

Sridevi Prasad  
Jane Hammaker  
Katherine Quant  
Douglas Glandon

# Use of performance-based contracts for road maintenance projects

A rapid evidence assessment

December 2022

Working  
Paper 54

Transportation



International  
Initiative for  
Impact Evaluation

# Use of performance-based contracts for road maintenance projects: a rapid evidence assessment

Sridevi Prasad  
International Initiative for Impact Evaluation (3ie)

Jane Hammaker  
3ie

Katherine Quant  
3ie

Douglas Glandon  
3ie

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## About 3ie

The International Initiative for Impact Evaluation (3ie) promotes evidence-informed equitable, inclusive and sustainable development. We support the generation and effective use of high-quality evidence to inform decision-making and improve the lives of people living in poverty in low- and middle-income countries. We provide guidance and support to produce, synthesise and quality assure evidence of what works, for whom, how, why and at what cost.

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## About this working paper

The authors of this paper, *Use of performance-based contracts for road maintenance projects: a rapid evidence assessment*, synthesise evidence from evaluations on the impact of performance-based contracts for road maintenance projects on cost savings, road quality, collaboration and direct user benefits. They also provide insights into the implementation, sustainability, and evaluation of these interventions, as well as a risk of bias assessment for each study. This work can help policymakers and practitioners determine the expected outcomes of their interventions and identify key barriers and facilitators of impact.

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## Executive Summary

Transportation networks are critical in economic and social development by connecting economies. Poorly maintained infrastructure, especially roads, can affect trade and mobility as well as higher-level outcomes such as poverty. Performance-based contracts have been more frequently used over the past thirty years to finance road construction and maintenance. However, the evidence base around using performance-based contracts is largely descriptive or observational and does not compare against a counterfactual. This makes it difficult to assess the effectiveness of these contracts in improving road quality, direct user benefits, or cost savings.

In this paper, we present results from a rapid evidence assessment in which we systematically reviewed and summarized the impact evaluations that used performance-based contracts for road maintenance in low- and middle-income countries. We review the evidence on the impact of PBC in road construction and maintenance in L&LMIC contexts on cost savings, road quality, collaboration and direct user benefits.

We conducted a systematic search of academic bibliographic databases and library catalogues to identify qualifying studies. We included studies provided that they met the following criteria: 1) setting was of a low and middle-income country; 2) study used performance-based contracts for road management and maintenance; 3) performance-based contracts were compared to traditional output-based contract types; 4) study assessed a change in some indicator of cost savings, direct user benefits, maintenance quality and collaboration ; 5) studies used an experimental or quasi-experimental design or assessed cost-effectiveness.

We identified 1,589 articles from our systematic search. After screening, we identified five articles that met the inclusion criteria. The studies took place in Zambia, Brazil, Argentina, Sri Lanka, and Indonesia. Three studies incorporated a cost-analysis. Three studies used quasi-experimental or non-experimental methods to assess changes in road quality. All five studies were found to have a high risk of bias and results should be interpreted with caution.

Three studies found that performance-based contracts performed better at improving road quality and increased the frequency of maintenance works compared to traditional contracts. The studies that incorporated a cost analysis found that performance-based contracts had cheaper costs compared to traditional contracts. Only one study found that the areas that used performance-based contracts increased agricultural production compared to areas with output-based contracts.

This rapid evidence assessment found that the use of performance-based contracts in road maintenance does lead to improved road quality and cost savings compared to traditional output-based contracts. However, this review also highlighted the lack of evidence regarding the use of performance-based contracts in road maintenance. Most studies included in this review did not construct a valid counterfactual. Additional effectiveness studies should be conducted to guide investment decisions, especially due to the high level of investment in transportation infrastructure.

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# 1. Introduction

Transportation networks are crucial to both economic and social development by connecting economies and facilitating cooperation. Poorly maintained roads constrain trade and mobility, raise vehicle operating costs, increase accident rates, and aggravate isolation and poverty (Bunningham and Stankevich, 2005). In the last 30 years, performance based contracting (PBC) mechanisms have emerged as a popular tool for financing road construction and maintenance. In this REA, we define PBCs as contracts that require contractors to perform both infrastructure works and road maintenance at pre-determined intervals. Payout is contingent on the quality of the infrastructure after the maintenance works have been completed.

Performance-based contracting models for financing road works have been increasingly popular since the early 1990s. The first PBC was launched in British Columbia, Canada and the model was quickly adopted by neighboring countries in North and South America (Anastasopoulos *et al.*, 2009; Thennakoonwela, 2011). Recent studies in both low-and lower-middle income countries (L&LMICs) and high income countries (HIC) contexts have reported many benefits associated with the PBC approach, including cost savings, reduction of labor requirements for government staff, improved road conditions, greater road user satisfaction, and mechanisms for financing longer-term maintenance programs (Zietlow, 2005; Stankevich, Qureshi and Queiroz, 2009; Greenwood, Porter and Henning, 2012; Mutai and Aila, 2018).

Despite the expansion of the PBC approach worldwide, according to a recent review of the literature, the evidence base supporting their use is largely based on descriptive, observational and/or case study methods that summarize contextual factors, risks and implementation considerations for PBCs in HICs (Mutai and Aila, 2018). Many studies are not rigorously compared to a counterfactual, making it difficult to generalize findings on the effectiveness of PBCs to L&LMIC contexts; for example, one paper notes that PBC studies tend to rely on cost savings computed as the difference in the final cost of the PBC as compared to the engineer's initial estimate, rather than as compared to quantity-based contracts (Anastasopoulos *et al.*, 2009).

## 1.1. Aims and objectives

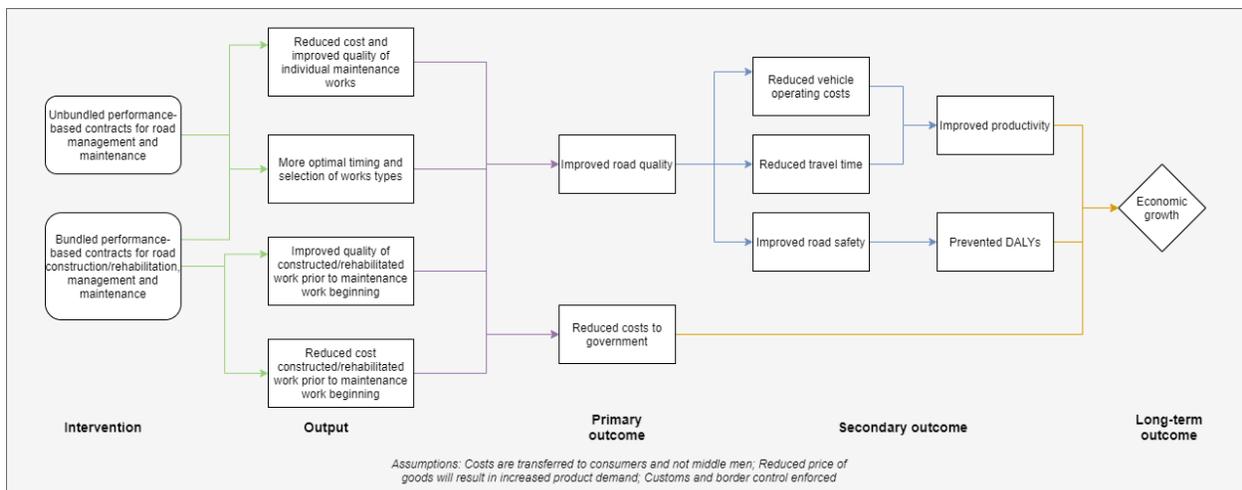
The purpose of this REA is to identify studies in L&LMIC contexts that use comparators or cost-effectiveness analyses (CEA) to measure and test the effectiveness of PBCs as compared to traditional quantity-based/output-based contracting mechanisms. We review the evidence on the impact of PBC in road construction and maintenance in L&LMIC contexts on cost savings, road quality, collaboration and direct user benefits by using 3ie's rapid evidence assessment methodology. REAs follow the same protocol as systematic reviews, but have a focused search strategy that targets databases that are most likely to yield the most relevant results. This narrow focus identifies fewer articles to screen and review (e.g., from a possible yield of 20,000 articles down to 2,000), allowing these assessments to quickly respond to specific evidence needs. However, it is possible that some articles are missed due to the limited scope of the assessment. We also provide insights into the implementation, sustainability, and evaluation of these interventions, as well as a risk of bias assessment for each study. The goal of this work is

to help policy makers and practitioners determine the expected outcomes of their interventions and identify key barriers and facilitators of impact.

## 1.2. Interventions and theoretical model

We considered any intervention that used a PBC for road management and maintenance. In this context, we are defining road management to refer to activities that enhance institutional capacity to facilitate road construction and periodic maintenance (Millennium Challenge Corporation, no date). Maintenance activities are works to periodically improve road conditions and extend their useful life. These contracts could be bundled with road construction and rehabilitation or could be initiated separately. Interventions that used unbundled contracts were theorized to reduce the cost and improve the quality of individual maintenance work as well as to provide a more optimal timing and selection of maintenance work types (Figure 1). For bundled contracts, these interventions were theorized to improve the quality and reduce the cost of constructed and rehabilitated works prior to maintenance work beginning. For both sets of outputs, the primary outcomes are improved road quality and reduced costs to the government. The improved road quality is expected to lead to reduced vehicle operating costs, reduced travel time, and improved road safety. These are then expected to lead to improved productivity and prevented loss of disability-adjusted life years (DALYs). Ultimately, these interventions are theorized to result in economic growth.

**Figure 1: Theory of change developed from initial conversations with MCC and 3ie**



## 2. Methods

The protocol for the rapid evidence assessment was finalized *a priori* to decrease risk of selection bias (Appendix 1). The following section outlines the search process and inclusion criteria for this review.

## **2.1. Search strategy**

A systematic search of academic bibliographic databases and library catalogues was completed to identify qualifying studies (Appendix 2).<sup>1</sup> An example of search strings employed by the strategy is presented in Appendix 3.

## **2.2. Screening**

The selection of studies for data extraction as part of the review was managed using EPPI-Reviewer 4 software (EPPI) and completed by implementing the standard steps of de-duplication, title and abstract screening, and then full text screening (Appendix 4). During the screening process, articles that did not meet the inclusion criteria but were determined to be relevant to the implementation and evaluation of the three interventions of interest were tagged to be included in the practitioner's brief.

### **Inclusion / exclusion criteria (PICOS)**

This section presents the criteria used to identify studies included in the review, drawing on the PICOS format.

### **Population (types of study participants)**

The review includes any study that focused on primary roads in L&LMICs. Countries were defined to be L&LMICs using the World Bank Country and Lending Groups classification for the first year of the intervention. Primary roads were defined using the World Bank functional classification. Studies that were set in upper-middle or high-income countries were excluded.

### **Interventions**

We include studies that used performance-based contracts for road management and maintenance. All potential contract types (such as, network management, design-build-maintain-operate-transfer, design-build-finance-maintain, etc.) in this sector are eligible for inclusion. The intervention could either bundle road construction/rehabilitation and maintenance into one performance-based contract or the performance-based contract could be solely used for the road maintenance. Studies are included only if an element of the intervention incorporates performance-based contracts for road management and maintenance. Studies that only use performance-based contracts for road construction/rehabilitation only are excluded.

### **Comparison group**

We include studies that compare the effects of performance-based contracts on economic and social outcomes, where the comparison received traditional contracts. We exclude studies without a control group. Traditional contracts include any non-performance based contract used for road maintenance, such as standard quantity-based road maintenance contracts or concession agreements.

### **Outcomes**

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<sup>1</sup> The search strategy development for this review was supported by John Evers, an information specialist contracted by 3ie.

The review considers outcome(s) that assess a change in some indicator of cost savings, direct user benefits, maintenance quality and collaboration (Appendix 5). If quantitatively assessed in the study, we did summarize additional outcomes in the narrative but were not included in the screening criteria.

### **Study design**

We include impact evaluations that employ an experimental or quasi-experimental design and/or analysis method, which seek to robustly measure the net change in outcomes that are attributed to an intervention or policy as compared to some appropriate counterfactual. We include randomized studies and non-randomized studies that attempted to address issues of confounding and selection bias. We include standalone economic evaluations provided that they had an appropriate comparison group. Feasibility studies, acceptability studies, and non-systematic literature reviews are not accepted. Process evaluations and qualitative studies are excluded from this review as they do not provide effect sizes. Systematic reviews are included so long as some of the included studies would individually qualify for this rapid evidence assessment. However, effect sizes are presented only if the meta-effect sizes are reported in such a way that allows for the isolation of the effect of the interventions of interest.

### **Date, language, and form of publication**

Only studies published in English are included. Studies are included if their publication date is 1990 or after. Peer-reviewed publications and grey literature reports are both included.

### **2.3. Data extraction**

All articles included after full-text screening underwent the same data extraction process. One reviewer read the manuscripts and recorded the information in a template similar to Table 1. Narrative summaries of results were written by a single reviewer and reviewed by two other reviewers. Due to the heterogeneity in the interventions, outcomes and comparison groups, a meta-analysis was not conducted.

### **2.4. Risk of bias assessment**

We conducted a risk of bias on the included studies using 3ie's rapid risk of bias assessment tool (International Initiative for Impact Evaluation (3ie), no date). This tool assessed a study's risk along five dimensions: establishment of valid counterfactual; attrition bias (relevant for (Iimi and Gericke, 2017)); protection against spillovers/contamination; outcome measurement; and reporting of methods and analyses. One reviewer used the tool to assess the included studies which was then reviewed by a second reviewer to determine a final assessment rating.

While this tool assesses the risk of bias for the included studies, we have not been able to account for reporting bias. Organizations which conducted interventions that did not have positive impacts may choose not to publish their results. Furthermore, journals may not wish to publish articles on projects that had null impacts. Even interventions with several studies indicating positive effects could be subject to this bias as there could be many more unpublished interventions showing a null or even negative effect.

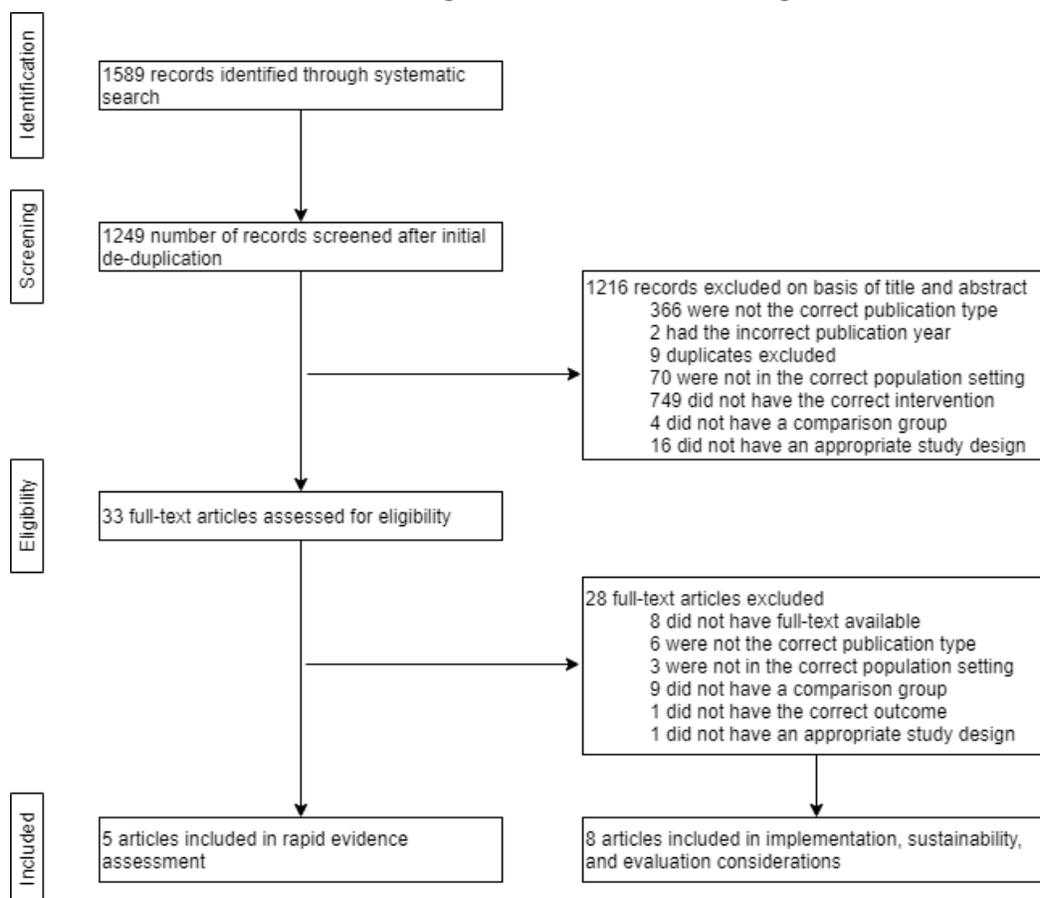
## 2.5. Considerations regarding implementation, sustainability, and evaluation

In an effort to support the adoption of evidence-informed policy, we have provided commentary regarding the implementation, maintenance, sustainability and evaluation of PBC interventions. This section was developed alongside the REA. During the screening process for this rapid evidence assessment, studies were flagged if they provided relevant information regarding the implementation, maintenance, or evaluation of the relevant interventions but otherwise did not meet the inclusion criteria for this assessment. For the most part, these studies had inappropriate comparators and/or insufficient evaluation design to meet our inclusion criteria. Actionable information for the use of practitioners in implementing, maintaining, and evaluating these interventions was extracted from these studies and from the studies included in the REA main text. This information is presented after the main results.

## 3. Results

### 3.1. Search results

Figure 2: PRISMA flow diagram



Through the search for performance-based road maintenance contracts, we identified 1,589 papers, of which 1,249 remained after de-duplication (Figure 2). After title and abstract

screening, 33 papers were included for full-text screening. Finally, five studies were identified for inclusion in this rapid evidence assessment. One study measured the impact of road works under output-and-performance based contracts (OPRCs) on agriculture production in Zambia (Table 1). Two of the studies analyzed the Contrato de Recuperación y Mantenimiento (CREMA) project in Brazil and Argentina. The remaining studies occurred in Sri Lanka and Indonesia. All the studies were published after 2011. Three studies incorporated a cost-analysis. Three studies used quasi-experimental or non-experimental methods to analyze changes in road quality or percent change in performed works.

**Table 1: Summary of included studies in the REA**

| Study                    | Year | Title  | Country | Study design                              | Intervention   | Outcome  |
|--------------------------|------|--|---------|---|--|--|
| (Iimi and Gericke, 2017) | 2017 | Output- and Performance-Based Road Contracts and Agricultural Production: Evidence from Zambia   | Zambia  | Quasi-experimental impact evaluation (IV) | This study examines the impact of output- and performance-based contracts (OPRC) on the sustainability of road maintenance. The contracts were implemented over a five-year period where a total of 385 km of roads were improved with a gravel surface, box culverts, and stone patching. | OPRC increases the agricultural production of 7 crops overall. Crop production was increased where road improvement works were implemented, regardless of contractual arrangements. More road works were implemented on OPRC roads than non-contract roads, indicative that road sustainability may have improved, but road quality was not included in the analysis. Greater access to roads did not significantly increase farmers' market participation.  |
| (Lancelot, 2010)         | 2010 | Performance Based Contracts in the Road Sector: Towards Improved Efficiency in the Management of Maintenance & Rehabilitation: Brazil's experience | Brazil  | Non-experimental                          | In Brazil, the CREMA contract is a performance-based contracting model that includes services and works in four subcomponents: 1) deferred maintenance, 2) routine maintenance service, 3) rehabilitation works, 4) limited improvement works.   | CREMA unit cost of works per kilometer (km) was 25%—35% lower than the unit cost of traditional contracts signed over the same period. CREMA maintenance unit costs per km were 34% lower than the traditional maintenance unit costs. On average, road conditions for CREMA contracts scored 25 ('Very Good') on the IGGE index compared to traditional contracts, which scored 49 ('Regular'). Executing agencies reported that the CREMA contracts optimized the nature of the rehabilitation works and their timing of execution, low-cost intervention, decreased administrative burden, and provided better results to road users. |

|                                |      |   |           |   |   |  |
|--------------------------------|------|---|-----------|---|---|--|
| (Silva and Liautaud, 2011)     | 2011 | Performance-based Road Rehabilitation and Maintenance Contracts (CREMA) in Argentina                  | Argentina | Non-experimental with cost-effectiveness analysis | In Argentina, the CREMA is a 5-year road rehabilitation and maintenance contract. Rehabilitation works are carried out within the first 18 months of the contract, and maintenance activities are conducted throughout.   | <p>The CREMA contracting system improves the condition and riding quality of the national road network. Time-series roughness measurements over 12 years show positive impact of both rehabilitation and subsequent maintenance of pavements. The study also reports that the backlog for maintenance and proportion of low quality roads (IRI&gt;4) has been reduced from 35 to 10 percent and roads in bad condition (IRI&gt;5) reduced from 11 to 2 percent; the proportion of good roads increased from 65 to 90 percent.</p> <p>Using the HDM-4 model, study authors also found that the long-term performance-based contract system was more cost effective than traditional contracting methods by 15 percent on average.</p> <p>In terms of road users' costs, the savings that have accrued from the realization of the CREMAs on the non-concessioned network are substantial and estimated to be at least in the order of US\$275 million annually.</p> |
| (Susanti <i>et al.</i> , 2019) | 2019 | Life cycle cost comparison between performance based and traditional contracts for roads in Indonesia | Indonesia | Life cycle cost (LCC) analysis                    | <p>The study conducts life-cycle cost (LCC) analysis of several roadworks projects to compare LCC of performance-based contracting (PBC) and traditional contracting models.</p> <p>The primary permutations of scenarios vary road length, initial road condition, and duration of the project.</p> <p>For the traditional contracting models, the study used historical</p> | <p>The results demonstrate that the PBC application could generate an LCC efficiency of 9.4% compared to the application of the traditional contract. There was some tendency for LCCs to decline for longer PBC contracts, due to the low administrative costs for multi-year contract compared to a single-year traditional contracts.</p>   |

|                        |      |  |           |                  |   |   |
|------------------------|------|--|-----------|------------------|---|---|
|                        |      |  |           |                  | <p>maintenance and administrative cost data to construct the comparison simulations. For the PBC scenarios, the study used administrative and maintenance costs from a pilot project where a PBC was used on a section of the national road in West Java.</p> |   |
| (Thennakoonwela, 2011) | 2011 | Evaluation of cost-effectiveness of performance-based maintenance contract | Sri Lanka | Non-experimental | <p>The study compares performance-based contracts and traditional maintenance control contracts.</p>  | <p>The study found an improvement in road quality for PBCs as compared to normal maintenance contracts. The authors found that the PBC method resulted in the lowest maintenance cost, while the normal maintenance control method had the highest maintenance cost. The low maintenance cost have been reported in PBC due to: 1) contractor attending the maintenance work in proper time (at the initial stage); 2) quality control by the contractor.</p> |

### **3.2. Effects on road maintenance works and quality**

The studies overall found that performance-based contracts performed better at improving road quality measures and frequency of maintenance works compared to traditional contracts (Table 2). In Zambia, roads that were part of an output- and performance-based contract increased their likelihood of receiving maintenance works by 18 percentage points compared to those that were part of traditional contracts (limi and Gericke, 2017). In Sri Lanka, roads with a performance-based contract received a better rating on road quality compared to traditional contracts (Thennakoonwela, 2011). In Brazil, CREMA roads performed better on the International Roughness Index (IRI) ( $\beta = 0.06$ ) and Brazil's Indice de Gravidade Global Expedito (IGGE) ( $\beta = 24.17$ ) compared to the traditional rehabilitation and maintenance contracts (Lancelot, 2010).

### **3.3. Effects on costs**

Overall, the studies that performed a cost analysis found that performance-based contracts had cheaper costs compared to traditional contracts. In a life cycle cost analysis comparing performance-based contracts to traditional output-based contracts, a study in Indonesia found that costs for PBC projects were lower by 9.4% (Susanti *et al.*, 2019). Lancelot (2010) found that the overall costs, which included both rehabilitation and maintenance costs, for the 5-year CREMA project in Brazil were 19% lower than the standard rehabilitation contracts. When comparing the maintenance costs from the CREMA project to the traditional contracts, Lancelot (2010) found that CREMA contract's maintenance unit costs were 34% lower than conventional contracts as the focus was on regular, preventive actions rather than on remedial actions. Silva & Liautaud (2011) found that the CREMA project was also more cost-effective and found that the CREMA project was 15% more cost-effective than traditional contracts.

### **3.4. Effects on productivity**

Only one study looked at the downstream effects of using PBCs on productivity. In Zambia, limi and Gericke (2017) found that areas where PBCs were used had increased agricultural production ( $\beta = 1.30$ ;  $SE = 0.79$ ) compared to areas that had traditional output-based contracts. This increase in productivity was most likely driven by the increase in production of maize as areas with PBCs found a 50% increase in maize production compared to the comparison areas. In areas where road improvement work was implemented, crop production increased regardless of the type of contract arrangements ( $\beta = 0.95$ ,  $SE = 0.36$ ). The authors found that the gains in productivity they found due to being in a PBC area was because they were areas where road work was actually performed. However, the road improvements due to having a PBC did not have an impact on revenue from market sales. Despite the road improvements, households' market participation was still limited. Households did not have access to affordable transport to reach the markets or to complementary services, such as warehouses and processing mills, that they needed to process their crops to sell. Since the households were primarily subsistence farmers, the lack of these additional factors did not stimulate market participation which then impacted the intervention's ability to increase revenue.

### **3.5. Study quality and risk of bias**

Included studies were assessed using 3ie's short risk of bias assessment tool (International Initiative for Impact Evaluation (3ie), no date). All five studies have high risk of bias and should be interpreted with caution. The most common risk of bias was that studies generally did not achieve a valid counterfactual. While this constraint was relaxed to "over include" studies using CEA or non-experimental methods, studies that do not account for underlying differences between areas that received PBCs and areas that did not may not accurately measure the impact of PBCs. Variation in comparator groups also reduces confidence in our comparison of effects across studies. While the effect sizes reported should be treated with caution, there is still value in the implementation and evaluation considerations that were described from these studies.

## **4. Considerations for implementation, sustainability, and evaluation of performance-based contracting interventions**

### **4.1. Implementation and sustainability considerations**

#### **Bidding and contract structure**

One of the critically important parts in developing the bid documents is producing the preliminary design and identifying the performance targets. These should be both set by the road authority and provided to the contractors in the bid documents (Lancelot, 2010; Silva and Liautaud, 2011; Sultana, 2013; Ateş, 2019). The preliminary design should be based on recent inspections so that it can aid in accurate estimations of the type of work that needs to be done (Silva and Liautaud, 2011; Ateş, 2019). This ensures that contractors are able to produce a cost-efficient proposal (Lancelot, 2010; Silva and Liautaud, 2011; Ateş, 2019). In Zambia, the study authors found that the elevation of the road segments was an important predictor to understand where road work needed to be performed (Iimi and Gericke, 2017). In the Philippines, the lack of information on the condition and history of the road segment to be contracted exposed the bidders to potential additional risks, which increased the cost estimates of the proposals that were submitted (Asian Development Bank, 2018). In addition, the indicators used to set performance standards should be clearly defined in the contract to avoid ambiguity and expose the bidder to more risk which may end up in an increased cost proposal (Sultana, 2013; Asian Development Bank, 2018).

Longer contracts are generally more attractive to bidders. Increasing the contract duration from 1.5 years to 5 years in Brazil ensured that contractors were interested in road maintenance and that there was additional flexibility during contract execution (Lancelot, 2010). If comprehensive road maintenance is desired, contracts should be at least 3-10 years (Sultana, 2013). However, the longer the contract, the more risk that the contractor assumes and increased risk could influence the tender price that the contractor submits (Asian Development Bank, 2018).

Bundling rehabilitation and maintenance in the same PBC increases the accountability that the contractor has (Lancelot, 2010; Silva and Liautaud, 2011). Bundling the two services together

also incentivizes the contractor to perform well on the rehabilitation work to avoid any issues later on that may increase the cost of maintenance (Thennakoonwela, 2011). It also ensures that there is not a delay between rehabilitation and routine maintenance work. If rehabilitation is bundled with road maintenance, then contracts should be extended to at least 7-8 years to allow for 5-6 years of maintenance by the same contractor after rehabilitation finishes (Silva and Liautaud, 2011).

### **Balancing penalties**

In the contract structure, it is important to include sufficient penalties to incentivize that contractors are compliant with the pre-determined performance standards (Lancelot, 2010; Silva and Liautaud, 2011; Radović *et al.*, 2014; Samra, Osman and Hosny, 2017; Asian Development Bank, 2018; Ateş, 2019). Penalties can be applied for late report submissions or partial/no compliance with the determined standards, such as presence of cracks or potholes (Silva and Liautaud, 2011; Asian Development Bank, 2018). However, it is critical to balance the penalty values in the contract. If the penalty value is too low, contractors may not be compliant; but if it is too high, contractors may either increase their tender price or may not be incentivized enough to maintain road quality (Asian Development Bank, 2018; Ateş, 2019). In Brazil, the initial CREMA contracts tried to use fines to penalize non-compliance but both the contractors and road authority staff were unfamiliar with the concept so instead, penalties were designed to be a portion of the monthly payment (Lancelot, 2010). Penalties should be weighted according to the seriousness of the predicted consequence (Lancelot, 2010; Asian Development Bank, 2018).

### **Importance of capacity development**

Both the government agency staff and the contractor should be well trained and knowledgeable about the specifics of using PBCs. In the Philippines, both the contractors and the Department of Public Works did not receive training on PBCs prior to implementation, which significantly impacted the success of the program (Asian Development Bank, 2018). Since government agency staff responsibilities are primarily to manage the contracts and inspect the quality of work, it is critically important that staff are trained, especially as the in-house staffing does not need to be as large for PBCs (Lancelot, 2010; Sultana, Rahman and Chowdhury, 2012a; Radović *et al.*, 2014; Asian Development Bank, 2018; Ateş, 2019; M'Arimi, 2019). In Brazil, having a workforce that had improved their project management skills was critical in improving the admissions to the CREMA program (Lancelot, 2010). Government agency staff also need to be technically skilled to produce the initial engineering designs used to construct the bidding documents. Having trained government staff at all levels is important to ensure that there is sufficient political will to support implementation of PBCs (Silva and Liautaud, 2011).

It is also important that the contractors are trained in PBCs since a larger portion of the risk is shifted from the road authority to the contractor (Sultana, 2013; Asian Development Bank, 2018). Contractors are also generally required to conduct quality assurance on their work (Sultana, 2013; Asian Development Bank, 2018). Contractors should have trained staff that can conduct daily patrols or run an emergency call center to promptly respond to emergency maintenance needs (Asian Development Bank, 2018).

## **Ensuring financial sustainability**

The use of PBCs has generally ensured that there is money set aside for road maintenance, even during times of financial strife. In Argentina and Zambia, road works were still performed even when there were fiscal constraints which traditional contracts were susceptible to (Silva and Liautaud, 2011; Iimi and Gericke, 2017). Road networks that did not have sufficient revenue generated from tolls benefit from the assured funding that comes with PBCs (Silva and Liautaud, 2011). However, it was highlighted that many PBCs are dependent on external funding, such as the World Bank, and that there needs to be an emphasis on establishing internal funding sources (Sultana, Rahman and Chowdhury, 2012b).

PBCs can also improve bureaucracy and efficiency at road agencies by making them more cost-effective. Having longer PBC contracts allows road agencies to be less bureaucratic as funding is assured for several years so that they can focus on other efforts (Susanti *et al.*, 2019). Since more risk and the quality assurance responsibility is shifted to contractors, less staff are needed at road authorities (Lancelot, 2010; Sultana, Rahman and Chowdhury, 2012a; Radović *et al.*, 2014; Asian Development Bank, 2018; Ateş, 2019). Compared to managing traditional maintenance contracts where additional data collection and work is done in-house, this work is shifted to the contractors instead.

One of the advantages for contractors is in having regular monthly payments. In Kenya, having consistent payments contributed significantly to the success of the PBC program (M'Arimi, 2019). In Brazil, an earlier rendition of the CREMA project tried to impose monthly payment limits to improve payment predictability (Lancelot, 2010). These limits were subsequently dropped as they did not actually improve payment predictability and it impeded the contractor's ability to be accountable and have decision-making power.

## **4.2. Considerations for design of an impact evaluation**

Performance-based contracts for road maintenance is generally implemented at the national level by a country's national road agency/authority. Since these are usually large national bidding programs, traditional experimental impact evaluations cannot be used. Quasi-experimental designs can still be used to construct valid counterfactuals. Difference-in-difference designs can be leveraged to assess impacts. If combined with matching on variables related to road length, baseline IRI, or household productivity measures, difference-in-difference can be a suitable design. If the PBC program is being rolled out in phases along different sections of the road, phased designs can also be used to evaluate the program. However, there could be issues in endogeneity, especially if the areas where PBCs are being implemented initially are being selected due to reasons connected to outcomes of interest. In Zambia, areas that had PBCs were selected because of their productivity potential (Iimi and Gericke, 2017). To mitigate this issue in endogeneity, the authors used an instrumental variable design. They identified two instruments, elevation and slope angle of terrain, which were both likely to be associated with needing road works but ultimately not associated with their selected outcome of interest, agricultural productivity. Provided that a reasonable instrument can be identified that

would explain why those areas were being selected for a PBC, instrumental variable method can be combined with the phased designs to compensate for issues with endogeneity.

Interrupted time series designs can also be utilized if sufficient historical data is available from the road agency/authority. Susanti *et. al* (2019) utilized historical cost data to construct comparison simulations for the cost analysis. Spatial data can also be used to identify covariates of interest that should be controlled for. Iimi and Gericke (2017) used spatial data to construct level of elevation that was used as an instrument.

If rehabilitation and maintenance are combined into a single 5 year contract, outcomes should be measured at least 3-4 years after work begins. Since rehabilitation often occurs in the first year, impacts related to maintenance will not be realized until a few years later (Lancelot, 2010; Silva and Liautaud, 2011). In Zambia, the contracts studies were awarded over a 5 year period (2009-2014) but the study authors were only able to conduct their follow-up survey 3 years (2012) after the first contracts had been awarded (Iimi and Gericke, 2017). This meant that most of the impacts identified were due to the initial rehabilitation work that occurred in the first few years and only some of the data captured the maintenance and emergency works performed.

**Table 2: Effectiveness of PBC interventions**

| Study                 | Country | Study design                              | Intervention   | Analysis method  | Outcome                              | Effect Estimate Type     | Effect Estimate*   | Effect Interpretation   |
|-----------------------|---------|---|--|------------------|--------------------------------------|--------------------------|--|---|
| limi & Gericke (2017) | Zambia  | Quasi-experimental impact evaluation (IV) | Output-and-performance based road contracts (OPRCs)                        | Regression       | Performing road work                 | Beta coefficient         | 0.18 (0.021)   | OPRC roads were 18 percentage points more likely to receive road works than other non-OPRC roads  |
| Lancelot (2010)       | Brazil  | Non-experimental                          | Performance-based contracts of road maintenance and rehabilitation (CREMA) | Means comparison | Conditions of road sections (IGGE**) | Difference of means      | Weighted Average of IGGE for comparison: 49.19 (44.43)<br><br>Weighted Average of IGGE for CREMA: 25.02 (14.85)<br><br>Difference†: -24.17 | IGGE conditions for CREMA roads were better (lower) by 24.17 percentage points, on average  |
|                       |         |   |  |                  | Conditions of road sections (IRI***) | Difference of means      | Weighted average of IRI for comparison: 3.09 (1.28)<br><br>IRI for CREMA: 3.03 (0.8)<br><br>Difference†: -0.06                             | IRI conditions for CREMA roads were better (lower) by 0.06 index points, on average   |
|                       |         |   |  |                  | Unit cost of road works              | Percent change over time | -19% (SE not reported; n=13)   | CREMA final unit costs over a full 5 year rehabilitation and maintenance cycle (for 13 roads) were 19 percent lower than the standard rehabilitation and maintenance cumulative costs |

|                        |           |                                |  |                  |   |   |                               |  |
|------------------------|-----------|--------------------------------|--|------------------|---|---|-------------------------------|--|
| Silva & Liataud (2011) | Argentina | Cost-effectiveness analysis    | Performance-based contracts of road maintenance and rehabilitation (CREMA) | HDM-4 Model‡     | Cost effectiveness and efficiency over 20-year period | Cost effectiveness†, percent difference | 15% (SE not reported)         | On average, CREMA is 15 percent more cost-effective than traditional contracts                                 |
| Susanti et al. (2019)  | Indonesia | Life cycle cost (LCC) analysis | Performance-based contract for road improvement and maintenance            | LCC analysis     | Overall life cycle costs                              | Percent change over time                | -9.4% (SE not reported; n=48) | Compared to traditional contracts, costs for PBC roads were 9.4% lower.  |
| Thennakoonwela (2011)  | Sri Lanka | Non-experimental               | Performance based contract   | Means comparison | Road rating (1=excellent, 6=very bad)                 | Difference of means                     | -0.27 (SE not reported;n=12)  | Compared to normal maintenance contracts, PBC roads had better (lower) ratings at the end of the study period. |

\* Mean (Standard Deviation/Standard Error); \*\*IGGE - Indice de Gravidade Global Expedito - a composite index based on visual road distress; \*\*\*IRI – International Roughness Index; †Impact estimate was calculated manually by REA authors so standard error is not available; ††Cost effectiveness is calculated using maximum net present value for a prespecified investment amount; ‡Assuming initial IRI is between 3.5-4 and traffic volume is in the range of 1500-2000 vehicles per day

## 5. Discussion

The results indicate that the use of performance-based contracts in road maintenance has reduced costs and that they have been more effective in improving quality compared to roads that used traditional contracts. The three studies that performed cost analyses found that costs reduced for PBC roads on a magnitude between 9-19% (Lancelot, 2010; Silva and Liautaud, 2011; Susanti *et al.*, 2019). The difference in magnitude of cost savings between these three studies could be due to the differences in the contracts. In the analyses conducted by Susanti *et al.* (2019), two thirds of the simulations assumed that PBCs would be used on road segments that were less than 100 km whereas the average contract size in both Lancelot (2010) and Silva and Liautaud (2011) was between 150-500 km. Susanti *et al.* (2019) did find that as the length of contracted roads increase, the lifecycle costs for PBCs decrease so the smaller magnitude in cost savings found in that study may be explained by the majority of simulations assuming smaller road segments.

The studies that analyzed changes in quality varied in the magnitude of the effect sizes. Two of the effect sizes that looked at changes in quality found a moderate change in quality improvement (Lancelot, 2010; Thennakoonwela, 2011). However, Lancelot (2010) found a substantial improvement in quality when using the IGGE index but they did not find this same level of improvement when looking at the change in IRI. The IGGE is a composite index that assesses change in visual distressors, such as cracks, edge erosion, and sinking whereas the IRI uses change in road profile to assess roughness. The IGGE measure may then be more sensitive to changes in road quality than the IRI. These visual distressors (cracks, edge erosion, etc.) may not initially affect road roughness (measured by the IRI) but could serve as an early detection signal to the contractors that maintenance works are needed. The use of PBCs ensures that preventative maintenance is conducted frequently so for these roads, the preventative maintenance would fix the visual distressors before they could deteriorate further and affect road quality. Since the comparison contracts in this study either only performed rehabilitation or started maintenance work two years after rehabilitation, we would expect that there would more visual distressors measured so that the IGGE would be much higher. Then the use of PBCs would have a stronger impact on the change in IGGE rather than the IRI. Only one study (Lancelot, 2010) differentiated between the costs of road rehabilitation and road maintenance using performance-based contracting; authors report that relative to traditional contracting methods, PBC rehabilitation per unit costs were 25-34 percent lower, and PBC maintenance per unit costs were 34 percent lower.

### 5.1. Strengths, limitations, and future directions

The primary strength of this work is that it is a result of a rigorous and systematic search of the available peer-reviewed literature. Due to the rapid nature of this assessment, the search was limited to six databases and did not perform any searches in the grey literature or specialist websites. While these results are promising, only one rigorous impact evaluation was identified through this systematic search. We identified an additional four studies that were either non-experimental or were cost analyses that had a comparison group. Most articles were excluded

during screening because they did not have a comparison group or the intervention was incorrect, in that the study looked at the impacts of output-based contracts or solely focused on road construction and rehabilitation.

All of the studies included bundled maintenance and rehabilitation contracts and only one study reported results differentiating between rehabilitation and maintenance (Lancelot, 2010). We were not able to look at the effects of PBCs on road maintenance and management alone. The included studies also primarily looked at cost savings or used road quality measures, such as the IRI. We did not have any studies that looked at other secondary outcomes related to PBCs, such as reduced vehicle costs, reduced travel time, or improved road safety. Only one study looked at agricultural productivity outcomes (Iimi and Gericke, 2017).

The included studies all had a high risk of bias. Most of the studies were not impact evaluations and so used non-experimental designs that did not construct a valid counterfactual that was able to address issues of confounding and selection bias. The one impact evaluation included still had issues in comparability between the treatment and control groups (Iimi and Gericke, 2017). In this study, they also conducted their follow-up study two years after the contracts were awarded so they most likely were able to primarily measure the initial rehabilitation works that were conducted in the first year of award, though some contracts may have also had the opportunity to conduct maintenance and emergency works as well.

This indicates that there has not been sufficient research in this field looking at the effectiveness of these types of contracts in road management and maintenance. Within international development, substantial resources have been dedicated to implementing transport infrastructure programs. In 2019, about 86 billion US dollars were invested in transport infrastructure (United Nations Conference on Trade and Development, 2021). Given the amount of investment into this sector, the lack of effectiveness studies to guide where investments should go is a surprising finding and suggests that further research should be conducted in this area.

## **6. Conclusion**

This rapid evidence assessment found that the use of performance-based contracts in road maintenance and management does lead to moderately better road quality improvements and cost savings compared to traditional maintenance contracts. Though the magnitude in improvement and cost savings varied across the studies, they all did find that PBCs are effective. However, majority of the studies included were not impact evaluations and thus did not construct a valid counterfactual so these effect estimates should be interpreted with caution. Since transportation infrastructure, with a focus on road maintenance, is an area with high investment, additional effectiveness studies should be conducted to guide investment decisions.

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# **Appendix A: Protocol | Rapid Evidence Assessment on Use of Performance-Based Contracts for Road Maintenance Projects – Protocol**

## **1. Background**

### **1.1 The scope**

MCC's Regional Benin-Niger Transport Program and the Niger Compact plan to use performance-based contracts (PBCs) for the infrastructure works. In these contracts, the firm performing the infrastructure works will also be responsible for performing maintenance, with maintenance payments contingent upon verification that the maintenance works have been performed. As this program is designed, key questions include the following: What is the evidence that PBC contracts reduce the cost of road maintenance works in low and lower-income countries? What is the evidence on whether low and lower-income countries using PBC contracts have been able to accurately verify whether maintenance works have been performed (establishing the link between performance of works and payment)? What is the evidence that PBCs have in practice led to more optimal life-cycle maintenance investment?

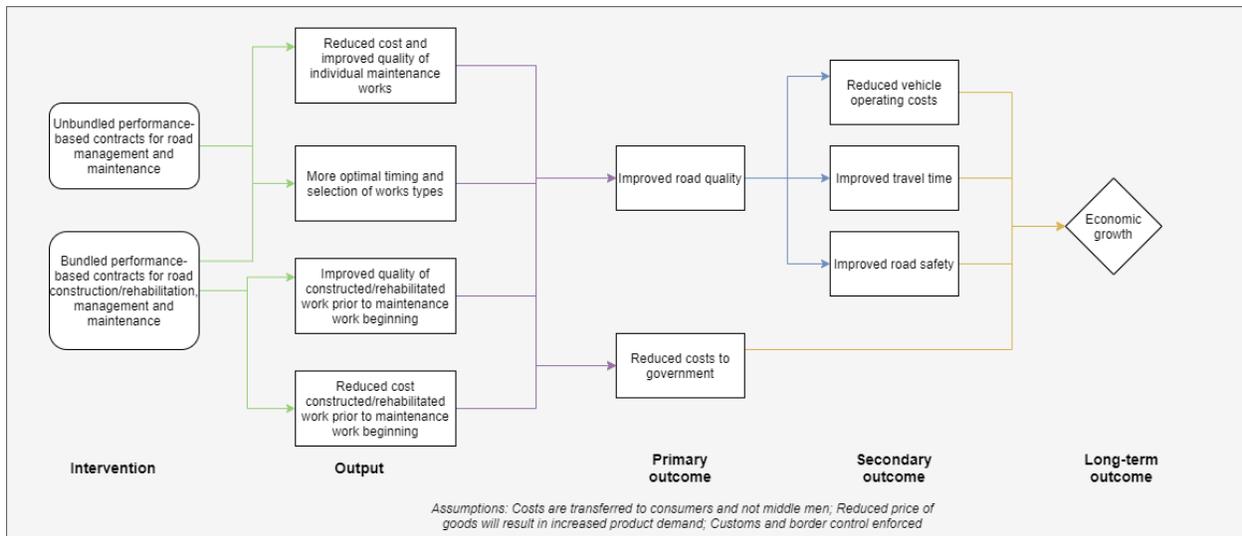
To inform the project design and cost-benefit analysis (CBA) parameters for the Benin-Niger regional compact, 3ie will conduct a rapid evidence assessment (REA) of the literature on the effectiveness of PBCs for transportation infrastructure maintenance with specific applicability to the Benin/Niger regional context.

### **1.2 The interventions**

The primary intervention to be included in this rapid evidence assessment is the use of performance-based contracts for road management and maintenance.

### 1.3 Expected Theories of Change

Figure 1: Tentative theory of change developed from initial conversations with MCC and 3ie



### 1.4 Rationale for the review

This rapid evidence assessment will inform the cost-benefit analysis for the Benin-Niger regional compact at the Millennium Challenge Corporation. It will also serve as a public good to provide a rapid synthesis of the available evidence on the use of performance-based contracting for road maintenance projects in L&MICs.

## 2. Review objectives

The purpose of this review is to identify the expected social and economic effects of using performance-based contracts for road maintenance projects in L&MICs. The review is guided by the following three questions:

1. What is the evidence that PBC contracts reduce the cost of road maintenance works in low and lower-income countries?
2. What is the evidence on whether low and lower-income countries using PBC contracts have been able to accurately verify whether maintenance works have been performed (establishing the link between the performance of works and payment)?
3. What is the evidence that PBCs have in practice led to more optimal life-cycle maintenance investment?

## 3. Method

This objective will be accomplished through a targeted, systematic literature search. The literature will be screened for quality and summarized visually and in a narrative format.

### 3.1 Criteria for including and excluding studies in the review (PICOS)

| <i>Criteria</i> | <i>Included</i>  | <i>Excluded</i>   |
|-----------------|--|---|
| Participants    | Primary roads in low & middle income country settings  | High income settings<br>Secondary roads or tertiary roads in L&MICs   |
| Intervention    | Performance-based contracts for management and maintenance of roads, either bundled with road construction/rehabilitation or unbundled as a standalone service | Quantity-based (output) road maintenance contracts<br>Time and materials (input) contracts<br>Performance-based contracts for other sectors, such as electrification<br>Performance-based contracts for road construction alone |
| Comparator      | Placebo or "business as usual" comparison group  | If there is no comparison   |
| Outcome         | Cost savings<br>Direct user benefits<br>Maintenance quality<br>Collaboration   | Socio-economic spillovers (e.g., change in property value; access to education, markets or health services)   |
| Study Design    | Impact evaluations<br>Systematic reviews<br>Ex-post cost-effectiveness analyses  | Feasibility studies<br>Acceptability studies<br>Non-systematic literature reviews<br>Qualitative studies<br>Process evaluations   |

#### 3.1.1 Types of study participants

- Primary roads in L&MICs
  - L&MICs defined using the [World Bank Country and Lending Groups classification](#) in year of intervention
  - Primary roads defined using [World Bank functional classification](#)

#### 3.1.2 Types of interventions

- Performance-based contract for road management and maintenance

- All potential contract types in this sector will be eligible for inclusion (such as, network management, design-build-maintain-operate-transfer, design-build-finance-maintain, etc.)
- The intervention could either bundle road construction/rehabilitation and maintenance into one performance-based contract or the performance-based contract could be solely used for the road maintenance. Studies will only be included if an element of the intervention incorporates performance-based contracts for road maintenance. Studies that only use performance-based contracts for road construction/rehabilitation only will be excluded.

### **3.1.3 Comparator**

We will include studies that compare the effects of performance-based contracts on economic and social outcomes, where the comparison received "business as usual" conditions. We will exclude studies without a control group. "Business as usual" conditions could include the standard quantity-based road maintenance contracts.

### 3.1.4 Types of outcome measures

| <i>Outcome measure definition</i>  | <i>Example outcome indicators</i>  |
|--|--|
| <p><i>Costs savings:</i></p> <p><i>Measures related to changes in maintenance costs that generate savings</i></p>  | <ul style="list-style-type: none"> <li>● Overall maintenance work cost</li> <li>● Individual maintenance work types costs</li> <li>● Optimal selection of work types</li> <li>● For bundled contracts: Cost of constructed/rehabilitation work performed before maintenance works begin</li> </ul>   |
| <p><i>Road quality:</i></p> <p><i>Measures related to changes in overall road quality over specified period</i></p>  | <ul style="list-style-type: none"> <li>● Road usability (keep road open to traffic)</li> <li>● Road durability (pavement, shoulder defects/hazards, drainage, bridges, slows, etc.)</li> <li>● Safety* (guardrails, signs, marking) <ul style="list-style-type: none"> <li>○ Accident mortality*</li> </ul> </li> <li>● User service</li> <li>● Performance indicators such as International Roughness Index (IRI)*</li> <li>● Response times</li> <li>● Optimal selection of work types</li> <li>● Work meets the prespecified indicators in contract</li> <li>● For bundled contracts: Quality of constructed/rehabilitated road before maintenance works begin</li> </ul> |
| <p><i>Collaboration:</i></p> <p>Measures related to collaboration between the service provider (road maintenance firm) and owner/customer (the government)</p> | <ul style="list-style-type: none"> <li>● <i>Innovative service delivery</i></li> <li>● Higher responsiveness</li> <li>● Greater motivation (service provider is incentivized to achieve best results to maximize financial gain)</li> </ul>  |
| <p><i>Direct user benefits:</i></p> <p>Measures related to convenience or personal safety of road users, due to improved road conditions</p>                   | <ul style="list-style-type: none"> <li>● Vehicle operating costs</li> <li>● Travel time</li> <li>● Highway safety [reduced fatal accidents; reduced non-fatal accidents]</li> <li>● Generated Traffic</li> </ul>   |

### 3.1.5 Types of study design

Impact evaluations that employ an experimental or quasi-experimental design and/or analysis method, which seek to robustly measure the net change in outcomes that are attributed to an

intervention or policy as compared with some appropriate counterfactual. Studies that attempt to address issues of confounding and selection bias will be included. Designs that will be included are:

- Randomized controlled trial
- Regression discontinuity design
- Controlled before-and-after studies, including
  - Propensity score matching
  - Instrumental variable
  - Difference-in-differences
- Simulation modeling
- Case-control
- Interrupted time series

Systematic reviews will also be included, provided that some of the included studies in the review would also qualify for inclusion in this REA.

Ex-post cost-effectiveness analyses will be included, provided that they are associated with an impact evaluation.

### **3.1.6 Date, language, and form of publication**

- Date: Publications must be published after 1990, and studies must be of settings that are post-1990
- Language: English
- Publication forms: Peer-reviewed or grey literature

## **3.2 Search strategy**

See Appendix C

### **3.2.1 Electronic searches of bibliographic databases, library catalogues and grey literature repositories**

The following academic databases will be searched:

- Ebsco Discovery
- Africa-wide (Ebsco)
- Econlit (Ovid)
- Web of Science (Social Sciences Citation Index, Arts and Humanities Citation Index, Sciences Citation Index Expanded)
- CAB Abstracts
- TRID

The following websites will be searched to identify grey literature:

- FCDO's Research Output Database
- World Bank
- Asian Development Bank

- African Development Bank
- Millennium Challenge Corporation
- GIZ
- USAID
- DANIDA

After screening has completed on the results from the academic databases and grey literature search, we will conduct forwards and backwards citation searches on the included studies in the REA to identify any additional results for screening.

### **3.3 Selection of studies**

#### **3.3.1 Screening**

Study screening will be conducted in accordance with standard 3ie guidelines. At title and abstract, each study will be screened by two reviewers. In the case of disagreements between the two reviewers, a third reviewer will be brought for reconciliation. Full texts of each included study from the title and abstract stage will be screened by two reviewers. A third reviewer will be brought in to reconcile any disagreements between the two reviewers.

#### **3.3.2 Data extraction and coding procedures**

Data extraction templates will be modified from 3ie's repository coding protocol and the coding protocols typically used for systematic reviews. This includes bibliographic, geographic information, and substantive data, as well as standardized methods information. In addition, we will extract data on interventions, outcomes, population, and effect sizes for parameters that will be used in the cost-benefit analysis model. Narrative, qualitative data related to challenges in implementation, sustainability, and evaluation will be extracted where feasible. If available, we will also extract differences related to bundled contracts vs unbundled contracts and will also briefly summarize distal downstream effects (such as, GDP growth, commercialization, urbanization, establishment of new communities, etc.) of these interventions. We will also extract qualitative evidence related to the mechanisms related to upstream outcomes such as road quality, collaboration, and service delivery. Finally, we will note if an indicator that is also present in MCC's Common Indicator (2021) list uses a different definition than MCC so that can be taken into account when interpreting the data.

#### **3.3.3 Quality appraisal**

All included systematic reviews and impact evaluations will be appraised using a modified version of 3ie's risk of bias tool.

### **3.6 Data presentation**

We will provide a narrative summary of the papers identified. This will include an overall description of the available literature and general synthesis of findings. Individual studies will be briefly described in the text. In addition, parameters from each study will be summarized in a table. Qualitative information will be summarized in a practitioner's brief to support project design and implementation.

## **Appendix B: Databases and catalogues searched**

**Electronic searches of bibliographic databases, library catalogues and grey literature repositories:**

- Ebsco Discovery
- Africa-wide (Ebsco)
- Econlit (Ovid)
- Web of Science (Social Sciences Citation Index, Arts and Humanities Citation Index, Sciences Citation Index Expanded)
- CAB Abstracts
- TRID

## Appendix C: Search strings

### 1. Ebsco Discovery – Searched 15<sup>th</sup> June 2021

- S5 S1 AND S2 AND S3 AND S4 Limiters - Date of Publication: 19900101-20211231  
1,229
- S4 TI ( ((output\* OR performance\*) AND contract\*) ) OR AB ( ((output\* OR performance\*) AND contract\*) ) OR SU ( ((output\* OR performance\*) AND contract\*) )  
236,545
- S3 TI ( (construct\* OR build\* OR maintain\* OR maintenance OR rehabilitat\* OR repair\* OR improv\* OR preserv\*) ) OR AB ( (construct\* OR build\* OR maintain\* OR maintenance OR rehabilitat\* OR repair\* OR improv\* OR preserv\*) ) OR SU ( (construct\* OR build\* OR maintain\* OR maintenance OR rehabilitat\* OR repair\* OR improv\* OR preserv\*) )  
55,950,322
- S2 TI ( (road\* OR highway\* OR motorway\* OR freeway\*) ) OR AB ( (road\* OR highway\* OR motorway\* OR freeway\*) ) OR SU ( (road\* OR highway\* OR motorway\* OR freeway\*) )  
3,137,784
- S1 TI ( (afghanistan OR albania OR algeria OR "american samoa" OR angola OR "antigua and barbuda" OR antigua OR barbuda OR argentina OR armenia OR armenian OR aruba OR azerbaijan OR bahrain OR bangladesh OR barbados OR belarus OR byelarus OR belorussia OR byelorussian OR belize OR "british honduras" OR benin OR dahomey OR bhutan OR bolivia OR "bosnia and herzegovina" OR bosnia OR herzegovina OR botswana OR bechuanaland OR brazil OR brasil OR bulgaria OR "burkina faso" OR "burkina fasso" OR "upper volta" OR burundi OR urundi OR "cabo verde" OR "cape verde" OR cambodia OR kampuchea OR "khmer republic" OR cameroon OR cameron OR cameroun OR "central african republic" OR "ubangi shari" OR chad OR chile OR china OR colombia OR comoros OR "comoro islands" OR "iles comores" OR mayotte OR "democratic republic of the congo" OR "democratic republic congo" OR congo OR zaire OR "costa rica" OR "cote d'ivoire" OR "cote d'ivoire" OR "cote divoire" OR "cote d ivoire" OR "ivory coast" OR croatia OR cuba OR cyprus OR "czech republic" OR czechoslovakia OR djibouti OR "french somaliland" OR dominica OR "dominican republic" OR ecuador OR egypt OR "united arab republic" OR "el salvador" OR "equatorial guinea" OR "spanish guinea" OR eritrea OR estonia OR eswatini OR swaziland OR ethiopia OR fiji OR gabon OR "gabonese republic" OR gambia OR "georgia (republic)" OR georgian OR ghana OR "gold coast" OR gibraltar OR greece OR grenada OR guam OR guatemala OR guinea OR "guinea bissau" OR guyana OR "british guiana" OR haiti OR hispaniola OR honduras OR hungary OR india OR indonesia OR timor OR iran OR iraq OR "isle of man" OR jamaica OR jordan OR kazakhstan OR kazakh OR kenya OR "democratic people's republic of korea" OR "republic of korea" OR "north korea" OR "south korea" OR korea OR kosovo OR kyrgyzstan OR kirghizia OR kirgizstan OR "kyrgyz republic" OR kirghiz OR laos OR "lao pdr" OR "lao people's democratic republic" OR latvia OR lebanon OR "lebanese

republic" OR lesotho OR basutoland OR liberia OR libya OR "libyan arab jamahiriya" OR lithuania OR macau OR macao OR "macedonia (republic)" OR macedonia OR madagascar OR "malagasy republic" OR malawi OR nyasaland OR malaysia OR "malay federation" OR "malaya federation" OR maldives OR "indian ocean islands" OR "indian ocean" OR mali OR malta OR micronesia OR "federated states of micronesia" OR kiribati OR "marshall islands" OR nauru OR "northern mariana islands" OR palau OR tuvalu OR mauritania OR mauritius OR mexico OR moldova OR moldovian OR mongolia OR montenegro OR morocco OR ifni OR mozambique OR "portuguese east africa" OR myanmar OR burma OR namibia OR nepal OR "netherlands antilles" OR nicaragua OR niger OR nigeria OR oman OR muscat OR pakistan OR panama OR "papua new guinea" OR "new guinea" OR paraguay OR peru OR philippines OR philipines OR phillipines OR phillippines OR poland OR "polish people's republic" OR portugal OR "portuguese republic" OR "puerto rico" OR romania OR russia OR "russian federation" OR ussr OR "soviet union" OR "union of soviet socialist republics" OR rwnda OR ruanda OR samoa OR "pacific islands" OR polynesia OR "samoan islands" OR "navigator island" OR "navigator islands" OR "sao tome and principe" OR "saudi arabia" OR senegal OR serbia OR seychelles OR "sierra leone" OR slovakia OR "slovak republic" OR slovenia OR melanesia OR "solomon island" OR "solomon islands" OR "norfolk island" OR "norfolk islands" OR somalia OR "south africa" OR "south sudan" OR "sri lanka" OR ceylon OR "saint kitts and nevis" OR "st. kitts and nevis" OR "saint lucia" OR "st. lucia" OR "saint vincent and the grenadines" OR "saint vincent" OR "st. vincent" OR grenadines OR sudan OR suriname OR surinam OR "dutch guiana" OR "netherlands guiana" OR syria OR "syrian arab republic" OR tajikistan OR tadjikistan OR tadhikistan OR tadhik OR tanzania OR tanganyika OR thailand OR siam OR "timor leste" OR "east timor" OR togo OR "togolese republic" OR tonga OR "trinidad and tobago" OR trinidad OR tobago OR tunisia OR turkey OR "turkey (republic)" OR turkmenistan OR turkmen OR uganda OR ukraine OR uruguay OR uzbekistan OR uzbek OR vanuatu OR "new hebrides" OR venezuela OR vietnam OR "viet nam" OR "middle east" OR "west bank" OR gaza OR palestine OR yemen OR yugoslavia OR zambia OR zimbabwe OR "northern rhodesia" OR "global south" OR "africa south of the sahara" OR "sub-saharan africa" OR "subsaharan africa" OR "africa, central" OR "central africa" OR "africa, northern" OR "north africa" OR "northern africa" OR magreb OR maghrib OR sahara OR "africa, southern" OR "southern africa" OR "africa, eastern" OR "east africa" OR "eastern africa" OR "africa, western" OR "west africa" OR "western africa" OR "west indies" OR "indian ocean islands" OR caribbean OR "central america" OR "latin america" OR "south and central america" OR "south america" OR "asia, central" OR "central asia" OR "asia, northern" OR "north asia" OR "northern asia" OR "asia, southeastern" OR "southeastern asia" OR "south eastern asia" OR "southeast asia" OR "south east asia" OR "asia, western" OR "western asia" OR "europe, eastern" OR "east europe" OR "eastern europe" OR "developing country" OR "developing countries" OR "developing nation\*" OR "developing population\*" OR "developing world" OR "less developed countr\*" OR "less developed nation\*" OR "less developed population\*" OR "less developed world" OR "lesser developed countr\*" OR "lesser developed nation\*" OR "lesser developed population\*" OR "lesser developed world" OR

"under developed countr\*" OR "under developed nation\*" OR "under developed population\*" OR "under developed world" OR "underdeveloped countr\*" OR "underdeveloped nation\*" OR "underdeveloped population\*" OR "underdeveloped world" OR "middle income countr\*" OR "middle income nation\*" OR "middle income population\*" OR "low income countr\*" OR "low income nation\*" OR "low income population\*" OR "lower income countr\*" OR "lower income nation\*" OR "lower income population\*" OR "underserved countr\*" OR "underserved nation\*" OR "underserved population\*" OR "underserved world" OR "under served countr\*" OR "under served nation\*" OR "under served population\*" OR "under served world" OR "deprived countr\*" OR "deprived nation\*" OR "deprived population\*" OR "deprived world" OR "poor countr\*" OR "poor nation\*" OR "poor population\*" OR "poor world" OR "poorer countr\*" OR "poorer nation\*" OR "poorer population\*" OR "poorer world" OR "developing econom\*" OR "less developed econom\*" OR "lesser developed econom\*" OR "under developed econom\*" OR "underdeveloped econom\*" OR "middle income econom\*" OR "low income econom\*" OR "lower income econom\*" OR "low gdp" OR "low gnp" OR "low gross domestic" OR "low gross national" OR "lower gdp" OR "lower gnp" OR "lower gross domestic" OR "lower gross national" OR Imic OR Imics OR "third world" OR "lami countr\*" OR "transitional countr\*" OR "emerging econom\*" OR "emerging nation\*") ) OR AB ( (afghanistan OR albania OR algeria OR "american samoa" OR angola OR "antigua and barbuda" OR antigua OR barbuda OR argentina OR armenia OR armenian OR aruba OR azerbaijan OR bahrain OR bangladesh OR barbados OR belarus OR byelarus OR belorussia OR byelorussian OR belize OR "british honduras" OR benin OR dahomey OR bhutan OR bolivia OR "bosnia and herzegovina" OR bosnia OR herzegovina OR botswana OR bechuanaland OR brazil OR brasil OR bulgaria OR "burkina faso" OR "burkina fasso" OR "upper volta" OR burundi OR urundi OR "cabo verde" OR "cape verde" OR cambodia OR kampuchea OR "khmer republic" OR cameroon OR cameron OR cameroun OR "central african republic" OR "ubangi shari" OR chad OR chile OR china OR colombia OR comoros OR "comoro islands" OR "iles comores" OR mayotte OR "democratic republic of the congo" OR "democratic republic congo" OR congo OR zaire OR "costa rica" OR "cote d'ivoire" OR "cote d'ivoire" OR "cote divoire" OR "cote d ivoire" OR "ivory coast" OR croatia OR cuba OR cyprus OR "czech republic" OR czechoslovakia OR djibouti OR "french somaliland" OR dominica OR "dominican republic" OR ecuador OR egypt OR "united arab republic" OR "el salvador" OR "equatorial guinea" OR "spanish guinea" OR eritrea OR estonia OR eswatini OR swaziland OR ethiopia OR fiji OR gabon OR "gabonese republic" OR gambia OR "georgia (republic)" OR georgian OR ghana OR "gold coast" OR gibraltar OR greece OR grenada OR guam OR guatemala OR guinea OR "guinea bissau" OR guyana OR "british guiana" OR haiti OR hispaniola OR honduras OR hungary OR india OR indonesia OR timor OR iran OR iraq OR "isle of man" OR jamaica OR jordan OR kazakhstan OR kazakh OR kenya OR "democratic people's republic of korea" OR "republic of korea" OR "north korea" OR "south korea" OR korea OR kosovo OR kyrgyzstan OR kirghizia OR kirgizstan OR "kyrgyz republic" OR kirghiz OR laos OR "lao pdr" OR "lao people's democratic republic" OR latvia OR lebanon OR "lebanese republic" OR lesotho OR basutoland OR liberia OR libya OR "libyan arab jamahiriya" OR

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madagascar OR "malagasy republic" OR malawi OR nyasaland OR malaysia OR "malay  
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 OR "deprived nation\*" OR "deprived population\*" OR "deprived world" OR "poor countr\*"  
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 botswana OR bechuanaland OR brazil OR brasil OR bulgaria OR "burkina faso" OR  
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 OR cameroun OR "central african republic" OR "ubangi shari" OR chad OR chile OR  
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 ivoire" OR "ivory coast" OR croatia OR cuba OR cyprus OR "czech republic" OR  
 czechoslovakia OR djibouti OR "french somaliland" OR dominica OR "dominican  
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21,541,917

The same strategy was used to search other Ebsco databases searched on 15<sup>th</sup> June 2021:

**2. CAB Abstracts – 18**

**3. Africa-Wide - 15**

S6 S1 AND S2 AND S3 AND S4 Limiters - Date of Publication: 19900101-20211231

**1,234**

S5 S1 AND S2 AND S3 AND S4

1,785

S4 TI ( (construct\* OR build\* OR maintain\* OR maintenance OR rehabilitat\* OR repair\* OR improv\* OR preserv\* OR restor\* OR renovat\* OR resurfac\* OR renew\* OR refurbish\* OR mend\*) ) OR AB ( (construct\* OR build\* OR maintain\* OR maintenance OR rehabilitat\* OR repair\* OR improv\* OR preserv\* OR restor\* OR renovat\* OR resurfac\* OR renew\* OR refurbish\* OR mend\*) ) OR SU ( (construct\* OR build\* OR maintain\* OR maintenance OR rehabilitat\* OR repair\* OR improv\* OR preserv\* OR restor\* OR renovat\* OR resurfac\* OR renew\* OR refurbish\* OR mend\*) )

60,056,276

S3 TI ( ((output\* OR performance\*) AND contract\*) ) OR AB ( ((output\* OR performance\*) AND contract\*) ) OR SU ( ((output\* OR performance\*) AND contract\*) )

236,703

S2 TI ( (road\* OR highway\* OR motorway\* OR freeway\*) ) OR AB ( (road\* OR highway\* OR motorway\* OR freeway\*) ) OR SU ( (road\* OR highway\* OR motorway\* OR freeway\*) )

3,155,073

S1 TI ( afghanistan OR albania OR algeria OR "american samoa" OR angola OR "antigua and barbuda" OR antigua OR barbuda OR argentina OR armenia OR armenian OR aruba OR azerbaijan OR bahrain OR bangladesh OR barbados OR belarus OR byelarus OR belorussia OR byelorussian OR belize OR "british honduras" OR benin OR dahomey OR bhutan OR bolivia OR "bosnia and herzegovina" OR bosnia OR herzegovina OR botswana OR bechuanaland OR brazil OR brasil OR bulgaria OR "burkina faso" OR "burkina fasso" OR "upper volta" OR burundi OR urundi OR "cabo verde" OR "cape verde" OR cambodia OR kampuchea OR "khmer republic" OR cameroon OR cameron OR cameroun OR "central african republic" OR "ubangi shari" OR chad OR chile OR china OR colombia OR comoros OR "comoro islands" OR "iles comores" OR mayotte OR "democratic republic of the congo" OR "democratic republic congo" OR congo OR zaire OR "costa rica" OR "cote d'ivoire" OR "cote d'ivoire" OR "cote divoire" OR "cote d ivoire" OR "ivory coast" OR croatia OR cuba OR cyprus OR "czech republic" OR czechoslovakia OR djibouti OR "french somaliland" OR dominica OR "dominican republic" OR ecuador OR egypt OR "united arab republic" OR "el salvador" OR "equatorial guinea" OR "spanish guinea" OR eritrea OR estonia OR eswatini OR swaziland OR ethiopia OR fiji OR gabon OR "gabonese republic" OR gambia OR "georgia (republic)" OR georgian OR ghana OR "gold coast" OR gibraltar OR greece OR grenada OR guam OR guatemala OR guinea OR "guinea bissau" OR guyana OR "british guiana" OR haiti OR hispaniola OR honduras OR hungary OR india OR indonesia OR timor OR iran OR iraq OR "isle of man" OR jamaica OR jordan OR kazakhstan OR kazakh OR kenya OR "democratic people's republic of korea" OR "republic of korea" OR "north korea" OR "south korea" OR korea OR kosovo OR kyrgyzstan OR kirghizia OR kirgizstan OR "kyrgyz republic" OR kirghiz OR laos OR "lao pdr" OR "lao people's democratic republic" OR latvia OR lebanon OR "lebanese republic" OR lesotho OR basutoland OR liberia OR libya OR "libyan arab jamahiriya" OR lithuania OR macau OR macao OR "macedonia (republic)" OR macedonia OR madagascar OR "malagasy republic" OR malawi OR nyasaland OR malaysia OR "malay federation" OR "malaya federation" OR maldives OR "indian ocean islands" OR "indian ocean" OR mali OR malta OR micronesia OR "federated states of micronesia" OR kiribati OR "marshall islands" OR nauru OR "northern mariana islands" OR palau OR tuvalu OR mauritania OR mauritius OR mexico OR moldova OR moldovian OR mongolia OR montenegro OR morocco OR ifni OR mozambique OR "portuguese east africa" OR myanmar OR burma OR namibia OR nepal OR "netherlands antilles" OR nicaragua OR niger OR nigeria OR oman OR muscat OR pakistan OR panama OR "papua new guinea" OR "new guinea" OR paraguay OR peru OR philippines OR philipines OR phillipines OR phillippines OR poland OR "polish people's republic" OR portugal OR "portuguese republic" OR "puerto rico" OR romania OR russia OR "russian federation" OR ussr OR "soviet union" OR "union of soviet socialist republics" OR rwnda OR ruanda OR samoa OR "pacific islands" OR polynesia OR "samoan islands" OR "navigator island" OR "navigator islands" OR "sao tome and principe" OR "saudi arabia" OR senegal OR serbia OR seychelles OR "sierra leone" OR slovakia OR "slovak republic" OR slovenia OR melanesia OR "solomon island" OR "solomon islands" OR "norfolk island" OR "norfolk islands" OR somalia OR "south africa" OR "south sudan" OR "sri lanka" OR ceylon OR "saint kitts and nevis" OR "st. kitts and nevis" OR "saint lucia" OR "st. lucia" OR "saint vincent and the grenadines" OR "saint vincent" OR "st. vincent" OR grenadines OR sudan OR suriname OR surinam OR "dutch guiana" OR "netherlands guiana" OR syria OR "syrian arab republic" OR tajikistan OR tadjikistan OR tadjhikistan OR

tadzhik OR tanzania OR tanganyika OR thailand OR siam OR "timor leste" OR "east timor" OR togo OR "togolese republic" OR tonga OR "trinidad and tobago" OR trinidad OR tobago OR tunisia OR turkey OR "turkey (republic)" OR turkmenistan OR turkmen OR uganda OR ukraine OR uruguay OR uzbekistan OR uzbek OR vanuatu OR "new hebrides" OR venezuela OR vietnam OR "viet nam" OR "middle east" OR "west bank" OR gaza OR palestine OR yemen OR yugoslavia OR zambia OR zimbabwe OR "northern rhodesia" OR "global south" OR "africa south of the sahara" OR "sub-saharan africa" OR "subsaharan africa" OR "africa, central" OR "central africa" OR "africa, northern" OR "north africa" OR "northern africa" OR magreb OR maghrib OR sahara OR "africa, southern" OR "southern africa" OR "africa, eastern" OR "east africa" OR "eastern africa" OR "africa, western" OR "west africa" OR "western africa" OR "west indies" OR "indian ocean islands" OR caribbean OR "central america" OR "latin america" OR "south and central america" OR "south america" OR "asia, central" OR "central asia" OR "asia, northern" OR "north asia" OR "northern asia" OR "asia, southeastern" OR "southeastern asia" OR "south eastern asia" OR "southeast asia" OR "south east asia" OR "asia, western" OR "western asia" OR "europe, eastern" OR "east europe" OR "eastern europe" OR "developing country" OR "developing countries" OR "developing nation\*" OR "developing population\*" OR "developing world" OR "less developed countr\*" OR "less developed nation\*" OR "less developed population\*" OR "less developed world" OR "lesser developed countr\*" OR "lesser developed nation\*" OR "lesser developed population\*" OR "lesser developed world" OR "under developed countr\*" OR "under developed nation\*" OR "under developed population\*" OR "under developed world" OR "underdeveloped countr\*" OR "underdeveloped nation\*" OR "underdeveloped population\*" OR "underdeveloped world" OR "middle income countr\*" OR "middle income nation\*" OR "middle income population\*" OR "low income countr\*" OR "low income nation\*" OR "low income population\*" OR "lower income countr\*" OR "lower income nation\*" OR "lower income population\*" OR "underserved countr\*" OR "underserved nation\*" OR "underserved population\*" OR "underserved world" OR "under served countr\*" OR "under served nation\*" OR "under served population\*" OR "under served world" OR "deprived countr\*" OR "deprived nation\*" OR "deprived population\*" OR "deprived world" OR "poor countr\*" OR "poor nation\*" OR "poor population\*" OR "poor world" OR "poorer countr\*" OR "poorer nation\*" OR "poorer population\*" OR "poorer world" OR "developing econom\*" OR "less developed econom\*" OR "lesser developed econom\*" OR "under developed econom\*" OR "underdeveloped econom\*" OR "middle income econom\*" OR "low income econom\*" OR "lower income econom\*" OR "low gdp" OR "low gnp" OR "low gross domestic" OR "low gross national" OR "lower gdp" OR "lower gnp" OR "lower gross domestic" OR "lower gross national" OR lmic OR lmic OR "third world" OR "lami countr\*" OR "transitional countr\*" OR "emerging econom\*" OR "emerging nation\*") ) OR AB ( (afghanistan OR albania OR algeria OR "american samoa" OR angola OR "antigua and barbuda" OR antigua OR barbuda OR argentina OR armenia OR armenian OR aruba OR azerbaijan OR bahrain OR bangladesh OR barbados OR belarus OR byelarus OR belorussia OR byelorussian OR belize OR "british honduras" OR benin OR dahomey OR bhutan OR bolivia OR "bosnia and herzegovina" OR bosnia OR herzegovina OR botswana OR bechuanaland OR brazil OR brasil OR bulgaria OR "burkina faso" OR "burkina fasso" OR "upper volta" OR burundi OR urundi OR "cabo verde" OR "cape verde" OR cambodia OR kampuchea OR "khmer republic" OR cameroon OR cameron OR cameroun OR "central african republic" OR "ubangi shari" OR chad OR chile OR china OR colombia OR comoros OR

"comoro islands" OR "iles comores" OR mayotte OR "democratic republic of the congo" OR "democratic republic congo" OR congo OR zaire OR "costa rica" OR "cote d'ivoire" OR "cote d'ivoire" OR "cote divoire" OR "cote d ivoire" OR "ivory coast" OR croatia OR cuba OR cyprus OR "czech republic" OR czechoslovakia OR djibouti OR "french somaliland" OR dominica OR "dominican republic" OR ecuador OR egypt OR "united arab republic" OR "el salvador" OR "equatorial guinea" OR "spanish guinea" OR eritrea OR estonia OR eswatini OR swaziland OR ethiopia OR fiji OR gabon OR "gabonese republic" OR gambia OR "georgia (republic)" OR georgian OR ghana OR "gold coast" OR gibraltar OR greece OR grenada OR guam OR guatemala OR guinea OR "guinea bissau" OR guyana OR "british guiana" OR haiti OR hispaniola OR honduras OR hungary OR india OR indonesia OR timor OR iran OR iraq OR "isle of man" OR jamaica OR jordan OR kazakhstan OR kazakh OR kenya OR "democratic people's republic of korea" OR "republic of korea" OR "north korea" OR "south korea" OR korea OR kosovo OR kyrgyzstan OR kirghizia OR kirgizstan OR "kyrgyz republic" OR kirghiz OR laos OR "lao pdr" OR "lao people's democratic republic" OR latvia OR lebanon OR "lebanese republic" OR lesotho OR basutoland OR liberia OR libya OR "libyan arab jamahiriya" OR lithuania OR macau OR macao OR "macedonia (republic)" OR macedonia OR madagascar OR "malagasy republic" OR malawi OR nyasaland OR malaysia OR "malay federation" OR "malaya federation" OR maldives OR "indian ocean islands" OR "indian ocean" OR mali OR malta OR micronesia OR "federated states of micronesia" OR kiribati OR "marshall islands" OR nauru OR "northern mariana islands" OR palau OR tuvalu OR mauritania OR mauritius OR mexico OR moldova OR moldovian OR mongolia OR montenegro OR morocco OR ifni OR mozambique OR "portuguese east africa" OR myanmar OR burma OR namibia OR nepal OR "netherlands antilles" OR nicaragua OR niger OR nigeria OR oman OR muscat OR pakistan OR panama OR "papua new guinea" OR "new guinea" OR paraguay OR peru OR philippines OR philipines OR phillipines OR phillippines OR poland OR "polish people's republic" OR portugal OR "portuguese republic" OR "puerto rico" OR romania OR russia OR "russian federation" OR ussr OR "soviet union" OR "union of soviet socialist republics" OR rwanda OR ruanda OR samoa OR "pacific islands" OR polynesia OR "samoan islands" OR "navigator island" OR "navigator islands" OR "sao tome and principe" OR "saudi arabia" OR senegal OR serbia OR seychelles OR "sierra leone" OR slovakia OR "slovak republic" OR slovenia OR melanesia OR "solomon island" OR "solomon islands" OR "norfolk island" OR "norfolk islands" OR somalia OR "south africa" OR "south sudan" OR "sri lanka" OR ceylon OR "saint kitts and nevis" OR "st. kitts and nevis" OR "saint lucia" OR "st. lucia" OR "saint vincent and the grenadines" OR "saint vincent" OR "st. vincent" OR grenadines OR sudan OR suriname OR surinam OR "dutch guiana" OR "netherlands guiana" OR syria OR "syrian arab republic" OR tajikistan OR tadjikistan OR tadhikistan OR tadhik OR tanzania OR tanganyika OR thailand OR siam OR "timor leste" OR "east timor" OR togo OR "togolese republic" OR tonga OR "trinidad and tobago" OR trinidad OR tobago OR tunisia OR turkey OR "turkey (republic)" OR turkmenistan OR turkmen OR uganda OR ukraine OR uruguay OR uzbekistan OR uzbek OR vanuatu OR "new hebrides" OR venezuela OR vietnam OR "viet nam" OR "middle east" OR "west bank" OR gaza OR palestine OR yemen OR yugoslavia OR zambia OR zimbabwe OR "northern rhodesia" OR "global south" OR "africa south of the sahara" OR "sub-saharan africa" OR "subsaharan africa" OR "africa, central" OR "central africa" OR "africa, northern" OR "north africa" OR "northern africa" OR magreb OR maghrib OR sahara OR "africa, southern" OR "southern africa" OR "africa, eastern" OR "east

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21,550,728

#### **4. Web of Science (SCI/SSCI/AHCI) – Searched 15<sup>th</sup> June 2021**

# 14 107

#13 AND #12 AND #11 AND #10

**Indexes=SCI-EXPANDED, SSCI, A&HCI Timespan=1990-2021**

# 13 8,109,485

TS=(construct\* OR build\* OR maintain\* OR maintenance OR rehabilitat\* OR repair\* OR improv\* OR preserv\* OR restor\* OR renovat\* OR resurfac\* OR renew\* OR refurbish\* OR mend\*)

# 12 40,371

TS=((output\* OR performance\*) AND contract\*)

# 11 186,070

TS=(road\* OR highway\* OR motorway\* OR freeway\*)

# 10 12,687,178

#9 OR #8 OR #7 OR #6 OR #5 OR #4 OR #3 OR #2 OR #1

# 9 11,485,578

CU=(Afghanistan OR Albania OR Algeria OR Angola OR Antigua OR Barbuda OR Argentina OR Armenia OR Armenian OR Aruba OR Azerbaijan OR Bahrain OR Bangladesh OR Barbados OR Benin OR Belize OR Bhutan OR Bolivia OR Botswana OR Brazil OR Brasil OR "Burkina Faso" OR "Burkina Fasso" OR "Upper Volta" OR Burundi OR Urundi OR Cambodia OR "Khmer Republic" OR Kampuchea OR Cameroon OR Cameroons OR Cameron OR Camerons OR "Cape Verde" OR "Central African Republic" OR Chad OR Chile OR China OR Colombia OR Comoros OR "Comoro Islands" OR Comores OR Mayotte OR Congo OR Zaire OR "Costa Rica" OR "Cote d'Ivoire" OR "Ivory Coast" OR Cuba OR "Djibouti" OR "French Somaliland" OR Dominica OR "Dominican Republic" OR "East Timor" OR "East Timur" OR "Timor Leste" OR Ecuador OR Egypt OR "United Arab Republic" OR "El Salvador" OR Eritrea OR Ethiopia OR Fiji OR Gabon OR "Gabonese Republic" OR Gambia OR Gaza OR "Georgia Republic" OR "Georgian Republic" OR Ghana OR "Gold Coast" OR Grenada OR Guatemala OR Guinea OR Guam OR Guiana OR Guyana OR Haiti OR Honduras OR India OR Maldives OR Indonesia OR Iran OR Iraq OR Jamaica OR Jordan OR Kazakhstan OR Kazakh OR Kenya OR Kiribati OR Korea OR Kosovo OR Kyrgyzstan OR Kirghizia OR "Kyrgyz Republic" OR Kirghiz OR Kirgizstan OR "Lao PDR" OR Laos OR Lebanon OR Lesotho OR Basutoland OR Liberia OR Libya OR Madagascar OR "Malagasy Republic" OR Malaysia OR Malaya OR Malay OR Sabah OR Sarawak OR Malawi OR Nyasaland OR Mali OR "Marshall Islands" OR Mauritania OR Mauritius OR "Agalega Islands" OR Mexico OR Micronesia OR "Middle East" OR Moldova OR Moldovia OR Moldovian OR Mongolia OR Montenegro OR Morocco OR Ifni OR Mozambique OR Myanmar OR Myanma OR Burma OR Namibia OR Nepal OR Antilles OR "New Caledonia" OR Nicaragua OR Niger OR Nigeria OR "Mariana Islands" OR Oman OR Muscat OR Pakistan OR Palau OR Palestine OR Panama OR Paraguay OR Peru OR Philippines OR Philipines OR Phillipines OR Phillippines OR "Puerto Rico" OR Rwanda OR Ruanda OR "Saint Kitts" OR "St Kitts" OR Nevis OR "Saint Lucia" OR "St Lucia" OR "Saint Vincent" OR "St Vincent" OR "Grenadines" OR "Samoa" OR "Samoan Islands" OR "Navigator Island" OR "Navigator Islands" OR "Sao Tome" OR "Saudi Arabia" OR Senegal OR Seychelles OR "Sierra Leone" OR "Sri Lanka" OR "Solomon Islands" OR Somalia OR Sudan OR Suriname OR Surinam OR Swaziland OR Syria OR Tajikistan OR Tadjhikistan OR Tadjikistan OR Tadzhih OR Tanzania OR Thailand OR Togo OR "Togolese Republic" OR Tonga OR Trinidad OR Tobago OR Tunisia OR Turkey OR Turkmenistan OR Turkmen OR Uganda OR Ukraine OR Uruguay OR Uzbekistan OR Uzbek OR Vanuatu OR "New Hebrides" OR Venezuela OR Vietnam OR "Viet Nam" OR "West Bank" OR Yemen OR Zambia OR Zimbabwe OR Jamahiriya OR Jamahiryria OR Libia OR Mocambique OR Principe OR Syrian OR "Indian Ocean" OR Melanesia OR "Western Sahara")

# 8 2,456,329

TS=(Afghanistan OR Albania OR Algeria OR Angola OR Antigua OR Barbuda OR Argentina OR Armenia OR Armenian OR Aruba OR Azerbaijan OR Bahrain OR Bangladesh OR Barbados OR Benin OR Belize OR Bhutan OR Bolivia OR Botswana

OR Brazil OR Brasil OR "Burkina Faso" OR "Burkina Fasso" OR "Upper Volta" OR Burundi OR Urundi OR Cambodia OR "Khmer Republic" OR Kampuchea OR Cameroon OR Camerouns OR Cameron OR Camerons OR "Cape Verde" OR "Central African Republic" OR Chad OR Chile OR China OR Colombia OR Comoros OR "Comoro Islands" OR Comores OR Mayotte OR Congo OR Zaire OR "Costa Rica" OR "Cote d'Ivoire" OR "Ivory Coast" OR Cuba OR "Djibouti" OR "French Somaliland" OR Dominica OR "Dominican Republic" OR "East Timor" OR "East Timur" OR "Timor Leste" OR Ecuador OR Egypt OR "United Arab Republic" OR "El Salvador" OR Eritrea OR Ethiopia OR Fiji OR Gabon OR "Gabonese Republic" OR Gambia OR Gaza OR "Georgia Republic" OR "Georgian Republic" OR Ghana OR "Gold Coast" OR Grenada OR Guatemala OR Guinea OR Guam OR Guiana OR Guyana OR Haiti OR Honduras OR India OR Maldives OR Indonesia OR Iran OR Iraq OR Jamaica OR Jordan OR Kazakhstan OR Kazakh OR Kenya OR Kiribati OR Korea OR Kosovo OR Kyrgyzstan OR Kirghizia OR "Kyrgyz Republic" OR Kirghiz OR Kirgizstan OR "Lao PDR" OR Laos OR Lebanon OR Lesotho OR Basutoland OR Liberia OR Libya OR Madagascar OR "Malagasy Republic" OR Malaysia OR Malaya OR Malay OR Sabah OR Sarawak OR Malawi OR Nyasaland OR Mali OR "Marshall Islands" OR Mauritania OR Mauritius OR "Agalega Islands" OR Mexico OR Micronesia OR "Middle East" OR Moldova OR Moldovia OR Moldovian OR Mongolia OR Montenegro OR Morocco OR Ifni OR Mozambique OR Myanmar OR Myanma OR Burma OR Namibia OR Nepal OR Antilles OR "New Caledonia" OR Nicaragua OR Niger OR Nigeria OR "Mariana Islands" OR Oman OR Muscat OR Pakistan OR Palau OR Palestine OR Panama OR Paraguay OR Peru OR Philippines OR Philipines OR Phillipines OR Phillippines OR "Puerto Rico" OR Rwanda OR Ruanda OR "Saint Kitts" OR "St Kitts" OR Nevis OR "Saint Lucia" OR "St Lucia" OR "Saint Vincent" OR "St Vincent" OR "Grenadines" OR "Samoa" OR "Samoan Islands" OR "Navigator Island" OR "Navigator Islands" OR "Sao Tome" OR "Saudi Arabia" OR Senegal OR Seychelles OR "Sierra Leone" OR "Sri Lanka" OR "Solomon Islands" OR Somalia OR Sudan OR Suriname OR Surinam OR Swaziland OR Syria OR Tajikistan OR Tadjhikistan OR Tadjikistan OR Tadjhik OR Tanzania OR Thailand OR Togo OR "Togolese Republic" OR Tonga OR Trinidad OR Tobago OR Tunisia OR Turkey OR Turkmenistan OR Turkmen OR Uganda OR Ukraine OR Uruguay OR Uzbekistan OR Uzbek OR Vanuatu OR "New Hebrides" OR Venezuela OR Vietnam OR "Viet Nam" OR "West Bank" OR Yemen OR Zambia OR Zimbabwe OR Jamahiriya OR Jamahiryria OR Libia OR Mocambique OR Principe OR Syrian OR "Indian Ocean" OR Melanesia OR "Western Sahara")

# 7 308,061

TS=((developing OR (less\* NEAR developed) OR "under developed" OR underdeveloped OR "middle income" or (low\* NEAR income) ) NEAR (countr\* or nation\* or population\* or world) )

# 6 16,213

TS=((developing OR (less\* NEAR developed) OR "under developed" OR underdeveloped OR "middle income" or (low\* NEAR income) ) NEAR (economy or economies) )

# 5 2,902

TS=( low\* NEAR (gdp OR gnp OR "gross domestic" OR "gross national") )

# 4 20,772

TS=(low NEAR/3 middle NEAR/3 countr\*)

# 3 11,833

TS=(Imic OR Imics OR "third world" OR "lami country" OR "lami countries")

# 2 11,906

TS=("transitional country" OR "transitional countries" OR "global south" OR "emerging econom\*")

# 1 544,030

TS=(Africa OR Asia OR Caribbean OR "West Indies" OR "South America" OR "Latin America" OR "Central America" OR "Middle East")

##### **5. Econlit (Ovid) <1886 to June 10, 2021> Searched 15<sup>th</sup> June 2021**

1 (afghanistan or albania or algeria or american samoa or angola or "antigua and barbuda" or antigua or barbuda or argentina or armenia or armenian or aruba or azerbaijan or bahrain or bangladesh or barbados or republic of belarus or belarus or byelarus or belorussia or byelorussian or belize or british honduras or benin or dahomey or bhutan or bolivia or "bosnia and herzegovina" or bosnia or herzegovina or botswana or bechuanaland or brazil or brasil or bulgaria or burkina faso or burkina fasso or upper volta or burundi or urundi or cabo verde or cape verde or cambodia or kampuchea or khmer republic or cameroon or cameron or cameroun or central african republic or ubangi shari or chad or chile or china or colombia or comoros or comoro islands or iles comores or mayotte or democratic republic of the congo or democratic republic congo or congo or zaire or costa rica or "cote d'ivoire" or "cote d'ivoire" or cote divoire or cote d ivoire or ivory coast or croatia or cuba or cyprus or czech republic or czechoslovakia or djibouti or french somaliland or dominica or dominican republic or ecuador or egypt or united arab republic or el salvador or equatorial guinea or spanish guinea or eritrea or estonia or eswatini or swaziland or ethiopia or fiji or gabon or gabonese republic or gambia or "georgia (republic)" or georgian or ghana or gold coast or gibraltar or greece or grenada or guam or guatemala or guinea or guinea bissau or guyana or british guiana or haiti or hispaniola or honduras or hungary or india or indonesia or timor or iran or iraq or isle of man or jamaica or jordan or kazakhstan or kazakh or kenya or "democratic people's republic of korea" or republic of korea or north korea or south korea or korea or kosovo or kyrgyzstan or kirghizia or kirgizstan or kyrgyz republic or kirghiz or laos or lao pdr or "lao people's democratic republic" or latvia or lebanon or lebanese republic or lesotho or basutoland or liberia or libya or libyan arab jamahiriya or lithuania or macau or macao or republic of north macedonia or macedonia or

madagascar or malagasy republic or malawi or nyasaland or malaysia or malay federation or malaya federation or maldives or indian ocean islands or indian ocean or mali or malta or micronesia or federated states of micronesia or kiribati or marshall islands or nauru or northern mariana islands or palau or tuvalu or mauritania or mauritius or mexico or moldova or moldovian or mongolia or montenegro or morocco or ifni or mozambique or portuguese east africa or myanmar or burma or namibia or nepal or netherlands antilles or nicaragua or niger or nigeria or oman or muscat or pakistan or panama or papua new guinea or new guinea or paraguay or peru or philippines or philipines or phillippines or phillippines or poland or "polish people's republic" or portugal or portuguese republic or puerto rico or romania or russia or russian federation or ussr or soviet union or union of soviet socialist republics or rwanda or ruanda or samoa or pacific islands or polynesia or samoan islands or navigator island or navigator islands or "sao tome and principe" or saudi arabia or senegal or serbia or seychelles or sierra leone or slovakia or slovak republic or slovenia or melanesia or solomon island or solomon islands or norfolk island or norfolk islands or somalia or south africa or south sudan or sri lanka or ceylon or "saint kitts and nevis" or "st. kitts and nevis" or saint lucia or "st. lucia" or "saint vincent and the grenadines" or saint vincent or "st. vincent" or grenadines or sudan or suriname or surinam or dutch guiana or netherlands guiana or syria or syrian arab republic or tajikistan or tadjikistan or tadjikistan or tadjhik or tanzania or tanganyika or thailand or siam or timor leste or east timor or togo or togolese republic or tonga or "trinidad and tobago" or trinidad or tobago or tunisia or turkey or turkmenistan or turkmen or uganda or ukraine or uruguay or uzbekistan or uzbek or vanuatu or new hebrides or venezuela or vietnam or viet nam or middle east or west bank or gaza or palestine or yemen or yugoslavia or zambia or zimbabwe or northern rhodesia or global south or africa south of the sahara or sub-saharan africa or subsaharan africa or africa, central or central africa or africa, northern or north africa or northern africa or magreb or maghrib or sahara or africa, southern or southern africa or africa, eastern or east africa or eastern africa or africa, western or west africa or western africa or west indies or indian ocean islands or caribbean or central america or latin america or "south and central america" or south america or asia, central or central asia or asia, northern or north asia or northern asia or asia, southeastern or southeastern asia or south eastern asia or southeast asia or south east asia or asia, western or western asia or europe, eastern or east europe or eastern europe or developing country or developing countries or developing nation? or developing population? or developing world or less developed countr\* or less developed nation? or less developed population? or less developed world or lesser developed countr\* or lesser developed nation? or lesser developed population? or lesser developed world or under developed countr\* or under developed nation? or under developed population? or under developed world or underdeveloped countr\* or underdeveloped nation? or underdeveloped population? or underdeveloped world or middle income countr\* or middle income nation? or middle income population? or low income countr\* or low income nation? or low income population? or lower income countr\* or lower income nation? or lower income population? or underserved countr\* or underserved nation? or underserved population? or underserved world or under served countr\* or under served nation? or under served population? or under served world or deprived countr\* or deprived nation? or deprived population? or deprived world or poor countr\* or poor nation? or poor population? or poor world or poorer countr\* or poorer nation? or poorer population? or poorer world or developing econom\* or less developed econom\* or lesser developed econom\*

or under developed econom\* or underdeveloped econom\* or middle income econom\* or low income econom\* or lower income econom\* or low gdp or low gnp or low gross domestic or low gross national or lower gdp or lower gnp or lower gross domestic or lower gross national or lmic or lmic or third world or lami countr\* or transitional countr\* or emerging economies or emerging nation?).ti,ab,sh,ct,gr,kw. (389262)

2 (road\* or highway\* or motorway\* or freeway\*).ti,ab,kw. (12529)

3 R42.cc. (3962)

Annotation: R42: Transportation Economics: Government and Private Investment Analysis; Road Maintenance, Transportation Planning

4 2 or 3 (15090)

5 ((output\* or performance\*) and contract\*).ti,ab,kw. (6392)

6 (D86 or H57).cc. (5399)

Annotation: National Government Expenditures and Related Policies: Procurement (H57); Economics of Contract: Theory (D86)

7 5 or 6 (11191)

8 (construct\* or build\* or maintain\* or maintenance or rehabilitat\* or repair\* or improv\* or preserv\* or restor\* or renovat\* or resurfac\* or renew\* or refurbish\* or mend\*).ti,ab,kw. (216880)

9 1 and 4 and 7 and 8 (32)

10 limit 9 to yr="1990 -Current" (32)

## **6. TRID Transport database (<https://trid.trb.org/>) – Searched 15<sup>th</sup> June 2021**

a. Keyword Search: "performance-based contract\*" OR "output-based contract\*" linked to index terms: Road Construction & Road Construction Industry – **19**

subject: Administration and Management, Construction, Economics, Finance, Highways, Maintenance and Preservation and with index terms: (Road construction, Road construction industry between dates 1990 – 2021 AND Developing Countries) – **197**

## Appendix D: Steps for study screening

1. **Import study records:** All output files of the implemented search strategy were imported into EPPI.
2. **Removal of duplicate studies:** An automated process within EPPI was used to remove known duplicate files.
3. **Development of study classifiers:** A study classifier was developed using input data from an initial round of title and abstract screening that identifies a probability that a study would be included in the review, using machine-learning techniques.
4. **Title and abstract screening:** The title and abstract (T&A) of all imported and de-duplicated studies were screened by two reviewers using the criteria set out in the protocol. Each reviewer indicated whether (s)he believed the study met the inclusion criteria. In practice, this means assigning a 'yes', 'no' or 'unsure' outcome to each T&A screened. Weekly meetings were held by the review team to reconcile any differences in screening outcomes and make refinements to the screening approach adopted. The output of this process was a set of screened studies that were put forward for full text screening.
5. **Full-text screening:** A full text for each study that met all inclusion criteria defined in the T&A screening was retrieved. Two reviewers examined each full text in detail against the protocol again and assigned a 'yes' or 'no' outcome only. The output of this stage was a set of studies deemed suitable to include in the review.

## Appendix E: Illustrative list of outcomes considered

| <b>Outcome definition</b>   | <b>measure</b> | <b>Example outcome indicators</b>  |
|---|----------------|--|
| <p><b>Costs savings:</b></p> <p><i>Measures related to changes in maintenance costs that generate savings</i></p>   |                | <ul style="list-style-type: none"> <li>● Overall maintenance work cost</li> <li>● Individual maintenance work types costs</li> <li>● Optimal selection of work types</li> <li>● For bundled contracts: Cost of constructed/rehabilitation work performed before maintenance works begin</li> </ul>   |
| <p><b>Road quality:</b></p> <p><i>Measures related to changes in overall road quality over specified period</i></p>   |                | <ul style="list-style-type: none"> <li>● Road usability (keep road open to traffic)</li> <li>● Road durability (pavement, shoulder defects/hazards, drainage, bridges, slows, etc.)</li> <li>● Safety* (guardrails, signs, marking) <ul style="list-style-type: none"> <li>○ Accident mortality*</li> </ul> </li> <li>● User service</li> <li>● Performance indicators such as International Roughness Index (IRI)*</li> <li>● Response times</li> <li>● Optimal selection of work types</li> <li>● Work meets the prespecified indicators in contract</li> <li>● For bundled contracts: Quality of constructed/rehabilitated road before maintenance works begin</li> </ul> |
| <p><b>Collaboration:</b></p> <p><i>Measures related to collaboration between the service provider (road maintenance firm) and owner/customer (the government)</i></p> |                | <ul style="list-style-type: none"> <li>● <i>Innovative service delivery</i></li> <li>● Higher responsiveness</li> <li>● Greater motivation (service provider is incentivized to achieve best results to maximize financial gain)</li> </ul>  |
| <p><b>Direct user benefits:</b></p> <p><i>Measures related to convenience or personal safety of road users, due to improved road conditions</i></p>                   |                | <ul style="list-style-type: none"> <li>● Vehicle operating costs</li> <li>● Travel time</li> <li>● Highway safety [reduced fatal accidents; reduced non-fatal accidents]</li> <li>● Generated Traffic</li> </ul>   |

Note: additional outcomes within these categories were included when identified

## Working Paper Series

International Initiative for Impact Evaluation  
Unit no. 306, 3rd Floor, Rectangle-1  
D-4, Saket District Centre  
New Delhi – 110017  
India

[3ie@3ieimpact.org](mailto:3ie@3ieimpact.org)  
Tel: +91 11 4989 4444



[www.3ieimpact.org](http://www.3ieimpact.org)

