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NUDGING SUSTAINABILITY: TRIGGERING CONSERVATION BEHAVIOUR IN THE HOUSEHOLD'S ELECTRICITY CONSUMPTION

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This study looks at potential polycentric solutions for reducing greenhouse gas emission by engaging and nudging residents to lower their household's electricity consumption. More specifically, it seeks to nudge respondents towards energy conservational behavior using libertarian paternalism ideology and the principles of choice architecture. The study is focused on subjects in Finland, where the electricity bill is not a financial burden and society is environmentally responsible. Based on the limited data provided by an energy company, the analysis provides insights on the patterns of household's electricity consumption and comparison of electricity usage between household's with smart solutions and without. Based on previous research and findings of the study, a prepaid contract is suggested to nudge people to more sustainable behavior in regards to their energy consumption with long-term effects and without the need for any financial incentives.

Keywords: Nudge, Choice Architecture, Behavioral Economics, Energy behavior, Environmental Values, Polycentricity

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Chapter 1: Motivation

Global Climate Change is one of the most discussed subjects of the 21st century. For the last 50 years, CO2 emissions have increased by about 90% (IPCC 2014). Developed countries are responsible for most of the carbon footprint of household electricity consumption worldwide. According to the US Environmental Protection Agency, residential and commercial energy usage accounts for 34% of total "Greenhouse Gas Emissions." While societies in developed countries pay attention to sustainable development, people do not necessarily recognize their individual role in carbon emissions. First of all, electricity is not something one can touch or see. The understanding of the value of one kWt in terms of money, efficiency, and emissions, is missing. To many, it is a mystery how much electricity their household appliances consume. Moreover, in developed countries, the share of the electricity bill as a proportion of the households' budget is relatively small and does not create financial pressure. Thus, electricity consumption may be hazardous. Is there a way to nudge people to be aware of their household's electricity consumption by improving choice architecture, and to lower it without imposing additional financial incentives? This research is directed to find a new solution in a libertarian paternalism style providing a new prepaid contract for electricity.

As energy efficiency plays a role in the strategic development of the country, municipalities take action to provide new solutions to lower household's electricity consumption along with industrial use. The city of Helsinki has set a target to reduce its greenhouse gas emissions in 2020 by 30 percent compared to the benchmark year of 1990. To find a way to achieve this goal in the most efficient way, the municipality has established a national pilot project. The project is focused on smart solutions that would help citizens to maintain a sustainable lifestyle. Together with various projects, an energy company in cooperation with city officials has provided residents with the HIMA service - an automated real-time tracking system for energy and water consumption.

The research was intended to show whether smart services nudge consumers to become aware of their electricity consumption and hence provide a long-term effect in reducing it. The polycentric approach engaging the population has a chance to achieve the goals to decrease greenhouse gas emissions and slow down climate change.

Chapter 2: Climate Change - Collective Action Problem?

Chapter 2.1: The Tragedy of Commons

Growing population problem and the shortage of resources were discussed in Garrett Hardin's influential essays back in 1968. His theory of the "Tragedy of Commons" explains the overuse of public goods. In his essay, Hardin illustrates the issue on the example of the pasture used by a number of herdsmen. The territory is restrained by size and sheep owners have an open access to the field. As the goal of each herdsman is to maximize the utility, they increase the size of the cattle for additional utility. As a result, the growing number of sheep causes the overgrazing of the pasture. Thus, with the time, no nutrition for cattle is left. The tragedy is in absence of incentives for each of herdsmen to limit the number of livestock, even though the end result of such behavior is the loss of cattle. "Freedom of Commons ruins it all," states Hardin. The offered solution is privatization: dividing the field in the privately owned areas for each of the actors. In this case, the incentive would change. Herdsmen would take care of the pasture condition and would not overpopulate it with stock.

Ostrom (2008) sees common-pool resources as '… sufficiently large that it is difficult, but not impossible, to define recognized users and exclude other users altogether. Further, each person's use of such resources subtracts benefits that others might enjoy'. Climate change, like other "global problems," is a cumulative outcome of the actions and decisions taken by national governments, international agreements, local and international firms, interest groups, households, and separate individuals. Just like most of the examples of "Tragedy of commons," everyone would benefit from lowering CO2 emission. Nevertheless, each of the actors has an incentive to free ride others and not to invest in the solutions either financially or using other resources (Cole, 2008; Sandler, 2004). Along with Elinor Ostrom's point of view, while climate change is a global problem, the causes of the issue come from actors at smaller scales. The long-term solution is in recognizing the impact of individual daily decisions on the reduction of emissions of GHGs. At the small scale, family's decisions about transportation use, choice of the vehicle, energy and heat consumption, products and services – most of the actions have an impact on the environment. There are ways to encourage residents to make better environmentally friendly decisions. A government can nudge citizens to use less personal vehicles by providing a high-quality of a public transport network. For example, Helsinki has set a goal to become a car-free capital by 2025 (Heikkilä, 2014) and Tallinn is the first European capital to provide free public transport for its citizens. Such policies have positive externalities of drawing migrants and investments to the city.

Chapter 2.2: Conventional theory and polycentric approach

In conventional theory of collective action problem, independent individual actions are costly, and only the joint effort can produce the desired outcome. According to this theory, the collective action problem can be solved with roadmaps and rules imposed by authorities, that monitors behavior and sets sanctions.

There are a couple of different attitudes towards ways how to resolve climate change issue. One is the global collective actions, second – polycentric efforts. The first group of people stresses that the problem is global and thus has to be tackled at the global level. Strictly imposed regulations at the global level are needed to reduce emissions (Brennan, 2009). The game theoretical approach shows that if one of 10 countries contributes to the CO2 reduction, all countries will benefit from it, which creates an incentive to free ride. To succeed globally there has to be a tough monitoring and punishment system. Also with privatization, imposing personal responsibility to the businesses or individuals is one way to approach the issue. The short-term material benefits can trigger irreversible damages that would be costly to fix in the long run.

The Intergovernmental Panel on Climate Change (IPCC, 2014) report concludes that climate change is one of the national priorities along with energy security and alleviation of poverty. There are a variety of policies that aim to lower global carbon emissions. However, environmental issues, such as high level of carbon emissions, are challenging to resolve due to its collective action problem.

Richard Meserve, President of the Carnegie Institution of Washington and former Chairman of the U.S. Nuclear Regulatory Commission, stressed: "climate change is a severe challenge that no one country can solve"(Meserve, 2008). To begin with, the weight of the responsibility for climate change lies on the shoulders of developed industrial countries. For example, China is responsible for nearly 30% of World's total emissions. USA and EU28 are in second and third places with 14% and 10% respectively. The Paris Climate agreement in 2016 was launched on the same notion.. The Paris Agreement was aimed to combine efforts towards slowing down global warming to no more than 1.5 °C above pre-industrial levels.

Another group argues that global actions and agreements are not enough to tackle the climate change problem. As Elinor Ostrom (2010) assesses the issue: "climate change is a global collective action problem since all of us face the likelihood of extremely adverse outcomes that could be reduced if many participants take expensive actions." Climate change is a complex problem with numerous reasons and triggers. Polycentricity is considered as a useful analytical tool to approach climate changes stabilization efforts, as there are diverse efforts at a global scale taken to tackle the issue. This concept was introduced by Ostrom et al. (1961). Using polycentric approach, they attempted to understand whether the various actions of private and public actors in

the urban environment were disorganized or potentially a productive arrangement: "Polycentric" connotes many centers of decision making that are formally independent of each other.… To the extent that they take each other into account in competitive relationships, enter into various contractual and cooperative undertakings or have recourse to central mechanisms to resolve conflicts, the various political jurisdictions in a metropolitan area may function in a coherent manner with consistent and predictable patterns of interacting behavior. To the extent that this is so, they may be said to function as a "system". (1961, pp. 831–32)

The extensive multi-year research has shown that "most efficient producers supply more output for given inputs in high multiplicity metropolitan areas than do the efficient producers in metropolitan areas with fewer producers" (Ostrom and Parks, 1999). In other words, the "Think globally, Act locally" is the right approach tackling the issue of growing GHG emissions.

It is important to acknowledge the risks of each tool. In her paper, Ostrom (2010) addresses the five most frequent problems within the collective action problem overall and polycentric approach. First, there is *leakage, which* is one of the externalities of the policies. Leakage implies that the reduction of activities in one locality results in its increase in the other. It underlines an importance of global treaties to provide global regulation to prevent the shifting of emissions to other countries or regions. Second, there is the *inconsistency of policies* that is interconnected with the issue of leakage. Here we have to see the world through the eyes of firms: it is costly to comply with inconsistent policies in different areas and invest in the development of certain technologies. *Inadequate certification* is the third issue. The need to comply with norms and certification created a new market for consultants creating a new principal agent problem. Now, there is a need to keep track on the global consultants on their professionalism and attention to cases. The last two issues are "*gaming the system*" and "*free riding*". As a nudge to reduce emission, there are various programs for funding or crediting initiation of companies moving towards sustainability. According to Wara (2007), some firms take advantage of the current carbon credit trading systems. The fifth is the major problem of free riding. As Ostrom (2010) puts it "Whenever actions taken by some individuals or organizations benefit a larger group, a risk always exists that some participants will free ride on the efforts of others and not contribute at all or not contribute an appropriate share."

Chapter 3: Environmental Values and its Importance

There is a notion that environmental protection is a 'first world problem.' Indeed, when there is no objective local problem with the pollution and environment, it is a rare case to engage in

environmental protection. In this master thesis, it is argued that the energy conservation behavior can be triggered with nudging. It would be wrong to argue that one solution fits all. A nudge is a useful tool when there is no financial pressure, or when it is not needed. In developing economies where there are strict budget boundaries, and the electricity bill eats a significant part of the monthly expenses, people do not need an additional push to lower their energy consumption. Therefore, the focus is on the developed countries, which, as stated earlier, are responsible for the largest part of world's CO2 emissions in the household energy consumption. Finland was chosen as a subject of the research, arguing that in the developed society with postmaterialistic values, people are ready to address the climate change and lower their electricity bill for a greater good.

In order to support the argument, the study has been conducted to show that reaching a certain level of life satisfaction and happiness makes people more aware of environmental problems, even with no local reasons for it. The hypothesis is demonstrated on the example of Finland and data from World Value Survey from 2005. Economic development and freedom of self-expression have an impact on strong environmental values.

One of the descriptions of 'values' given by Oxford dictionary goes as following 'principles or standards of behavior; one's judgment of what is important in life.' Schwartz & Bilsky (1987) have a wider definition of values: "According to the literature, values are (a) concepts or beliefs, (b) about desirable end states or behaviors, (c) that transcend specific situations, (d) guide selection or evaluation of behavior and events, and (e) are ordered by relative importance".

Much research has been undertaken on this by a number of social sciences including ethics, psychology, philosophy, economics, and others. There is a certainty that values take an important role in decision-making. In ethics theory, values influence people's decisions. Hecter (1994) argues that value system help to determine the preferred choice when there are multiple alternatives with different trade-offs. In economic theory, there is a notion that human behavior is solely maximizing of utility. However, in social choice theory, we identify that values of an individual have a severe impact on utility function of one – rational choice theory. Moreover, values play a major role in personal identity and have a strong weight in the cost-benefit analysis. Here the difference between classical and behavioral economics comes to play.

One of the most widely used measures of values, The Schwartz Value Survey, were developed by Schwartz & Bilsky (1987). Based on the previous work by Rokeach (1973), it contains 56 factors that are rated on a 9-point scale, indicating the importance of a stated value as a guiding life principle. For measurement of environmental values, Schwartz items have been regrouped to capture the biospheric-humanistic values distinction (Stern et al., 1998). In the original paper, Stern et al. (1993) offered the following model to measure the influence of value:

M= VegoACego+VsocACsoc+VbioACbio

The model reflects three predetermines of environmental concern: self-interest, humanistic altruism, and biospheric altruism. In the model, M is a motivation to take a course of action. Vego is a weight and ACego is awareness of consequences of the course of action to self-interest (Stern et al, 1993). "Soc" part reflects relation to other humans (i.e. humanistic altruism). The latter one, "Bio" corresponds to outcomes for other species, ecosystem, and biosphere (i.e. biospheric altruism). These three factors for environmental concern are distant from each other (Stern et al, 1993), as each of then illustrates different motivation. Humanistic altruism includes (1) A world at peace, free of war and conflict; (2) Social justice, correcting injustice, care for the weak; (3) Equality, equal justice for all. Biospheric values represent following components: (1) Protecting the environment, preserving the nature; (2) Unity with nature, fitting into nature; (3) Respecting the Earth, harmony with species. For the purpose of this study, biospheric values will be used for identifying the link between self-expression, environmental values in different regimes.

There is a notion that environmental values arise as a part of postmaterialistic values on the societal level (Inglehart 1990). Inglehart (1995) later found that environmental protection is greater in countries that have severe environmental issues like air or water pollution and countries with postmaterialistic values. Interestingly, he hypotheses that "given individuals pursue various goals in hierarchical order—giving maximum attention to the things they sense to be the most important unsatisfied needs at a given time" (Inglehart 1971).

The hypothesis of the research is that self-expression values are connected to environmental values. Previous studies have indicated that self-expression and subjective well-being indexes are higher in democratic regimes. As Inglehart (1995) has found that societal support for environmental protection emerges from severe objective problems and subjective cultural factors, this study concentrates on the latter. Nordic society is a frontrunner in environmental policies and societally responsible attitudes. The pollution indexes in these countries are the lowest in the world. Therefore, the argument of objective problems of the environment in Finland can be crossed out, and significance of the post-materialistic values is left. The hypothesis is that environmental values are strongly correlated postmaterialistic and self-expression values, and subjective well-being value. In the wide study of 43 countries, Inglehart (1995) stated that Postmaterialistic publics rank higher level of readiness to invest into environmental protection.

For the analysis, relationship between self-expression and environmental values has been investigated using World Value Survey (WVS) data developed by Ronald Inglehart. Wave 5 of World Value Survey has been used for this study as it includes the Schwarts value measures required for the study. As an independent variable reflecting the importance of environmental

values amongst the respondents, the best fit was a question where respondents had to identify the importance of looking after environment for them. This statement is from Schwartz value measure, which identifies biospheric altruism. The answer to this question is 6-points scaled: 1. Very much like me; 2. Like me; 3. Somewhat like me; 4. A little like me; 5. Not like me; 6. Not at all like me. This variable is included only in the fifth wave of World Value Survey. Therefore, it was possible to examine only one wave of the WVS.

In line with Inglehart's previous studies, , Subjective Well-Being (SBW) Index has been used as a dependent variable. In the survey, respondents were asked to place their life satisfaction on a scale from 1 to 10, where 1 is not at all satisfied, and 10 is very satisfied.

Happiness was measured by four categories (very happy, rather happy, not very happy, and not at all happy). SBW measure combines the answers on life satisfaction and happiness level with equal weight to each variable. Similarly, as Inglehart uses the index, SWB is constructed in the following way: SWB=life satisfaction – 2.5xHappiness. As a result, countries, where satisfaction and happiness are well balanced, the index will equal zero. In countries, where people report to be very happy and very satisfied, the index can reach a maximum of 7.5 points. Otherwise, a country gets a negative score. Those variables have been included in all six waves of WVS. Also, respondents were asked to identify the statement that is closer to their point of view when discussing the environment and economic growth: 1. Protecting the environment should be given priority, even if it causes slower economic growth and some loss of jobs; 2. Economic growth and creating jobs should be the top priority, even if environment suffers to some extent. This statement strongly correlated with Schwartz environmental value.

Membership in an environmental organization is expected to be interactive with the dependent variable. In the survey, respondents identified whether they are active, inactive, or not members of an environmental organization.

As the next set of variables, the influence of tolerance and a sense of free choice indicators are investigated. In previous studies (Inglehart at al. 2008) the impact of tolerance and a sense of free choice are correlated on SWB. Therefore, such variables are included in the model as well. It is identified if respondent mentions that he or she would not like to have homosexuals as their neighbors. Also, as a tolerance measure, respondents reported on the important child qualities such as tolerance and respect for other people. The sense of free choice was indicated by 10-point scale how much do they have free choice and control over their life, where 1 means "no choice at all" and 10 means "a great deal of choice."

There is no need to test the impact of economic factors and democratization as values from one wave of the WVS were used. However, it is important to mention that a Finnish level of

democracy from the Polity IV project is ranked 10 – the highest level in the democratic measure. The GDP per capita in 2005 (the year of survey) was 38,969.17 USD dollars calculated by the World Bank Database.

In Finland, the Environmental values are reported to be rather high. To the query "It is important to this person looking after the environment", most people identify themselves as those looking after the environment. Over 60% of the sample has reported that the statement describes their attitude as "Very much like me" and "Like me". Almost 25 per cent consider themselves to the category "Somewhat like me" (see Appendix, Table 1).

The regression model has shown that four factors correlated with environmental value (see Appendix, Table 2. The Environmental Values regression model). It is important to mention that the negative beta coefficient must be interpreted as a positive influence on the dependent variable. The inverse interpretation comes from the scale of the dependent variable, where lowest value 1 is Very much like me, and highest 6 is Not at all like me.

As expected, Environment protection over economic growth and Membership of environmental organization has the highest significance with 0,000 and 0,017 respectively. The Subjective Well-Being index's significance level is 0,043, which is 95% significant. Hence, it has a positive impact on environmental values. The tolerance and freedom of choice and control factors showed no significance, except acceptance of homosexuals as neighbors, which identifies the tolerance to inner groups.

Happier and more satisfied people get more aware of the environment. As Inglehart (Inglehart et al. 2005) has discussed, postindustrialization values belittle objective constraints on human choice. Socioeconomic development aids people to become materially more secure and puts emphasis on human autonomy making them more independent. At the same time, the postindustrialization increases the value of self-expression. The argument is that when this index is high, people can concentrate on biospheric altruism like environmental values. The model has shown that higher the SWB index – higher is the environmental value.

There is a strong link between being active in issues connected to environmental protection, putting environmental protection over economic growth, and reporting high environmental value. This correlation comes as no surprise. As has been seen shown from Schwartz value measurement question, in Finland, people tend to look after the environment. In line with Dietz et al. (2005), there is a need for more data, and more detailed research as the inner group tolerance shows a significant positive impact on the environmental values while other factors appear to have no effect.

High level of life satisfaction and happiness make people care more about the environment even in the conditions when there are no objective problems of local pollution in the country. The high SWB index has a liberation effect releasing the constraints allowing people to concentrate on subjective matters. Therefore, Finland is an exceptive example for nudging to lower electricity consumption where financial incentive is a weaker nudge than appealing to behavioral aspects.

Chapter 4: Are People the Rational Decision-Makers Classical Economic Theory Assumes them to be?

"Behavioral economics provides a powerful new set of tools for policymakers and citizens to address the challenges of today and improve the quality of our lives. But even though many of the key insights are twenty to thirty years old, policymakers have been slow to apply them … The application of behavioral economics could offer substantial gains in relation to the environment, crime, pro-social behavior, education, welfare and health."

David Harpern, The Hidden Wealth of Nations, 2010

In classical economics, the theory of the rational actor model is the basis for human behavior. The model states that people make decisions by evaluating the outcomes and its effects of various possible choices (Jaeger, 2001). Classical economic theory describes human beings as rational actors who can make well weighted, fully informed decision towards maximizing utility. In other words, being fully rational and selfish, people gather all available information on the product or service, perform the cost-benefit analysis and make the best decision according to the maximization of their utility. However, common practices show otherwise. While wanting to go on a luxurious vacation or purchase a new vehicle, people have problems with savings, controlling impulsive purchases and falling for marketing. Moreover, in the global markets, choices are usually complicated, and the payoffs are rarely clear. At times, the financial incentive does not carry as much value as the irrational characteristics of the options.

The process of human decision-making still requires deeper scientific research. The mechanism of human logic and desires is dictated by various factors such as physical needs, environment, social background, cultural bias, and personal preferences. Herbert Simon (1956) drew a comparison between a simple organism's actions and human behavior. The former has one goal of finding nutrition by randomly traveling, eating the first food it finds, resting to regain its energy, and repeating the "algorithm". In the described model, the simple organism is indifferent to the options and is compelled to maximize the utility. Simon (1956) further added more goals for the

organism and more characteristics for the environment. Thus, while still being indifferent to the options, its choices are fully rational. Half a century ago, Simon questioned the usefulness of the classical economic approach that ignores social and individual human factors. Combining economics, mathematics, and cognitive psychology, he emphasized the complexity of the decision process. In his previous paper, Simon (1955) added additional characteristics to the choice of actions, like preferences, interdependency, the cost and process of information gathering, sequentiality of the choice, "aspiration level", values, preference, and other characteristics and boundaries. While being a pioneer of behavioral economics, Simon was known as well with his innovating research on artificial intelligence due to blending the study of decision-making and computer science.

Behavioral economics claims that classical economics oversimplifies human behavior. In short, a person can prefer one product or action to another not only in light of its price but also with regards to one's individual distinctive value system. Therefore, it is necessary to combine different subjects like economics, sociology psychology and other sciences determining the reasons for the choice. Examples of human characteristics discovered by behavioral economists are draw further in the study.

In 1979, Daniel Kahneman and Amos Tversky published a seminal on decision-making. They are the authors of prospect theory showing how individuals base their decisions between probabilistic choices involving risks and an unknown probability of different outcomes. Social sciences differentiate between risk averse, risk neutral, and risk seekers. The way these three groups evaluate their outcomes is drastically different from each other. With this theory, economists extended classical economics by adding probabilistic alternatives with risks and the unknown probability of different outcomes.

Samuelson and Zeckhauser (1988) illustrated the status quo bias in numerous situations that can fall into three categories "(1) rational decision making in the presence of transition costs and/or uncertainty; (2) cognitive misperception; (3) physiological commitment stemming from misperceived sunk cost, regret avoidance, or a drive for consistency." One can see the value of an object higher than others as a result of his/her background, education level, knowledge of the subject, emotional connection with it, amongst others. The empirical evidence (Samuelson and Zeckhauser 1988) showed that prevailing status quo bias parallels with testing the loss aversion. As complicated as the human mind is, the irrational factors are interdependent on each other, making it extremely hard to replicate a decision process. However, the development of behavioral economics allows us to get a deeper insight into the human brain and the economic outcomes.

Behavioral economics shows that people can act based on their preferences and emotions with possible altruistic intentions. There are a number of characteristics that define decision-making: peer pressure, risk aversion, default bias, myopia, loss aversion, excessive confidence, peer pressure, and others. Understanding the reasons behind the choice is important in policy-making to predict outcomes, impacts, and externalities. The following characteristics are described in the next chapter when talking about nudging and paternal liberalism.

Chapter 5: Nudging People to Make Better Choices

In their book "Nudge: Improving Decisions about Health, Wealth, and Happiness", Richard Thaler and Cass Sunstein (2008) coined a new "economical" meaning of nudge as a part of their *libertarian paternalism* ideology. According to authors, it is possible to nudge people to perform better actions and decisions through a choice architecture. "A nudge, as we will use the term, is any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates. Putting fruit at eye level counts as a nudge. Banning junk food does not" (Thaler and Sunstein, 2008). The essence of the nudge is to gently direct people using a better design of services and products towards smarter behavior without imposing boundaries and financial incentives.

Thaler's and Sunstein's way of thinking supports that the best way to achieve the goal is by making respondents want themselves to commit to a goal, act one or another way. *Libertarian paternalism* is a way of influencing decisions in a way that makes a person better off "as judged by himself or herself" (Thaler and Sunstein, 2008): paternalism stands for wishing the best for the chooser and thinking of his/her benefit, libertarian - for not restricting the choice options so as to provide liberty to go with his/her preference. In most cases, libertarian paternalism reminds marketing, when a buyer has to be persuaded to purchase a product or service by raising awareness, providing better design and additional value, placing the object in the most accessible place, all of it while not blocking the competitors, but in a social welfare context. In their book and papers (Thaler and Sunstein, 2003, 2008; Thaler et al. 2010), libertarian paternalism is based on the idea that while having the freedom of choice people lean towards smarter solutions without material punishments or endorsements. It is so-called prevention mechanism of making children to eat more vegetables in the school by placing them at the eye level and easily accessible places without monitoring their actions. In the long term, healthy nutrition will decrease the probability of health complications. To some degree, correct nudging makes monitoring – one of the most costly collective action solution tools – unnecessary as people individually commit to one or another goal.

Thaler and Sunstein also distinguish between "econs" and "humans." People do not behave rationally as described in the rational choice theory of classical economics. For example, in his previous work, Thaler (1980) presented the endowment effect, when people value a high price of an object they possess and do not will to sell it while they would never purchase same object with the market price as they do not value it that as much. As an example, collectibles are gaining more value with time and their worthiness increases while being the exactly same object. Not selling the object without a goal of earning more money in the long-term is irrational behavior. Nevertheless, "humans" are not rational and derive pleasure of simply owning an expensive object.

According to the authors, each person is a choice architect sometime in the life. What Thaler and Sunstein (2008) point out is that the power of choice architecture, as well as recognizing benefits of human "flaws" in decision-making, is underrated. To some degree, the correct nudging makes the monitoring – one of the most costly collective action solution tool – unnecessary as people individually commit to one or another goal. Moreover, financial incentives can have less effect to the end result than a way policy or contract is formulated. Thaler's and Sunstein's viewpoint isn't completely new. However, what is innovative is that they've brought together their knowledge, experience, and facts of what they've have witnessed to provide the scheme or important points for policy design. They introduce six tools, conveniently constructed from the word nudge, which should be followed or considered to enhance the policy or the decision-making process. There are six principles of good choice architecture:

"i**N**centives

Understanding mapping

Defaults

Give feedback

Expect error

Structure complex choices" (Thaler and Sunstein, 2008)

Let's deal with each of them individually. To begin with, *incentives* are one of the most important parts of any action taken. Why does the person choose one object/service/action over another? Who buys, pays, uses and profits? Often, free markets solve the problem of incentives. Products and services compete for the own target audience with the quality, price and other attributes. However, the free market often fails. One of the examples is a health care system where incentives differ and interfere with each other depending on the actor. While the main goal must be to make and keep people healthy, there are numerous complications that result from blended incentives. For instance, let's analyze the previous U.S. medical care system and the incentives of the participating agents: patients, doctors prescribing the treatment, insurance companies paying,

and equipment producers with pharmaceutical companies lobbying their services. Insurance companies prefer to sell policies to young and healthy customers, as they are the most profitable while escaping expensive patients with preexisting conditions. It is important to have a sensible choice architecture to define the incentives of all the actors, so they will not interfere, bringing new issues, and need of additional costly monitoring.

Another important point of incentives is salience. People do not always notice the incentives. As the example in the book, the family considering buying the car worth of 10 000 dollars, compare this option to using a taxi or public transport. However, the initial investment value of ten thousand is rarely accounted for, underweighting the opportunity cost of owning the vehicle. In the energy consumption case, it is important to remind users their expenditure not only once a month with a bill but, for instance, with showing them the monetary cost of raising the heating of the household by 1 degree or price of 10 minutes shower comparing to 15 minutes. Moreover, in some cases, it is even possible to appeal to other emotions, peer pressure, and environmental values besides financial.

Although, the financial incentive is a powerful tool as stated by classical economic theory, there are other ways to motivate irrational and emotional human beings. The incentives are complex and not restricted by financial maximization utility. Thanks to psychology and the works of behavioral scientists, there is an extensive list of factors influencing human decision-making process besides the financial ones. For instance, loss aversion - people hate losing more than they like earning. It can result in inertia making people stick with the current holdings instead of performing the change that could potentially be a more beneficial alternative financially. While risk-seeking people are likely to engage in lotteries, gambling, or high-stake high-risk situations, risk neutral and especially risk averse people prefer to hold to their current positions.

One interesting example is a field experiment on influencing teachers' performance using the loss aversion tool by Fryer et al (2012). Their empirical study has shown that changing the description of the payoffs, while having them same for both treatment and control groups, can change human behavior. Teachers' productivity was the focus of the study. All teachers received bonus for the performance of their students. However, the control group received the bonus according to the student performance at the end of the year, while teachers in the treatment group were entitled to the bonus at the beginning of the year and were losing money when their student did not perform well enough. The results were groundbreaking: framing teachers incentive program regarding losses improved students' performance. It once again proves that there is a potential in exploiting loss aversion for the policymaking. Just changing the characterization of the contract without introducing additional financial incentives can improve the efficiency and productivity.

There is a number of commitment contracts built on the thesis of loss aversion. It is important to keep in mind that loss can be not only financial but as well time, energy, and other resources.

As people are not able to gather all available information and compare it in the most rational way, as it is timely and costly, it is important to explain the alternatives and their advantages. Of course, the decisions vary by importance. The choice of ice cream flavor and medical treatment has drastically different effects on a human being. A *mapping system* helps people to understand the impacts of the each option allowing to identify and allocate them according to their characteristics and choose the one that makes them better off. In the case of energy consumption, the mapping is certainly the concern. As kWt/h is not a substance one can touch or see, it is relatively a mystery of what is the value of 1 kWt. Furthermore, even if one can recall the price per unit, the actual consumption of each household appliance or all of them together is a harder task for each of us. While it is a lot easier to monitor (not to control!) the own diet or personal consumption, when it comes to energy, the consumption is a result of actions of all residents in the household. It is not enough for one person to commit to lower the electricity consumption but the responsible usage has to be spread across all the residents. This brings us to the collective action problem. As it is illustrated in the book "Nudge" (Thaler and Sunstein 2008), when the object is something that person cannot see or touch like Mb, pixels, or kWt, the choice architect can come up with the description that can appeal to masses. For instance, "instead of being given the options of three, five, or seven megapixels, consumers might be told that the camera can produce quality photos at 4 ¥ 6 inches, 9 ¥ 12, or "poster size" (Thaler and Sunstein 2008).

The *defaults* are yet another powerful tool. By being humans as irrational as they are, lazy and overall busy with various life priorities, not every choice is carefully considered. Most of the online services have already successfully figured out the power default option with the monthly paid subscriptions. Why not use the defaults in the policymaking? In 2004, Thaler and Benartzi introduced "Save More Tomorrow" program focused on helping people to save for retirement appealing through several physiological principals, uses loss aversion and automatic enrollment default option as the main tools. As humans are not "econs", they are not likely to make a calculation of their lifetime earnings and the optimal size of savings for the retirement. As the solution, there are defined-benefit plans provided by employers that require employee to manually subscribe to the scheme. However, due to various irrational reasons, only 50% fill in the sign-up form. Moreover, giving away a part of the pay after receiving it (even thought money are not lost but transferred to the retirement account) hurts more than not earning that part of the income at all. Therefore, authors came up with the smart solution for, first of all, establishing the default enrollment option. Once workers are eligible to join the plan, they are automatically a part of the

system, and they have to fill up the form to opt out. Appealing to money illusion and loss aversion, the Save More Tomorrow program offers employees committed to increasing their saving rates by around 3% next times they would get the pay raise. It turns out that it is easier to decide to save the money that has not been earn. The program proved its positive effect and had been adopted by various companies.

It is impossible to improve the behavior without keeping track on the achievements or, in other words, receiving the *feedback*. Well-designed systems are notifying respondents on the progress, warning in the urgent or close to urgent situations, and allow comparing own results with peers. All types of feedback are demonstrated to be helpful improving people's behavior. In many cases, feedback itself is a nudge. As it will be shown in the "Electricity Conservation Experiments" part, provision of more detailed information on electricity consumption helps to achieve a short-term reduction. The collective action problem arises as lowering one household's energy consumption will not impact the issue of climate change. Moreover, the feedback fro nature comes years after and the household is unlikely to get the feedback on the participation in tackling the problem. Therefore, it is important to find a way to provide the feedback that will appeal to the household well enough to improve energy behavior.

Every system can make mistakes, especially when the subject is a Human. One of the common and predictable phenomena described by philologists (Byrne and Bovair 1997) is a "postcompletion" *error*, when once the task is finished thoughts about previous things disappear. Examples are leaving the gas cap opened after fueling the vehicle, forgetting to close the door of the fridge, not remembering where is the recently used pen, and others. Other predictable errors are unfamiliarity with new technology, new system, or unusual (even thought more convenient) solution. For instance, it takes time for tourists to get used to looking left when crossing the road in the UK. Therefore, Thales and Sunstein include expecting errors as on of principals for choice architecture. Fortunately, controlled randomized trials tend to lower the errors before putting the policy, service, or product, public.

Structuring complex choices is an important principal that can aid to reduce expecting errors as well. It is essential to remember that one size does not fit all. When designing the contract, architect better to mind the difference between current users and new enrollees. As well, defining a couple of groups by their characteristics will ensure to reach the larger sample. For instance, when talking about energy conservation, there might be following three groups: less involved people; people with a relative interest in the energy savings; people highly interested and ready to invest themselves into the issue.

Thaler's and Sunstein's approach has caused a debate. Hausman's and Welch's (2010) articles offers a critics to the notion of "libertarian paternalism". They bring upfront that the ideology principles are mostly presented in the form of examples; there is no definite theory. Moreover, in some cases, described nudges go on the edge of limiting people's choice. Opposing economists argue that the libertarian paternalism cannot exist in a manner the "Nudge" book. On their opinion, nudging changes people's judgment and plays on the flaws of decision making, which is interference itself. They claim: "one should be concerned about the risk that exploiting decision-making foibles will ultimately diminish people's autonomous decision-making capacities" (Hausman and Welch, 2010). Also, Hausman and Welch argue that those nudges are largely a rational persuasion than light interference.

Chapter 6: Electricity Conservation Experiments

Chapter 6.1: Experiments around the globe

The environmental problem cannot be solved via the free market. Moreover, the climate change is a complex issue that needs to be tackled both globally, to avoid leakage, and locally, to increase efficiency. The nudge is not the solution of the global efforts. The transaction cost is high and requires interference of the state, as citizens themselves are not in the right to make voluntary agreements. Nevertheless, when talking about polycentric approach, a nudge can be a powerful tool leading people to choices that decrease electricity consumption, waste generation, water and heating utilization, along with other ways maintaining the environment. The impact of lowering the energy consumption by household can be significant, especially for developed economies. For instance, a deep penetration of LED lamps in Finland would mean a 1.3 % reduction from the total electricity use in Finland by 2020 (Tetra, Sarvaranta and Syri 2014). Recognizing the potential, researches all over the world attempt to households' to lower electricity consumption levels using a variety of methods.

Recently the terms "sustainable development" and "energy saving" gained remarkable public attention. Many policies and campaigns in the developed and fast emerging market economies aim to raise awareness and responsibility among households when it comes to energy consumption. Some of them were successful, although there are no clear signs of positive change in consumers' behavior in the long-term. Facing global energy consumption issues nowadays, many researchers conduct experiments to discover new models, which may have the desired impact on energy savings among households.

A study carried out in California in 2008 (Costa and Kahn 2011) suggested that the magnitude, to which people react to information about their electricity consumption, is defined

partly by their political preferences. Moreover, subjects with expressed liberal and environmentalist ideology seemed to be more responsive to the "nudges" used in the research and tried to decrease their consumption further, although they were already energy efficient. On the contrary, participants with conservative political views were more likely to opt out from the experiment and to react negatively to the Home Energy report provided to them. It was also documented that conservatives increased their electricity usage when they have been told that their consumption is less than their neighbors.

Another study found a place in Denmark (Grønhøj and Thøgersen 2011) in which 20 Danish households took part over a five-month period. The researchers wanted to test whether providing households with detailed feedback on the energy usage would decrease in electricity usage. The feedback was accountable for more than 8% electricity savings in the treatment group since it made energy consumption more visible, as information was presented on the screens, and salient to the participants. As a side effect, the information stimulated social influence and awareness related to energy saving between spouses and parents and their children.

Schwartz et al (2013) from Carnegie Mellon University conducted an experiment, which replicates the Hawthorne Effect. In the study, the subjects were informed by postcards that their electricity consumption is being monitored. Without requesting any kind of action, participants in the treatment group, in fact, reduced their use by 2,7%. After the monitoring period ended the saving effects vanished.

LaRiviere et al (2014) conducted a large field experiment with more than 50,000 households involved. The subjects have been given information about the average consumption of their neighbors, recommendations of how to save the electricity, subsidies for in-home energy audits, and special offers on energy-efficient applications. Three comparison frames were used in the treatment groups - electricity usage in KWhs, the size of the electricity bill, and amount of greenhouse gas emissions CO2 emissions. The political preferences of the respondents were also observed and had a causal effect. It was found that private good and public good frames have a different impact on the economic decisions of the households - the former influenced the audits uptake probability and the latter – the electricity usage. There was no significant effect on actual installations of new energy efficient, durable goods.

Sacramento officials started an initiative to raise the awareness of the residents about energy saving. Each household received information about their consumption compared to their neighborhood. To emphasize the message, they have been given smiley or frowny faces depending on their achievements. Similarly, The Tidy Street Project in Brighton the electricity consumption of the residents has been recorded on the street for all to see. As a consequence, some households

managed to reduce their use of energy by around 30%. Both projects relied on friendly competition among peers and conformism to succeed in lowering the average electricity consumption of the subjects.

Chapter 6.2: Rebound effects

All of above mentioned experiments have one common feature, the effect of the treatment disappeared after the experiment and respondents returned to their pre-intervention habits. Nonetheless, household's energy consumption depends on the efficiency of electrical appliances as well as consumption habits. Newer technologies have a higher efficiency level and lower energy consumption. Moreover, innovations in engineering lower the cost of the energy production. As the result, the energy prices go down, which vanishes financials incentive to lower households' electricity spending (Borenstein 2015). Also, these developments might create a rebound effect in energy consumption. Sustainably directed consumer behavior, like changing traditional light bulbs to LED and substituting old household appliances to new energy efficient ones give a space for more careless electricity consumption habits. The income effect as well comes to play, as people can purchase more electrical appliences, even though energy efficient, which increases the consumption overall (Gillingham, Rapson, and Wagner 2015). The *direct rebound effect* is an effective tool for assessing the impact of energy efficiency on the first order consumer response on the electricity use. At the same time, *indirect rebound effect* explains the shift of the demand on other products and services due to technological breakthrough. For instance, the causality is important as well, as people are more likely to switch to the public transportation due to fuel prices than energy efficiency (Gillingham 2011).

According to Gillingham, Rapson, and Wagner (2015) literature review on the rebound effect, there is no evidence yet that energy efficiency gains will be reversed due to people starting to consume more energy. Nevertheless, the one-way efforts form the engineers to fight the energy crisis is not enough. Considering that there is a trend of increase of global income level and the threat of possible income rebound effect on energy consumption, there is a need to nudge to conservative electricity consumption.

Chapter 6.3: Nudging Energy Saving in Pori, Finland

During the master program, Ielyzaveta Harjunpää, Arseniy Lobanovskiy, Mohammad Ahsan Qureshi, and Daniel Kaltschev, have conducted an "Energy Saving Experiment" in Finnish city Pori as a part of the project work for one of the courses. The main purpose of the project was to examine the extent to which people may change their consumption behavior, given information about their own and peers' electricity consumption, without revealing to them the exact objective of the experiment. The contribution of the study was that examination of the response to the treatment

in a Finnish society, which highly evaluates norms like environmental responsibility, efficient use of energy and sustainable development.

Respondents were recruited solely from private houses, not apartment blocks, due to the logistical ease of recruitment. A brief description of the project was presented to the participants. Respondents also had to sign a consent form and to fill in a short questionnaire concerning some additional information. The exact purpose of the experiment was not revealed to the subjects. Instead, they were told that the researchers investigate the correlation between the weather change and electricity consumption. This misbelief was necessary to allow to measure the differences in the behavior correctly without any bias. For two weeks the subjects in the treatment group received everyday e-mails with a graph presenting information about their daily consumption, the average consumption of other participants and daily temperature. In the first week (or period), subjects were provided with data higher than the treatment mean and in the second week of the field experiment with lower data. Researchers wanted to examine to what extent people react to the nudge when they are in a "comfort" zone, that is, when their individual consumption is below average, or when they find themselves above the data for the other subjects. Of course, the willingness of the respondents to check their e-mails with the above-described information was crucial to the success of the study.

The significant relationship found between the information on usage and consumption habits. However, this complemented with the pro-activeness of the participant's showcases the potential for future, larger-scale implementation of similar studies. The participants considered themselves responsible energy users, which imply that if provided with the opportunity and awareness, they could adapt smart means and habits of electrical consumption. Finally, the most of the control variables exhibited the predicted relationship, allowing to generalize usage trends. If such trends could be observed and accounted on a larger scale, profile specific measures could be taken to target individual households to check consumption habits. A blend of all these findings would allow organizations both at municipality level as well as state level to nurture a habit of smart electrical consumption, reducing the bulging demand of electricity and overall carbon emissions in the environment.

Chapter 7: Data and Methodology

Chapter 7.1: Data

Helsinki has launched a national pilot project of a new smart eco urban environment. An old industrial area, Kalasatama, was reimbursed supplemented with the latest technologies. One of the main directions of research is smart solutions, data analysis, and provisions the subjects of their electricity and water consumption. Construction of the new district began in 2011 and will continue untill the 2030s. It is expected that it will host up to 20 000 habitants. The area has ten quartiles.

Kalasatama is a target for various technological and social experiments. One of them is HIMA project, which was conducted in cooperation with an energy company. HIMA is an automated monitoring system for electricity and water consumption. A couple of buildings for the area has taken part in the project.

The intent of this research was to measure the nudging impact of the smart solutions on the households' electricity consumption. Residents that participated in the project will be referred as a "smart households" or "smart houses." Smart households had access to the real-time consumption information with the ability to control their household appliances remotely via a mobile application. In addition, smart houses had access to the information on real-time prices to test demand-response approach. Previously, there have been some studies on the impact of the HIMA project. However, there was a need for additional study to see the effect of the smart technologies on the energy consumption with a comparison to the control group.

The researcher was provided with a sample of the sum of hourly consumption of the 50 households comprising both smart and normal houses during the period from 1st March 2015 to 30th March 2017. The first of March 2015 was the date when citizens moved into the building possessing intelligent technology. The control group, normal houses, was picked up from the buildings next to Kalasatama area.

Chapter 7.2: Experimentation in economics

Papers with experimental methods in economics have been growing almost exponentially in the beginning of the 21st century (Kalaitzidakis et al. 2003). There are three main types of field experiments: artifactual, framed and natural (Harrison and List, 2004). Each of them has its pros and cons. In a field experiment, there is usually a real randomized sample from a population, while labs use students. Comparing to the lab experiments, there is almost no control over the environment in the artifactual and framed, and no control at all is the natural experiment. Artifactual type is the closest to the lab one but uses "nonstandard" subjects randomly drawn from the market of interest. The framed field experiment is closer the most natural environment. In the natural field, respondents are not aware that they are a part of the experiments. Usually, researchers get the data after the event has naturally occurred. The natural field experiment is already randomized and generalizable as it is as close to reality at it can get.

The present research was treated as a natural field experiment for following reasons. There was no control over the subjects' environment. No intervention appeared in their life and the actions. Subjects were not aware of being monitored. There were the limitations with sample randomization that are discussed later in the thesis.

Chapter 7.3: Ethics

To begin with, it is important to mention that the study did not bear a vulnerable topic. Thus, the electrical consumption data for the period of time in the past cannot harm respondents, especially when they are not identifiable. The ethical principals regarding the current study are as follows:

Chapter 7.3.1: Privacy and confidentiality. The researcher was provided with the raw data on hourly electricity consumption with no additional information on socioeconomic measures that would allow identification of the subjects. However, the HIMA project is publicly known as well as the geographical area it was implemented in. Even though the area is not large, Kalasatama has approximately ten blocks, there was no information provided on the buildings that participated in the project. Moreover, as the data was cumulative, no privacy or confidentiality principles have been violated.

Chapter 7.3.2: Informed consent. This study has been conducted in cooperation with the energy company that provided data on cumulative hourly consumption for the two years period. When customers sign the agreement with an energy company, they allow the company to use the data for analysis to improve services. As data was neither individual nor identifiable, there was no need for consent.

Chapter 7.3.3: Assessing risk. The risk of harm of the social and behavioral sciences can fall into three categories: invasion of privacy, breach of confidentiality, and study procedures. The study has no risk of harm to the subjects. As mentioned before, there was neither individual consumption data nor any identifiable information about the respondents. The study is to be considered low risk, as it does not involve physically invasive procedures.

Chapter 7.4: Controls: available and desired

It is valuable to explain each control that would improve the analysis. The energy company has provided by the energy company with hourly electricity consumption, temperature, and price per kWt/h for the period of two years.

Chapter 7.4.1: Temperature. Weather and seasonality have an impact on the energy consumption. It can be seen with the data (See Appendix Table 6. Descriptive statistic of seasonal consumption for the whole sample). For example, June was the month with the lowest energy consumption with about 14000 kWt for 100 apartments from the sample, while December and January were about 19000 kWt. Due to the climate, winters are cold and dark in Finland. Therefore, the lifestyle moves towards the indoor activities, which results in higher electricity consumption. Summers are the vacation season, warm and mostly bright. It is a well-known fact that Finnish residents prefer to spend time outside and in the summer cottages. Seasonality and weather significantly influence household's electricity consumption.

Chapter 7.4.2: Lifestyle: The second important group of controls would be information about residents in the household and their lifestyle. As in this thesis, the argument was that the human factor has the biggest impact on the household's energy consumption; the habits of people play the biggest role in the issue. In the previous experiment in Pori, researchers had an opportunity to interview respondents with questions regarding a number of residents, habits on sauna usage, the heating methods of the house/apartment, their income and approximate time residents spend at home. In the current case, this information was not available, which is yet another limitation of the research.

Chapter 7.4.3: Location. The location of the house and apartment in the house as well impacts energy consumption. As one of the sources from HIMA project claimed, the new buildings do not have the good air-conditioning system. The architecture of new buildings has large windows letting in as much light in the apartment as possible. Therefore in summers, apartments that have a direct sunlight had a need to purchase a separate air-conditioning to cool down their rooms. It is impossible to check for the air-conditioning in the treatment and control groups and their usage. However, it is important to keep in mind that it could bring the difference in the energy consumption in seasons.

Chapter 7.4.4: Income. As discussed in the literature, there can be a rebound income effect on the energy consumption. Along with other socio-demographic measures, income level has to be controlled for to establish the causality.

Chapter 7.4.5: The size of the household premises and residents. It is intuitive to assume that the larger apartment is, the higher electricity consumption. However, the provided data did not include characteristics of apartments. Ideally, it would be correct to perform a matchmaking between control and treatment group by a number of people (including children and elderly) and the size of the household. Ideally, the matching would be done in the preparation of the experiment. After pairing the similar subjects, they would be randomly assigned to control and treatment.

Chapter 7.4.6: Electrical heating and cooling. Electrical heating and cooling are correlated with the energy consumption. As well, it has its seasonality. Previous studies, like the experiment in Pori, have shown a positive connection between the amount of kWt spent and the availability of electrical heating.

Chapter 7.4.7: Sauna. While the sauna in the house is not a definitive feature to have a drastically impact on the energy consumption, the habit of using it is a gem. On the discussion of the controls and provision of more data with the energy company, it has been noticed that the habits of residents had more impact on the frequency of using sauna than the size of the household. Therefore, unless there would be an opportunity to break down the electricity consumption by

appliances, controlling for the availability of sauna does not help with the establishment of causality.

Chapter 7.4.8: Price. In addition to temperature and electricity consumption data, it was possible to get the kWt/h price for the period of the study. At first, this variable was included in the research. However, in Finland, there are different types of electricity: fixed priced and market priced contracts. As there was no information on the type of respondents' contract, it is impossible to establish the demand-response influence on their electricity consumption. It would be beneficial to see the effect of smart solutions and demand-response system in combination.

Chapter 7.5: Limitations in the analysis

To begin with, there was no way to witness the consumption of treatment group before they moved into new smart apartments. Pre-intervention data would help to avoid a compound with timing However, as the energy company was not able to provide a direct contact with respondents, pre-intervention data was not available. Moreover, for the same reason, it was impossible to control the bias of subjects' choice and reasons of buying/renting the smart apartments. The research had a number of limitations that was impossible to address without additional data.

Below is a hypothesis and description on planned analysis:

Ho: Null Hypothesis

HA: Alternate Hypothesis

Ho: There is no relationship between Smart functions of the house and electricity consumption

H0 β: = 0

H1: There is a significant negative relationships between the Smart functions and electricity consumption

H1 β: $\neq$ 0

Y = electricity use

X = house posesses with smart features (vs. not)

T = observation is post-treatment (vs. pre-treatment)

The basic treatment regression is

$Y = a + b\,X + c\,T + d\,(X*T) + u$

The total effect of X, having the smart feature of remote control over the household's appliances is $dY/dX = b + d\ T$. Following the equation, it is important to control for the interactive effect d. Otherwise, there is a confounding of the true treatment effect b, due to the T variables. However, as mentioned before, the pre-intervention data was not available.

T represents items that are constant for both the treatment and control groups within each period (pre and post). Those would be controls described in the previous section: seasonality, climate, consumer tastes in housing, socio-demographic characteristics, sauna, electrical heating and cooling.

$b = dY/dX - d\ T,$

the observed effect dY/dX is potentially much higher than the true causal effect b. Thus it is important to remove the confounding part. Even if there is not enough data on the T item directly, it is possible to address Y data in both control and treatment groups for both pre and post data. This would allow subtracting out the average value of the confounding by just running the regression.

The study had a selection problem, as people have not been randomly assigned to the treatment and control group. Therefore, dY/dX is potentially overstated, because the people who most want the smart features may also be more inefficient users in the first place. As literature shows, there is income effect. The Kalasatama is a newly built area by the sea with high real estate prices. It is possible only to presume that the treatment group has higher income level than the control group.

Formulating an initial "selection regression" determining the reason people opt into the Kalasatama buildings with smart solutions, would significantly ease the research. However, that would require having a short qualitative research with the residents of the area. Using that data, it would be possible to run the original treatment regression called the "Heckman selection model". The model helps to tackle the selection bias. This type of analysis would require at least one variable in the selection regression that does not belong in the treatment regression. In other words, there would have to be a variable that exclusively dictates selection into smart houses (X), and does not affect electricity consumption (specifically the unobserved part u) at all.

Due to the lack of data, there were conditions that affect electricity use (Y) that were not observed (u), while correlated with the availability of smart features (X). From observable variables, that have an influence on the energy consumptions are weather, sauna, location, the energy efficiency of the building, the location of the apartment, consumer tastes in housing, lifestyle, demographics, the size of apartments, number and age of residents, energy package.

However, due to internal policies of the energy company, the only provided to researcher temperature and price of the electricity.

To sum up, the restrictions with the available data and having only the hourly consumption and the temperature, it is impossible to establish a causality of the smart solutions on the electricity consumption. Nevertheless, the study allowed describing the electricity consumption with respect to seasonality and time of the day.

Chapter 8: Results

The study included 36 488 observations, half of smart households and half of normal ones. The subjects have been observed for two years. According to the data, the highest temperature in the area during this period was 26.6 degrees and the lowest -23.8 degrees (See Appendix Table 4. Descriptive statistic of the sample). While minimum electricity consumption is 2 kWt/h and 4 kwT/h in smart and normal households, the maximum reached 62 kWt/h and 27 kWt/h respectively.

The least energy consuming season was summer with a mean of 9.91 kWt/h for the whole sample. In winter respondents spent 12.63 kWt/h by mean, in spring and autumn the consumption was lower with means 10.89 kWt/h and 11.73 kWt/h respectively (See Appendix Table 6. Descriptive statistic of seasonal consumption for the whole sample).

When comparing treatment and control group electricity consumption, there was an intriguing trending. Smart households used 30% more electricity compared to normal ones. What is interesting is that in the first three months of the observation period, when people had just moved into the new smart buildings, the difference between consumption was -2%, 6%, and 11% respectively. After that, the gap reached 22% and remained higher throughout the whole period.

		Smart	Normal	Difference
2015	March	7736	7913	-2%
	April	7801	7336	6%
	May	8471	7522	11%
	June	8033	6275	22%
	July	7964	5996	25%
	August	9177	6458	30%
	September	8980	7071	21%
	October	9715	7198	26%
	November	10395	7794	25%
	December	11923	7808	35%
2016	January	11626	8039	31%
	February	9761	7207	26%
	March	9770	7325	25%
	April	9404	6685	29%
	May	8742	6410	27%
	June	8190	6010	27%
	July	7941	6136	23%
	August	9257	6128	34%
	September	9417	6193	34%
	October	10704	7101	34%
	November	10803	7150	34%
	December	11678	7253	38%
2017	January	11250	7194	36%
	February	9421	6560	30%
	March	9733	6570	33%
	SUM	**237891**	**173330**	27%

Table 1. Comparison of electricity consumption throughout the observation period.

In the evenings, consumption was the highest with a mean of 22.51 kWt/h and 14.37 kWt/h in the treatment and control groups respectively. While the consumption gap between the groups during mornings, day times and evenings was relatively high, the nights were even with a mean between 6 and 7 kWt/h for both groups (See Appendix Table 9. Descriptive statistic of consumption throughout the day for Smart vs. Normal households).

The seasonal mean consumption gap reached almost 5 kWt/h in winter, 4 kWt/h in autumn, 3 kWt/h in summer, and about 2 kWt/h in spring (See Appendix Table 7. Descriptive statistic of seasonal consumption Smart vs. Normal households).

Chapter 9: Discussion

Higher electricity consumption for smart households can be explained in a couple of different arguments or all of them combined. To begin with, as the Smart buildings are newer than Normal ones, there might be an income rebound effect assuming that new residents are relatively wealthy. First, the growing consumption can be explained with people getting more appliances to home first three months after moving in. Second, due to low trust in the data, some apartments might not have been in use for the first period of time. Thus, it is possible that at the beginning of the period, there is a comparison of the sum of 50 normal with, for instance, the sum of 48 smart households. However, the energy company has not provided any additional information or check on the data. The third possible reason, subjects figured out how to benefit from the smart HIMA program. The presumption is that rebound effect appeared when a user got a remote access to the household appliances and started to consume energy hazardously. For example, the dishwasher and washing machine, as well as heating up the sauna, can only be used with the physical presence of the user in the normal building. However, smart solutions allow controlling the equipment remotely. As a result, there is a possibility that subjects in the treatment group increased the usage of appliances.

There are many examples of "rebound effects" in electricity policy. When an item becomes more efficient, this effectively represents a reduction in the cost of operating it — a reduction in shadow prices. Even though their original amount of use may require less electricity, people respond to the fall in shadow prices by increasing consumption.

Another important reason for the possible hazardous behavior is the absence of feedback. The respondents could not rationally compare the consumption pre- and post- moving into a new apartment. In case if their consumption has increased, they might assume that it was connected to

the new building and other factors but not their habits. Moreover, there was no opportunity to compare consumption to others'. As previous studies have shown, the feedback, peer pressure and ability to benchmark have an influence on the households' energy behavior.

Chapter 10: New Prepaid Contracting form to Nudge Households' Energy Conservation

The nudging techniques are used in various industries for businesses and policymaking. There have been some attempts and experiments to lower households' electricity consumption and trigger new conservational behavior.

In Finland, energy companies already implement some of the nudge tools to help their customers to reduce the electricity consumption by providing feedback and recommendations. Feedback is provided online with information on hourly consumption in kWt and the price. This way, customers can monitor their consumption and compare it in time. This information is given to clients by default. However, the interest of respondents to monitor electricity consumption disappears in time. Evidently, from the experiments, the treatment effect disappears right after the intervention is gone.

Triggering new sustainable conservative electricity behavior is not an easy task to achieve. First of all, in Finland the share of spending on the electricity bill is rather small; thus, it is not a financial incentive to use appliances more responsible. Moreover, nowadays, electricity is almost as important as water, and the goal is not to make electricity consumption stressful. Therefore, utilizing the extensive research, the logical way is to find a solution that can influence on long-term: a prepaid contract that could nudge people to more sustainable behavior in regards to their energy consumption. The goal of the new contracting form is to cause a habitual change of household electricity conservation. The contract is designed in a way to nudge subjects for responsible electricity use without changing the prices or introduction of financial incentives.

The new prepaid contract is offered to the user as a choice of three energy packages that are based on their average consumption: higher, same or lower than their current level. The package is described by kWt, monetary value and amount of emission. By default, the current level of the consumption is chosen for the customer.

The choice of three energy packages satisfies the principle of nudging – structuring complex choices. New enrollees or people less interested in the project get choose the larger package and worry not about their consumption level. Somewhat involved users can opt for their current level of consumption. There might be various reasons why people would like to challenge themselves and lower their consumption. Whether for saving the nature or decreasing the electricity

bill, customers can prepay the package that is lower than their regular consumption. As the package will provide the information on price, kWt, and emissions, there will be a gentle nudge to choose the smaller package.

What is important, that those prepaid packages will not change the actual amount of money user would spend with the post-paid contract. The contract does not bound household with the electricity consumption. There are no penalties for spending over the package, and the underspent money does not disappear and will be returned to the customer. The overspent kWt will have to be paid by the end of the month, similarly as it is done currently with the post-pay. All underspend amount will be returned in a monetary value at the end of the year. As the Christmas period in Finland is associated with tax return time besides the holiday itself, it seems to be beneficial to connect the non-used kWts in euros at the same time. The money is not returned at the end of each mouth and not in the additional kWt for the package. The reason is to pursue the goal of lowering the consumption instead of transferring it to another period.

Besides the "getting the present for Christmas for using less energy", paying the same service twice in case of spending over the package is timely is unpleasant even if it is a matter of a couple of euros. It is expected that to loss averse subjects would try to avoid the second bill.

As a result, the behavioral mechanisms involved in the process are loss aversion, money illusion, self-control, positively impacting environment, and monetary return during Christmas.

In order to help customers to stay in control with the progress, there has to be a feedback. Customers will get a notification when 50%, 30%, and 10% of the prepaid kWt left from the package. With the feedback and the online service monitoring the hourly consumption, users will be able to adjust their behavior to the commitment they made with the prepaid package.

Ideally, there has to be a mobile application to access the information on the electricity consumption. The application has to provide information on the trend of consumption, current situation with the package usage, and advice how to lower the energy utilization. This part will resemble the mapping to customers nudging the habitual change. Moreover, using the smart house technologies and demand-response pricing in combination with the feedback on the trend of consumption, the app will make the process as simple as possible. Also, there is a possibility to add the option of comparison to the other similar households. In case household's consumption is at the same time or lower than peers, the smile will appear encouraging a user to stay on the same consumption pattern. Otherwise, a sad smile will notify that there is a place for improvement.

To sum up, this contracting form satisfies all principals of nudging:

i**N**centives – loss aversion, money illusion, self-control, positively impacting environment, monetary return during Christmas.

Understand mappings – provision of information and action-consequences information from personal to global scale.

Defaults – offering default package that is lower/equal average consumption.

Give feedback – notification when 50%, 30%, and 10% of the prepayed kWt left from the package.

Expect error – encouraging automatic enrollment.

Structure complex choices - New enrollees and less involved / somewhat envolved / extremely involved contract forms.

Chapter 10.1: Testing the contracting form to nudge households' energy conservation

Described above contracting form needs to be tested using controlled randomized trial. As a further research, the field experiment can shed light on the mechanisms involved in the contract and lower the errors before going commercial.

The aim of the experiment is to see the treatment effect of the prepaid contracting form on the household's electricity consumption. To capture the real effect, field experiment will provide a real setting with real subjects. The incentives to respondents are quasi-artificial: the electricity bill, satisfaction level, peer pressure, environmental responsibility. The most valid way would be an automatic enrollment of the chosen target group. It will help to avoid the selection bias. As well, automatic enrollment factor will require cooperation with the municipality officials and energy company. At the same time, field experiment will not provide control over the subjects, and they will act according to their preferences and habits. The experiment should last at least three months with the extension to a year to show that the change, if happens, is habitual and sustainable.

As the controls for the analysis, there has to be information on a number of people in a household, socio-demographic factors, size of household, income level, ownership of the apartment, heating/cooling source, temperature, and the pre- and post- questionnaire. Questionnaires have to capture the qualitative characteristics of the household's residents such as environmental responsibility, values, and lifestyle habits.

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APPENDIX

Table 1. The descriptive analysis of biospheric altruism value "It is important to this person looking after the environment"

Schwartz: It is important to this person looking after the environment

		Frequency	Percent	Valid Pernt	Cumulative
Valid	Very much like me	207	20.4	20.5	20.5
	Like me	434	42.8	42.9	63.3
	Somewhat like me	252	24.9	24.9	88.2
	A little like me	91	9.0	9.0	97.2
	Not like me	23	2.3	2.3	99.5
	Not at all like me	5	.5	.5	100.0
	Total	1012	99.8	100.0	

Table 2. The Environmental Values regression model

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.770	.163		17.033	.000
	SWB	-.023	.011	-.066	-2.025	.043
	EnvirOverEc	-.434	.066	-.206	-6.602	.000
	Active/Inactive membership of environmental organization	-.200	.084	-.074	-2.382	.017
	Neighbours: Homosexuals	-.211	.075	-.089	-2.821	.005
	Important child qualities: tolerance and respect for other people	-.135	.092	-.047	-1.476	.140
	How much freedom of choice and control	.012	.019	.021	.647	.518

a. Dependent Variable: Schwartz: It is important to this person looking after the environment

Table 4. Descriptive statistic of the whole sample

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Temperature	36488	-23.80	26.70	6.8229	8.03777
HIMA	36488	1	2	1.50	.500
Consumption	36488	2	62	11.27	6.446
Season	36488	1.00	4.00	2.4830	1.09773
DayTime	36488	1.00	4.00	2.4580	1.15404
Valid N (listwise)	36488				

Table 5. Descriptive statistic of Smart vs Normal households

Descriptive Statistics

HIMA		N	Minimum	Maximum	Mean	Std. Deviation
Smart	Temperature	18244	-23.80	26.70	6.8229	8.03788
	Consumption	18244	2	62	13.04	7.754
	Valid N (listwise)	18244				
Normal	Temperature	18244	-23.80	26.70	6.8229	8.03788
	Consumption	18244	4	27	9.50	4.090
	Valid N (listwise)	18244				

Table 6. Descriptive statistic of seasonal consumption for the whole sample

Descriptive Statistics

Season		Mean	Std. Deviation	N
Winter	Consumption	12.63	7.381	8688
	Temperature	-1.4837	6.06181	8688
Spring	Consumption	10.89	6.038	10228
	Temperature	5.4008	5.21688	10228
Summer	Consumption	9.91	4.999	8832
	Temperature	16.0628	3.26090	8832
Autumn	Consumption	11.73	6.882	8740
	Temperature	7.4070	5.74713	8740

Table 7. Descriptive statistic of seasonal consumption Smart vs Normal households

Descriptive Statistics

HIMA	Season		Mean	Std. Deviation	N
Smart	Winter	Consumption	15.11	8.765	4344
		Temperature	-1.4837	6.06216	4344
	Spring	Consumption	12.06	7.289	5114
		Temperature	5.4008	5.21713	5114
	Summer	Consumption	11.45	5.911	4416
		Temperature	16.0628	3.26108	4416
	Autumn	Consumption	13.73	8.291	4370
		Temperature	7.4070	5.74746	4370
Normal	Winter	Consumption	10.14	4.448	4344
		Temperature	-1.4837	6.06216	4344
	Spring	Consumption	9.73	4.134	5114
		Temperature	5.4008	5.21713	5114
	Summer	Consumption	8.38	3.215	4416
		Temperature	16.0628	3.26108	4416
	Autumn	Consumption	9.73	4.237	4370
		Temperature	7.4070	5.74746	4370

Table 8. Descriptive statistic of consumption throughout the day for the whole sample

Descriptive Statistics

DayTime		Mean	Std. Deviation	N
Night	Consumption	6.54	2.532	10648
	Temperature	5.7098	7.43502	10648
Morning	Consumption	8.92	3.156	7600
	Temperature	6.0449	7.84067	7600
Day	Consumption	11.58	4.452	9120
	Temperature	8.1157	8.34808	9120
Evening	Consumption	18.44	6.957	9120
	Temperature	7.4779	8.30586	9120

Table 9. Descriptive statistic of consumption throughout the day for Smart vs Normal households

Descriptive Statistics

HIMA	DayTime		Mean	Std. Deviation	N
Smart	Night	Consumption	6.91	3.056	5324
		Temperature	5.7098	7.43537	5324
	Morning	Consumption	10.25	3.504	3800
		Temperature	6.0449	7.84118	3800
	Day	Consumption	13.05	5.199	4560
		Temperature	8.1157	8.34854	4560
	Evening	Consumption	22.51	7.243	4560
		Temperature	7.4779	8.30631	4560
Normal	Night	Consumption	6.16	1.789	5324
		Temperature	5.7098	7.43537	5324
	Morning	Consumption	7.59	2.026	3800
		Temperature	6.0449	7.84118	3800
	Day	Consumption	10.12	2.886	4560
		Temperature	8.1157	8.34854	4560
	Evening	Consumption	14.37	3.357	4560
		Temperature	7.4779	8.30631	4560