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Original Paper

Does Coproduction Enhance Quality of Public Infrastructure?

Miriam Katunze[1] & Jan P. Voon[2]

[1] Victoria University, Kampala, Uganda

[2] Department of Economics, Lingnan University, Hong Kong

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Abstract

Coproduction is viewed in this paper as joint effort or cooperation between citizens and public infrastructure service providers. There is a paucity of studies on the impact of coproduction on public infrastructure quality or performance. Poor public infrastructure development poses a financial burden to many developing countries. In this paper, we use road maintenance as the example of public infrastructure. Using the Afro-barometer wave-6 dataset on Uganda, we develop the appropriate coproduction indexes as well as the road maintenance performance indexes from the survey data. Our results show that coproduction has significantly positive impacts on public road maintenance performance (RMP), which raises social welfare and economic development. Our results are robust to various model specifications and the conclusions remain valid after controlling for any potential endogenous influence or reverse causality problem that might arise. Our analysis points to the practical importance of cooperation between community and government in transport infrastructure provision such as road maintenance. It also provides practical implications for policy makers on how coproduction between community and government could be arranged.

Keywords

Coproduction, public infrastructure, road maintenance performance, community, government, cooperation

1. Introduction

Public infrastructure constitutes one of the most important inputs for economic growth. It is also effective in enhancing social welfare. An efficient transport network for instance will greatly facilitate production and increase consumption utility. Yet, inefficiency in provision and development of a public infrastructure service (such as maintenance of a transportation network) is common and endemic in most developing countries. Alternative approaches to reducing public infrastructure inefficiency are therefore of paramount importance in the face of increasing public debts and government deficits in many developing

countries (see Bovaird & Loeffler, 2012; Clark, Brudney, & Jang, 2013; De Witte & Geys, 2013). Among the various available approaches, community involvement has been identified in this paper as an important alternative for mitigating the financial, administrative, and political risks in public infrastructure and service provisions. Previous research focuses on the potential importance of cooperation between community and private sector (Bennmarker, Grönqvist, & Öckert, 2013; Blom-Hansen, 2003; Bøgh Andersen & Blegvad, 2006; Petersen & Houlberg, 2016; Soukopová, Vaceková, & Klimovský, 2017). There is a lack of research on how cooperation between community and government may enhance performance of public infrastructure (see also Adams & Boateng, 2018). We bridge this gap by exploring specifically how community involvement and individual's cooperation with government (hereafter coproduction) may enhance quality and performance of transport infrastructure such as road provision and maintenance.

Coproduction between community and government for crucial services such as health (Tummers, Teo, Brunetto, & Palumbo, 2016) and water (Adams & Boateng, 2018) has been widely explored in the literature. However, there is a paucity of studies on the impacts of coproduction between community and government on road provision and maintenance. Muvawala, Sebukeera, and Ssebulime (2020) pointed out qualitatively the crucial importance of road provision and maintenance in raising economic growth of a developing country. Studies on coproduction in the past were largely skewed toward conceptualizations and theoretical expositions (Fawcett and South, 2005; Pestoff, 2006; Wiewiora, Keast, and Brown, 2016; Kay & Edgley, 2019).

Inadequate provision, poor conditions and poor maintenance of unpaved rural roads have impeded the economic developments of many developing countries (Peterson, 1986; Iimi & Gericke 2017). This paper examines quantitatively using actual survey data if coproduction between community and government helps to improve road maintenance quality (or performance) in the case of Uganda. Uganda has been plagued by poor conditions and maintenances of its rural roads. This research explores if coproduction helps to raise the performance of road maintenance in the case of Uganda. Furthermore, we explore how the different ways of community participation and collaboration with the government (such as the use of multimedia technologies) affect the provision of road maintenance performance. Our results provide government policy makers with practical ways to enhance road maintenance performance (RMP) which ultimately increases the economic growth and social welfare of the country.

The rest of the paper is organized as follows. Section 2 examines the theoretical background, defines the concept of coproduction and reviews prior work that have investigated the impact of coproduction on public service performance. Section 3 explores coproduction in road maintenance in the case of Uganda. Section 4 presents the data and the methodology used in our quantitative analysis. Section 5 reports the results and the use of an instrumental variable to alleviate any potential endogeneity. A robustness check is conducted in Section 6. The conclusions and practical implications are outlined in Section 7.

2. Literature Review and Hypotheses

Coproduction may be seen as cooperation between a combination of two or more agents in the society. These agents include producer, consumer and government. Wiewiora et al. (2016) provides a theoretical framework for research on coproduction of public sector services. Various concepts on coproduction, including co-initiating and co-designing, have also been presented (Garlatti et al., 2019; Verschuere, Brandsen, & Pestoff, 2012). Our paper focuses on coproduction between the consumer and the government. The performance of the coproduction in the case of road maintenance is measured using the preferences of the consumers (or road users).

Coproduction is a concept which has been embedded in the new public governance theory (NPG) embodying public administration and public management theories. It emphasizes interdependent cooperative relationships between agents with the purpose to enhance performances and outcomes (Osborne, 2006). NPG is built and functioned on the premises of mutual trust or social contracts. NPG leverages citizen involvement in community services such as service designs and provisions (Wiewiora et al., 2016, Brandsen, Verschuere, et al., 2018). Coproduction entails a joint production and maintenance of public infrastructure between government or private sector provider on the one hand and citizen or community consumers on the other. There is a general acceptance that government should no longer treat service users passively but active participants in joint provision of public infrastructure or services. The skills, capabilities, and resources of community would make the users/citizens as government's valuable partners (Loeffler & Bovaird, 2016; Ryan, 2012).

Since the seminal work by Ostrom (1996), several conceptual studies on coproduction have emerged (see Nabatchi, Sancino et al., 2017; Brandsen & Honingh, 2016). Nabatchi et al. (2017) defines co-production as "numerous activities that may occur in different phases of the public service cycle through which state and lay actors complement each other to produce benefits" (p. 769). Another departure from Ostrom's (1996) definition is the intricacy and significance of coproduction from politics, history, and autonomy (Goodwin, 2019). Many different concepts have emerged which embodies a multifaceted nature of coproduction (Alford, 2014). In the context of this paper, coproduction is community's participation in road infrastructure maintenance through committee meetings, feedback, complaints, voluntary assistances, supply sourcing, and other forms of physical engagement.

Previous studies seem to have skewed towards qualitative exposition of the importance of coproduction in public service provision (Alford & Yates, 2016; Sorrentino, Sicilia, & Howlett, 2018; Garlatti, Fedele, Iacuzzi, & Costa, 2019). This paper bridges the gap in the literature by examining the quantitative roles of coproduction in public infrastructure maintenance. While acknowledging the significance of the qualitative expositions, quantitative study is of practical importance in this field of research because it provides useful information and strategies to policy makers based on various coproduction alternatives and performance measures using factual survey data and revealed preferences (Garlatti, Fedele, Iacuzzi, & Costa, 2019). Earlier data and evidence were extracted mainly from isolated interviews with limited information from service users (Alford & Yates, 2016; Sorrentino, Sicilia, & Howlett, 2018). Quantitative

analysis provides insightful clues on how coproduction can be organized and geared towards enhancing public service quality, and performance.

The original call for citizens to participate in public service was posited by Ostrom (1996). Subsequently, Bovaird and Loeffler (2012) pointed out that public service quality could be enhanced by community involvement. Community engagement through various telecommunication technologies for instance reduces costs in determining the services needed (Clark, Brudney, & Jang, 2013; Palumbo et al., 2018). Coproduction activities in school meal provision lead to quality services, reflected through enhanced user satisfaction and reduced logistical expenditures (Palumbo et al., 2018). However, there were mixed reactions on whether higher performance efficiency was a definite outcome of coproduction (see Voorberg, Jilke, Tummers, & Bekkers, 2018). Voorberg et al. (2018) demonstrates that co-creation comes at a cost (see also Bovaird et al. 2012). Coproduction produces service quality but requires substantial resources to initiate and sustain it (Bovaird & Loeffler, 2012). The disagreement also stems from reports of negative accounts of coproduction, one of which relates to the '*self-serving bias'*, postulating that clients or consumers tend to take credit for the positive outcomes of coproduction but blame the service providers for the adverse outcomes, thereby infringing on mutual trust in this case (Bendapudi & Leone, 2003; Fledderus, 2015). Some studies were inconclusive as to whether citizen participatory decision-making leads to effectiveness in public service (Hong & Cho, 2018).

The ultimate objective of joint production with various forms of inputs from community end-users is to enhance the quality or performance in final delivery of the infrastructure service. Better quality roads from viewpoints of end-users for instance is one of the measures of the final performance. The other tacit performance indicators include the ways in which quality roads meet citizen's expectations and preferences for lower travelling time, health hazard reduction, easier access to amenities, enhancement of rural production capacity, and so on. These form the revealed preferences of the road users. The revealed quality performance indicators are reflected more appropriately by the service users within the community. Therefore, large scale community survey data are appropriate measures of the public service such as road maintenance performances.

2.2 Coproduction and Road Maintenance: The Case of Uganda

Nabatchi et al. (2017) delineated two major actors in coproduction: government and citizen. Other actors in Uganda, however, include district road committee members and sub-county local council representatives. Although these actors jointly produce road maintenance services, possibly as a cost-saving strategy (Nabatchi, Sancino, et al. 2017), or to enhance user's living standard, early community involvement appeared to be initiated by the road committee through the Western Uganda Road Maintenance Capacity Building (WURMC) project between 1995 and 2001. With the notion that road users are important stakeholders in maintaining a road network, the roads committee's approach has been fully adopted as a community engagement strategy (Leyland, Tumwebaze, & Lubega-Kagere, 2001). The local council Chairperson remains focal in organizing community road cleaning events, coordinating with the community, and advertising contracts for labor-based community access road contracts for every

30km road stretch. The local council Chairperson, district/municipal engineer, and the contractors work with citizens to commission road maintenance in budgeting, advertising road cleaning events, and identifying problem areas. Citizens also participate in co-designing in view of their experiences with accident-prone spots, drainage problems, and usage of the road network.

Citizens also engage in occasional road cleaning events under headman supervision. Such road cleaning events happen for feeders and community access roads. Besides the occasional road maintenance drives organized by the local leaders, community households are providers of borrow pits, water, and other materials (also noted from a stakeholder interview) and providers of important information regarding the best gravel sources. The community prevents the misuse of resources such as fuel and other materials by contract employees and residents by reporting such offenses to the concerned bodies (contractors, district engineer, and local council chairpersons). When assessing road maintenance services, citizens actively engage in evaluations.

Although road maintenance services are done mainly collectively, it may yield social and personal benefits such as safety of travellers and animals, vehicle protection and reduced travel time. According to stakeholder consultations, cattle ranch owners are more likely to coproduce by cutting grass and drainage desilting of roads next to their homes, according to key informant interviews with headmen of Mbarara district held 10th July to 20th August 2019. Previous research also suggests that collective coproduction is more beneficial to individual coproduction as it provides the highest benefits in terms of efficiency and or performance (Brudney & England, 1983; Bovaird et al., 2015; Needham, 2008).

The above reviews lead us to the following hypothesis:

H1: Coproduction between community and government increases the quality or performance of road maintenance in Uganda

3. Variables, Models and Data

3.1 Dependent Variable

As outlined in the previous section, road maintenance performance (hereafter RMP) is aptly based on the community or end-users' revealed preferences for what they construe as quality or satisfactory maintenance services. Our dependent variable RMP is therefore a categorical variable which is constructed by using the following questionnaire:

What about local government? I do not mean the national government. I mean, your District Council. How well or badly would you say your local government is handling the following matters [maintaining local roads], or haven't you heard enough about them to say? Responses include: (1) very badly, (2) fairly badly, (3) fairly well, (4) very well, (9) do not know/haven't heard enough (DNR).

Responses/categories 1-4 are considered, while those in 9 are discarded because if merely 37 respondents had selected DNR, then the variation of this category is likely to be low.

3.2 Explanatory Variables

Our consideration of the main independent variables stems from Marschall's, (2006) reference on coproduction and its consideration on a range of behavior including discussions, involvement in non-political organizations and participation in activities that are more supportive in nature. Our key explanatory variable is a summation scale of seven questions measuring the extent and intensity of coproduction. The first question measures the extent of involvement in a community or voluntary group and is stated in the following way. *Could you tell me whether you are an official leader, an active member, an inactive member, or not a member of some voluntary association or community group?* Involvement in a religious group that meets outside of regular worship services is not investigated for no other studies have evidence that religious grouping is linked to coproduction. Noteworthy is a proliferation of memberships in the western Uganda than any other region, such as farmer groups, credit associations, and social voluntary groups (Adong, 2014; Heikkilä, Kalmi, & Ruuskanen, 2016; Kuteesa & Mawejje, 2016). Prior studies have explored group membership from the environmental or climate change dimension (Alonso, Andrews, Clifton, & Diaz-Fuentes, 2019).

We also consider two questions in the study that measure the interviewee's collective action (Coffe & Bolzendahl, 2011), elucidated as follows. *Here is a list of actions that people sometimes take as citizens. For each of these, please tell me whether you, personally, have done any of these things during the past year. If not, would you do this if you had the chance? A. Attend a community meeting; B. Got together with others to raise an issue*. The responses for each of these questions include (1) several times; (2) once or twice; (3) if I had the chance; (4) would never do this; (5) do not know.

The extent or frequency of community contacting the leaders relates to two questions in the survey. *Thinking of the last time you contacted these leaders. Did you go A. Alone or with a group; B. To discuss a community problem or personal problem?* Responses to A and B also include not applicable and do not know which are turned to missing. Parrado et al. (2013) find that it is more successful in dealing with specific problems than "general participatory activities" (p. 107). Alonso et al. (2019) have alluded to contacting leaders as a coproduction measure in their papers that investigate factors influencing citizens' co-production of environmental services. According to Pestoff (2006), participating in groups, taking on leadership roles, or making decisions that affect service provision are in themselves a form of coproduction.

Lastly, on citizens' coproduction activities, are 2 questions measuring the extent of citizens' democratic tendency. *For each of the following actions: A) Complain to government officials when public services are of low quality and B) agree with the majority of people in his or her community on political issues, please tell me whether you think it is something a good- citizen in a democracy should always do, never do, or do only if they choose to?*. This question asks several scenarios but for this paper, the scenario on political issues appeared more appropriate for measuring coproduction. All the seven items were turned to binary, and the coproduction scale is considered a continuous variable in the analysis. A coproduction

index, created through factor analysis, has been developed (as in Zambrano-Gutiérrez, Rutherford, & Nicholson-Crotty, 2017).

3.3 Control Variables

Specific individual characteristics determine the variation in citizens' opinion towards RMP. For instance, older persons may rate district councils more favorable. Urban dwellers may underscore service performance because of their higher public service exposure. Social economic characteristics have been found to influence tendencies to coproduce public services.

We start with citizens' altruistic values on citizens' willingness to coproduce and their self-efficacy. By self-efficacy, we mean one's self-evaluation to carry out actions for expected results (Alonso et al., 2019; Parrado et al., 2013). It is important to note that our dataset does not assess citizens' willingness to coproduce and therefore we are unable to replicate what prior studies have alluded to as self-efficacy. Given the dataset's substantial inclination towards politics, we follow Parrado et al.'s (2019) political self-efficacy measure, explained in our analysis as the feeling that individual citizens' political actions can play an essential role in social change. As proxies for political self-efficacy (hereafter abbreviated as SPE), we develop a scale of four questions in the survey. *Think about how elections work in this country. How well [very well, well, not very well, not at all well] do elections: A. Ensure that members of parliament reflect the views of the voters and B. Enable voters to remove from office leaders who do not do what the people want?* In relation are two questions that measure citizens' ability to listen to their leaders. *How much of the time [Never, only times, often, always] do you think the following A. [Members of Parliament., B. District Councilors] try their best to listen to what people like you have to say?* While this question asked for leaders' listening intensity, we believe that communication is a two-way traffic that requires citizens' role in reciprocating the leaders' ability to listen. For instance, leaders will listen if citizens complain about inadequate services or the need for them to volunteer in coproduction. Therefore, as mentioned above, the indices are proxies for coproducers' political self-efficacy, as in Parrado et al. (2013).

We include several control variables representing citizens' demographic, social and economic characteristics. We account for gender, which has been observed from a pilot study of qualitative interviews with Ugandan road maintenance stakeholders. Women are more likely to engage in community road maintenance drives, according to the key informant interviews with district and municipal engineers, sub county chiefs (Soroti, Kisoro, Mbarara, Kotido, Moroto districts) and Uganda National Road Authority- Head of Maintenance were held 10th July to 20th August 2019. Moreover, similar work on Uganda reiterates that LC3 chairpersons encourage women to not only take part in road maintenance contractual work but also coproduction activities (Leyland, Tumwebaze, & Lubega-Kagere, 2001). This factor has been mentioned in prior research, which found that women are better volunteers in public service coproduction activities (Bovaird, Van Ryzin, Loeffler, & Parrado, 2015; Christensen & Lægreid, 2005; Einolf, 2011; Parrado, Van Ryzin, Bovaird, & Löffler, 2013). We also include citizens' education level which is demarcated into four categories, namely, no schooling, primary, secondary, and

tertiary (Egerton, 2002). A positive correlation with coproduction in a library context (De Witte & Geys, 2013) and a weak and inconsistent association (Parrado et al., 2013) have been established. Moreover, tertiary education was found to be less likely correlated with coproduction (ibid).

Residential status [urban/rural], employment status (Parrado et al., 2013), mobile and internet (Clark, Brudney, & Jang, 2013; Lember, Brandsen, & Tõnurist, 2019) and ethnicity [transformed into an index using the Simpson method] was added to the analysis. Ethnic diversity has been reported to have a negative correlation with service efficiency (Alesina, Baqir, & Easterly, 1999). Moreover, it is interesting to assess the role of ethnic diversity in mediating co-production in-service performance (Grossman & Lewis, 2014; Miguel & Gugerty, 2005). After data cleaning, we remained with a working sample of 2,400 observations.

3.4 Econometric Specifications

To examine the impact of coproduction on RMP, we use an ordered logit estimation (as in Long, 1997; Powers & Xie, 2008), which is specified as follows.

$$RSP_i^* = x_i\beta + \varepsilon_i \quad (1)$$

Our response variable RMP_i^* is an ordered variable. We use a general probability model expressed in terms of cumulative probabilities. The *i*th individual for each response level is be written as:

$$C_{i,j} = \Pr(RMP_i \le j) = \sum_{k=1}^{j} \Pr(RMP_i = k), j = 1(\text{very badly}), 2(\text{fairly badly}), 3(\text{fairly well}), 4(\text{very well}) \quad (2)$$

where k is the cut points, which in this case are $\alpha_2, \alpha_3, \alpha_4$ taking one category as the reference, i.e., $j-1$. When the cumulative probability is a function of coproduction and other independent variables (context variables), x_i, we obtain the following

$$C_{i,j} = F(\alpha_j + x_i'\beta), \ j = 1, \dots, j-1) \quad (3)$$

Equation 3 depicts the probability of observing RMP to the probability that the estimated linear function is within the cut points range. In each category of RMP, we estimate coproduction and other covariate coefficients $\beta_1, \beta_2, \dots, \beta_k$ along with the cut points $k_1, k_2, \dots, k_{k-1}$, where k is the number of possible outcomes. We presume that u_j is logistically distributed in ordered logit.

The cumulative probability of the ordered logit model can be written as:

$$C_{i,j} = \Pr(RSP_i \le j|x_i) = \frac{\exp(\alpha_j + x_i'\beta)}{1+\exp(\alpha_j + x_i'\beta)} \quad (4)$$

3.5 Data and Summary Statistics

To examine the effect of coproduction on road maintenance performance (RMP), we use the Afro-barometer Survey data for Uganda. The round 6 surveys of 2015 interviewed a randomly selected sample of 2400 individuals, aged 18 and above, and enhanced by gender through an alternating interview system between men and women. The survey provides evidences on the quality of democracy and governance in Uganda. The sampling framework follows the Uganda's census 2014 so that respondents are selected from strata of sub-region and urban-rural locations. To ensure that densely populated areas have a greater probability of being selected a probability proportional to population size (PPPS), random sampling

technique was applied especially in the first stage. Four stages were applied in the urban areas while five stages were applied in the rural areas, as a cost reduction strategy in the later stratum.

In each location, eight households are clustered per the primary sampling unit (also known as the Enumeration Area-EA). While the Afro-barometer's stratification strategy enhances the precision of estimates, clustering may reduce the precision. According to the round 6 survey manual, it is less costly to interview eight households in one EA than one interview per EA. Therefore, it is essential to note the presence of similarity in responses as people who live closer together tend to share similar views due to the effect of shared networks, class, and ethnicity (Afro-barometer Network, 2017).

Table 1 presents the descriptive summary statistics of our dataset. Out of 2363 data points that rated the district council's performance on road maintenance, 26.11 % said *very badly*, 28.44 % selected *fairly badly*, 39.91 picked *fairly well,* and 5.54 % ticked *very well*. Therefore a slightly higher number of respondents that think that the district council performs fairly well at road maintenance. Respondents with the following characteristics rate the council fairly well: tertiary educated, females, in urban areas and 37 year olds.

Table 1. Descriptive Summary Statistics

Variable	Obs.	Mean	S.D	Min	Max
RMP	2,363	2.25	0.91	1	4
Age	2,387	36.77	14.68	18	96
Education	2,397	1.31	0.84	0	3
Coproduction	2,400	3.56	1.87	0	7
SPE	2,400	1.30	1.12	0	4
Urban	2,400	1.67	0.47	1	2
Sex	2,400	1.50	0.50	1	2
Employment status	2,320	0.92	1.58	0	4
Ethnic diversity	2,257	0.75	0.22	0.22	1
ICT	2,400	4.90	4.09	0	20

Notes. RMP denotes road maintenance performance, SPE is political self-efficacy and ICT stands for information communication technology. Source: Afro-barometer Uganda Round-6 dataset

4. Empirical Results

4.1 Baseline Model

Table 2 corresponds to our baseline results computed from model 1. Results from the ordinal logit regression show that coproduction is highly significant at the 1 percent level and has positive impact on road maintenance performance (RMP). The result suggests that citizen's participation in all coproduction

activities (i.e. coproduction=7) is likely to lead to better or preferred road performance that fulfils the user's criteria for satisfactory performance.

Accounting for regional effects has led to a negligible reduction of 0.02 in the coproduction coefficient, as observed in model 2. Models 1 and 2 show that some covariates are significant. For example, SPE, private sector, student/unemployed, and ethnic diversity are positively associated with RMP. Rural inhabitants are less likely to report higher RMP.

Subsample robustness checks at the regional level are conducted with the results reported under model 3. After accounting for the regional effects, we have 1988 observations left. This removed Karamoja (northeast Uganda) with 72 observations and Kigezi (southwest Uganda) with 96 observations, rendering central 1 region the reference category. The results tabulated under Model 3 of Table 2 confirm our baseline effects, pointing to a negligible reduction in magnitude of the coproduction coefficient by a meagre 0.01 point. Our findings remain significant at the 5 percent level. The cut-off points differentiate one level from another; for example, the coefficient in cut-off point1 differentiates the fairly badly category from the fairly well, very well, and very badly performance categories. All the models are clustered at the EA. Cluster robust estimate account for variation across the EA (see Green, 2012:327-328) and the population.

Table 2. Impact of Coproduction on Road Maintenance Performance (RMP): Ordinal Logit and Robustness Model

	1	2	3
Coproduction	0.08***	0.06**	0.05**
	(0.03)	(0.03)	(0.03)
Age	0.01	0.01*	0.01*
	(0.00)	(0.00)	(0.00)
Primary	-0.17	-0.13	-0.04
	(0.13)	(0.14)	(0.14)
Secondary	-0.16	-0.07	0.00
	(0.15)	(0.16)	(0.17)
Tertiary	-0.25	-0.10	-0.07
	(0.22)	(0.22)	(0.21)
SPE	0.20***	0.21***	0.18***
	(0.05)	(0.05)	(0.05)
Urban	-0.23**	-0.06	-0.04
	(0.11)	(0.11)	(0.14)
Sex	0.10	0.11	0.12
	(0.08)	(0.08)	(0.09)

Private sector	0.45***	0.49***	0.44***
	(0.16)	(0.16)	(0.16)
NGO/CSO	-0.37	-0.29	-0.24
	(0.40)	(0.42)	(0.44)
Government	0.43	0.39	0.55*
	(0.32)	(0.31)	(0.31)
Student/unemployed	0.21*	0.17	0.02
	(0.13)	(0.12)	(0.14)
Ethnicity	0.89***	0.53*	0.36
	(0.27)	(0.28)	(0.39)
cut1	0.05	0.46	0.36
	(0.39)	(0.40)	(0.56)
cut2	1.32***	1.75***	1.71***
	(0.39)	(0.40)	(0.56)
cut3	4.10***	4.55***	4.62***
	(0.41)	(0.43)	(0.57)
N	2134	2134	1988

Note. This table contains the ordinal logit results on correlation between coproduction and road maintenance performance (RMP). Column 1 is our baseline result without regional effect. The regional effect is continuous under column 2 and categorical under column 3. Primary, Secondary and Tertiary correspond to different education level with no formal schooling as the reference category. Private Sector, NGO/CSO, Government and Student/unemployment are categories for employment status using self-employment as the reference. SPE is political self-efficacy. Standard errors in parentheses; *** denotes $p<0.01$, ** denotes $p<0.05$, and * denotes $p<0.1$. All models are clustered at the EA level and weighted at the population.

4.2 Structural Equation Modelling

Table 3 presents the results computed from the structural equation model (SEM). In this model, we test to see how the baseline model's results may deviate if the coproduction is constructed as a latent rather than scale variable. Latent means unobserved or does not exist in the dataset. A latent variable is constructed from observed variables within the dataset using confirmatory factor analysis (CFA) (Qureshi & Kang, 2015). The SEM model comprises two parts. The first is the measurement model which allows the analysis of unobservable latent variables. The second is the structural model which enables us to examine the direction and strength of the relationship between the endogenous/independent and the exogenous/dependent variables (Sekyi, Asiedu, & Oppong, 2020).

Our SEM analysis shows that the impact of coproduction on RMP remains positive and highly significant at the 1 percent level. The coproduction latent variable's coefficient in the structural model has increased

marginally by 0.37 point. The goodness of fit shows that our model has a good fit, further confirming the robustness of our baseline results. Note that the Standardized Root Mean Squared Residual (SRMR) is 0.066 out of 0.08, while the Coefficient of Determination (CD) (similar to R2) is 0.727, close to 1 (recommended for a good fit).

4.3 Generalized Linear Latent Mixed Model

Given that RMP corresponds to the local government, there is a likelihood that variations at the EA, district and regions could affect the coproduction impact on RMP. To capitalize on the multi-level feature of our data sets, we also construct a generalized linear latent and mixed model (GLLAMM). GLLAMM combines structural equation models (Jöreskog, 1970) and multilevel models (Goldstien, 2003) because of their similarities in handling latent variables (Rabe-Hesketh, Skrondal, & Pickles, 2004). GLLAMM framework comprises three parts, i.e., the response model, the structural model for latent variables, and the latent variables (ibid). Column 2 of Table 3 shows that the reported results are again similar to those computed using the ordinal logit method, implying that our results are robust to this model specification. Note that the variation in RMP is explained by the following magnitude: 54% EA, 33% district and 47% region. While it was possible to have a latent equation (i.e. made up of coproduction items) with in the GLLAMM estimation, we did not incorporate it due to severe convergence problems. Nonetheless, when we used the main coproduction scale, our results do not change from our baseline model.

Table 2. Impact of Coproduction on RMP: Structural Equation Model (SEM) and Generalized Linearized Latent Mixed Model (GLLAMM)

	1	2
Coproduction (latent)	0.43**	
	(0.15)	
Coproduction (scale)		0.07**
		(0.02)
Age	0.00	0.00
	(0.00)	(0.00)
Education	-0.04	0.06
	(0.04)	(0.06)
SPE	0.11***	0.22***
	(0.03)	(0.04)
Urban	-0.10*	-0.08
	(0.06)	(0.11)
Sex	0.00	0.10
	(0.05)	(0.08)
Employment status	0.02	0.01

	(0.02)	(0.03)
Ethnicity	0.52***	0.59
	(0.14)	(0.39)
Constant	1.88***	
	(0.20)	
Cut 1		0.07
		(0.44)
Cut 2		1.51***
		(0.44)
Cut 3		4.46***
		(0.46)
EA		0.54***
		(0.08)
District		0.33**
		(0.11)
Region		0.47***
		(0.12)
N	1392	2134

Notes. SPE is political self-efficacy. Column 1 corresponds to SEM estimation and column 2 to GLLAMM, both clustered at the EA and weighted at the population. Standard errors in parentheses; *** denotes p<0.01, ** denotes p<0.05, and * denotes p<0.1.

4.4 Instrumental Variable Model: Control for Endogeneity

Another concern is the possibility of endogeneity or reverse causality in our estimation. It may be argued that poor road maintenance or services may lead to compel citizens or users to engage in the coproduction process. To mitigate this, we identify and adopt the frequency of obtaining news through newspapers, internet, TV, radio and social media (all items are classified as ICT) as our instrumental variable (IV). A rationale for our choice is that ICT affects the independent variable "coproduction" but not the dependent variable "RMP". This is to say that ICT is correlated with citizens' coproduction behavior but does not affect or correlate with the dependent variable (road service performance). This logical mechanism supports the exclusion restriction assumption, necessary to run an instrumental variable regression. We resort to using an iv-probit model which is deemed appropriate for this type of analysis. RMP was turned into an indicator variable to accommodate IV probit model specification.

The empirical results presented in Table 4a and Table 4b point again to a significantly positive impact of coproduction on RMP, suggesting that our findings are unlikely to be driven by reverse causality or endogenous factors. It is of interest that the coproduction coefficient is reported to be bigger by about 0.35 point relative to our baseline coefficients. In the survey the question to this variable is as follows:

How often do you get news from the following sources? The responses include every day; a few times a week; a few times a month; less than once in a month; do not know. The responses were collapsed to yes or no and all 'do not know's were turned to missing. The scale is a continuous variable from 0-20 and although suitable with IVprobit, it was unstable in meeting the endogenous test. This is because we reject the null of no endogeneity in the first regression i.e. model 1 without clustered standard errors and without weights in Table A4. However, in model 2 we fail to reject the null hypothesis of no endogeneity when we cluster SEs and add weights

Table 3a. Effect of Coproduction on RMP: Instrumental Variable Approach

	1	2
Coproduction	0.44***	0.39**
	(0.10)	(0.20)
Age	-0.01*	-0.01
	(0.00)	(0.01)
Private	-0.12	-0.16*
	(0.08)	(0.09)
Secondary	-0.22**	-0.26**
	(0.11)	(0.13)
Tertiary	-0.22*	-0.20
	(0.12)	(0.13)
Urban	0.06	0.01
	(0.07)	(0.13)
Sex	0.25***	0.24***
	(0.06)	(0.08)
Private	0.27**	0.31***
	(0.11)	(0.11)
NGO/CSO	-0.40	-0.22
	(0.29)	(0.31)
Government	0.16	0.17
	(0.20)	(0.28)
Student/unemployed	0.34***	0.31***
	(0.08)	(0.12)
Ethnicity	0.24	0.27
	(0.20)	(0.32)
Constant	-2.04***	-1.78***
	(0.26)	(0.53)

Table 4b. Effect of Coproduction on RMP: Instrumental Variable Approach

First stage results		
ICT	0.03***	0.03**
	(0.01)	(0.01)
Age	0.02***	0.03***
	(0.00)	(0.00)
Private	0.17	0.14
	(0.12)	(0.15)
Secondary	0.51***	0.49***
	(0.14)	(0.16)
Tertiary	0.32*	0.24
	(0.19)	(0.21)
Urban	-0.26***	-0.33***
	(0.08)	(0.10)
Sex	-0.41***	-0.44***
	(0.08)	(0.08)
Private	-0.21	-0.36**
	(0.15)	(0.18)
NGO/CSO	0.30	0.35
	(0.44)	(0.34)
Government	0.24	0.36
	(0.26)	(0.23)
Student/unemployed	-0.61***	-0.60***
	(0.10)	(0.11)
Ethnicity	0.43**	0.59***
	(0.19)	(0.22)
Constant	3.19***	3.13***
	(0.31)	(0.39)
Observations	2134	2134
Wald test (p-value)	0.03	0.20

Notes. ICT is the instrumental variable. Primary, Secondary and Tertiary correspond to different education level and No formal schooling as the reference category. Private Sector, NGO/CSO, Government and Student/unemployment are categories for employment status, taking Self-employment as the reference. Results under column 2 are clustered at the EA and population weights have been applied. Standard errors in parentheses; *** denotes p<0.01, ** denotes p<0.05, and * denotes p<0.1.

4.5 District Level Analysis

Because our dataset is based on individual opinions, which may differ from those expressed by the larger community, we extend our analysis to the district level, given the availability of the data (see Table 5). The use of the district level data using the Logit model confirms the results of our prior estimations. This suggests that the districts whose citizens engage in coproduction are likely to perform better at road maintenance, suggesting that opinions expressed at the individual level dovetail with those at the district level, hence alleviating the concern that the individual preferences could be different from those collected at the district level whose weighting is sometimes deemed to be higher or more reliable, given the collective power of the masses in decision making.

In Table 6, we estimate a random effects panel model. In model I, we selected three indicator variables (*Belong to voluntary/community group*; *attend community meeting and got with others to raise an issue*) to construct a coproduction scale. Only these three items were found in the 2011 survey. For consistence, SPE was left out because we could not trace it in year 2011. We find an insignificant result in model 1. In model 2, active group membership is positively corelated with RMP. Positive effects, significant at 5 percent, were observed in model 3 when the coproduction variable is constructed from categorical variables. In model 4, after accounting for the time effects, we observe negligible change in results as compared with model 3.

Table 5. Impact of Coproduction on RMP: District Level Analysis

	1	2
Coproduction	0.60*	0.74*
	(0.36)	(0.41)
Age		0.02
		(0.06)
Education		-0.49
		(0.39)
SPE		0.61
		(0.37)
Employment status		0.31
		(0.23)
Ethnicity		-2.12*
		(1.18)
Constant	-3.55	-5.41
	(2.40)	(3.77)
Observations	94	93

Notes. SPE is political self-efficacy. Standard errors in parentheses, robust in column 2; *** denotes p<0.01, ** denotes p<0.05, and * denotes p<0.1.

Table 6. Coproduction Impact RM: Panel Data Analysis at District Level (2011-2015)

	1	2	3	4
Coproduction (created from binary items)	-0.03			
	(0.10)			
Coproduction (created from scale items)			0.45*	0.62**
			(0.18)	(0.22)
Coproduction (Belong to voluntary/community group only)		0.55*		
		(0.30)		
Age	0.02	-0.01	0.00	0.03
	(0.05)	(0.05)	(0.05)	(0.06)
Education	-0.01	0.05	-0.06	-0.29
	(0.35)	(0.34)	(0.36)	(0.40)
Ethnicity	-1.79*	-1.99*	-2.03*	-2.08*
	(0.95)	(0.95)	(0.98)	(1.03)
Year				-1.03*
				(0.51)
Constant	1.36	0.46	-2.39	-3.92
	(2.32)	(2.31)	(2.78)	(3.10)
Log of variance	-0.61	-1.01	-0.51	-0.16
	(1.69)	(2.26)	(1.60)	(1.32)
Observations	154	154	154	154

Notes: Our baseline results consist of 7 binary variables that measure coproduction. However, we could only find three items in 2011-2015 (see columns 1, 3 and 4). Since belonging to community/voluntary group was most significant when we ran separate equations, we then included it in this Table for comparison with results in Table 7. Coproduction coefficients under columns 3 and 4 are based on scale/ categorical scale and those under column 1 are binary. Coproduction under Column 2 considers only the item "Belong to Voluntary/community group). Standard errors in parentheses; *** denotes p<0.01, ** denotes p<0.05, and * denotes p<0.1.

5. Further Robustness Check

5.1 Validity of the Coproduction Index Measure

Another robustness check relates to the validity of the coproduction index. In other words, is it necessary for us to use an index instead of estimating each item separately? This test determines whether our

baseline result is driven by the dominance of one single item. That is, is there a singular item of our coproduction variables that drives our results? After disembodying the coproduction activities, significant and positive impact of coproduction on RMP is reported under "*belonging to a voluntary or community group," "contact leaders,"* and "*joined others to raise an issue."*

The results in Table 7a and Table 7b reveal that the impact of coproduction on RMP is not driven by a single variable construct. Creating a coproduction scale appears to be the right approach to take. Separate regressions for each coproduction activity are also estimated to control for potential multicollinearity (see A1 for the correlation matrix).

Table 7a. Regression Results on Each of the Coproduction Items

	1	2	3	4	5	6	7
1. Belonging to community group	0.34***						
	(0.09)						
2. Contact leaders alone or with group		0.20*					
		(0.12)					
3. Contact leaders to discuss community or personal problem			0.25**				
			(0.11)				
4. Got with others to raise an issue				0.25***			
				(0.09)			
5. Agree with majority on political issues					-0.18*		
					(0.11)		
6. Complain about poor quality services						-0.09	
						(0.10)	
7. Attend community meeting							0.12
							(0.11)
Age	0.01*	0.01	0.01	0.01*	0.01**	0.01**	0.01*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Private	-0.20	-0.17	-0.18	-0.16	-0.13	-0.11	-0.17
	(0.14)	(0.18)	(0.18)	(0.13)	(0.14)	(0.13)	(0.13)
Secondary	-0.17	-0.11	-0.14	-0.14	-0.13	-0.06	-0.12
	(0.15)	(0.21)	(0.21)	(0.15)	(0.16)	(0.15)	(0.15)
Tertiary	-0.25	-0.36	-0.40	-0.28	-0.20	-0.15	-0.22
	(0.22)	(0.28)	(0.28)	(0.23)	(0.22)	(0.23)	(0.22)
SPE	0.21***	0.25***	0.25***	0.20***	0.21***	0.21***	0.21***
	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)

Urban	-0.26**	-0.16	-0.17	-0.25**	-0.31***	-0.26**	-0.26**
	(0.11)	(0.14)	(0.14)	(0.11)	(0.11)	(0.11)	(0.11)

Table 8b. Regression Results on Each of the Coproduction Items

	1	2	3	4	5	6	7
Sex	0.08	0.03	0.04	0.10	0.03	0.08	0.08
	(0.08)	(0.10)	(0.11)	(0.08)	(0.09)	(0.08)	(0.08)
Private	0.44***	0.74***	0.74***	0.50***	0.41**	0.41**	0.42**
	(0.16)	(0.25)	(0.25)	(0.17)	(0.17)	(0.17)	(0.17)
NGO/CSO	-0.39	-0.50	-0.52	-0.28	-0.43	-0.34	-0.37
	(0.41)	(0.40)	(0.42)	(0.40)	(0.40)	(0.39)	(0.38)
Government	0.39	0.66*	0.65*	0.45	0.70**	0.48	0.44
	(0.32)	(0.34)	(0.35)	(0.31)	(0.33)	(0.32)	(0.31)
Student/unemployed	0.21*	0.10	0.10	0.18	0.15	0.16	0.18
	(0.13)	(0.17)	(0.16)	(0.13)	(0.13)	(0.13)	(0.13)
Ethnicity	0.88***	1.09***	1.05***	0.89***	0.97***	0.91***	0.90***
	(0.27)	(0.30)	(0.30)	(0.27)	(0.27)	(0.28)	(0.27)
Cut 1	-0.16	0.07	0.04	-0.11	-0.40	-0.19	-0.14
	(0.37)	(0.48)	(0.48)	(0.38)	(0.39)	(0.40)	(0.38)
Cut 2	1.13***	1.39***	1.36***	1.16***	0.90**	1.08***	1.13***
	(0.37)	(0.49)	(0.49)	(0.38)	(0.39)	(0.40)	(0.38)
Cut 3	3.90***	4.30***	4.27***	3.93***	3.71***	3.85***	3.90***
	(0.39)	(0.51)	(0.51)	(0.40)	(0.42)	(0.42)	(0.40)
Observations	2121	1464	1459	2123	2030	2096	2131

Notes: Our baseline coproduction variable is a scale composing of all the 7 items. In this table, we examine if the baseline results are driven by each of these 7 items. Primary, Secondary and Tertiary correspond to different education level taking no formal schooling as the reference category. Private Sector, NGO/CSO, Government and Student/unemployment are categories for employment status, taking self-employment as the reference. SPE is political self-efficacy. All models are clustered at EA and population weights are applied. Standard errors in parentheses; *** denotes $p<0.01$, ** denotes $p<0.05$, and * denotes $p<0.1$.

5.2 Do We Need a Moderator?

Due to the bureaucratic nature of public services in most developing countries, citizens may not be able to readily contact the service providers or the service providers may not be willing to take the initiatives to touch-base with the citizens. There is a possibility that the communication between the citizen and the

service provider could be mediated by the politicians. In this case, coproduction has an indirect rather than a direct impact on RMP. To examine if this is true, we use one of the SPE constructs "listening capability of the politicians" as our moderating variable. We used the SEM approach to determine the extent to which politician's listening capability can conjure a positive impact of coproduction on RMP. Table 8 reports generally positive results using SEM to examine the possible moderating effect by the politician, Four out of the seven coproduction items estimated separately were found to be positive. These include *belonging to a voluntary or community* group," "*contact leaders alone or in a group*," "*contact leaders to discuss community or personal problem"* and "*joined others to raise an issue*." Our results show that a more influential political moderator may be necessary to bring the two parties, namely, the citizen and the service provider, together so the joint production could be facilitated. This is likely to be the case if citizens belong to a community group.

Table 8. Indirect Impact of Coproduction on RMP

	1	2	3	4	5	6	7	8
Coproduction (baseline)	0.04***							
	(0.01)							
1.Belong to community group		0.16***						
		(0.04)						
2.Contact leaders alone or with group			0.10*					
			(0.05)					
3.Contact leader to discuss problem				0.11**				
				(0.05)				
4.Got with others to raise an issue					0.16***			
					(0.05)			
5.Agree with majority on political issues						-0.06		
						(0.05)		
6.Complain about poor quality services							-0.06	
							(0.05)	
7.Attend community meeting								0.06
								(0.06)
Age	0.00	0.00	0.00	0.00	0.00	0.00**	0.00**	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Education	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	-0.00	-0.01
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Urban	-0.10*	-0.11**	-0.05	-0.06	-0.11**	-	-0.11**	-
	(0.06)	(0.05)	(0.07)	(0.07)	(0.05)	0.14**	(0.06)	0.12**

						(0.06)		(0.05)
Sex	0.06	0.04	0.02	0.02	0.05	0.03	0.05	0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Employment status	0.04**	0.04**	0.04*	0.04*	0.03**	0.03**	0.03**	0.03**
	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
Ethnicity	0.44***	0.44***	0.48***	0.46***	0.44***	0.48***	0.44***	0.45***
	(0.14)	(0.13)	(0.15)	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)
Constant	1.77***	1.87***	1.81***	1.83***	1.86***	1.96***	1.92***	1.88***
	(0.18)	(0.17)	(0.21)	(0.21)	(0.18)	(0.18)	(0.19)	(0.18)
Observations	2030	2019	1399	1394	2020	1937	1997	2028

Notes. In this table, we ran SEM on individual coproduction scale/index items separately to find out if we need a moderator (political mediation). Column 1 is our baseline result. The results are clustered at the EA and population weights applied. Standard errors in parentheses; *** denotes p<0.01, ** denotes p<0.05, * denotes p<0.1.

6. Conclusions and Practical Implications

Escalating fiscal deficits have prompted governments to identify alternative financing options for enhancing the quality of public infrastructure service. Coproduction is identified to be one of the options for enhancing public service performance such as road maintenance. This paper analyses the impact of coproduction on road maintenance performance. The results from the ordinal logit model point to a positive impact of coproduction on road maintenance performance. Our results are robust to alternative model specifications.

An attempt has also been made in our analysis to alleviate the potential endogeneity concern using the instrumental approach. We find that coproduction or community participation, both at the individual and the district levels, was indeed driving the road maintenance performance in Uganda. Our research calls for more active and more creative community participation in road maintenance, which would potentially give rise to higher road maintenance performance and higher economic efficiency. Community participation is observed to be voluntary and altruistic in many developing countries. Therefore, more community participation in road maintenance raises the voluntary employment and hence the aggregate output of the economy.

Our paper points to a few ways in which individual citizen or community may participate. In our analysis of the various coproduction activities/indexes, we observe that belonging to a voluntary community group has yielded the highest coefficient, implying that community membership is among the most important when it comes to enhancing the service performance. A rationale for this is that community membership provides a platform not just for fellowship but also for members to interact together which then stirs up discussions and mutual interests to improve the service quality.

The development of information and multimedia technology, as shown in this paper (through identification of ICT as the instrumental variable), has facilitated and complemented community participation. Hence, government and community awareness program in the use of ICT should be developed.

Our paper shows that influential leaders may be necessary to bring the citizen closer in communication to the service providers, especially in the case where the citizens belong to certain community memberships. In addition, our results also have practical implications for applications to other types of public services in Uganda as well as for applications to other developing countries with relatively poor transport infrastructure.

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Appendix

Table A1. Descriptive statistics and covariance matrix of indicator coproduction variables

	Mean	S.D.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7
(1) Alone or with group	0.52	0.50	0	1	1						
(2) Discuss community or personal problem	0.57	0.50	0	1	0.70	1					
(3) Complain about poor quality services	0.71	0.45	0	1	0.08	0.07	1				
(4) Agree with majority on political issues	0.60	0.49	0	1	0.00	0.00	0.20	1			
(5) Belong to voluntary/community group	0.49	0.50	0	1	0.10	0.15	0.00	0.06	1		
(6) Attend community meeting	0.77	0.42	0	1	0.07	0.14	0.02	0.07	0.26	1	
(7) Got with others to raise an issue	0.58	0.49	0	1	0.17	0.24	0.03	0.04	0.31	0.53	

Notes. S.D. stands for Standard DeviatioObservations = 1537