Drivers and barriers for municipal retrofitting activities – Evidence from a large-scale survey of German local authorities

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Abstract: Local authorities are key actors for implementing innovative energy efficiency technologies (retrofitting) to reduce end-use energy demand and consequently reduce negative effects of high energy use such as climate change and public budget deficits. This paper reports the results of a large-scale survey of German municipalities assessing drivers and barriers for deploying LED street lighting as an example of innovative retrofits. The results indicate competencies and capacities, transparency of the underlying technology base, and a clear proposition of savings are crucial drivers for municipal retrofitting engagement. Most significant barriers include lack of experience, the tendency to wait for future improvements of innovative energy efficiency technologies, and existing contracts with energy suppliers, manufacturers, or other conventional retrofitting contractors. Investments in municipal competency building (both regarding technologies and procurement) as well as diffusing standard tendering criteria and (public) monitoring their effectiveness are highly recommended to accelerate the municipal modernisation process.

Keywords: energy efficiency, retrofitting, local authorities, LED, lighting

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1 Introduction

Reducing energy demand by implementing novel energy efficiency technologies represents one solution to combatting climate change while also reducing energy costs, fossil-fuel dependency and related issues such as energy insecurity and fuel poverty (IEA, 2014a, 2014b; Polzin, 2017; Sorrell, 2015; Sovacool, 2009). Municipalities play a central role implementing measures that reduce end-use energy demand (EUED) and deliver more efficient energy services as they are often the proprietors of aging infrastructure (IEA, 2016; Polzin et al., 2016a; Sorrell, 2015; Steinberger et al., 2009).

Many modernisation (retrofitting) activities are driven by the need to increase energy and cost effectiveness, to tackle climate change, to reduce budgetary deficits, to maintain adequate level of public services or to comply with increasing regulation (Sorrell *et al.*, 2004; Schischke *et al.*, 2008; Sorrell, 2015). Qualitative, case-study based research points towards technological factors (e.g. quality, durability and missing standards), economic factors (high upfront costs, transaction costs and uncertain future energy costs), competency factors (for procurement and management of retrofits) and institutional factors (such as public infrastructure maintenance backlog) hindering retrofitting activities (Nolden et al., 2016; Polzin et al., 2016a; Sorrell et al., 2004; Sorrell, 2015; Wilson et al., 2012).

Quantitative analysis of drivers and barriers for retrofitting, on the other hand, have been lacking (Polzin et al., 2016a; Schleich, 2009; Sorrell et al., 2004; Sorrell, 2015). Statistically backed recommendations for local authority administrations and national policy makers are required to enhance and accelerate retrofitting activities in municipalities (see for example Offermann et al., 2013). Based on a review of recent studies published, our research question reads as follows: *Which factors enable or prevent local authorities (municipalities) from modernising energy infrastructures?*

We analyse the case of LED (light-emitting diodes) street lighting in Germany. Street lighting in Germany, as in many other countries, represents a major cost factor, accounting for almost one third of municipal electricity budgets (De Almeida et al., 2014; DStGB, 2010). With municipal debt in Germany amounting to 152.71 EURbn in 2016 or 13,4 EURm per local authority (Eurostat, 2017a, 2017b), LED streetlights, with energy efficiency gains of up to 90% compared to conventional light bulbs, provide an innovative and cost-effective retrofitting option (Bennich et al., 2014; De Almeida et al., 2014; Gayral, 2017). Modernizing public street lighting appliances allows municipalities to reduce end-use energy demand and costs and to alleviate budget constraints (Difu, 2014).

The remainder of this paper is structured as follows: The next section (Section 2) contains a literature review. Section 3 develops the hypotheses based on theoretical insights. Section 4 introduces the methodology. Section 5 reviews the results of the quantitative survey analysis. Section 6 discusses our findings and concludes this paper by deriving policy implications.

2 Literature review

Financing, operating and maintaining public sector properties is a global challenge (dena, 2015; Hannon and Bolton, 2015; Radulovic et al., 2011). At the same time, local authorities and cities in particular find themselves increasingly at the heart of global energy and climate change action (IEA, 2016). Although maintenance backlogs and aging infrastructure may place increasing strains on limited resources, retrofitting and energy performance improvements provide windows of opportunities to procure innovative retrofits and services given the relatively large municipal responsibility to minimise costs while ensuring, investment and climate action (Comodi et al., 2012; Nolden et al., 2016; Poggi et al., 2017; Testa et al., 2016).

However, modernisation activities using innovative end-use energy demand technologies ('retrofitting') requires significant upfront investments and enhanced capacities such as evaluating between different types of LED, integrating LED into the existing infrastructure and setting up intelligent lighting systems. Our qualitative research (Polzin et al., 2016a) on municipal retrofitting governance suggests that designing the content of tenders to include cost transparency and open-book accounting is an important determinant for competition among organisational (governance) structures[1] which often determine retrofitting investment and capacities. Depending on the local situation, especially in the absence of appropriate skills and institutions, outsourcing using Energy Service Companies (ESCOs) may help accelerate the retrofitting process (Polzin et al., 2016a). Our quantitative research (Polzin et al., 2016b) suggests that the cost of outsourcing may be higher if in-

[1] In this context modes of governance refers to how transactions are organised through governance structures where in-house refers to complete control over the procurement and retrofitting process and long-term performance contracts refer to outsourcing (Polzin et al., 2016a; Williamson, 1985),

house competencies and capacities as well as existing partnerships are sufficient to engage in innovative retrofitting activities (Polzin et al., 2016b). Both papers indicate that market transparency and municipal capacities play an important role in accelerating retrofitting activities by allowing municipal representatives to make rational choices among modes of governance most suitable for their specific retrofitting priorities (Polzin et al., 2016a, 2016b).

The role of intermediaries is particularly relevant in this context as they raise awareness and lower transaction costs for non-hierarchical (as opposed to in-house/hierarchical) options (Nolden et al., 2016; Polzin et al., 2016a, 2016b). The number of drivers increasing municipal engagement with retrofitting in general is increasing rapidly which are the emergence of public procurement frameworks that reduce the transaction costs for both the public sector and contractors in the UK (Nolden et al., 2016; Nolden and Sorrell, 2016), innovative business models mimicking 20-year power purchase agreements such as MEETS (Measured Energy Efficiency Transaction Structures) in the US (Nolden and Sorrell, 2016) and the increasing drive towards making energy efficiency projects 'investor ready' internationally, such as the Investor Confidence Project[2] (Nolden et al., 2016; Nolden and Sorrell, 2016).

Despite innovations in the retrofitting/energy efficiency service market there are still many barriers to overcome, mostly linked to high transaction costs arising out of uncertain returns on investment and payback period linked to a lack of verified information on quality, energy savings and longevity of new retrofits (such as LED) (Jackson, 2010; Sorrell, 2015; Sorrell et al., 2004). Below, drivers and barriers for retrofitting in the municipal context are discussed.

3 Hypotheses

This section provides an overview of the hypotheses regarding drivers and barriers for retrofitting derived from the literature.

[2] see http://www.eeperformance.org/

3.1 Drivers for retrofitting (using EUEDs – LED)

First, enhanced competencies, such as those described above, stimulate the procurement of innovative (green) goods and services to improve energy performance (Nolden et al., 2016; Nolden and Sorrell, 2016). These competencies were previously not necessary as more efficient energy technologies in the lighting industry evolved slowly (De Almeida et al., 2014; Gayral, 2017; Sanderson and Simons, 2014; for an extended review see Fouquet and Pearson, 2006). In the case of local authorities, staff only needed to replace the lightbulbs without changing the adjacent infrastructure. Hence local authority competencies regarding tendering and implementation of retrofitting are crucial (Polzin et al., 2016a).

H1a: Higher municipal competencies (technical knowledge) increase engagement in retrofitting activities.

Second, potential savings result from the application of innovative EUEDs (in this case LEDs yield 90% efficiency gains and associated energy and cost reductions compared to conventional lighting depending on drivers and other components) (Bennich et al., 2014; De Almeida et al., 2014). Hence we hypothesize that this is one important incentive for engaging in retrofitting activities (Polzin et al., 2016a; Sorrell et al., 2004). This is supported by research on consumers (Mills and Schleich, 2014). In addition these savings need to be verified in order plan and implement retrofitting measures (Poggi et al., 2017).

H1b: The larger the potential saving (anticipated savings / financial return) the greater the interest in retrofitting.

H1c: Measurement and verification of these savings drive engagement in retrofitting activities

LEDs as innovative technologies are still more expensive than conventional lighting technologies which leads to a longer payback period for retrofitting (Gayral, 2017). Public support programs represent a driver for the implementation of novel EUEDs (de Almeida et al., 2012), energy efficiency investments (Sorrell et al., 2004) and low-carbon innovation in general (Polzin 2017).

H1d: Subsidies/support schemes constitute a driver for retrofitting activities.

To further support the planning and implementation process, previous research has highlighted the importance of consultants (facilitators) in filling the knowledge gap that municipalities face regarding retrofitting activities and specific innovative technologies (Lemon et al., 2015; Nolden et al., 2016). Our quantitative study on the topic found that consultants discourage outsourcing of retrofitting activities while maintaining their role as drivers for in-house municipal initiatives (Polzin et al., 2016b).

H1e: Engagement of a consultant increases the likelihood of retrofitting the public lighting infrastructure

Our final hypothesis builds on the fact that behaviour plays a significant role in saving energy. Previous research has found that decision makers do not necessarily act rationally when it comes to assessing costs and benefits (Jaffe and Stavins, 1994; Sorrell, 2015; Sorrell et al., 2004). Despite the expectation that investment opportunities in energy with a reasonable payback time will be realized, political will and support remain important drivers for retrofitting activities (Polzin et al., 2016a; Salvia et al., 2015).

H1f: Political will and support determine a municipality's engagement in retrofitting.

3.2 Barriers to retrofitting (using LED)

Major factors limiting municipal engagement with innovative EUED are linked to their technological nature, such as their diversity and widespread application, small scale and low visibility (Sorrell et al., 2004; Wilson et al., 2012). From the procurement literature (Nolden et al., 2015; Schleich, 2009; Sorrell et al., 2004; Testa et al., 2016), we derive that potential users require enhanced knowledge to evaluate, plan and implement innovative EUEDs (Testa et al., 2016). Also, the management of retrofitting processes requires enhanced capabilities i.e. for neutral and cost-transparent tenders as well as measurement and verification (M&V) once the technology has been installed (Hannon and Bolton, 2015; Poggi et al., 2017; Testa et al., 2016).

H2a: Missing personnel capacities limit engagement in retrofitting activities.

A central barrier to the adoption of new technologies in the innovation diffusion literature is the lack of opportunity to try the new product and gain experience ('trialability', see Rogers, 1995; Salvia et al., 2015; Sorrell et al., 2004; Sorrell, 2015). In this case municipalities with limited experience of innovative EUEDs fail to harness energy savings (Comodi et al., 2012; Polzin et al., 2016a) because the management of associated retrofitting processes requires enhanced capabilities and capacities.

H2b: Missing experience with novel technologies (EUEDs/LED) limits engagement in retrofitting activities.

In addition to missing experience, there is a tendency to 'wait' for future improvements of innovative technologies and associated greater savings. This failure to harness current savings has been coined the 'energy efficiency paradox' (Jaffe and Stavins, 1994; van Soest and Bulte, 2001). At the municipal level, this tendency to wait for more mature product versions and associated backlogs is particularly pronounced (Jensen et al., 2010) and hence represents a key barriers for innovative EUEDs diffusion, including lighting (De Almeida et al., 2014; Fouquet and Pearson, 2006; Mills and Schleich, 2014).

H2c: Municipalities that perceive new technologies as too innovative tend to refrain from retrofitting activities.

Retrofitting public energy infrastructure requires significant amounts of upfront investments into energy-related technologies that typically have a long payback period (Schleich, 2009; Sorrell et al., 2004). Investments in innovative EUEDs may therefore be perceived as unprofitable as the result of uncertainty regarding energy savings (Eichhammer et al., 2013; Polzin et al., 2016a; Sorrell et al., 2004).

H2d: Budget constraints and/or perceived high investments reduce engagement in retrofitting activities.

We have previously defined lock-in contracts with existing suppliers of conventional technologies as a combination of institutional and economic barriers (Polzin et al., 2016a). These contractors (for example with Energy utility companies – EUCOs[3] and multi-utility companies - MUCOs[4]) build on

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[3] EUCos typically engage in energy generation, supply and distribution and transmission (Hannon et al., 2013, p. 1036).

[4] In the German context MUCo refers specifically to local 'Stadtwerke', which often provide a wide range of utilities such as gas, electricity and municipal waste management for individual households and companies in a specific geographical region (Betsill and Bulkeley, 2006).

decades of experience of current lighting systems, providing maintenance and potentially selling energy at the same time (Hannon et al., 2013; Hannon and Bolton, 2015; Polzin et al., 2016a). Unsurprisingly, our previous research suggests that such lock-in contracts limit the choice of alternative modes of governance (Polzin et al., 2016b). The nature of these contracts may also limit the choice of innovative technologies.

H2e: Contractual lock-in limits retrofitting activities.

Finally, acceptance by the general public represents a salient institutional barrier to technology transitions, especially those that directly affect the public. Prior research has highlighted this as an issue for renewable energy technologies but also for lighting or EUEDs in general (Arabatzis and Myronidis, 2011; Wilson et al., 2012; Wüstenhagen et al., 2007).

H2f: Missing public acceptance leads to a lower engagement in retrofitting activities.

4 Methodology

4.1 Research context

To uncover the factors affecting municipal retrofitting activities and the importance of competition between different modes of governance for accelerating these activities, we analysed public lighting infrastructure retrofits with LED lamps in German municipalities (see also Polzin et al., 2016a, 2016b). As mentioned above, investing in retrofits can alleviate financial constraints in the long run and help municipalities meet climate change targets although debt burden often limits efforts to seek and engage in energy efficiency projects. As mentioned above, German municipal debt amounts to 13,4 EURm per municipality in 2016, the sixth highest ratio in the European Union (Eurostat, 2017a, 2017b).

At the same time, the lighting industry has undergone major shifts from traditional (fluorescent and halogen) lamps towards LED with significant savings in terms of energy and costs (De Almeida et al., 2014; IEA, 2013; Sanderson and Simons, 2014). Consequently, implementation of this technology is challenging for both producers and customers (Sanderson and Simons, 2014; Smink et al., 2015), despite forecasted LED market shares of 70% by 2020 (McKinsey, 2012) and the share of LED street lighting predicted to reach a 65% market share as early as 2018 (LEDinside, 2017).

In the German case, municipal independence and its federal structure have resulted in diverse mechanisms for the provision of street lighting. 30% of municipalities provide street lighting in-house, 28% outsourced the management to EUCOs, another 15% to MUCOs and 21% partially outsourced services such as maintenance. 2% of municipalities use ESCO solutions (Polzin et al., 2016b; von Flotow and Polzin, 2015).

This paper is the third and final publication of a research project focusing on municipal LED retrofits in Germany funded by the German Federal Ministry of Education and Research (BMBF) and the German Energy Agency (dena). The first publication developed a taxonomy of modes of municipal retrofitting governance based on qualitative research (Polzin et al., 2016a). The second established why local authorities engage with energy performance contracting for retrofitting based on a quantitative survey of German municipalities (Polizin et al., 2016b). What sets this publication apart from the other two is the specific focus on the more basic question of why municipalities do or do not engage in retrofitting in the first place whilst integrating prior evidence and creating a review character. It uses the same example of LEDs as the other two papers and the same qualitative survey as the second paper although the response rate (8.3%) and total number of responses (927) is smaller (11.6% and 1298 respectively). As opposed to the factors determining municipal engagement with energy performance contracts (EPCs) for retrofitting, this paper provides quantitative evidence of drivers and barriers for energy related public infrastructure modernisation (retrofitting) in general.

4.2 Survey design

To derive a quantitative research design and model for this study, we conducted an extensive literature review (see section 2), a qualitative study which involved interviewing 40 experts engaging in the process of retrofitting public street lighting (with LED), and a the previous version of the large-scale quantitative survey (Polzin et al., 2016a, 2016b; von Flotow and Polzin, 2015). The aim of the present study is to:

- Analyse the status quo of municipal street lighting in Germany;

- analyse modernization trends; and
- quantitatively identify challenges, success factors and barriers regarding the modernization of municipal street lighting.

4.3 Data collection, sample and data processing

We collected data on public property retrofitting (in this case: public street lighting) through a large-scale quantitative survey of municipalities. A potential caveat when using this methodological approach lies in the potential presence of common method bias, i.e. gathering all information via one empirical instrument, e.g. survey (Podsakoff et al., 2003). Following Testa et al. (2016) we adopted several measures to reduce this bias. We minimized item ambiguity in the questionnaire by avoiding vague concepts, complicated syntax and unfamiliar terms. Questions were deliberately kept simple, specific and concise. Experiences with a previous wave of the survey (see Polzin et al., 2016b) could be used to improve the current set-up[5]. Finally we also guaranteed the respondents' anonymity.

In the period between December 2015 and February 2016 all of the approximately 11.000 German municipalities were asked to fill out a standardized fully structured online survey (29 questions in 12 groups with an adaptive design). For a detailed list of questions please consult the appendix. Invitations were sent via postal mail and electronic mail to all German local authorities using a specialised service provider. Of the 11,168 municipal entities in Germany distributed across 16 federal states, 927 responded to our survey, which represents a response rate of 8.3 %. This sample mainly is

[5] The full survey and the codebook are available under https://doi.org/10.5281/zenodo.1039565. Changes compared to previous version (Polzin et al., 2016b): *Added questions* 6, 9, 11, 12, 13, 23, 24, 28; *edited questions* 15 (added option 'no financial support anymore'), 17 (added options ', Power Saving / economic savings', 'Payback / return /profitability', 'Funding or financial support', 'acceptance of local population', political will'), 18 (removed options 'the necessary financial resources for the modernisation of the adjacent infrastructure (masts, cables, etc.) are not available', 'there are too high risks vs. potential savings'), 20 (added options 'Minimising the investment and the necessary borrowing, implementation of a modernization without own investments', 'minimizing the financial risk (long-term calculable costs for energy-saving effect and light quality, transfer of default risk to the Contractor)', 'minimizing the current staffing and other resources of the local authority for the operation and planning of the municipal street lighting', 'use of knowledge from energy service company', there are no drivers/reasons'), 21 (added option ' a contracting solution is uneconomical'), 22 (added options 'engineering company',' lighting company', 'local craft', 'MUCO/EUCO'), 27 (removed option 'local level'), 29 (added options 'No own funds for co-financing', 'missing personnel capacity', 'duration of the procedure is too long, too little information and too little notice of the existing programs'), *removed questions* 8, 19, 20, 21, 27 (these numbers refers to the old list of questions in Polzin et al, 2016b/appendix);

representative in terms of sizes and states (see Table 1). Very small and small municipalities are under-represented.

Table 1: Response rates across the sample

Size	Inhabitants	Population	Responses	Response rate
Very small	< 5,000	8307	211	2.5
Small	5,000 < 50,000	2679	619	23.1
Medium	50,000 < 100,000	106	54	50.9
Large	> 100,000	76	43	56.6
Total:		**11,168**	**927**	**8.3 %**

We gathered key performance indicators and the level of agreement with statements was determined using a 5 point likert scale, ranging from 1, strongly disagree, to 5, strongly agree (see Table A.1)[6]. The investigation content firstly included ownership and management form and the lighting inventory. Secondly, participants were asked about issues regarding lighting modernization (technologies for modernization and success factors/obstacles) and contracting (type of contracting, success factors/ obstacles). Finally, information about competencies and capacities, tools for retrofitting, advice, consulting and support or conditions were requested.

4.4 Model

Based on the hypotheses we developed two models for the analysis of municipal retrofits, one for drivers and one for barriers. These models are described in the following sections (Figure 1).

[6] The full anonymized dataset is available under https://doi.org/10.5281/zenodo.1039565.

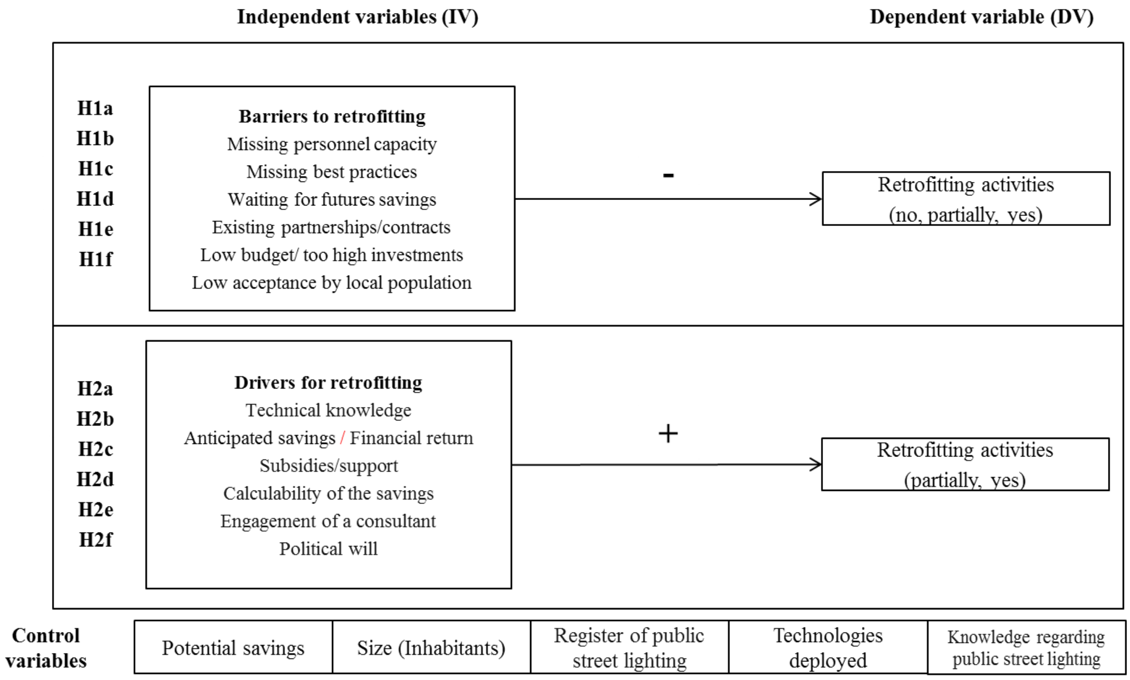

Figure 1: Models (I and II) for the survey analysis

4.4.1 Dependent variable

To analyse the determinants that encourage municipalities to engage in retrofitting activities we use two questions in the survey. Firstly, participants were asked about retrofitting and modernisation activities in the past. Secondly, current and future retrofitting activities were considered. The results of the two questions were aggregated in a three-point scale. (0 - no retrofitting activities; 1 – retrofitting activities in the past OR present/future; 2 - retrofitting activities in the past AND present/future). At the time of the survey, approximately 75 % of surveyed municipalities were engaging in modernization or were planning to retrofit municipal street lighting. Approximately 85 % had modernized their streetlights in 5 years prior to December 2015 – February 2016. For our subsequent analysis we proceed in two steps: First we evaluate Model I which includes municipalities that have not engaged in any retrofitting activities to find out what role which barriers play. Model II sheds light on the drivers for engagement in retrofitting activities.

4.4.2 Independent variables

The independent variables include drivers for retrofitting (such as necessary technical knowledge, potential savings, measurability of the savings, engagement of a consultant and the political will) and barriers to retrofitting (such as missing personnel capacity, and best practices etc.). The drivers and barriers variables have been evaluated on 5 point likert scales. All other variables have been assessed on categorical or binary scales (see Table A.1).

4.4.3 Control variables

Finally, we include demographic factors (*control variables)* that are assumed to influence municipal retrofitting engagement. The presence of an inventory of technologies deployed is assumed to trigger retrofitting activities as it facilitates the calculation of potential savings. General knowledge regarding public street lighting is equally conducive to engaging in any kind of change concerning lighting systems. Management and ownership structure of municipal lighting infrastructure also influence the likelihood to engage in retrofitting activities, e.g. if a municipality owns the lighting infrastructure or if a utility does the maintenance influences the municipality’s ability to retrofit the existing infrastructure. Finally, the size of the local authority (inhabitants) determines its capacity to engage in large-scale retrofitting projects. A full list of variables can be obtained from Table A.1.

4.5 Correlation and regression analysis

The econometric approach to the data is based up previous research (Polzin et al., 2016b).To obtain a first indication of the relationships we run a correlation analysis using dependent and independent variables (Cohen et al., 2009; Hair, 2010). Here we include ownership structure, management of street lighting and states as dummy variables.

In a second step, we determine the categories of *modernisation activities (2, 1 or 0)* using ordered logistic regression. It enables the calculation of the propensity of a certain case belonging to one category based on discriminant Z scores which are influenced by values of the independent variables (Agresti, 2010; Kutner et al., 2005)[7]. We report odds ratios i.e. the probability of belonging to a higher group of the dependent variable categories. An odds-ratio >1 suggests that with an increase of 1 unit of independent variable the probability of belonging to a higher group of the dependent variable is greater (i.e. 1 instead of 0). Vice versa an odds-ratio <1 suggests that with an increase of 1 unit of independent

[7] Ordered logistic regression has relaxed assumptions regarding normally distributed variables and equal variance-covariance matrices. The independent variable might also display characteristics of heteroskedasticity (i.e. common variance). It behaves similar to multivariate regression for metric dependent variables and can incorporate metric as well as non-metric variables and is capable of handling non-linear effects (Agresti, 2010; Hair, 2010).

variable the probability of belonging to a higher group of the dependent variable is lower. Overall effectiveness of the model is assessed using Chi² and (McFadden) pseudo R^2 results. The sample sizes of 896 (Model I) and 855 (Model II), which were obtained through the listwise deletion of missing answers from the initial sample, provide a robust basis for the analysis (Agresti, 2010; Hosmer and Lemeshow, 2000). Our econometric models can predict the outcome (i.e. to what degree the local authority engages in retrofitting activities) – see Chi² statistic significant at the 0.01 level. The fitted model further explains one eight of reasons why a municipality is retrofitting – see McFadden's pseudo R^2 of 0.12 and 0.14 (Long and Freese, 2006). Finally, we investigated the variance inflation factors (VIFs) which reveal no multicollinearity as the mean VIF of 1.49 (Model I) and 1.42 (Model II) are well below the critical value of 5 (see Kutner et al. (2005).

5 Results

5.1 Descriptive results

Respondents expect a high potential for energy savings regarding their street lighting infrastructure: 18 % of respondents expect potential savings of more than 50 %; 41 % expect 20 to 50 %. At the same time, rapid modernization is exposed to significant barriers. Local authorities emphasize the budgetary situation and lack of funds available for the comprehensive modernization of street lighting (42 %), the lack of human capacity (38 %) and perceived high investment or an excessively long payback period (36 %). All other factors are well below 20 %. These correspond to outcomes form the previous survey wave (von Flotow and Polzin, 2015). Smaller municipalities have a greater tendency to wait for increasing technological maturity (with a score of 15%) compared to larger municipalities (with an average score of about 7 %).

Around 76 % of local authorities modernize their street lighting predominantly or mostly with LED. At the same time, major disincentives for the use of LED are previous sodium-vapor-lamp (SVL) retrofits and the high price of LED (both 44 %). Approximately 10 % of the larger municipalities continue to rely mostly or mainly on high-pressure sodium-vapor lamps (SVL) for modernization. The proportion of local authorities with a majority share of LED lamps in use has increased from 16 % (von Flotow and Polzin, 2015) to 20 % between 2014 and 2016. 32 % of municipalities use SVL technologies predominantly or exclusively for street lighting, which is similar to 2014 (von Flotow and Polzin, 2015). This technology is used mainly in medium and larger municipalities. The proportion of old mercury vapor lamps (MVL) has dropped significantly: only 12 % of municipalities still use them primarily or predominantly. In 2014 this figure still stood at 18 % (von Flotow and Polzin, 2015). Today, 70 % of municipalities have minimised the use of MVL lights, up from 61 % in 2014 (von Flotow and Polzin, 2015).

Overall, 77 % of local authorities estimate their expertise as excellent (57 %) or very good (20 %). This contrasts with 23 % of local authorities who assess their expertise as bad. There has been only a slight increase compared to the survey in 2014 (von Flotow and Polzin, 2015). 56 % of surveyed municipalities state that they systematically manage their inventory using a lighting register. Nearly one third of municipalities have at least an incomplete coverage of their lighting inventory.

Although the vast majority of municipalities retains ownership of its street lighting (76 %), only half of the municipalities (58 %) manages the street lighting (partially or completely) in-house. In 70 % of the municipalities street lighting is managed wholly or partly by external contractors. But only 18 % of municipalities included an energy saving guarantee within such management contracts.

5.2 Correlation analysis

The correlation analysis investigates the relationship between retrofitting activities and ownership[8], management[9] and state of the individual municipalities to detect patterns that might influence the perceptions of drivers and barriers regarding retrofitting. Only 4 out of 16 federal states have significant correlation with retrofitting activities which rules out this variable as major influencing factor. Depending on the ownership structure of street lighting systems, municipalities engage differently in retrofitting activities. Owning the public street lighting is positively correlated with retrofitting activities (10% level) whereas private ownership negatively correlated with retrofitting

[8] Complete ownership of the municipality, complete ownership of EUCO/MUCO, partially privatized, completely privatized

[9] Own management, partly outsourced, management by municipal utility, management by regional utility company, management by regional utility company, energy service contracting

activities (1% level). This contradicts our previous research highlighting outsourcing/privatisation as a means to overcome barriers to retrofitting (Nolden et al., 2016; Polzin et al., 2016b).

On the other hand, doing maintenance and other management activities in-house does not have an influence on retrofitting whereas assigning this task to a local utility (MUCO) is significantly positive correlated with engagement in retrofitting (1% level). However, outsourcing management to a regional or national utility is negatively correlated with modernisation (1% and 5% level respectively).

Table A.2 and Table A.3 provide the correlation matrix for Model I and II. To avoid multi-collinearity issues we did not include the dummy variables for management, ownership structure and state in the main analysis.

5.3 Econometric outcomes

The outcomes of our baseline model (control variables) show the expected effects: If the municipality keeps track of its infrastructure using a street lighting register the odds are 1.2 higher. This effect is non-significant in Model II. General lighting competencies are also a predictor of higher municipal engagement in retrofitting. It can be deduced from our results that the deployment of older (conventional) lighting technologies such as MVL, SVL and MHL lead to higher retrofitting activities, with this effect being highest for metal halide lamps (1.15-1.46 higher odds of belonging to the higher retrofitting category, depending on the type of lamp currently installed model). Belonging to a higher retrofitting category is also strongly correlated with a higher use of LED during retrofitting. In addition our results show that larger municipalities tend to have a higher engagement in retrofitting activities than smaller municipalities. This result should be treated with caution as small and very small municipalities are underrepresented in this sample. Having a larger sample of these group would permit a better evaluation of the problems of small municipalities.

5.3.1 Barriers to retrofitting (Model I)

Interestingly, the first hypothesized barrier (**H2a**), low personnel capacities, does not appear to imply lower retrofitting activities (Table 2, line b1). Rather the contrary is the case. The higher the personal constraints the more likely it is that the municipality engages in retrofitting activities (with an odds ratio of 1.13 on a 10% significance level). Our results provide support for **H2b and H2c**, highlighting missing experience with innovative LED technology as well as the perception of future technological improvements as significant barriers to engaging in retrofitting activities (Table 2, lines b2-3), especially in the case of LED lighting which represents a major technology shift. For municipalities perceiving these barriers as high, scoring high on retrofitting versus the combined middle and low, the odds are 0.84 and 0.82 times lower respectively compared to municipalities perceiving these barriers as low, if the other variables are held constant.

Table 2: Results of the ordered logistic regression analysis (Model I)

	Dependent variable: retrofit	Odds ratio	Std. Err.
b1	Barriers to retrofitting: Personnel capacity	1.12*	(0.07)
b2	Barriers to retrofitting: Missing experience	0.86*	(0.07)
b3	Barriers to retrofitting: Waiting for future savings	0.85**	(0.07)
b4	Barriers to retrofitting: Budget constraints	1.11	(0.08)
b5	Barriers to retrofitting: Too high investments	1.02	(0.08)
b6	Barriers to retrofitting: Existing contracts	0.87**	(0.06)
b7	Barriers to retrofitting: Public acceptance	0.87*	(0.06)
8	Register streetlight present	1.30**	(0.15)
9	Inhabitants	1.68***	(0.24)
10	Competencies Lighting	1.83***	(0.24)
11	Existing lighting stock: High pressure mercury vapor lamps (MVL)	1.16*	(0.10)
12	Existing lighting stock: Sodium vapor lamps (SVL)	1.15	(0.10)
13	Existing lighting stock: Metal halide lamps (MHL)	1.30**	(0.16)
14	Existing lighting stock: (Compact) fluorescent lamps	1.01	(0.09)
15	Existing lighting stock: LED lamps	1.02	(0.11)
16	Potential savings	1.48***	(0.12)
	Observations (N)	896	
	Pseudo R^2	0.12	
	Model Chi^2 (d.f.)	164.57 (16) ***	
	Initial –2LL	1242.48	

Notes: ***,**,*, denote significance at 1%, 5% and 10% significance levels, respectively; ologit command was used (Stata 13.1)

H2d (Table 2, linesb 4-5) relating to budget constraints and high upfront investments into innovative technologies for retrofitting cannot be confirmed in our case. Our research highlights institutional barriers as relevant in the retrofitting process of local authorities (Table 2, lines b6-7). Both existing contracts with suppliers of conventional technologies or energy (**H2e**) and missing public acceptance (**H2f**) prevent municipalities from engaging in retrofitting activities. With an odds-ratio of 0.82 (everything else held constant), existing contracts are among the most severe barrier in our analysis. This also relates to our correlation analysis (see section 5.2) which reveals that selling public infrastructure to a private third-party contractor is negatively correlated with the modernization of lighting infrastructure. On the other hand, only sourcing the management externally can have positive or negative effects, depending on the contracting party (MUCO or EUCO).

5.3.1 Drivers for retrofitting municipal street lighting (Model II)

First, our results show that municipal competencies are indeed a driver for retrofitting activities (Table 3, line d1). 1 unit increase in competencies leads to 1.2 increase in likelihood of being in a higher retrofitting category, significant on a 1% level (**H1a**).

Both anticipated savings and expected financial return represents strong drivers for a local authority to engage in retrofitting activities (odds ratios of 1.7 and 1.3 on a 1% and 5% level respectively, see Table 3, lines d2 and 3) and thus we can confirm our hypothesis **H1b**. However, (and surprisingly) M&V of these savings appears to have a strong negative effect on retrofitting activities, which is contrary to what we hypothesised in **H1c**. Hence 1 unit increase in the possibility to calculate the savings lead to a 0.6 decrease of belonging to a higher retrofitting category, statistically significant on the 1% level.

Table 3 Results of the ordered logistic regression analysis (Model II)

	Dependent variable: retrofit	Odds ratio	Std. Err.
d1	Drivers for retrofitting: Technical knowledge	1.23**	(0.10)
d2	Drivers for retrofitting: Anticipated savings	1.67***	(0.30)
d3	Drivers for retrofitting: Anticipated financial return	1.31**	(0.18)
d4	Drivers for retrofitting: Financial support (subsidies)	1.00	(0.09)
d5	Drivers for retrofitting: Calculability (Measurement & Verification)	0.60***	(0.08)
d6	Drivers for retrofitting: Engagement of Consultant	0.85**	(0.06)
d7	Drivers for retrofitting: Political will	1.02	(0.10)
8	Register streetlight present	1.19	(0.14)
9	Inhabitants	1.44**	(0.22)
10	Competencies Lighting	1.71***	(0.23)
11	Existing lighting stock: High pressure mercury vapor lamps (MVL)	1.30***	(0.12)
12	Existing lighting stock: Sodium vapor lamps (SVL)	1.25**	(0.12)
13	Existing lighting stock: Metal halide lamps (MHL)	1.47***	(0.20)
14	Existing lighting stock: (Compact) fluorescent lamps	1.13	(0.11)
15	Existing lighting stock: LED lamps	0.97	(0.11)
16	Potential savings	1.44***	(0.13)
	Observations (N)	855	
	Pseudo R^2	0.14	
	Model Chi^2 (d.f.)	155.12 (16) ***	
	Initial –2LL	918.92	

Notes: ***,**,*, denote significance at 1%, 5% and 10% significance levels, respectively; ologit command was used (Stata 13.1)

Neither subsidies and support schemes nor the dedicated political will of the local administration **(H1d and H1f)** play a role in encouraging local authorities to deploy EUEDs (Table 3, lines d5 and 7). Engaging a consultant even has a negative impact on the extent to which a municipality modernises its aging infrastructure (Odds ratio of 0.85, Table 3, line d6) which contradicts our hypothesis **H1e**.

6 Discussion, conclusions and policy implications

This large-scale survey analysis covering a representative sample of German municipalities adds to the discussion around drivers and barriers for retrofitting using innovative EUEDs (Comodi et al., 2012; Poggi et al., 2017; Testa et al., 2016). Potential savings and competencies regarding the EUED (in this case LED) represent the strongest factors encouraging local authorities to engage in retrofitting (Hannon et al., 2013; Hannon and Bolton, 2015; Jensen et al., 2013). However, the 'mode of governance' relating to retrofitting is also correlated with infrastructure modernization. In-house management or a (self-owned) MUCO as partner appear to facilitate the modernization process whereas partnerships with a regional or national EUCO slow the process as these companies show less interest in retrofitting a local authorities' infrastructure. These general findings are line with (our) previous research (Hannon et al., 2013; Hannon and Bolton, 2015; Polzin et al., 2016a).

Based on explicit drivers/barriers analysis among local authority experts, we can confirm the crucial importance of experience with an innovative product (Comodi et al., 2012; Sorrell, 2015; Sorrell et al., 2004). We also find strong evidence of the 'energy efficiency paradox' i.e. the waiting for improved energy efficiency technologies to harness more savings in the future based on the assumption of linear improvements or possibly even greater leaps in technology efficiency instead of investing now to harness current saving possibilities (Jaffe and Stavins, 1994; van Soest and Bulte, 2001) in the case of municipal decision making (Jensen et al., 2010). On the other hand, personnel constraints do not appear to hinder the retrofitting process. This contradicts (our) previous research (Hannon and Bolton, 2015; Polzin et al., 2016a; Testa et al., 2016). A possible explanation lies in the fact that small municipalities engage in smaller retrofitting projects that can be realised despite personnel constraints whereas larger municipalities require more personnel for modernisation projects. Interestingly, high upfront investments and budget constraints, highlighted as the 'classic' energy efficiency barriers, do not significantly hinder retrofitting using LED. These findings suggest that some of the economic, behavioural and organisational barriers to energy efficiency (for an overview see Sorrell et al., 2004) might not be strongly pronounced in the case of LEDs (see also Eichhammer et al., 2013; Polzin et al., 2016a). Possible explanations point towards the sample composition of local authorities that have/will modernise/d. LED prices also recently dropped significantly, which makes them more cost-competitive compared to conventional energy-saving technologies which significantly reduces the risk of investment and consequently increases access to capital (De Almeida et al., 2014; Gayral, 2017; Sorrell et al., 2004; ZVEI, 2015).

Our findings in relation to institutional barriers to modernising aging infrastructure, such as existing contracts and acceptance by the local population (H2e/H2f), confirms earlier work (Hannon et al., 2013; Hannon and Bolton, 2015; Polzin et al., 2016a). Similar to renewable energy installations (i.e. the 'not in my backyard effects' for wind turbines) (Arabatzis and Myronidis, 2011; Wilson et al., 2012; Wüstenhagen et al., 2007), acceptance of LED lighting by the local population is critical for successful municipal implementation of the retrofitting process.

Once a local authority has passed the hurdle of engaging in infrastructure modernisation our research identifies several interesting factors that drive the extent of their engagement in retrofitting. A high level of technical knowledge appears to be driving the use of innovative technologies to harness savings. Hence our findings are in line with (our) prior qualitative evidence regarding retrofitting experience (Polzin et al., 2016a) and competencies as relevant for procurement decisions more generally (Testa et al., 2016; Uyarra et al., 2014). Our research further confirms the general notion (see above) that an understanding of savings and resulting monetary benefits are central for local authority decision making in favour of infrastructure modernisation (Polzin et al., 2016a; Sorrell et al., 2004). Surprisingly, the M&V aspect of energy efficiency investment appears to hinder as opposed to facilitate modernisation (Poggi et al., 2017). Interestingly, neither subsidies nor the willingness of the local administration to drive the modernisation process accelerate the retrofitting process. The latter in particular stands in stark contrast to (our) prior research findings, which overwhelmingly suggest that management and the shaping of values play a crucial role in guiding change (de Almeida et al., 2012; Polzin et al., 2016a; Salvia et al., 2015; Sorrell et al., 2004). Engaging a consultant in the modernisation even negatively impacts the extent to which a local authority engages in public street lighting retrofitting. Research in other contexts highlighted intermediaries, facilitators and consultants as conducive (Lemon et al., 2015; Nolden et al., 2016).

In summary, the results suggest that the technological modernization process (and the harnessing of associated savings) in municipalities may be accelerated through the development of local skills and capacities. Transparency at all levels of the process ensures that appropriate modes of governance can be chosen, which appears to be of particular relevance regarding lock-in contracts with established suppliers such as EUCOs. Measurement and verification (M&V) activities do not appear to be key drivers in this context although transparency of cost savings and the process in general are key drivers for municipalities to engage in retrofitting activities. On the other hand, personnel constraints are not among the significant barriers, rather the contrary is the case. Confirmed barriers include missing experiences with the novel technologies and the waiting for improvements of these retrofits (‘energy efficiency paradox’) that reflects the underlying risk aversion. Abovementioned existing contracts with EUCOs or MUCOs tend to severely hinder local authorities to modernise their infrastructure. Finally, acceptance of the local population needs to be guaranteed in order to roll out the retrofitting measures, even in the case of relatively unobtrusive LED technology.

6.1 Implications for policy makers

Based on the discussion of the results, better documentation and communication of the modernization process and statistical analysis of conducted modernization and the energy savings achieved are recommended. This documentation and evaluation of prior experience needs to go beyond the communication of best practice. Instead there is a need for skills and expertise to reduce perceived investment risks and related uncertainties, especially given that our findings suggest that the risk of investment in LEDs is low and access to capital does not pose a barrier to technology diffusion. Instead of subsidizing the procurement of EUEDs, the rapid generation of knowledge and experience could help accelerate the process of modernization but documentation and facilitation are necessary to harness the benefits without constant reinvention of the wheel.

With the abovementioned measures, a strengthening of (technical or business/market) competency among municipalities and utilities to assess the quality of innovative technologies and possible savings, as well as risks, can be achieved. This is particularly critical regarding the planning phase of modernization projects (database, cost transparency, etc.), tender design, and implementation of modernization projects.

It is also recommended to further develop alternative business models and service offerings (governance arrangements) to overcome institutional lock-ins (see Polzin et al., 2016a). In relation to product and performance criteria, clarifying the possibilities of extending the (energy saving) guarantees might be a fruitful way forward. In addition, a timely clarification of the possibilities to further standardize products and contracts appears desirable (Nolden et al., 2016).

6.2 Limitations and future research

As the third publication from the same research project this publication could be potentially limited in terms of the novelty of the research results the cross-sectional nature of the data, the focus on only one market, and possible application for once particular end-use energy demand reduction technologies (i.e. LED). Also the groups of very small and small municipalities are under-represented in our sample potentially due to limit capacities to respond to the survey. Overall, our emphasis on overall drivers and barriers regarding municipal retrofitting should represent a sufficiently distinct focus compared to our other two publications' focus on modes of governance in general and performance contracting in particular (Polzin et al., 2016a, 2016b).

In general, more research is required on how experience and competencies can be harnessed and enhanced to ensure that retrofitting takes on the character of a market in its own right. For example based on this dataset[10], the effect of municipal retrofitting tools such as technical checklists or comparative calculations schemes as well as different forms of consulting or specific barriers to LED usage on retrofitting activities could be analysed. Also longitudinal analyses to see how drivers and barriers for innovative EUEDs in the public sector change over time or in different institutional

[10] see https://doi.org/10.5281/zenodo.1039565

contexts lend themselves to this end. But more importantly, the development of relevant skills and business models accompanying this change need to be monitored to enable more precise intervention.

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9 Appendix

9.1 Descriptive statistics

Table A.1: Descriptive statistics (Model I and II)

	Variable	Obs	Mean	Std. Dev.	Min	Max	Measurement
	Retrofit	927	1.60	0.58	0	2	No retrofitting (0), Past retrofitting OR present/ future retrofitting (1), Past AND present/ future retrofitting
d1	Drivers for retrofitting: Technical knowledge	884	3.82	1.07	1	5	Likert scale 1-5 (Agreement)
d2	Drivers for retrofitting: Anticipated savings	884	4.70	0.54	1	5	ibid
d3	Drivers for retrofitting: Anticipated financial return	884	4.42	0.79	1	5	ibid
d4	Drivers for retrofitting: Financial support (subsidies)	884	4.08	1.04	1	5	ibid
d5	Drivers for retrofitting: Calculability (Measurement & Verification)	884	4.20	0.80	1	5	ibid
d6	Drivers for retrofitting: Engagement of Consultant	884	2.97	1.28	1	5	ibid
d7	Drivers for retrofitting: Political will	884	4.17	0.96	1	5	ibid
b1	Barriers to retrofitting: Personnel capacity	927	2.82	1.37	1	5	ibid
b2	Barriers to retrofitting: Missing experience	927	1.98	1.07	1	5	ibid
b3	Barriers to retrofitting: Waiting for future savings	927	2.00	1.09	1	5	ibid
b4	Barriers to retrofitting: Budget constraints	927	2.90	1.38	1	5	ibid
b5	Barriers to retrofitting: Too high investments	927	2.79	1.30	1	5	ibid
b6	Barriers to retrofitting: Existing contracts	927	1.60	1.06	1	5	ibid
b7	Barriers to retrofitting: Public acceptance	927	2.09	1.18	1	5	ibid
8	Register streetlight present	927	1.41	0.73	0	2	Yes (2), partially (1), No (0)
9	Inhabitants	927	1.92	0.68	1	4	< 5.000 (1), 5.000 < 50.000 (2), 50.000 < 100.000 (3), > 100.000) (4)
10	Competencies Lighting	927	1.96	0.66	1	3	Poor (1), moderate (2), good (3)
11	Existing lighting stock: High pressure mercury vapor lamps (MVL)	927	2.08	1.07	1	5	None (0%) (1), Rarely (0-20%) (2), Medium (20-50%) (3), By the majority (50-80%) (4), Predominantly (> 80%) (5)
12	Existing lighting stock: Sodium vapor lamps (SVL)	927	2.93	1.19	1	5	ibid
13	Existing lighting stock: Metal halide lamps (MHL)	927	1.52	0.66	1	5	ibid
14	Existing lighting stock: (Compact) fluorescent lamps	927	2.05	1.01	1	5	ibid
15	Existing lighting stock: LED lamps	927	2.67	1.06	1	5	ibid
16	Potential savings	896	3.60	1.00	1	5	No savings potential (1), 0 to 10 percent savings (2), 10 to 20 percent savings (3), 20 to 50 percent savings (4), More than 50 percent savings (5)

Note: Dummy variables used for correlation analysis: Ownership (Complete ownership of the municipality, Complete ownership of EUCO/MUCO, Partially privatized, Completely privatized); Management (Partly outsourced, Management by municipal utility, Management by regional utility company, Management by regional utility company, Energy service contracting); State (16 German regional states)

9.2 Correlations

Table A.2: Correlation matrix (Model I)

	retrofit	b1	b2	b3	b4	b5	b6	b7	8	9	10	11	12	13	14	15	16
retrofit	1.00																
b1	0.01	1.00															
b2	-0.15***	0.29***	1.00														
b3	-0.15***	0.24***	0.44***	1.00													
b4	-0.01***	0.26***	0.21***	0.36***	1.00												
b5	-0.07**	0.25***	0.30***	0.47***	0.64***	1.00											
b6	-0.13***	0.13***	0.23***	0.28***	0.12***	0.18***	1.00										
b7	-0.11***	0.27***	0.29***	0.31***	0.27***	0.32***	0.23***	1.00									
8	0.14***	-0.11***	-0.12***	-0.12***	-0.17***	-0.11***	-0.05*	-0.03	1.00								
9	0.22***	0.08**	-0.02	-0.06*	0.01	-0.02	-0.00	0.07**	0.23***	1.00							
10	0.23***	-0.23***	-0.22***	-0.19***	-0.13***	-0.18***	-0.16***	-0.15***	0.22***	0.27***	1.00						
11	0.04	0.13***	0.09**	0.04	0.15***	0.07*	0.04	0.07*	-0.17***	-0.09**	-0.11***	1.00					
12	0.08**	0.02	0.12***	0.20***	0.22***	0.19***	0.05	0.15***	-0.02	0.18***	-0.03	-0.09***	1.00				
13	0.12***	0.08**	-0.02	-0.00	0.02	-0.02	-0.01	0.04	0.10***	0.29***	0.06*	0.02	0.01	1.00			
14	-0.02	0.10***	0.05	0.10***	0.06*	0.14***	0.13***	0.10***	0.11***	0.20***	-0.06*	-0.08**	-0.22***	0.23***	1.00		
15	-0.01	-0.16***	-0.23***	-0.32***	-0.35***	-0.35***	-0.20***	-0.23***	0.13***	-0.10***	0.13***	-0.33***	-0.48***	-0.14***	-0.22***	1.00	
16	0.20***	0.10***	-0.03	-0.03	0.08**	-0.03	-0.04	0.02	-0.04	-0.01	-0.03	0.29***	0.15***	0.02	-0.04	-0.24***	1.00

Notes: Category numbers stem from Table 2; *** p<0.01, ** p<0.05, * p<0.1 (Significance levels)

Table A.3: Correlation matrix (Model II)

	retrofit	d1	d2	d3	d4	d5	d6	d7	8	9	10	11	12	13	14	15	16
retrofit	1.00																
d1	0.13***	1.00															
d2	0.09***	0.14***	1.00														
d3	0.03	0.11***	0.47***	1.00													
d4	-0.04	0.14***	0.26***	0.27***	1.00												
d5	-0.07*	0.16***	0.33***	0.56***	0.33***	1.00											
d6	-0.11**	0.18***	0.09**	0.15***	0.29***	0.22***	1.00										
d7	0.02	0.20***	0.22***	0.16***	0.17***	0.23***	0.25***	1.00									
8	0.14***	0.05	0.04	0.05	-0.04	0.08**	-0.10***	0.03	1.00								
9	0.22***	0.22***	-0.07**	-0.06*	-0.13***	-0.02	-0.14***	0.03	0.23***	1.00							
10	0.23***	0.10***	0.01	0.01	-0.06	0.05	-0.22***	-0.04	0.22***	0.27***	1.00						
11	0.04	-0.00	-0.02	-0.04	0.06	-0.01	0.06*	-0.01	-0.17***	-0.09**	-0.11***	1.00					
12	0.08**	0.07**	-0.03	-0.02	-0.02	-0.03	-0.05	-0.01	-0.02	0.18***	-0.03	-0.09***	1.00				
13	0.12***	0.10***	-0.10***	-0.08**	-0.05	-0.06	-0.03	0.00	0.10***	0.29***	0.06*	0.02	0.01	1.00			
14	-0.02	0.05	-0.08**	-0.01	-0.09**	-0.04	-0.00	0.01	0.11***	0.20***	-0.06*	-0.08**	-0.22***	0.23***	1.00		
15	-0.01	-0.03	0.02	0.02	0.05	0.03	0.02	0.02	0.13***	-0.10***	0.13	-0.33***	-0.48***	-0.14***	-0.22***	1.00	
16	0.20***	0.05	0.11***	0.03	0.08**	0.06*	0.03	0.11***	-0.04	-0.01	-0.03	0.29***	0.15***	0.02	-0.04	-0.24***	1.00

Notes: Category numbers stem from Table 3; *** p<0.01, ** p<0.05, * p<0.1 (Significance levels)