How Marketing and Sales can Push and Accelerate Residential Refurbishment

Results of an Agent-based Simulation on pushing and accelerating Refurbishment Decisions

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***Abstract*—Agent-based models can be used to assess the impact of different mixes of marketing and sales measures on homeowner's energetic refurbishment decision-making. During the last two decades, governments have been using especially marketing-like measures (e.g., mass media campaigns) to push residential refurbishment – for a large part unsuccessfully. Only recently, more sales-like activities (e.g., visits of energy consultants) have been offered for that purpose. The question now arises whether this will be a more successful approach. This paper addresses the research question asking what mix of marketing and sales measures is optimal to support homeowners during their refurbishment decision-making.**

***Keywords*— Agent-Based Modeling (ABM); refurbishment Decision-Making (DM); marketing and sales; empirically grounded.**

I. Introduction and Motivation

Much research has been published about the importance of residential refurbishment for sustainability. Germany's building stock has been erected for the largest part before the existence of any energetic building standards. Furthermore, German homeowners tend to energetically refurbish their property slowly and doubtingly. Consequently, heating residential buildings consumes too much energy and is accompanied by a huge ecological footprint [1].

More recently, the dependence of many European countries on Russian gas for heating buildings and the war Russia has been fighting against Ukraine has recharged the debate that energy efficiency in housing should be improved and refurbishment should be speeded up to lessen the dependency on Russian gas.

This paper draws on a previous idea contribution of the author as discussed in [2]. It deals with the question asking how governments can optimally push homeowners in the direction of a positive refurbishing decision with the help of marketing and sales measures. In the past, governments used mass media campaigns to do this. More recently, local governments have been offering visits of energy consultants at a reduced (or even at no) charge to convince homeowners to refurbish. The question is whether there are optimal (cost efficient and concerning speed) mixes of marketing and sales measures that help homeowners make this decision positively. An empirically grounded Agent-Based Model for refurbishment is developed and the impact of different mixes of marketing and sales on refurbishment Decision-Making (DM) is simulated.

Science has applied ABM in the context of the current energy transition numerous times before. Du et al. [3] conclude in their review that ABM has been developed to model socio-demographic factors, housing factors, social influences, and environmental attitudes as drivers of DM in a context of energy transition. Most ABM, however, have focused on solar energy diffusion and less research was done to study refurbishment. Furthermore, Du et al. [3] conclude "Future studies can also evaluate the effectiveness of market-based policies […]" (p. 8).

Jager already stated in 2007 that the effectiveness of marketing could benefit from social simulations like ABM [4]. He proposed different formalizations of the 4 P's commonly used in marketing to be implemented in ABM (Product, Price, Place and Promotion). Delre et al. [5] focus especially on promotional activities, which is the category where mass and personal communication can be classified. Until today, however, ABM applied in consumer behavior DM studies do not differentiate between marketing and sales.

For both the literature concerning DM in an energy transition context, and ABM literature in the field of marketing, modeling an optimal usage of marketing and sales to push residential refurbishment is an interesting contribution.

This paper is structured as follows. Section II briefly explains the key concepts used in this paper. Here, the Hierarchy Of Effects (HOE) model, the German Sinus lifestyle typology, and the ABM approach are discussed, as they are used to simulate the refurbishment DM of 17 Mi. homeowners in Germany. Section III discusses all specifics and details of the developed ABM for refurbishment. Finally, Section IV presents and discusses the modeling results and answers the research question of this paper.

II. Key Concepts used in this paper

The objective of commercial communication (or "touchpoints") is to have an impact on consumers and to support consumers in buying DM. A large body of research exists to assess this impact. HOE models represent a family of models that examine this impact of touchpoints on different steps in the buying behavior. In this logic, HOE models assume

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forthcoming steps in the DM process can only be reached when previous ones have been effectively completed. Consequently, the number of people who reach the next step in the process is usually reduced, compared to the previous step. This transfer from a previous step onto the next is called conversion. HOE models enable the calculation of transfer rates under the influence of communication – and as well under the influence of different kinds of communication: mass and personal communication.

Section I mentioned that ABM has not distinguished between marketing and sales until today. HOE models can do exactly this: The first stages in the model are primarily impacted by marketing (mass communication touchpoints), and the last stages primarily by sales (personal communication touchpoints). This is the main rationale behind applying the HOE logic within the ABM for refurbishment.

In previous research, the author developed a HOE model for energetic refurbishment of residential buildings [6]. The resulting model is based on Lewis [7], Lavidge and Steiner [8] and is shown in Figure 1. This model assesses the impact of touchpoints on DM for energetic refurbishment.

The ABM approach simulates decisions and/or behavior of different individual agents. These agents can interact with their environment, as well as with each other. Within an ABM, usually different agents behave according to their individual preferences, their characteristics, their interactions, as well as their environment. Software for ABM allows for the setup and description of different agents, their preferences, interactions, as well as their environment. In this way, the aggregated system with its dynamics (that emerges from many different individual behaviors) can be simulated.

ABM is especially interesting when problems of emergence are studied [9]. This work uses this approach to study refurbishment intention (after interactions with marketing and sales) at a lifestyle and system level.

The last concept described is the Sinus Lifestyle typology. The typology is used in marketing & sales, both in practice and in academics. The Sinus Institute has been monitoring sociocultural developments and trends in the German society since the 1980ies and small adaptations to the lifestyle typology are carried out regularly. The lifestyles are positioned in a two-dimensional space. The x-axis describes their orientation: Traditional towards progressive lifestyles. The y-axis describes social status: Lower class towards upper class.

Ten lifestyles are located within this two-dimensional space. Previous research by the author [6] showed that depending on the Sinus lifestyle, German homeowners have very diverse attitudes and behaviors concerning energetic refurbishment of residential housing. This work uses the Sinus lifestyle approach as it forms an efficient segmentation approach to create differentiated, empirically grounded, agents within the ABM.

Figure 1. Hierarchy of effect model for energetic refurbishment [6]

After this brief description of the key concepts of this paper, the following section will provide a detailed description of the ABM that was developed to simulate the impact of marketing and sales on homeowner’s refurbishment decisions.

III. ABM FOR REFURBISHMENT

The ABM for refurbishment is based on empirical data, taken from [6] as displayed in Table 1. The representative sample (n = 4,471) describes the status quo of the DM concerning energetic refurbishment of 17 mi. homeowners in Germany.

It comprises Sinus lifestyle [10] data and their status quo concerning the DM process in the format of the developed HOE model as described in the previous section.

As an example, the adaptive pragmatic lifestyle (with 22.4% behavioral intention) is more than two times as likely to invest in energetic refurbishment compared to the precarious lifestyle (9.3% behavioral intention).

With the help of this data, conversion rates (CR) can be calculated, e.g., 65% of the social ecological lifestyle is converted from knowledge (80.0%) to attitude (52.3%).

Within the ABM for refurbishment, 17,000 agents (homeowners) are set up according to the distribution of the status quo in their refurbishment DM (as displayed in Table 1) and taking into account the real sizes of the ten Sinus lifestyles in German society.

The impact of touchpoints on each individual agent’s DM concerning energetic refurbishment is simulated with the HOE model. As a result of the interaction with various touchpoints an agent is guided through the five steps of the HOE model (see Figure 1). Taking one step within the HOE model is calculated with the help of a threshold variable. It is assumed that an agent’s threshold variable needs to reach a value of 4, prior to being transferred to the next step in the HOE model. Each touchpoint is increasing the threshold variable with a specific amount. Once an agent has been transferred, the threshold variable is set to 0 again. During the initialization of the model, the threshold variable is set randomly between 0 and 3. Each year, every agent’s threshold variable is updated as a result of being exposed to (different) touchpoints.

How much a specific touchpoint increases the threshold variable depends on the touchpoint itself. Touchpoints exist in many appearances and should not be generalized. Not every touchpoint generates the same impact. It is generally acknowledged in marketing and sales, that Mass Communication (MC) touchpoints (e.g., advertising campaigns and information brochures) are best suitable to transfer consumers through the first stages of DM, especially awareness, but as well knowledge and to a lesser extend interest. Furthermore, Personal Communication (PC) touchpoints (e.g., sales talks) are generally more suitable to transfer consumers through the last stages of DM, especially intention, but as well conviction and to a lesser extend interest [11][12].

TABLE I. EMPIRICAL DATA FROM [6]

German's Sinus lifestyle	Status quo in DM				
	Aware -ness [%]	Know-ledge [%]	Atti-tude [%]	Con-viction [%]	Inten-tion [%]
Homeowners in general	98.7	77.1	48.5	33.5	14.3
1. Established conservat.	99.0	80.1	51.0	33.7	14.9
2. Liberal-intellectual	99.7	82.9	57.9	40.6	13.3
3. High achiever	98.9	79.5	48.4	32.9	18.4
4. Movers and shakers	98.4	76.9	52.3	34.6	16.6
5. Adaptive pragmatics	99.5	69.0	53.9	42.4	22.4
6. Social-ecological	99.7	80,0	52.3	36.2	17.0
7. New middle class	98.5	76.9	44.1	32.6	11.8
8. Traditional	99.0	78.8	44.5	30.8	10.6
9. Precarious	99.6	64.4	36.1	20.6	9.3
10. Escapists	92.8	59.3	33.7	21.9	12.2

In the specific case of energetic refurbishment, homeowner have varying informational needs. In the first stages of DM there is usually a stronger focus on information gathering. In the later stages of DM, an interaction is usually necessary, to assess and to judge different financial, technical, or constructional aspects of the energetic refurbishment [13]-[15]. Especially these informational needs cannot be satisfied by mass communication alone.

So, mass communication can unfold a full impact in the beginning, but no impact at the end of the DM process. Personal communication can unfold a full impact at the end, but no impact in the beginning of the DM process.

This phenomenon is reflected in the model by incorporating a correction factor (CF) for the additions to the threshold variable. The correction factor for mass communication (CF_{MC}) is decreasing for every consecutive step (1.0; 0,5; 0.0 and 0.0) and the correction factor for personal communication (CF_{PC}) is increasing for every consecutive step (0.0; 0.0; 0.5 and 1.0) in the DM process. These values of the correction factors at specific stages of DM are assumed. Finally, every agent's threshold variable is increased with a value as shown in (1) in each period.

$$(CR * MC * CF_{MC}) + (CR * PC * CF_{PC}) \qquad (1)$$

Equation (1) incorporates the variables MC as well as PC, which stand for Mass Communication (MC) and Personal Communication (PC). During the initializations of the model, these variables can be set equal to the amount of mass and personal communication that the agents is exposed to during one period (of the simulation).

The amount of mass communication has a range between 0 and 5, which means that a homeowner is exposed to one mass communication touchpoint (e.g., a television or a radio commercial or an online advertising) between 0 (no exposure) and 5 times in one period. The amount of personal communication has a range of 0 to 5 as well. The meaning of this personal communication touchpoint range is linked to the number of energy consultants that is available and active. Currently, approx. 15,000 to 30,000 energy consultants for residential buildings are active in Germany, depending on the used definitions [16][17]. They realized approx. 280,000 energy consultancy reports in 2022 (compared to approx. 180,000 reports in 2021 and 100,000 reports in 2020 [18][19]). Such an energy consultancy report is assumably the result of a series of five personal communication touchpoints (e.g., personal emails and phone calls and visits). So, 30,000 energy consultants realized 1.4 mi. personal communication touch points in 2022. This paper assumes that 30,000 energy consultants could realize a maximum of 3 mi. personal communication touchpoints, leading to a maximum of 600,000 energy consultancy reports per period, in the years to come. This maximum practically means doubling their output in terms of personal communication touchpoints, compared to already high 2022 levels.

Section I described that in the past, governments mainly campaigned to push refurbishment. This can now be simulated with, e.g., MC = 5 and PC = 0. More recently, (local) governments have been offering and facilitating personal visits and consultancy by energy consultants in a limited way, which can be seen as a sales measure. This can now be simulated with, e.g., MC = 5 and PC = 1. The impact of any mix of marketing and sales measures can now be simulated by the model.

Section I mentioned as well that some ABM include social influence to simulate DM in a context of energy transition. Baranzini et al. investigated social influence in photovoltaic panel diffusion in Switzerland and conclude that "Social contagion is also a driver of adoptions in the private sector". They add "We also confirm […] that social contagion is a very localized and short-term phenomenon, whose strength declines with distance and time." [20]. The ABM for refurbishment incorporates this phenomenon in the following way. Each positive refurbishment decision in the direct neighborhood of an agent leads to an acceleration of the DM process. This is implemented in the model by increasing the threshold variable by 30% for every neighboring agent's positive refurbishment, as shown in (2).

$$(100\% + (\text{No. of agents} * 30\%)) \qquad (2)$$

Potentially, the acceleration can reach multiples of 30%. The maximum acceleration however is set to 120% (because of 4 neighboring agents, or more than 4 neighboring agents, taking positive refurbishment decisions). This acceleration effect is limited to two periods after the period of the refurbishment. In the model 5,041 districts with 17,000 homeowners exist. Each district has an average of 3,4 homeowners.

Another essential aspect of touchpoints is their price. In general, mass communication is less costly than personal communication. A common way to quote prices in mass media is with the help of the costs per mille (CPM) metric, which expresses the price per 1,000 views. Price ranges for CPM vary greatly, as media vary greatly in type and quality. An average CPM for mass media in the ABM for refurbishment is set to € 13.50. This is based on a media mix of Television (30 seconds advertisement, median $ 36 CPM), Radio (30 seconds advertisement, median $ 6.75 CPM), Online (300 x 250 banner ad, median $ 2.27 CPM) and magazines (full page color ad, median $13.24 CPM) [21]. US-Dollar ($) to Euro (€) conversion done on the 25th of August 2023. The

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costs for a personal communication touchpoint in the ABM for refurbishment is set to € 16.67. It is assumed that a salesperson costs € 80,000 per year and has 200 working days per year. During a typical 5-day work week in average of 16 potential customers can be visited. Furthermore, during each working day, 10 phone calls and 10 Emails can be processed. This leads to 4,800 touch points, or € 16.67 per touchpoint.

An optimization of refurbishment intention and costs is not sufficient, as the speed of refurbishment needs to increase (see Section I). As time is an importance factor, this paper limits the modeling time to 27 years (2023 to 2050) and tries to identify the costs for more refurbishment speed.

Finally, it must be mentioned that the ABM for refurbishment was realized in the Netlogo environment [22]. The model's code is available under GitHub [23]. The simulation results were imported in Microsoft Excel to analyze and plot them.

IV. RESULTS AND DISCUSSION

This section presents and discusses the results of the ABM for refurbishment. First, the impact of different levels of mass and personal communication over a fixed period of 27 years (from 2023 – 2050) are investigated. Therefore, a first sample was created that consists of 720 observations (n = 720). One observation is the result of running the ABM for refurbishment 27 years. 20 observations were done for every combination of Mass Communication (MC) and Personal Communication (PC) between 0 and 5 (see Section III), to account for stochasticity in the model. Second, this paper looks into the velocity of developing refurbishment intention, for which a second sample is created. This sample consists again of 720 observations (n = 720), however, the ABM for refurbishment only runs until a refurbishment intention of 95% among homeowners is reached. With specific combinations of mass and personal communication, this happens in less than 27 years. Both samples documented all homeowner's reached status quo in the DM process. Furthermore, the costs that are involved with mass and personal communication are recorded, as well as Sinus lifestyle data. Analysis shows that the first and the second sample do not differ significantly for these key variables.

Figure 2 shows the impact of mass and personal communication on refurbishment intention at an overall system level after 27 years (sample I). One important finding is that mass communication alone does not convince homeowners to refurbish. This modeling result is in line with the previously described phenomenon that governments mainly used mass communication in the past and could hardly change the hesitant refurbishment behavior of German homeowners. The portion of homeowners with a refurbishment intention increases from 14.3% (see Table I) to 18.6% after 27 years of mass communication. This result can be interpreted as a indicator that governments have been working cost inefficiently by investing solely in mass communication campaigns.

The costs for mass and personal communications are illustrated in Figure 3. These are accumulated economic costs after a fixed period of 27 years of mass and personal communication exposure. Later in this paper, specific mixes of

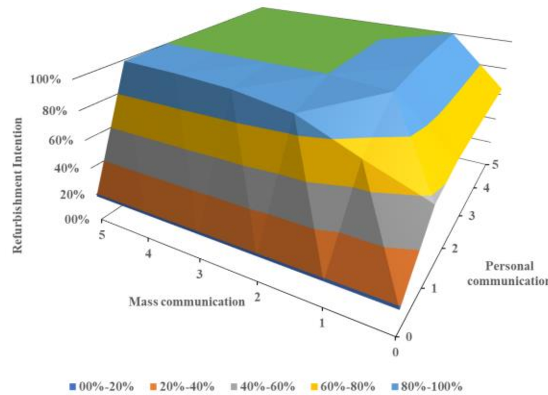

Figure 2. Mass and personal communication and refurbishment intention

mass and personal communication will be identified that enable an acceleration of the creation of refurbishment intention and less time than the fixed period of 27 years will be necessary, resulting in lower economic costs.

Figure 3 shows that personal communication is the main driver of total costs. And it is important to acknowledge that these accumulated costs represent the economic costs and are not necessarily paid by one and the same party. This makes them abstract and somehow intangible. While governments might invest in mass communication campaigns, households might invest in energy consultancy. Nevertheless, an optimal point should be identified, where all (or most) homeowners decide to refurbish at least costs. This point can be identified at MC = 5 and PC = 1. At this point, the model shows that after 27 years, 99.2% of German homeowners developed a refurbishment intention at economic costs of € 301.01 mi.

In a next step, this paper investigates the velocity of developing a refurbishment intention of 95% among homeowners, with the help of sample II. This seems a highly relevant information, as it could reveal levels of mass and personal communication that convince homeowners to refurbish more rapidly. In this way the model can determine the additional costs for more rapid refurbishment paths. The cost in Figure 3 should now be adjusted as well, as with specific mixes of mass and personal communication, less than 27 years are necessary to reach a 95% refurbishment intention. Figure 5 shows these adjusted total accumulated costs.

The optimal point can be identified for Figure 4 and 5 as well: still at MC = 5 and PC = 1 a 99.2% refurbish intention among Germany's homeowners until the year 2050 is reached (and a 95% refurbish intention is reached slightly earlier in the year 2048). The economic costs would yield up to € 301.01 mi. (at 99.2% in the year 2050) or € 278.7 mi. (at least at 95% refurbishment intention in the year 2048). Faster pathways however are now becoming visible and are listed in Table 2, as well as the additional costs for this acceleration. The additional costs are calculated by comparing the specific scenario with the optimal point MC = 5 and PC = 1. The table is sorted by the column duration in years and shows the levels of mass and personal communication (MC and PC) that reach a 95% refurbishment intention.

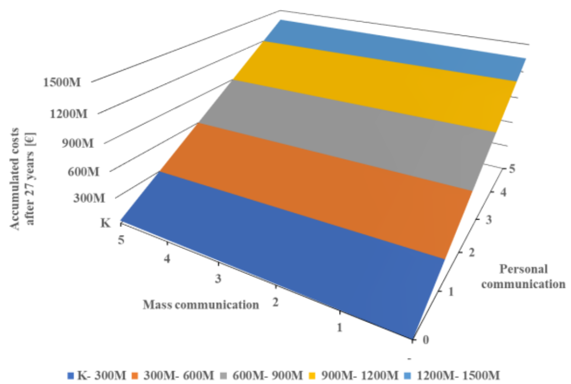

Figure 3. Total costs of communication after 27 years

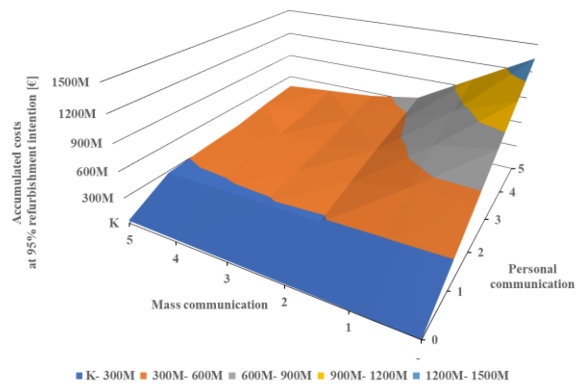

Figure 5. Total costs of communication at 95% refurbishment intention

As an example, the duration of developing a refurbishment intention of 95% among German homeowners can be reduced by 10 years by looking at the MC = 5 and PC = 2. With these levels of mass and personal communication, the system reaches a 95% refurbishment intention after 15 years with additional costs of € 38.6 mi. Practically, this means additional investments of 89% per year (€ 278.7 mi. over 27 years compared to € 317.3 mi. over 15 years), or 14% over the whole period. Another example is the point MC = 3 and PC = 2 at which a 95% refurbishment intention is reached after 17 years (instead of 25 years) with additional costs of € 73.1 mi. Practically, this means additional investments of 86% per year (€ 278.7 mi. in 25 years compared to € 351.8 mi. in 17 years), or 26% over the whole period.

V. CONCLUSION AND FUTURE WORK

The ABM for refurbishment and the results in this paper investigate the research question whether there are optimal (cost efficient and concerning speed) mixes of marketing and sales measures that help homeowners to create a positive refurbishment intention. To answer this research question model based, an ABM model for refurbishment is developed that utilizes (for German homeowners) representative data concerning their DM process for energetic refurbishment.

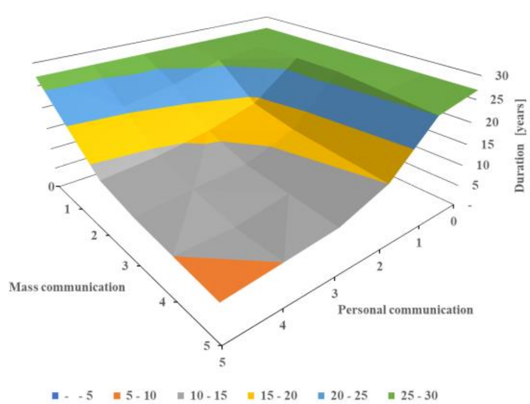

Figure 4. Time duration of reaching a 95% refurbishment intention

This paper describes different samples that were created for the two different sub questions. The ABM for refurbishment shows that advanced levels of Mass Communication (MC = 5) and small to moderate levels (PC = 1) of Personal Communication can lead to a refurbishment intention saturation among German homeowners in a cost-efficient way. This result suggests that past initiatives from governments to create refurbishment intention through mass communication only were inefficient. This paper explores as well additional costs for an acceleration of the development of refurbishment intention under the influence of mass and personal communication. Even if the economic costs estimated in this paper seem somehow abstract and intangible, the model shows that specific levels of mass and personal communication can significantly accelerate the creation of refurbishment intention in the population at accumulated costs that do not seem unfeasible. The explorations in this paper show that there is a potential to speed up the energy transition in buildings.

TABLE II. ADDITIONAL COSTS FOR FASTER REFURBISHMENT

Combinations of MC and PC		Characteristics of combination		
MC	PC	Duration [years]	Accumulated costs [mi. €]	Additional costs vs. MC = 5 / PC = 1[mi. €]
5	5	9	460.4	181.7
4	4	10	409.3	130.6
5	4	10	411.6	132.9
4	5	10	509.3	230.6
5	3	11	342.7	64.0
3	5	11	557.4	278.7
4	3	12	371.1	92.4
3	4	12	488.4	209.7
3	3	13	399.0	120.3
2	5	13	656.1	377.4
2	4	14	566.0	287.3
5	2	15	317.3	38.6
4	2	16	334.8	56.1
2	3	16	487.4	208.7
3	2	17	351.8	73.1
2	2	19	388.8	110.1
1	5	20	1,004.8	726.1
1	4	21	845.0	566.3
1	3	23	696.4	417.7
1	2	26	526.7	248.0

This paper does without an explicit sensitivity analysis for the ABM for refurbishment, as the explorations discussed in this paper represent a kind of sensitivity analysis for refurbishment intention among homeowners by itself. This paper presents different figures (e.g., Figure 2 and 4), which assess the sensitivity of refurbishment intention (in terms of the portion of homeowners with refurbishment intention, and in terms of the time to develop this refurbishment intention) as a result of different mass and personal communication levels.

Although this work develops a segmented approach to simulating German homeowners' DM for energetic refurbishment, it assesses the costs for touchpoints for these homeowners in a lump-sum kind of way at the end of Section III. Future work could address this issue and do an attempt to develop a segmented and more realistic cost calculation approach for the different Sinus Lifestyles.

Another issue lies in the simulation of specific (but static) mixes of mass and personal communication over a longer period. It is common marketing practice to vary campaigns over time, which is not incorporated in the ABM for refurbishment. Future versions should dynamize the levels of mass and personal communication over time (within the simulation time of 27 years, e.g., reducing mass communication from MC = 5 to MC = 1 and increasing personal communication from PC = 0 to PC = 1 over time).

The same holds for the static approach concerning the capacities of energy consultants. Section III discusses a maximum of 3 mi. personal communication touchpoints per period, in the years to come. Most likely, capacity will increase in case of change of momentum in the refurbishment market and this should be considered in the model.

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[23] Please refer to Github under https://github.com/mart-verhoog/marketing-and-sales-to-push-residential-refurbishment.git for all code in the NetLogo environment of the ABM for refurbishment.