

Behavioral Insights in Infrastructure Sectors: A Survey*

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Abstract

In the past two decades, insights from behavioral sciences, particularly behavioral economics, have been widely applied in the design of social programs such as pensions, social security, and taxation. This paper provides a survey of the existing literature in economics on the application of behavioral insights to infrastructure sectors, focusing on water and energy. Various applications of behavioral insights in the literature are examined from the perspectives of the three main actors in the infrastructure sectors: policy makers, service providers, and consumers. Evidence is presented from the literature on how behavioral regularities, such as imperfect optimization, limited self-control, and nonstandard preferences, affect the strategies, decisions, and actions of policy makers, service providers, and consumers, often leading to suboptimal outcomes for service investment, delivery, access, and use. The paper also highlights how behavioral interventions such as anchoring, framing, nonpecuniary incentives, and altering the choice architecture can lead to improvements in performance, adoption, consumption, and other outcomes of interest in the infrastructure sectors.

Key Words: D9: Micro-based Behavioral Economics; Publicly Provided Goods, Water, Energy, Infrastructure, Development Planning and Policy

JEL: D9, H4, O21, Q4

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1. Introduction and Background

Infrastructure is a key driver of economic growth, whether it be in transport (Cantu, 2017), energy (Sahin et al., 2014), or water and sanitation (Frone & Frone, 2014). In 2019, the total infrastructure investment globally stood at USD 2.7 trillion (Global Infrastructure Hub, 2019), while private investment constituted USD 96.7 billion (3.5% of the total) across 409 projects (World Bank, 2020). Nonetheless, though these sound like substantial sums, there is a pronounced infrastructural gap in developing countries. For instance, the estimated cost to meet the SDG for drinking water and sanitation services is \$1.7 trillion, three times more than has been invested in the sector to date (Nagpal et al., 2018). Moreover, approximately one billion people still lack access to electricity globally (Fay et al., 2021); 2.2 billion lack access to safe drinking water and 4.2 billion do not have safely managed sanitation services (WHO & UNICEF, 2019). Governments are called upon to extend, improve and better maintain existing infrastructure, but real investment in infrastructure sectors taken together does not match estimated needs. Real investments in Africa, South Asia, and Latin America are 3.5, 4.7, and 3.2 percent, respectively, while needs are estimated at 9.2, 7.5 and 4.5 percent of GDP (Rozenberg & Fay, 2019).

Beyond the acute need for increasing infrastructure investments and addressing the financing gap, infrastructure sectors are plagued with inefficiencies stemming from the suboptimal use of available inputs, limited exploitation of scale economies in service provision and underutilization

of the existing infrastructure stock by the intended users. For instance, Public Expenditure Reviews (PER) of the water supply and sanitation sector have shown inefficiencies constituting between 20% and 40% in the use of available inputs. Moreover, several infrastructure sectors such as energy and water supply and sanitation, face significant revenue losses due to transmission losses and nonpayment by users. Globally, utilities lose an estimated \$39 billion of billable water and \$96 billion in electricity each year due to transmission losses and non-payment (Liemberger et al, 2019; Northeast Group, 2017).

However, governments are often constrained in stepping up public spending on infrastructure due to a number of reasons such as limited fiscal space, political economy constraints and efficiency considerations. It is partly for this reason that international organizations have placed their faith in the potential for Public Private Partnerships (PPPs) to not just boost investment but also improve project efficiency since they first became popular in the 1980s (Fay et al. (2019)). However, not only are the efficiency gains of privatization contested (Fabre & Straub, 2019), but placing such faith in the private sector when it represents a maximum of 5 percent of yearly investments in infrastructure in developing countries (Fay et al. (2019)) is arguably too narrow a focus. This underscores the need to not just increase private investment, but to maximize the efficiency of public resources. Increasing public spending in the infrastructure sectors may also foster crowding in of private investments, thereby creating a virtuous circle.

Several unique characteristics of the infrastructure sectors - to include the water, sanitation, transport and energy sectors - have played a role in further aggravating these challenges, even in the ideal world of traditional neo-classical economics. According to traditional economic theory, competitive markets lead to efficient allocation of resources (Arrow and Debreu, 1954). In the framework of the traditional economic theory, existence of market imperfections such as market failures, public goods and externalities, as well as ubiquity of environments with imperfect competition and asymmetric information, often lead to departures from efficient and welfare maximizing outcomes for the related parties. The recent developments in behavioral economics made a departure from our understanding of human motivation as being driven by rational, self-serving and profit-maximizing goals to a characterization of humans as having limited cognitive abilities, bounded rationality and often lacking self-control. These behavioral regularities often interact with the market imperfections and market failures, or catalyze them to exacerbate or diminish their consequent impacts (Congdon et al, 2011). These in turn, have led to specific

bottlenecks for decision-making in infrastructure investment as well as its efficient utilization.

This paper is intended to explore how insights from behavioral economics can contribute to a more nuanced understanding of the challenges facing infrastructure sectors so as to provide policy options to address them better. In this paper, we refer to infrastructure sectors as those sectors with *a high concentration of physical assets of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions and maintain the surrounding environment* (Fulmer, J 2009). Typically, a non-exhaustive list of these sectors includes water supply, sanitation and irrigation systems, public transport facilitating networked connectivity, electricity networks, telecommunication and information and technology systems. Our approach in this paper is to identify the behavioral challenges for a subset of these infrastructure sectors: water, sanitation, energy and transportation. It is approached from the perspective of the three types of actors (the infrastructure service delivery triad)- (1) policy maker or the government, (2) service providers and (3) consumers.

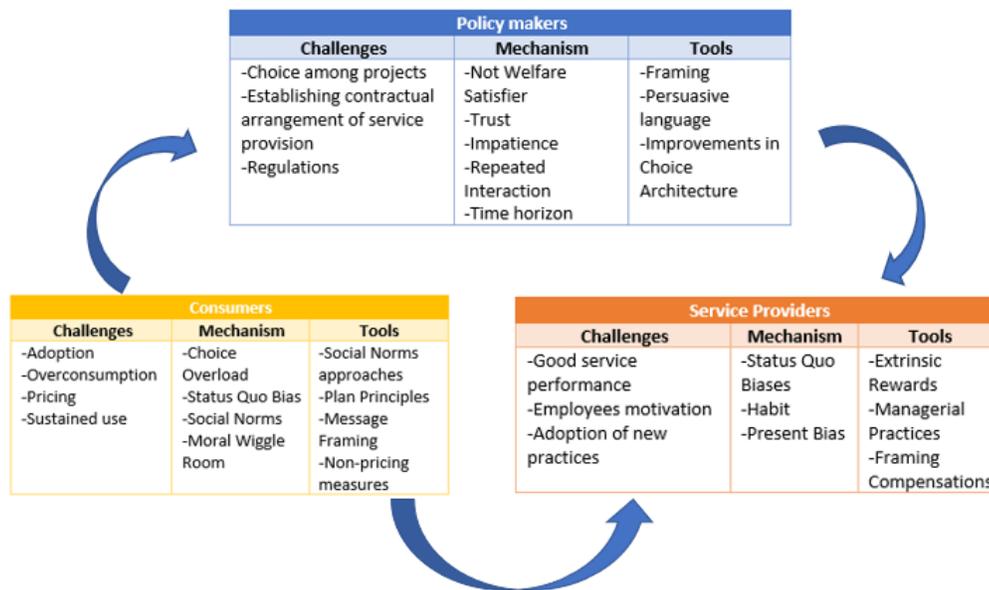


Figure 1: Infrastructure Triad through a Behavioral Lens

Note: Adapted based on World Development Report (2004).

This framework enables us to examine infrastructure challenges through a behavioral lens on individual motivations, attitudes and behaviors of the three actors in the triad. Decision-makers in government, service providers and consumers are subject to a range of behavioral biases. As

such, humans at all levels, not rational self-interested agents, bring their preferences, attitudes, and limitations to bear on decisions regarding infrastructure investments and their management, as well as their operation, adoption and use. We examine the frameworks and decisions that characterize the investment; management of the services provided, the provision and pricing strategies adopted; and finally users' adoption and consumption decisions. We argue that behavioral biases, attitudes, preferences, and the complexity of the relationships between actors in this chain permeate nearly every level of decision making in these sectors.

Though there have been many reviews of behavioral interventions across sectors, those that exist are primarily focused on social sectors such as health and education (Bloom, Propper, et al. (2015); Gauri et al. (2019); Ashraf et al. (2014); Bloom, Lemos, et al. (2015); Patel & Volpp (2012) and Bellé (2015)), while few are focused on infrastructure (Toledo (2016), Datta et al. (2017). Allcott & Mullainathan (2010), Andor et al. (2020)). The objective of this paper is to contribute to the literature by examining the peculiarities of infrastructure sectors, through the perspectives of these three actors. To illustrate the challenges, we review a series of studies which illustrate behavioral challenges and solutions in infrastructure from across government nudge units, the private sector, and research institutions/ NGOs, following the framework provided. Though not all studies highlighted are rigorous evaluations, the review will seek to show how conducting such experiments can provide useful insights into improving infrastructure management and service delivery.

The rest of this paper is organized as follows. The second section sets the stage by presenting the fundamental concepts from traditional economic theory and behavioral economics for understanding the behavioral issues in infrastructure. The section has two parts. The first part provides a brief overview of the behavioral regularities that have been identified in the literature which are of pertinent interest to the three actors in the infrastructure sectors, by affecting their strategies, decisions and actions. In the second part we outline some of the characteristic features of the infrastructure sectors such as market imperfections and market failures and their implications. In the third section, by drawing from the behavioral economics literature, we discuss the role of each of the three actors and how identified behavioral regularities could rise to peculiar behavior by actors leading to suboptimal outcomes. The fourth section provides a discussion and concluding remarks.

2. Infrastructure through the Lens of Behavioral Economics

2.1 Behavioral Regularities Relevant for the Infrastructure Sectors

Economics is the science of how individuals and collective institutions like governments and firms, make decisions when faced with limited resources and unlimited wants (Robins 1933). Needless to say, the underlying psychological and cognitive factors that affect human behavior should inform economic behavior as well (Camerer 1999). Over the past several decades, developments in psychology, neuroscience, and related disciplines have unraveled several behavioral regularities which have been able to nuance and sometimes alter our understanding of some human behavior in economic settings. In this section, we briefly review some of the behavioral regularities that have been identified as departures from the standard model of “homo-economicus”, which are of relevance to the infrastructure sectors. Here, at the risk of oversimplification, for exposition purposes, we follow the classification of deviations from the standard economic model developed by Congdon et al (2011); imperfect optimization, limited self-control and non-standard preference. These three categories are related and often overlapping aspects of individual and group behavior for which there is robust evidence from psychological experimentation (Kahneman and Tversky, 2013). In short, imperfect optimization refers to situations where people make choices that do not correspond to their desires, limited self-control exemplifies situations when people despite knowing what they want, are unable to implement their choices while non-standard preference implies that what people want is not what economic models presume as individual utility maximizers meaning individual preferences are modified by other regarding preferences.

2.1.1 Imperfect Optimization

Imperfect optimization poses challenges to the standard economics tenet that people are good at making decisions concerning their own well-being. More formally, traditional economic models assume that individuals are able to maximize their utility which is ensured by the assumptions of consistent preferences given all available information and independence of irrelevant alternatives. A large amount of literature on judgment and decision making in psychology has shown that people are in fact not very good at making decisions due to some of the characteristic features of the human brain which in turn lead to limited attention, limited computational reasoning and biased reasoning. Limited attention refers to the limited ability of the human brain to capture and process

all stimuli from a set of available choices taking into consideration their multiple attributes on multiple dimensions (Bernartzi and Thaler 2007). As a shortcut to overcome this challenge, individuals focus on selected features of their choice environment, ignoring many others. This makes choices sensitive to the salient features of the environment (salience effect) and particularly to where the attention is directed (local construal). Limited computational ability in turn refers to the limited cognitive power of the human brain which makes the act of choice a challenging task (choice overload). Biased reasoning arises in situations in which the human brain evaluates events of a statistical or probabilistic nature. In such situations they often tend to show persistent biases in decision making, particularly on choices involving ambiguity and risk. In short, evidence abounds in the literature showing that due to imperfect optimization, individuals make systematic errors in decision making in their attempt to maximize utility, by resorting to crude rules of thumb based on heuristics and biases.

2.1.2 Bounded Self-Control

Bounded self-control challenges the traditional economics view that not only do people know what they want but also that they are able to act on these interests by implementing their choices. In other words, neoclassical models assume that the choices people make are time consistent, and they can *ex-post* implement exactly what they had planned *ex-ante*. However, studies in psychology and behavioral economics have shown that people exhibit failures in self-control and often are time inconsistent, showing a bias of present over future consumption (Laibson, 2015). These bounded self-control issues manifest themselves as procrastination or succumbing to immediate temptation, both of which can result in suboptimal outcomes. Many psychological studies have found that small changes in the choice architecture or environment can substantially change the observed gap between choices and actions (Münscher, Vetter and Schuerle, 2016). These 'choice features' or 'channel factors' as they are known in psychology, show that small interventions or minor modifications can channel the actions of people towards or further away from their instinctive choices. The success of the introduction of default options in employer provided insurance programs or 401K plans are good examples of the use of channel effects in policy interventions as shown by Bernheim et al (2015). Further, the ability of individuals to exert self-control also depends on the state of the mind of the decision maker, or the conditions under which decisions are made (Mullainathan and Shafir, 2013), which calls for consideration of the context when designing choice architecture for decision makers.

2.1.3 Nonstandard Preferences

The nonstandard preferences phenomenon challenges some of the standard economic assumptions about choice. First, it is assumed that people value the end more than the means, as well as assessing the value of that outcome with respect to other outcomes. In reality, people evaluate choice outcomes relative to other options which may be available as a reference point. These are referred to as *reference dependent preferences* which in turn can give rise to systematic behavioral anomalies such as the *endowment effect*, *loss aversion* or *status quo bias*. The endowment effect is present when choices are affected by the initial endowments that the individuals possess since they create a reference point for how they value subsequent choices. The endowment effect is particularly useful in explaining the differences between the stated willingness to pay and willingness to accept valuations, a commonly observed facet in infrastructure sectors. Loss aversion indicates that people do not value gains and losses symmetrically, but losses are more intensely felt than gains. Loss aversion has implications for framing gains and losses since it makes people risk averse with respect to gains and risk loving with respect to potential losses. Status quo bias is present when people prefer to stick to what they have or to the current state regardless of potential gains from switching. This is behind the often observed reticence of consumers to make changes to the service options that utility companies offer from time to time despite possible economic gains. Experiments on default options clearly show that status quo bias can enhance these effects and hence matters much in the design of the choices (Kahneman, Knetsch & Thaler, 1991).

Second, it is commonly assumed in the neoclassical framework that individuals are at least weakly self-interested, that they try to maximize their utility regardless of the consequences to others. However, it has been shown systematically that people care not only about their utility but also on how they are seen by others as well as how they affect others. For instance, altruism, is often observed when people contribute to charities or public goods; fairness is often reflected when individual choices show that they care not only on the outcome but also on the process in which outcome was achieved as shown by the fair and cooperative behavior in countless trust and reciprocity experiments across the world (Henrich et al, 2001). Adherence to social norms is observed since people care about how they are perceived by the others as shown in energy conservation experiments.

In this subsection, we discussed the three important categories of behavioral regularities that

are commonly observed in human behavior which have implications for infrastructure sectors. It has been suggested that the impact of behavioral regularities on market imperfections and market failure has been mixed, sometimes ameliorating them while exacerbating them in some others. Moreover these behavioral features often work together reinforcing or counteracting their effects. Therefore, the significance of these behavioral regularities will depend on how common they are in settings relating to infrastructure sectors as well as how large the magnitude of their impacts is.

2.2 Characteristics of Infrastructure Sectors

Standard economic theory highlights instances when competitive markets fail to produce socially optimal outcomes. Broadly, they can be classified into two groups: - market power and nonexistence of robust markets which delivers efficient outcomes. Market power is present when some firms are price makers as in the case of monopolies where the output falls short of the efficient level of output and the marginal cost-based prices are not market clearing. Non- existence of markets can occur under various situations such as the presence of externalities or when the participants in the market transaction are characterized by asymmetries in information. In the case of externalities, where the consumption or production decisions of one party cause costs or benefits to others who are not part of that market exchange. With asymmetric information, when one party in the transaction has more information than the other, this can also affect the robust functioning of markets. Under all these instances, government intervention is typically called for to correct the market failures. Public goods such as parks, roads, research and development are a type of externality, which are non-excludable and nonrival in consumption. It has long been recognized in economics, that in competitive markets individual expenditure falls short of the socially optimal level of the production of public goods, which in turn calls for governments to intervene. Governments need to ensure adequate provision of infrastructure to the public in areas where the private sector will fall short.

In fact, infrastructure sectors have many of the characteristics of public goods such as non-excludability, limited non- rivalry and often high levels of public spending. We single out three characteristics of infrastructure sectors that are especially relevant from a behavioral perspective: Firstly, infrastructure investments combine high sunk costs for initial construction with time intensive, complex and low visibility operation and maintenance. Energy (on grid and off grid), water and sanitation networks, and transport (roads, bridges, public trans- port networks) all require a high starting investment in physical capital, usually irrecoverable and hence a sunk cost,

that is in many cases paired with a low marginal cost of serving additional consumers/units. Incentives are heavily skewed in favor of the initial investment whereas success in maintaining these investments, and effort invested by infrastructure managers to do so are deeply underappreciated. Secondly, infrastructure sectors are usually characterized as natural monopolies because of their high initial fixed costs and very low and marginal costs (Tirole and Jean, 1988). Given the important size of the initial investment, these agreements have a relatively long life (over 15 years on average). Thirdly, making such infrastructure available may not be sufficient for them to meet their welfare enhancing objectives. As the 'last mile connection' problem shows, it is necessary to build consumer trust, address social norms, and challenge status quo biases to ensure both adoption and sustained use of new services by those that often need them the most.

The situation becomes more complicated when we introduce insights on behavioral regularities which interact with and operate along with these traditional departures from competitive markets. For instance in insurance markets, even though individuals are imperfect optimizers and/ or have non-standard preferences, they may not even realize the value of their private information or are unable to take advantage of the private information they have as the standard theory predicts. In the case of infrastructure related decision-making, limited self- control and imperfect optimization can affect the policy makers, service providers and final consumers who fail to make optimal decisions by evaluating probabilistic outcomes and making risk assessments. This is often reflected in suboptimal infrastructure planning by policy makers in the context of climate change, limited disaster preparedness by service providers as well as overexploitation of common pool resources by users as in the case of excessive groundwater extraction in many parts of South Asia (Jacoby, 2017).

The situation is similar for externalities and public goods as well. Individuals, being imperfect optimizers with limited self-control and nonstandard preferences, often fail to adhere to the prescriptions of the traditional models. For instance, individuals contribute to public causes, or internalize externalities of polluting behavior by voluntary actions reflecting imperfect optimization and nonstandard preferences. To cite another example, a 'traditional' bottleneck at an institutional level could be scarce resources that limit the funds to be allocated for investment projects. However, the decision-maker could also be constrained in their ability to analyze all the options through 'choice overload', or their own prior beliefs. For example, status quo bias could play a role in the final decision on where to invest. Finally, the decision of the consumer to adopt

or use a service is influenced by the price, but also the complexity of the pricing schemes, social-norms, environmental attitudes, and other factors that can only be seen through a behavioral lens.

Similar behavioral and traditional factors play a role in the contract design between investors, providers of service and consumers. A common workhorse in the economics literature for understanding such agency and contract issues in the presence of information asymmetries is the principal agent framework. Here, the challenges relate to the principal-agent structure of the transaction between the policy maker and the service provider. For example, the principal (policy maker) may not be able to observe if the agent (the service provider), follows the agreements and exert the expected level of effort in the project as planned by the principal, which is a typical case of the presence of asymmetric information. Differences between principal and agent time horizons stemming from political or financial cycles and goals could add to misaligned incentives among parties, and sub-optimal outcomes. Under a traditional economics view, the immediate solution to this conflict relies on a competitive selection process, auctioning off the implementation, creating the right incentives and explicitly defining the terms of the contract. A behavioral approach enriches this perspective by recognizing that parties might not act solely as rational profit maximizers; it would reinforce the salience of repeated interaction between parties with the intention of increasing trust and diminishing parties' impatience. Behavioral tools such as framing, persuasive language, and improvements on agent choice architecture could help move projects towards better outcomes. In this paper, we discuss several instances of principal-agent problems, often modified by behavioral regularities, along the chain of infrastructure projects. These problems relate to differences in time horizons between the principal and the agent, difficulty of monitoring performance on project implementation and service provision among the contractual parties. Similarly, because infrastructure investment often generates common pool resources, we discuss the difficulty that service providers could have in pricing them properly.

In this context, viewing challenges facing the infrastructure sectors through a behavioral lens shifts the focus towards the three main actors- policy makers, service providers and the users – the three elements of the triad we proposed in the framework earlier. Since these actors are individuals or collectives of individuals, all the behavioral regularities discussed above will affect their decision-making and further accentuate or ameliorate already existing departures identified in the neoclassical economics literature (Congdon et al, 2011). Examining the involvement of the

private sector from this perspective may also help. If private sector participation can bring benefits, governments need to address public perceptions to increase trust and reduce uncertainty around private sector involvement in public service provision.

3. Infrastructure Service Delivery Triad through a Behavioral Lens

In this section, we will take a closer look at the three actors in the Infrastructure Service Delivery Triad - the policy maker, service provider and the consumer and explore how behavioral regularities are likely to influence many of the decision-making challenges they face in their respective roles. In this section, we focus our attention primarily on experimental evidence from the water sector to highlight the main findings. We recognize that some of these studies are not statistically well-powered, some of them are either lab based or lab in the field experiments (Harrison and List, 2004) and are of smaller scale with limited replications. However, they provide important insights which are useful for the sector.

3.1 Policy Makers and the Investor Side

The analysis will start with the beginning of the service delivery chain from the policy maker's perspective. In the realm of infrastructure, policy makers typically have the primary role in making decisions on: (1) what projects to invest in from across several alternatives and how to finance them, (2) setting up the contractual arrangements to build, maintain and manage the infrastructure, and (3) regulating the market, particularly when services are provided privately at large.

3.1.1 Infrastructure Prioritization and Financing

Policy makers have a key role in choosing which infrastructure projects should be prioritized (World Bank (2003)). The role of the policy maker is to identify the populations' needs, balance often conflicting interests and implement solutions, subject to the available resources. As a point of departure, we start with the traditional view of the government as a 'social welfare maximizer', affected by behavioral constraints. First, policy makers start by deciding what infrastructure projects are selected from among a number of alternatives. Apart from the obvious resource constraints posed by fiscal space, policy makers are influenced by a myriad of behavioral factors - imperfect optimization, bounded self-control and nonstandard preferences- in making

these decisions. For example, in the presence of multiple investment alternatives, policy makers typically face the cognitive challenge of choice overload, which in turn forces them to rely on simple heuristics rather than optimal cost benefit calculations to make decisions. Policy makers may be subject to the availability heuristic, a decision shortcut in which the likelihood of the selection is impacted by the ability of the respondent to recall information about the options (Gohmann, 2017). Similarly, the context in which the choices are presented affects the likelihood of the selected option -choice architecture-, this may have direct implications on the infrastructure projects choice. Moreover, noneconomic considerations such as reducing interpersonal and inter-regional inequities also affect the choice of investments. These tend to stem from political considerations, reference dependence and nonstandard preferences (Congdon et al, 2011). Thus, even when aiming to maximize the overall social benefit, policy makers are human and not *homo economicus* agents and therefore behavioral aspects- framing, beliefs, attitudes towards risk and ambiguity, inconsistency with the social planner's time horizons, and discount rates,- all affect government choices.

When we depart from the assumption of the policy maker as the social welfare maximizer, the behavioral factors play a major role. The literature (mainly in political science) offers substantial evidence on how the policy makers' private interests put the "social welfare maximizing" assumption at stake.² The misalignment of objectives between policy makers and citizens is driven by electoral aspirations, myopia, time inconsistencies, and a bias towards short-term returns driven by the electoral cycle. White elephants (Robinson & Torvik, 2005), i.e., investment projects with a negative social surplus, are the most well-known example of the negative growth and low social impact of these politically biased decisions.³ Moreover, the short term bias of decision makers has been shown to lead to a sub-optimal allocation of resources, for example negatively impacting maintenance of existing infrastructure in favor of new constructions (F. K. Rioja (2003), F. Rioja (2013)).

²The political science and political economy literature has widely documented the misalignment of preferences between governments and citizens. For example Olken & Pande (2012) survey the inefficiency impact of corruption in developing countries, Fisman et al. (2014) look into the private returns of holding public office, and Lehne et al. (2018) reflect on the direct impact of political connections on the cost of roads. In terms of time horizons, electoral cycles have been shown to significantly influence politicians choices (see for example the seminal paper Besley & Case (1995), or Faye & Niehaus (2012) as an example on how electoral cycles -and hence politicians' time horizons- also influence their development assistance linkages and flows of resources).

³ Development aid allocations for infrastructure projects have not been free of these political pressures, as shown in Dreher et al. (2019), and as Gupta et al. (2016) show this electoral bias in public investment is an issue not exclusive of non-democratic settings.

The choice of PPPs could be viewed at least in part as a consequence of the behavioral biases of policy makers. Policy makers are influenced not only by the financial, ideological, and political preferences of the government as a collective, but also the time horizons of their political tenure, and thus present bias and myopic inability to make credible commitments. On the one hand, the choice among different potential infrastructure investments may create tensions between interest groups in the population that the government must consider. This choice also affects the costs, potential revenues from user fees and ultimately the financial viability of the project. This in turn affects the feasibility of a private interested partner (as shown in Fay et al. (2021)). On the other hand, infrastructure investments are long term commitments while those holding political office may be working on much shorter timelines. This situation creates tensions both in the maintenance of the investments, and the choice to make the investments in the first place. The main behavioral inhibitor is that their return appears well after the current responsible politicians stay in office ends (Daniel et al. (2019)).

3.1.2 Establishing Contractual Arrangements for Service Provision

Once the government has decided on the specific investment, the policy maker must elaborate the contract. We observe a great variety of funding and service provision arrangements across sectors and countries. These range from direct public provision to private regulated contracts, with a variety of types of Private Public Partnerships (PPP) in between. Though there is a growing role for the private sector, it is beyond argument that infrastructure construction is mainly carried out by the public sector. Specifically, 83% of the investment in infrastructure projects in developing countries was executed by public entities and state-owned enterprises in 2017 (World Bank, 2017).

Conceptually, the principal (policy maker) gives authority and property rights over certain operations to the agent (service). The agent acts and makes decisions (some of these actions and decisions are explored in the next section). The government must design a contract that induces the agent to serve his/her interest of improving access to a quality service. The process for selecting a service provider must include fairness, neutrality, and transparency (World Bank, 2018). Transparent practices are key within the procuring organization, in the absence of which there could be reactions from the contracting parties as well the consumers. In this sense, procurement officers may be tempted to engage in corrupt practices due to present bias, with direct implications on the way that bidders act in the procurement process. For instance, the Procuring Infrastructure PPP Report (World Bank, 2018) evaluates laws and regulations of 135 economies and determines

that 82% of the procuring authorities provide clarification about the selection process to all bidders. However, low-income countries in the sample publish less information about the procurement process and results. This illustrates a lack of transparency, which may generate the wrong incentives among the bidders. Furthermore, the contractual arrangement must foresee the principal agent problems that may arise and establish the correct set of incentives, as well as the renegotiation and termination clauses.

Since the 1990s, Public Sector Participation has experienced a sharp rise due to its claims to increase Value for Money through a reduction in costs, and ability to increase service quality (Jomo et al., 2016). Viewing this from a behavioral perspective, it could be argued that the outsourcing of the long-term management of the investment to a private institution creates economic incentives to improve service provision. There are a wide variety in contractual arrangements between PPPs, - at least 25 different types were identified by Romero (2015). The different contractual arrangements do reflect both the costs of providing the service, the specificity of the infrastructure (example networks or stand-alone) and the capacity for service provision. The effectiveness of these contracts does vary across sectors and countries. Some studies have found that Private Sector Participation (PSP) in water projects leads to improved service quality (Porchet & Saussier (2018)) and higher connectivity rates due to the contractual incentives that PPPs in the water sector had (Fabre & Straub (2019)). However, there are also well documented cases of controversies in private sector participation which have led to large backfire effects. Privatization of water utilities in Cochabamba, Bolivia is a well-known example of where Aguas del Tunari was granted a 40 year concessional contract for water distribution in and around Cochabamba which was cancelled after widespread protests. The company's emphasis on cost recovery led to price increases of up to 50%, after user rates were indexed according to a US consumer price index. Nickson & Vargas (2002) document how asymmetries of information, moral hazard and first mover advantage were all issues which constrained the government's capacity to first negotiate and then regulate the PPP. Similarly in Dar es Salaam, Tanzania, an intended 10 year contract was cancelled two years after signing with City Water in 2003 for a myriad of reasons. At least in part this was due to an inability to meet contractual arrangements where planning fallacies may have played an important role (WaterAid, 2008).

Learning from some challenging experiences with PPPs, the World Bank (2018) has had to document lessons on some good practices for ensuring private provision does not contravene the

principles of public good provision. For the preparation process these include the following: projects should be assessed and prioritized along with all other public investment projects; the procuring authority should prepare a draft of the contract; they must use a standardized PPP model contract to guarantee consistency. There are many behavioral biases at play in the drafting of a contract. For example, policy makers may be subject to the availability heuristic (Gohmann, 2017) or constrained by their choice architecture (the policy structure within which they make decisions) both of which could impact the types of service providers chosen as well as the conditions of contract entered into. The example from Bolivia provided earlier is highly illustrative of how the bargaining power of the policy maker vis-a-vis the provider was constrained by the broader policy context of structural adjustment.

3.1.3 Enabling Effective Regulatory Arrangements

Apart from the standard instances of market failure, behavioral regularities can in turn interfere with markets and create unintended and often suboptimal outcomes (Barr et al. 2009). Regulation in infrastructure sectors typically takes the form of setting standards on quantity and quality of the services provided, setting controls on tariffs and subsidization policies and establishing transparency in the financing arrangements in infrastructure projects. Often regulatory decisions are endogenous and are influenced by the capture or corruption of politicians or regulators and collusion between service providers (Estache and Serebrinsky, 2020). Decisions on tariffs and subsidies are also influenced by political considerations, electoral gains and other short-term interests driven by myopic behavior of regulators. Service providers also react to the regulator's behavior, but as behaviorally informed agents. According to Barr et al. (2009), because firms have a great deal of latitude in issue framing, product design, they have the capacity to potentially pervert regulatory constraints. 'Ironically, firms' capacity to do so is enhanced by their interaction with consumers, since so many of the things a regulator would find very hard to control (for example, frames, design, complexity, etc.) can greatly influence consumers' behavior. The challenge of behaviorally informed regulation, therefore, is to be well designed and insightful both about human behavior and about the behaviors that firms are likely to exhibit in response to both consumer behavior and regulation. The regulators need to expand their toolkit beyond prices, quantities and quality standards to other behaviorally motivated interventions or 'nudges'. For instance, the regulators can increasingly use non-price measures for regulating consumption by appealing to social comparisons or emotions.

3.2 Service Providers

We will move to behavioral dimensions that affect the decisions of the service provider, focusing on the incentives and behavioral barriers around good service delivery. Here we explore how behavioral factors affect the internal structure of the organization of the firm, and challenge the service provider to improve the motivation and performance of their employees.

3.2.1 The Service Provider and the Policy Maker

The choice of financing and implementation taken by the government/ policy maker is key to how the service provider relates to the consumer in terms of access and quality of the service ultimately provided. Generally, responsibility of infrastructure service provision is handed over to public sector entities, private sector entities or a mix of public and private sector. The public- sector participation in service provision can potentially address several behaviorally oriented challenges facing infrastructure sectors by addressing issues of short- term biases, high discount rates dereliction of maintenance expenditures, and temporal inconsistency. However, public or semi-public provision of infrastructure services suffer from challenges of a soft budget constraint, where the managers have limited concerns for increasing efficiency due to assured financial bailout by the government (Kornai et al. (2003), Pettersson-Lidbom (2010), Dewatripont & Roland (2000). On the other hand, as Porchet & Saussier (2018) show, private management and associated managerial practices are in general associated with an improvement in service quality and technical efficiency. This has been one of the main points highlighted as the benefits of some type of private involvement in infrastructure service provision. Behaviorally informed contracts can improve the managerial practices of service providers thus improving efficiency and financial viability. At the same time, it is key that the procuring authority conduct due diligence for establishing the contract that fits best the relationship. Officers may be subject to a planning fallacy, where insufficient attention is paid to the preparation phase, thus affecting the performance of the rest of the project. It is also possible that private or semi- private service providers can present challenges for ensuring equitable access and affordability of service, as has been illustrated by the water utility examples from Cochebamba and Dar es Salaam above.

3.2.2 Management Practices and Internal Incentives of Service Providers

As seminal reviews have highlighted (Camerer & Malmendier (2007), Garicano & Rayo (2016)), an

appreciation of organizational behavioral dynamics is crucial for the optimal functioning of any institution. Solid management and smooth operation of a service provider requires incentives for decision makers and employees at all levels of the hierarchy; and an appreciation of the relevance of bounded rationality. The allocation of incentives within organizations (Bandiera et al., 2020), and how management practices affect performance in the civil service (Rasul & Rogger, 2018) are key questions to be considered for the design of optimal governance in infrastructure.

Employee's motivation lies at the heart of service provision in infrastructure, and literature has shown this motivation to be linked to (1) institutional organization and management and (2) to the prevailing monetary and non-monetary rewards systems. The literature on the first aspect is extensive, and has expanded across industrial organization, management, organizational economics and behavioral economics. It has shown the importance of the workplace environment; and how management is perceived by the employees - particularly when it comes to fairness and transparency. For example, Van Reenen et al. (2014) highlights the importance of managerial practices in accounting for the large differences in cross-country Total Factor Productivity as well as within country differences in firm performance, Ashraf & Bandiera (2018) provide a very comprehensive review of social incentives within organizations or Huck et al. (2012) discuss the importance of social norms within organizations. A common theme in this literature is the importance of team management and cohesion on employee's motivation. The questions of incentives within teams (Holmstrom, 1982) and of formal and real authority within organizations (Aghion & Tirole, 1997) have been followed by the increasing interest in the importance of identity within organizations (Akerlof & Kranton, 2005) and of the relationships within groups. (See for example Goette et al. (2006) for a pioneer paper on the topic or Balliet et al. (2014) for a meta-analysis of within-group favoritism (Balliet et al., 2014).)

The second important aspect that affects employee's motivation are the reward schemes, that include both economic motivation and work recognition.⁴ Before entering into the discussion of reward structures, it is relevant to highlight the possibility of self-selection by employees entering into the public sector. Besley & Ghatak (2018) show that agents working in the public sector may have pro-social motivations, which make them less sensitive to monetary rewards and more

⁴ The literature on incentives for public servants is extensive, especially in the health and education sectors (Bloom, Propper, et al. (2015); Gauri et al. (2019); Ashraf et al. (2014); Bloom, Lemos, et al. (2015); Patel & Volpp (2012) and Bellé (2015)).

sensitive to the social outcome of their work. This is important as it may have implications for the relative efficacy of financial vs. non-financial incentives in a way that would be quite dissimilar in the private sector.⁵ Besley & Ghatak (2018) build a framework of a principal-agent model adapted to public service delivery that considers pro-socially motivated employees. They conclude that organizations may benefit from motivated employees as effort can be elicited at a lower cost. The main highlight of this work from a behavioral perspective is on how to design contracts to achieve self-selection of behaviorally motivated individuals for public service. They mention alternative forms of nonpecuniary motivation: commitment to a mission, conforming to an identity, having reputational concerns, pursuing status, and being altruistic. Indeed, the importance of incentive design cannot be underestimated as financial incentivization may have perverse effects in the public sector. For example, an experiment conducted in Italy with nurses found that monetary incentives for activities with a pro-social impact may crowd out employee motivation Bellé (2015). In their review, Bowles & Polania-Reyes (2012) note that the effectiveness of economic incentives in a population with strong social preferences is not conclusive. Kuvaas et al. (2017) illustrate the difficulty to find the optimal incentive scheme in the presence of intrinsic and extrinsic motivation, with the danger of crowding out employees' motivation. In summary, the main difference between utilities run by public and private providers alike is that performance and employee motivation are not uniquely driven by profit, hence the incentive schemes to select and motivate employees will greatly differ from the standard bonus payments of profit maximizing settings. On the one hand, performance-pay (Eriksson & Villeval (2008), Dohmen & Falk (2011)) is difficult for the infrastructure service provision and maintenance tasks, given the team-work needed to perform the job, and hence the difficulty to identify individual output. On the other hand, it should be noted that at least in some cases, service providers are frequently constrained by their contractual choices with employees by their funders.⁶

3.3 Consumers

The success of an infrastructure project depends on how well it is being used by the final consumers in an affordable and sustainable manner. Several networked infrastructure investments such as electricity, water and sewer networks involve economies of scale where it is important to meet the

⁵ See Georgellis et al. (2011), Prendergast (2007) or Dal Bó et al. (2013) for additional empirical examples on sorting of intrinsically motivated workers towards the public sector.

⁶ A subsection on Service Provider and the User relating to trust and reciprocity etc. could be added.

needs of a larger pool of consumers to achieve cost advantages and ensure the best use of investments. Also, some infrastructure investments like water and sanitation, are merit goods with strong positive externalities, meaning the society will have more welfare gains by enabling the take up by more consumers. Finally, regardless of who builds the infrastructure - public, private or PPP - profitability and costs and benefits analysis of a given project depend on many potential users' decisions regarding final adoption of the service and its sustained use. Often the supply of goods or services of any infrastructure project should match demand to avoid or minimize wasteful use of resources as well as meet the profitability concerns of investors. Therefore, forecasting users' demands becomes crucial from the conception, planning and implementation of the project. Traditionally economists have based their predictions of users' actions on 'homo-economicus' models which implies that consumption behavior is predictable based on knowledge of consumer preferences. Under this paradigm, users' actions could be predicted with an acceptable degree of accuracy. Behavioral economists have challenged the use of 'homo-economicus' model that dictate how users consume the services and goods provided by infrastructure investments (Bowles, 2008). This section summarizes how behavioral insights have shifted several pre-existing assumptions regarding users' choices and decisions, having significant implications on the feasibility, profitability, and sustainability of infrastructure investments.

3.3.1 Behavioral Insights on Adoption

We start this section by describing how behavioral factors affect users' decisions of adoption and consumption. Notice here that in this paper, adoption refers to the extensive margin, while consumption, the intensive margin of any service provided by investment projects.⁷ Therefore, knowledge on how these two decisions are made is essential for estimating the feasibility, profitability, and sustainability of any given project. Characterizing these two types of decisions from a behavioral perspective will enable policymakers, investors, and researchers to target those factors responsible for contributing to either increase uptake or alter consumption.

⁷ By the extensive margin, we refer to the number of users that adopt the system. Thus, while new infrastructure construction is usually aimed to convert potential users into consumers once the infrastructure is in place, service providers need to manage its use. In contrast, when we refer to the intensive margin, we focus our attention on using existing infrastructure. Here service providers aim to manage how much infrastructure is used by the consumption patterns generated under different pricing schemes.

The choice architectures needed for encouraging adoption and modifying consumption behaviors are very different. When facing a decision on whether or not to take up a new service, potential users must ponder its costs and benefits. The degree of uncertainty behind the underlying cost and benefits is unclear, particularly for most who are facing problems of imperfect optimization and limited self-control. To address this, information can be presented through reframed or targeted messaging, which considers potential users' attitudes, identity, and beliefs, all of which could play a crucial role in their decision to adopt. In contrast, once the consumer has adopted the service or good, they can quickly no longer envision life without it. Therefore, apart from relative prices, several behavioral factors such as other-regarding preferences, social norms or habit formation could influence their consumption behavior.

Adoption of a new technology or service can often be challenging for the consumers, due to the uncertainties, or behavioral biases such as the status quo bias. For more than four decades, economists have studied how attitudes towards risk and ambiguity influences the adoption of agricultural technologies (Binswanger (1980), Barham et al. (2014)).⁸ More recently, economists have also studied how resources-saving technologies are adopted by households and businesses looking to adopt environmentally friendly practices (Álpizar, Bernedo, & Ferraro (2019), Kumar et al. (2020)). For instance, adoption of improved sanitation technologies including connecting to sewer networks is a challenging problem across several developing countries (Kennedy- Walker et al, 2020). But identifying what behavioral factors influence adoption in different contexts among various social groups is often a difficult empirical task. It has been observed in several contexts that traditional factors such as prices, costs, expected benefits, liquidity, and credit constraints might fail at painting a complete picture of the adoption problem and therefore researchers and policy makers should consider a broader behavioral approach. Evidence has shown that factors that have often not been included among economic variables such as wording in informational brochures, non-monetary cost (time costs), trust in the service provider or the governments affect the adoption decision. Furthermore, these factors could affect individuals and families of different strata, ideologies, or ethnic identities differently. For example, Toledo (2016) found that persuasive wording was as crucial as subsidies in increasing the purchase of light-bulbs by Brazilian slum

⁸ For an excellent and recent summary of the explanatory power on agricultural adoption the interested reader could peruse (Streletskaya et al., 2020).

inhabitants. In India, Hoffmann (2018) found that in the purchase of consumer durables such as water filters, monetary prices tend to screen out the poor while nonmonetary prices (time costs) have similar effects on the poor and the nonpoor. This implies that there is a need for monetary subsidies to encourage the uptake of new technologies by the poor. Power, and intrahousehold bargaining processes within the household could be crucial to influence decisions inside the family. For example, Álpizar, Del Carpio, et al. (2019) found a couple's attitude towards uncertainty is more relevant at explaining adoption decisions of resource-saving technologies than attitudes at the individual level. Similarly, Levine et al. (2018) provide additional evidence of how attitudes and cultural factors influence household decisions to adopt less polluting cook stoves in Uganda.

3.3.2 Behavioral Insights on Pricing and Consumption

As discussed in the second section, services and goods in infrastructure are usually public goods and governed by a natural monopoly that make them more difficult to price than regular private goods (Samuelson, 1954). Enabling socially efficient use of infrastructure services through pricing alone is an arduous task, even in theoretical settings. Two reasons contribute to this difficulty; first, most infrastructure services can be characterized as having externalities of a public good with limited excludability leading to congestion. Therefore, the gains from infrastructure services that a consumer could obtain is determined, at least partly, by the behavior of other consumers. Second, when the consumption of different users is interlinked, then individuals and families are likely to be driven by factors other than price. In the last two decades, several economic experiments have been conducted to test how social norms, identity, and other regarding behavior affect the consumption of the services and goods resulting from infrastructure investments. This section aims to summarize the lessons from the research conducted on this topic at risk of omitting several relevant articles.

A critical characteristic of human-made public goods (such as aqueducts, water purification plants, energy distribution networks, traffic, telephone, internet network, etc.) is that they could be congested, and congestion has a substantial social cost. Once congestion is incorporated into the pricing analysis, traditional economics has a primary approach called congestion pricing. Congestion pricing says that prices should reflect the social cost generated by those who saturated the system's capacity when congestion occurs. Under the traditional view, the incorporation of additional charges should help to decrease consumption towards desired levels. In practice,

although some relevant examples of congestion pricing exist, i.e., Singapore, Stockholm, and London's congestion charges and Uber's surge price, the wider applicability and political acceptability of congestion charges has been challenged for more than five decades (Evans (1992), Selimoune et al. (2020)).

Behavioral science has shown that limited cognitive abilities, imperfect optimization, limited self-control and nonstandard preferences significantly limit the ability of relative prices to guide optimal consumption decisions. In the field, instruments such as increasing block tariffs and non-linear prices are ubiquitous among water and electricity utilities (Komives et al., 2006). While helping utilities recover costs, these instruments can create welfare distortions when consumers face uncertain future marginal prices (Weitzman, 1974). Recently, several papers have highlighted that consumers often fail to understand block-tariffs due to their complexity (Ito (2014), Martimort & Stole (2020), Shaffer (2020)). Similarly, there is an increasing concern regarding the effects that inattention (due to complexity of pricing schemes and habit formation) has on changes in prices on the efficiency of electricity (Sallee, 2014) and water consumption (Wang et al., 2018). Several studies have highlighted the difficulty the consumers face in understanding the components of their utility bill, gadget's consumption standards and their effects on expenditure (Allcott (2011), Allcott & Wozny (2014)). Also it has been shown that consumers' decisions could often be misled by the usual lack of real-time feedback of prices in response to changes in their consumption (Strong & Goemans (2014), Strong & Goemans (2015)).

3.3.3 Behavioral Insights on Non-Price Measures and Consumption

It is important to note, as shown by many studies, when prices are set incorrectly, the price-setting in-situ could lead to unintended and even opposite of the intended effects, (Rustichini & Gneezy (2000), U. Gneezy & Rustichini (2000)). Thus if incorrect prices can backfire, then this makes finding the right prices an even more difficult but important task. A. Gneezy et al., 2012 note that it might be better to find additional instruments along with prices and charges to reach the intended outcomes. Behavioral economists have taken the opportunity to test behavioral instruments which rely on non-price measures in this context of inattentive consumers and complex decision environments. In these complex environments, instruments such as information, salient and carefully designed messages, default options, and additional modifications to the choice architecture could lead consumers to approximate the desired actions by the price-setting

institutions.

Despite being a promising field of research, little is known regarding the effects of behavioral insights on modifying traditional block tariff schemes and their potential impact on consumption. In a recent survey article, Lu and coauthors argue that block-tariff effects on guiding water consumption towards socially optimal quantities during droughts are mixed (Lu et al., 2019). Similarly, the authors argue that there is still limited conclusive evidence on the effects of nudges with social information on consumption during times of water scarcity. Though there is a paucity of replicated research in the field, several papers have shown that nudges and social information could have a potentially modest effect on diminishing water consumption during droughts. For example, during the 2015-2016 drought at Cape Town, South Africa, Brick et al (2018) demonstrated a modest effect on reducing water usage by sending behaviorally informed messages to households. Similarly, Visser et al (2021) study how schools reduced their consumption of water during the drought when they combined smart-meters and inter-school competition in 105 schools. The results have a much larger magnitude than previous studies, the intervention reduced water usage in these schools by 15%-26%. Overall, this sequence of studies in Cape Western State South Africa appears to agree with the conclusions of Lu et al. (2019) and the lessons from Lu (2020) on the importance of providing consumers with online water-use feedback.

The finding of Visser et al. (2021) in the school of South Africa's Western Cape goes in a similar direction to those found by Jessoe et al. (2017) working with Southern California Households. Jessoe et al. (2017) implemented a large intervention across Burbank, Southern California, during the drought of 2017. The authors found that the most effective treatment was nudging households to save water and provide advice on how to save water and gas. Additionally, this treatment provided a competitive incentive to the allocated participants.

Norm-based messages and social information nudges were used almost simultaneously to reduce water consumption; Ferraro & Price (2013) ran an experiment to reduce water consumption through norm-based messaging in Atlanta, Georgia, United States of America. The authors found that messages effectively reduced peak summer water consumption (Ferraro & Price, 2013). The use of norm-based messages to curtail water consumption has also been implemented in different countries. For example, Datta et al. (2017) used norm-based messages varying the language to attain great communal affiliation. i.e. your city versus your neighborhood in the city of Belen, Costa Rica.

A similar argument can be made for interventions to reduce electricity consumption during peak hours through behaviorally informed interventions (Sudarshan (2017), Brandon et al. (2019)). Economists leverage the use of social information nudges to develop several interventions in partnership with power and electricity utilities in the United States of America (Allcott & Mullainathan (2010), Allcott (2011), Ayres et al. (2013)). In experiments using this nudge, at least one of the treatments provides assigned households with feedback on their own and peers' household electricity usage. The central hypothesized mechanism behind social-information nudges' is to appeal to the human desire to conform to the perceived social pressure, which will enable users to alter their consumption. After more than a decade since the first large field experiments with social information treatments have been conducted, the results are rather mixed, and the effects are of relatively smaller magnitudes. Despite the mixed results, interventions have been at least partially replicated in different places, as well as with different resources such as water, electricity and waste management. To the best of our knowledge, in addition to several experiments conducted in the United States, and Europe (Costa & Kahn (2013), Andor et al. (2020)), researchers have not managed to implement similar large scale experimental designs in many places with the exception of India (Sudarshan, 2017).

Similarly, it is also interesting to note that norm-based messaging tend to have unintended spillover effects thus justifying their wider applicability. Lopez-Rivas uses a multilevel experimental design in Diamante, Colombia, to improve the accuracy of estimating the effects of norm-based messages. The multilevel experimental design allows him to account for spillover effects, i.e., effects on those consumers that were not part of the experiment (López-Rivas, n.d.). This article shows that when spillover effects norm-based, messages are even more effective in reducing consumption. Although it is still in its early stage, the literature on norm-based messages has transitioned from initial simple ones that just used descriptive norms, i.e. what other people do, to new goals. By combining descriptive norms with persuasive language and nudges, researchers aim to increase the likelihood of shifting consumption to those levels desired by policy makers.

Three main issues studied by researchers that have implemented norm-based interventions have great relevance for policy makers. The first issue relates to the persistence of the changes in consumption generated by the messages; it is crucial to examine whether these interventions have only short-run or motivate long-run effects (Ferraro et al. (2011), Allcott & Rogers (2014), Bernedo et al. (2014), Brandon et al. (2017)). Second, it is straightforward to see that researchers often do not observe behavioral changes but mostly consumption changes. Often households participating

in these interventions react differently to messages. Thus, some of them could invest in new energy saving gadgets, while other households could modify their behavior. Therefore, to evaluate these interventions' impact, it is of great relevance to know how heterogeneous treatment effects are generated and incorporated into the evaluations (Ferraro & Miranda, 2013). Finally, researchers have identified that even households that do not participate in the interventions could modify their consumption. Thus it is essential to know if there are spillover effects on non-treated households (Jessoe et al. (2017), Torres & Carlsson (2018), Carlsson et al. (2020)).⁹

We finish this section briefly reviewing the potential of new behavioral research targeted to change consumers' behavior to encourage regular repayment and reduce illegal connections. The different institutional settings across countries, states, municipalities, and legal status of the goods transported by these networks affect the consumers in different ways. These differences could affect behavior differently, based on cultural, moral, and religious values. Water networks present settings where difficulties in measuring, monitoring leakages and water provision's legal status have raised the belief that water consumers could be mainly driven to this kind of behavior. Evidence of the effects of these factors on utility revenues has been found for several places such as Kampala, Uganda (Mutikanga et al. 2011), Tunisia (Mattoussi and Seabright, 2014), and Nairobi (Coville et al. 2020). In Nairobi, the researchers acted in coordination with the local water utility implementing two interventions. The goal of these was to improve the repayment for sewerage connections the customers already received. Researchers vary the tone of message, going from soft encouragements to harsh language that threatened customers with disconnection from the water network. The authors found no effect of the soft encouragement treatment, while substantial effects of the treatment with the threat of disconnection. Despite this research's ethical concerns, this research's novelty in addressing such an important question does raise interest in conducting behavioral interventions to modify not consumption but other kinds of behavior such as repayment or prevention of illegal connection which are important for network service providers. The toolbox of the behavioral intervention designs has different instruments beyond threat of punishment. Ingenious researchers could choose to present intervention designs that use persuasive language and norm-based messages or even appeal to social status concerns. Furthermore, utilities could perform communal contributions, inform about the actions

⁹ For an analytical review of the effectiveness of the research using social-norm messages to promote environmental behavior, the interested reader could peruse Farrow et al. (2017) and Yoeli et al. (2017).

undertaken by the utilities to increase institutional trust and potentially modify consumer behavior in these realms.

In summary, the existing literature highlights three relevant issues. First, there is robust evidence on the ability of behavioral interventions to increase adoption and effect consumption decisions in infrastructure. However, secondly, more large-scale experiments for replication are needed across different social and cultural milieu to gain a better understanding of the magnitude of the effects and other confounding factors. At least till this moment, there is not enough evidence indicating that nudges or informational treatments are the silver bullet as claimed by some. Thirdly, there is room for complementary behavioral mechanisms alongside financing mechanisms. This could not only alter consumption and adoption but also other aspects such as bill payment and illegal connections.

4. Discussion and Conclusions

In this paper we examined how insights from behavioral economics and other behavioral sciences can enrich our understanding about typical challenges faced by the infrastructure sectors. Infrastructure sectors such as water supply, sanitation, irrigation, telecommunication, transport and energy are typically dominated by the public sector in most developing countries which have failed to provide access to services to a significant share of the population. Moreover, they also suffer from low levels of efficiency in several performance indicators. In order to reach the goals set by the Sustainable Development Goals and other national targets, countries have to step up the investment in infrastructure sectors significantly as well as improve the efficiency of the existing ones. However, due to political economy constraints and limited fiscal space, most developing countries must rely on private financing or blended financing to meet the infrastructure investment gap.

In traditional economic theory, many infrastructure sectors exhibit characteristics of externalities and public goods and investment projects are typically characterized by monopoly tendencies- all of which call for departures from the efficient first best competitive solutions. Further, asymmetric information and absence of robust markets further complicate the challenge. Moreover, recent developments in behavioral economics have unraveled the 'homo-economicus' model of utility maximizing agents and replaced them with agents that show distinct behavioral regularities such as imperfect optimization, limited self-control and nonstandard preferences. The paper delves deeper into each of these categories of behavioral regularities and examines how they can potentially affect

the infrastructure sectors.

This paper examines how the standard infrastructure challenges are affected by insights from behavioral economics through the prism of the infrastructure service delivery triad- the policy maker, service provider and the consumer. The policy makers are constrained by imperfect optimization, myopia and nonstandard preferences which affect their decisions on establishing infrastructure prioritization and financing, establishing appropriate contractual agreements for service provision and enabling regulatory systems. The service providers are constrained by behavioral factors particularly in their agent- principal relationship with the policy maker as well as enabling appropriate internal organization within the firm to promote managerial efficiency as well as workers' motivation. Finally, behavioral factors influence the decisions of the users in their adoption and consumption decisions. Experimental evidence has shown the modest but compelling effects of framing, social norms and powerful messaging on affecting consumption decisions which have widely been used in energy and water conservation.

Notwithstanding the critique that the behavioral approach with nudges is akin to "libertarian paternalism" (Sunstein and Thaler, 2003), behavioral economics have moved from the periphery to the center of economic science. However, expanding the toolbox of economics by integrating insights from behavioral sciences is not an easy task. Critiques have argued that differentiating between the innumerable behavioral tendencies that affect individual and group behavior is practically impossible (Crosson and Treich, 2014). In many cases, we only observe the actions of individuals in response to behavioral interventions but fail to understand the underlying mechanisms that drive the psychological processes underlying individual actions (Camerer and Lowenstein, 2003). Also integration of behavioral economics challenges the basis of normative welfare economics that individuals make decisions that maximize their self-interest (Bernheim and Taubinsky, 2018). This has implications for welfare analysis based on revealed preferences underlying the choices made by individuals and groups.

On the policy front, there is increasing use of behavioral economics tools in health, education, social security and insurance, while their use in the infrastructure sectors have been quite limited. Behavioral economics can improve the toolbox of economics by offering new policy tools, improving predictions about the effects of existing policies, and generating new welfare implications (Chetty,

2015). However, more replications and large-scale statistically well-powered experiments are needed to establish some of the behavioral findings from across different cultures and social groups to make a realistic assessment of the impact of different interventions and the magnitude of the effects. Several economists have argued that integrating behavioral economics research in practical policy areas such as environmental issues, climate change, water and energy conservation is only possible with active support and funding from the government as has been done for research and development in hard sciences. Moreover, governments can pursue policies on public information disclosures (such as in energy efficiency of appliances) which in turn can incentivize firms and utilities on undertaking conservation as well as pollution abatement initiatives from their side (Allcott and Mullainathan, 2010). Finally, as we advance beyond simple 'nudges' to more complex interventions, the political economy and institutional factors must be accounted for in developing behaviorally informed interventions to ensure their effectiveness.

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Annex

Table 1: Government and Investor Behavioral Challenges

Government and Investor Side		
Challenge	Reference	Main Results
Principal Agent Model	Fabre and Straub (2019)	For infrastructure, there is some evidence of PPPs leading to gains in labor productivity having entailed significant labor downsizing.
	Porchet & Saussier (2018)	PPPs in water had an increase or neutral impact on prices, private sector participation improves coverage, poor consumers welfare increased and there is no impact on technical efficiency
Time Horizon	Fay et al (2021)	Attracting private funding for infrastructure in developing countries has proven to be challenging, especially given the low institutional and political stability of recipients that makes contract implementation and renegotiation challenging,
Choice among projects	Nagpal et al (2018)	While in developed countries fiscal space for general taxes and tariffs and transfers for the use of the infrastructures are able to cover a big share of the costs, in developing countries the former is extremely low in comparison to the cost of providing the service. To find resources for the sustainable financing of infrastructure in line with the SDG is a crucial question.

Table 2: Service Provider Behavioral Challenges

Service Provider		
Challenge	Reference	Main Results
Good Service Performance	Bloom, Proper and Seiler (2015)	Adding rival hospital increases managerial quality and higher management scores are associated with better hospital outcomes.
	Rasul and Rogger (2016)	Increasing bureaucrats autonomy is positively associated with completion rates, yet practices related to incentives/monitoring of bureaucrats are negatively associated with completion rates.
	Bandeira et al (2019)	Organization design and anti-corruption policies must balance agency issues at different levels of the hierarchy.
	Bloom et al (2015)	Higher management quality is strongly associated with better educational outcomes.
	Porchet & Saussier (2018)	Private management and better managerial practices are associated with an improvement in service quality and changes in technical efficiency.
Employees Motivation	Gauri, Jaminson et al (2019)	Social recognition improved performance in 1 state but had no effect on the other
	Ashraf, Bandeira & Jack (2014)	Extrinsic rewards can improve the performance of agents engaged in public service delivery, and that non-financial rewards can be effective in settings where the power of financial incentives is limited.
	Belle (2015)	Monetary incentives for activities with prosocial impact may crowd out employee image motivation. No crowding-out effects when a symbolic reward was substituted for the monetary incentive.
	Van Reenen et al (2014)	Highlight the importance of managerial practices in firm performance.
	Belsey & Ghatak (2018)	Agents working on the public sector may have pro-social motivation, which changes the design of incentives.
Adoption of new practices	Alpizar, Del Caprio et al (2019)	Evidence suggest weakness in the common practice of using simple workshops for delivering capacity building and climate science.

Table 3: Consumers Behavioral Challenges

Consumer		
Challenge	Reference	Main Results
Adoption	Peletz, Delaire et al (2020)	Survey-based methods may not provide accurate estimates of consumer demand for safe, reliable and equitable sanitation products among low-income populations.
	Devoto et al (2012)	Willigness to pay for a private connection is high when it can be purchased on credit, because it increases time available for leisure
	Toledo (2016)	Persuasive wording was as crucial as subsidies to affect the adoption rates of poor Brazilian slum inhabitants.
	Hoffman (2018)	Monetary incentives were a valid variable to screen out most affluent individuals that were willing to pay for a water filter, time was a more valuable factor to assess the valuation of more impoverished individuals
	Kumar et al (2020)	The factor “organization culture” is the most influencing behavioral factor, followed by “commitment from higher authority” to achieve Operational excellence.
	Álpizar, Del Caprio, et al. (2019)	Evidence suggest weakness in the common practice of using simple workshops for delivering capacity building and climate science.
	Levine et al. (2018)	Attitudes and cultural factors influence household decisions to adopt less polluting cook stoves
Consumption	Datta et al (2017)	Norm-based messages varying the language to attain great communal affiliation have positive effect on water consumption reduction
	Brent and Olsen (2015)	Social comparisons to reduce water demand where effective on 2 out of 3 facilities
	Costa & Kahn (2013)	Popular electricity conservation “nudge” of providing feedback to households on own and peers’ home electricity usage in a home electricity report is two to four times more effective with political liberals than with conservatives.
	Allcott (2011)	Home Energy Reports, as non-price interventions can substantially and cost effectively change consumer behavior.

Consumer		
Challenge	Reference	Main Results
Consumption	Brandon et al (2017)	Considering social nudges to reduce water consumption, they find that 35 to 55% of the reductions persist once treatment ends, and this is consonant with investment in physical capital
	Alpizar, Ferraro and Meiselman (2019)	Evidence suggest weakness in the common practice of using simple workshops for delivering capacity building and climate science.
	Ferraro & Price (2013)	Norm-based messaging were able to effectively reduce peak summer water consumption in the US
	Ferraro & Miranda (2013)	Norm-based messages that combine technical information, moral suasion and social comparisons exhibit strong heterogeneity among households.
	Andor et al. (2020)	Outside US, electricity consumption levels and carbon intensities are much lower, hence Home Energy Reports interventions can only become cost-effective when treatment effect sizes are substantially higher.
	Allcott & Mullainathan (2010)	Recent examples of scaling behaviorally informed R&D into large energy conservation programs suggest that this could have very high returns.
	Ferraro et al. (2011)	Pro-social preferences affect short-run patterns of water use, while only messages augmented with social comparisons have a lasting impact on water demand.
	Allcott & Rogers (2014)	Social comparison reports in energy consumption showed that this intervention has relatively persistent effects and that consumers are slow to habituate.
	Bernedo et al. (2014)	Combining technical information, moral suasion, and social comparisons, nudges have a persistent effect even 6 years after.
	Ayres et al. (2013)	Using peer comparisons on home electricity and natural gas usage, authors found a reduction on energy consumption, with a decrease sustained over time.
Ito (2014)	Strong evidence support that consumers respond to average prices rather than marginal or expected marginal price.	

Consumer		
Challenge	Reference	Main Results
Consumption	Sallee (2014)	Often it will be rational for consumers to pay limited attention to energy efficiency when choosing among energy-consuming durable goods
	Wang et al. (2018)	Providing inattentive consumers with timely and frequent information about their water usage, simple usage-based pricing policy and non-price strategies based on consumers, decision-making may be effective to reduce water consumption.
	Strong & Goemans (2014)	That a combination of increasing block rates together with real-time information increases water consumption but makes households more price sensitive.
	Gneezy et al (2012)	When granted the opportunity to name the price, fewer consumers choose to buy it than when the price is fixed and low.
	Gneezy & Rustichini (2000)	Penalties may change the information that agents have, and therefore the effect on behavior may be the opposite of that expected
	Lu et al. (2019)	Block-tariff effects on guiding water consumption towards social optima quantities during droughts are mixed.
	Brick et al. (2017)	Behavioral messages to households had a modest effect at reducing water usage
	Booyesen et al. (2019)	Smart-meters and inter-school competition as drivers to modify water consumption in school have a positive effect.
	Jessoe et al. (2017)	Nudging households to save water and provide advice on how to save water and gas are an effective treatment
	Sudarshan (2017)	Households provided reports alone reduced summer consumption of electricity, however when weekly reports are augmented with monetary incentives rewarding electricity conservations, no longer reduce consumption.
	Brandon et al. (2019)	Findings suggest an important role for social nudges in the regulation of electricity market and a limited role for crowd out effects.

Consumer		
Challenge	Reference	Main Results
Consumption	López-Rivas (n.d)	When accounting for spillovers, the effects of norm-based messages are more effective at reducing consumption.
	Torres & Carlsson (2018)	Social information and appeals to norm-based behavior reduce water use by up to 6.8% in households in Colombia, with spillover effects.
	Carlsson et al. (2020)	Social information campaign aimed at reducing water use causes a spillover effect on the use of electricity.