT LITERATURE & THEORY SUPPORT

Construct	Literature	Extant Theory
Need	(Venkatesh et al., 2003), [12], [75], [67] [63]	- Social Cognitive Theory (SCT) [78] - Motivational Model (MM) [79] - Theory of Reasoned Action (TRA) [80] - Theory of Planned Behavior (TPB) [81]
Social Capital & Joy	[12], [67], [63], [82]	- Motivational Model (MM) (Davis et al., 1992), - Model of PC Utilization (MPCU) [83], - Mobile Technology Acceptance Models (MOPTAM) [12], - Useful, Social and Enjoyable Mobile Phone Adoption by Elderly Model [67]
Social Norms (Including Gatekeeper Influence)	[84], [12], [2]	- Theory of Reasoned Action (TRA) [80], - Theory of Planned Behavior (TPB) [81], - Motivational Model (MM) (Davis et al., 1992), - Model of PC Utilization (MPCU) (Thompson et al., 1991), - Innovation Diffusion Theory (IDT) [56], - Combined TAM and TPB (C-TAM-TPB) [85], - Unified Theory of Acceptance and Use of Technology (UTAUT) [54]
Simplicity & Familiarity	[38], [40], [42]	- Motivational Model (MM) (Davis et al., 1992)
Prudence (including cost, anxiety) (in the main category of 'Attitude toward Usage')	[38], [86], [87], [88], [71], (Weatherall, 2000), [33]	- Theory of Reasoned Action (TRA) [80], - Theory of Planned Behavior (TPB) [81], - Motivational Model (MM) (Davis et al., 1992), - Mobile Technology Acceptance Models (MOPTAM) [12]
Self-efficacy	[39], [42], [2], [33], [37]	- Social Cognitive Theory (SCT) [78], - Theory of Planned Behavior (TPB) [81], - Motivational Model (MM) (Davis et al., 1992), - Innovation Diffusion Theory (IDT) [56], - Combined TAM and TPB (C-TAM-TPB) [85], - Unified Theory of Acceptance and Use of Technology (UTAUT) [54]
Status Quo Bias (Attitude toward usage) Self-efficacy	[89], [68], [12], [44]	- Theory of Reasoned Action (TRA) [80], - Theory of Planned Behavior (TPB) [81]
Adoption Intervention	[13], [76]	- Motivational Model (MM) (Davis et al., 1992)
Innovation Domestication	[14], [9], [90]	- Senior Technology Acceptance & Adoption Model (STAM) [13]
Perceived Ease of Use	[2], (Venkatesh et al., 2003), [67], [71], [10], [77]	- Theory of Reasoned Action (TRA) [80], - Theory of Planned Behavior (TPB) [81], - Model of PC Utilization (MPCU) (Thompson et al., 1991), - Innovation Diffusion Theory (IDT) [56], - Technology Acceptance Model (TAM) [91], - Combined TAM and TPB (C-TAM-TPB) [85], - Unified Theory of Acceptance and Use of Technology (UTAUT) [54]
Perceived Usefulness	[2], [67], [92], [71]	- Social Cognitive Theory (SCT) [78], - Theory of Reasoned Action (TRA) [80], - Theory of Planned Behavior (TPB) [81], - Motivational Model (MM) (Davis et al., 1992), - Model of PC Utilization (MPCU) (Thompson et al., 1991), - Innovation Diffusion Theory (IDT) [56], - Technology Acceptance Model (TAM) [91], - Combined TAM and TPB (C-TAM-TPB) [85], - Unified Theory of Acceptance and Use of Technology (UTAUT) [54]
Facilitating Condition	[63], [11], [64], [2], [70], [71], [67], [93]	- Model of PC Utilization (MPCU) (Thompson et al., 1991), - Unified Theory of Acceptance and Use of Technology (UTAUT) [54]

Although all the categories, surfaced by the data analysis, are strongly recognized in gerontology, some are just starting to emerge in gerontechnology, and some are fairly new in the study of technology adoption. At the date of this writing, there could be only one technology adoption model found (Senior Technology Acceptance Model- STAM [13], in which the domestication process is recognized. However STAM's sequences of events are not entirely the same as those observed in this study. This could be due to STAM model conceptualizing elderly technology adoption in general, and not specifically focusing on elderly woman.

As tying emergent theory to existing literature is considered an essential part of case study research [16], this comparison of the emerged hypotheses with literature, while validating the findings, will help with the further generalizability and the efforts of theory building. The prevalence of this same pattern of elderly technology adoption, evident in other gerontechnology researches, suggests that this conducted research was simply an instance of a recurring theme (and possibly generalizable to elderly in general). Furthermore, as most of the triangulating literature, studied elderly technology adoption in general (as opposed to that of elderly woman), it appears that most of the proposed hypotheses could also apply to elderly, in general.

VII. CONCLUSION

By pioneering FCM Mapping into Grounded Theory approach, this study found that both the process and the product of Fuzzy Cognitive Mapping can be a great tool for conducting grounded theory research, augmenting both data collection and analysis. Aside from the simulation capability of FCM that provides computational power for the test of hypotheses, FCM mapping expands analytical thinking as the outmost important requirement of qualitative study.

The conducted research focused on explaining the process of adoption of smartphone by an elderly woman and studying if and how "gatekeeping" daughter influence this process. The findings suggest the gatekeeping daughter plays the most crucial role in the elderly woman technology adoption process. As hypothesized, this gatekeeper's influence is manifested in many ways, including: 1) Suggesting and encouraging, 2) Modeling, 3) Intervening, and 4) Providing the most effective facilitating condition. These effects were all separately and sporadically supported by the literature, however not a single research could be found that had captured all these influences together. As per major goal of grounded theory approach, to systematically search for the full scope of variations of the phenomena under study [23], to confirm or refute these insights, this research should preferably continue through further theoretical sampling [27] based on Yin's replication logic [24]. These samplings will look for similar and polar cases, such as extreme situations [94] that can, transparently, show the process of interest, and either replicate the current findings (further validating), or extend the emergent theory [16]. Upon practical theoretical saturation of the research, the generalized and verified substantive theory can be reached.

Additionally, the proposed model appeared to be the first technology adoption model specific to elderly woman. Consequently, the model specifically unveils conceptual insights to the process of adoption specific to this demographic, beyond the extant theories (such as TAM [91] or UTAUT [54]), and can readily provide deep understanding of the most pronounced drivers and barriers among this group. This specificity and granularity make the model most appropriate for immediate application in the field studies involving elderly women, and can support empirical implementations with minimal effort. The down side to such models is lack of generalizability; however as reported in detail, in earlier an earlier study [15], there are pressing demands for more empirical and specific application appropriate models [95]–[98].

The emerged core category of Innovation domestication, grounded in the case study data, although not groundbreaking, has not been fully explored in the context of elderly adoption, and the only model, recognizing this concept as a process toward adoption, found to date (STAM [13]), assumes a different sequence, not applicable to elderly woman. As captured in detail, elderly woman, due to low self-efficacy, needs to form the perception of ease of use before willing to experiment the technology. These findings are to be further validated or extended through theoretical sampling [23]; [24]. Multiple case designs are the preferred and robust ways in extending the theoretical framework, and sharpening its external validity [16] [24]. Regardless of number of units of analysis [24], the findings of this research should be attempted for replication [99], against other similar and opposite cases. While there are some guidelines (from up to 4 [16], to 4 to 10 [16]), Yin [24] suggests selecting cases based on the identified conditions, in which the phenomena is, and is not, anticipated to be found. In essence, the efforts are toward extending the theoretical framework, and to sharpen the insights' external validity [16].

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