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Maximiliano Lauletta
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Inter-American Development Bank
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· Maximiliano Lauletta · Martín A. Rossi · Juan Cruz Vieyra · Diego Arisi ·

IDB

ABSTRACT*

This paper analyzes the impact of *MapaRegalías* on efficiency in the execution of public investment projects in Colombia. *MapaRegalías* is an online platform that displays geo-referenced information and data on royalties coming from the extractives sector. The purpose of the platform is to reduce the cost incurred by public officials and citizens when monitoring the use of royalties. The main finding is that after the release of *MapaRegalías*, public investment projects financed with royalties showed an average increase in efficiency of execution of 7.996 percentage points.

JEL Codes: D73, O31, H83, H50, L78, O54
Keywords: digital innovation, efficiency, public investment, transparency

* Maximiliano Lauletta: Universidad de San Andrés, University of California, Berkeley, maximiliano_lauletta@berkeley.edu. Martín Rossi, Universidad de San Andrés, mrossi@udesa.edu.ar. Juan Cruz Vieyra, Inter-American Development Bank (IDB), juancr@iadb.org. Diego Arisi, IDB, diegor@iadb.org. The authors are grateful to Lea Gimenez, Division Chief of the Innovation in Citizen Services Division (IDB), Phil Keefer, Principal Economic Advisor, Institutions for Development Sector (IDB), and Roberto de Michele, Coordinator of the Transparency Cluster (IDB), for their excellent comments and suggestions. They also thank Luis Alberto Rodríguez, Director of the National Planning Department, and Carolina Londoño, Manager of the *MapaInversiones* Program (National Planning Department), for their leadership and collaboration with the IDB since the inception of *MapaRegalías*. The authors are indebted to Alejandro Baron for his outstanding contributions to previous drafts and to Antonia Vazquez, who provided critical research assistance. We are also grateful to José Niño, Diego Hernán Pérez, Liliana Cañas, and Gabriela Cohen for their valuable inputs.

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INTRODUCTION

Adequate and targeted access to information is crucial to enable citizens to monitor the activities of public institutions (Rose-Ackerman and Palifka, 2016). In turn, citizen monitoring or accountability can be a powerful force to detect and help deter corrupt activities (Klitgaard, 1988).[1] Since corruption reduces the efficiency of public projects, especially those funded by public investment (see Tanzi and Davoodi, 1997), lowering the cost to citizens of accessing information about public projects can potentially have a deterrent effect on corruption in those projects[2] while positively affecting the efficiency of their execution—the "watch effect."[3] At the same time, and as community members benefit the most from public investment projects, they may have greater incentives than government bureaucrats to monitor the execution of public projects (Stiglitz, 2002).[4]

There is scant, but solidly rooted, empirical literature on the effects of increasing grassroots monitoring on efficiency. Björkman and Svensson (2009) ran a field experiment in Uganda and report that increasing grassroots participation in monitoring health service providers led to large improvements in utilization and health outcomes, including reduced child mortality and increased child weight. Recently, Lagunes (2017) found that when information on public works is made public and combined with tools such as randomized audits, there may be a reduction in project cost overruns of up to 50 percent.

Most of the literature on the effects of grassroots monitoring is focused on small-scale programs whose characteristics may not be readily scalable to large-scale public investment projects. This paper contributes to the literature by studying the impact of a large-scale program that has released information on the origin and subsequent use of billions of dollars on more than 10,000 public investment projects. In particular, the *MapaRegalías* platform in Colombia is studied to capture the impact of reducing the cost of monitoring public investment projects on efficiency in the execution of these projects. The study finds that the release of *MapaRegalías* was associated with an overall increase in efficiency, as measured by the time

[1] Publishing information can also yield other positive effects, such as generating positive impressions about government activity among citizens. As Alessandro et al. (2019) show, providing information to citizens matters for shaping perceptions about transparency.

[2] In the classical Becker-Stigler corruption model (1974), the platform would be a useful tool to prevent and/or detect the probability of corruption.

[3] These platforms help to solve the collective action problem of curbing corruption, as explained in Pieth (2012), since they allow individuals to use ad hoc channels through which they can directly address executing agencies about concrete projects. For more information about collective action dilemmas in corruption, see Pieth (2012).

[4] This approach is not without drawbacks, for two main reasons: first, the monitoring of public projects is a public good (which may incentivize free-riding); second, grassroots monitoring may be susceptible to be captured by local elites (Bardhan, 2002; Bardhan and Mookherjee, 2006).

it takes to complete or finalize a public investment project.

Colombia's National Planning Department, with support from the Inter-American Development Bank (IDB), released the *MapaRegalías* platform in 2014 with the aim of facilitating access to and the use of public information by both citizens and public officials (Vieyra and Masson, 2014). In a nutshell, the purpose of *MapaRegalías* is to reduce the cost incurred by citizens and government officials to monitor the government's use of resources[5] by allowing them to see geo-referenced information and data on royalties coming from the extractive sector.[6]

Thanks to this platform, the whole public investment cycle financed by Colombia's General Royalties System, from the extraction of resource to the disbursement of funds, is available online. Before its release, citizens were either unable to find out how the government spent resources from royalties or had to undertake costly searches to do so (by, for example, going to ministries in person and/or waiting for an official to answer their queries). In addition to being a citizen-centered tool, the platform provides an internal management dashboard for public officials and decision makers. In this way, the platform aims to reduce the possibility of arbitrary allocation of resources by officials.

In addition to analyzing the linkage between access to information, citizen monitoring, and public project efficiency, this paper also ties in with the literature on the impact of technological improvements on state capacity (see, for example, Muralidharan, Niehaus, and Sukhtankar, 2014). Improvements in state capacity, of which *MapaRegalías* is an example, can improve efficiency while increasing citizens' trust in government and changing their attitude toward transparency (Bersch, Praça, and Taylor, 2013; Bertot, Jaeger, and Grimes, 2010; Heeks, 1998; Pathak et al., 2009).

[5] The cost can be measured in either time, money, or a combination of these. For example, having to attend a public office in person and wait for hours to gather information on the use of royalties is time costly, which translates into lost wages for the hours not worked.

[6] Royalties (or *regalías*) are tax revenues stemming from extraction of the country's natural resources, which are subsequently channeled into the General Royalties System and used to finance public investment projects at the local level.

1

CONTEXT OF THE INTERVENTION: THE STATE OF ROYALTIES AND PUBLIC INVESTMENTS IN COLOMBIA

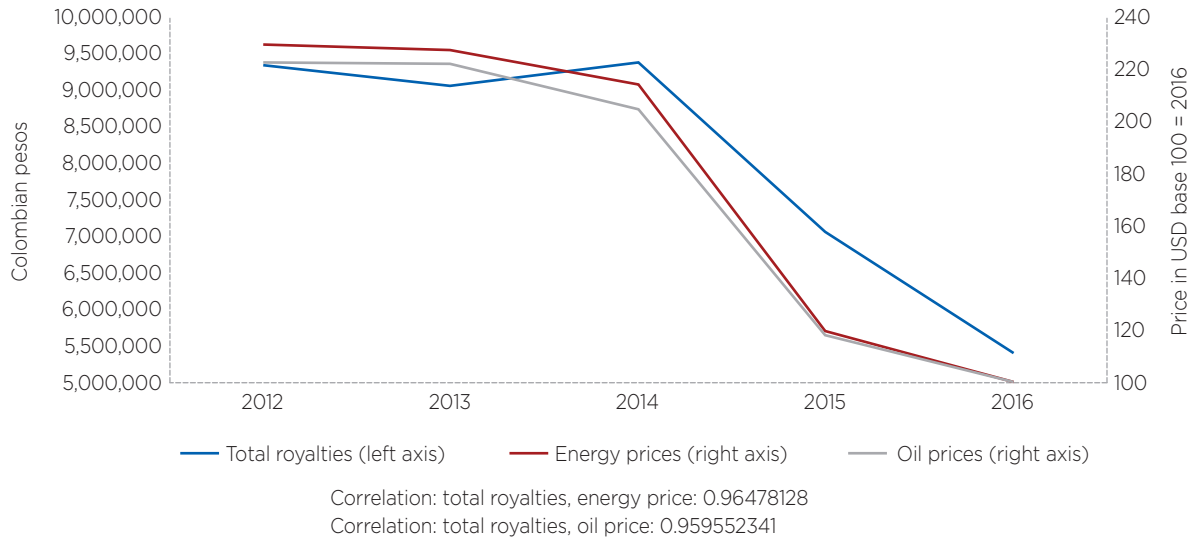
The State of Royalties in Colombia

Since 2010, public investments in Colombia have increased steadily, from nearly 2.5 percent of GDP at the beginning of the century to 4 percent of GDP in 2012 and 2013 (OECD, 2015). One source of funding of public investments are royalties, the taxes levied on oil and mining companies. As in the rest of Latin America, a boom in commodity prices fueled growth in public investments through royalties. This resource-related affluence of the extractive sector created the conditions for the expansion of capital expenditures by the State, which reached their peak in 2013–14 (Armendariz and Contreras, 2016; ECLAC, 2018; OECD, 2015), as Figure 1 shows. As such, royalty income (which is highly correlated with prices) drastically fell after 2014.

In numbers, royalties increased from 0.6 percent of GDP in 2002 to 1.66 percent in 2012. The Colombian State received nearly U$100 billion Colombian pesos in 2012 (Figure 1), more than doubling the yearly average of $44.5 billion Colombian pesos between 1995 and 2011 (Ministry of Finance, 2011). Royalty spending in projects peaked, especially in 2012/2013 with the creation of the General Royalties System. After the commodity price bust in 2014, however, the amount of royalties destined to projects funded by the General Royalties System fell overall, but the decrease was not constant every year. Moreover, although royalty income from 2014 to 2015 fell, the total amount of resources (and of royalties, as a share of these resources) destined to projects rose, since projects can be funded by royalties and other sources.

Before 2011, the Constitution mandated that royalties were to be distributed mainly to the subnational entities where the exploitation and extraction of national resources took place. A smaller proportion was given to the National Royalties Fund, a national fund in charge of distributing these resources. There were flaws and inefficiencies in the decision-making process for royalty allocation to the subnational level. Several studies show that prior to 2014, royalties did not guarantee an improvement in socioeconomic development and quality of life for the population (Bonet and Urrego, 2014; Hernández, 2010; Rojas, 2015). On the contrary, the municipalities that received royalties from the government became fiscally dependent (Zapata, 2010), their risk of corruption increased (Arisi and Gonzalez, 2014), and they exhibited problems related to equity, efficiency, and transparency (Echeverry, Alonso, and García, 2011).

FIGURE 1 **EVOLUTION OF ROYALTY INCOME VS. COMMODITY PRICES**



Sources: Total royalties: Ministry of Finance and Public Credit, Colombia (left axis); IMF Commodity Data Portal, available at: https://data.imf.org/?sk=471DDDF8-D8A7-499A-81BA-5B332C01F8B9 (right axis).

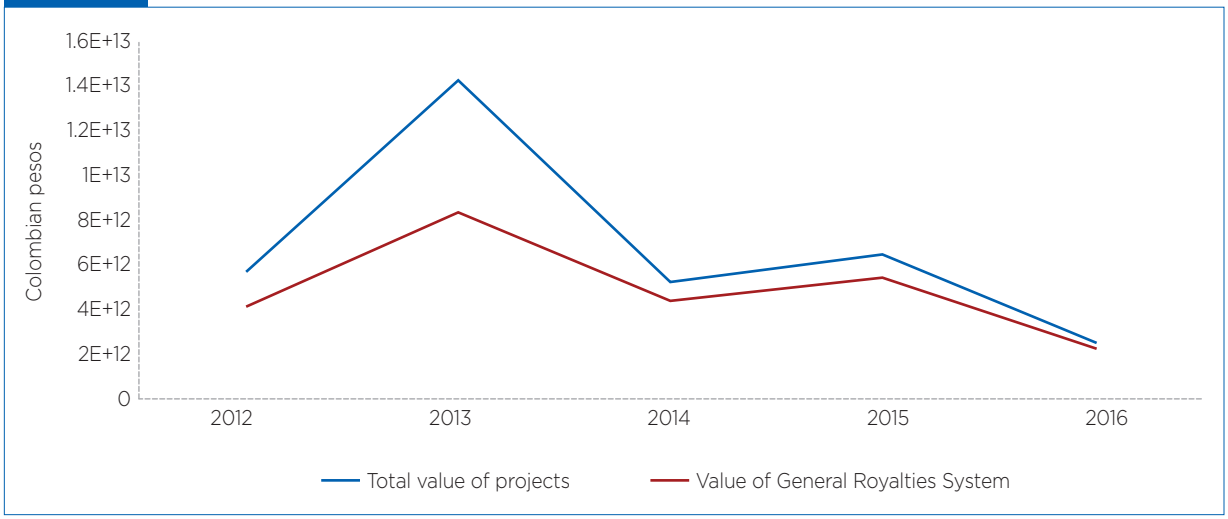
In 2011, Congress passed a constitutional reform (Acto Legislativo 05) to modify Articles 360 and 361 of the Constitution. This amendment created the new General Royalties System, which was further regulated by Act 1530 of 2012. This system's main goals were to reduce the concentration of revenues derived from royalties in a small number of subnational entities; increase overall savings; improve governance of these resources by sharing decision making among municipal, departmental, and national levels;[7] and tackle corruption in their administration by increasing transparency and strengthening administrative control systems.

The constitutional reform mainly fixed the distribution and destination of the resources, and changed the mechanisms for management, monitoring, and control of royalties. From then on, resources channeled through the General Royalties System had three main objectives: (i) to fund investment projects, (ii) to provide savings for the future, and (iii) to finance the pension liabilities of the subnational entities. According to these objectives, public investments should be aimed at generating impacts on regional and local development, especially regarding a number of indicators that consider social, economic and environmental factors, as well as science, technology, and peace building. According to the Royalties Resources Plan for the period 2013–2022 (published by the National Planning Department), 61.4 percent of royalties should be used for investments.

Furthermore, the reform created legal mechanisms to strengthen the institutions that manage the General Royalties System. These include oversight mechanisms, such as a monitoring, control, and evaluation system. According to Arisi and Gonzales (2014), this system is a fundamental transparency tool. Its goals are to ensure efficient and effective use of resources and strengthen transparency, citizen

[7] The reform created decision and management bodies to identify the investment projects that receive funds from the General Royalties System. These bodies also in charge of assessing, prioritizing, and approving the projects' funding and designating the public agency in charge of their execution (Article 6, Act 1530 of 2012).

FIGURE 2 **TOTAL VALUE OF PROJECTS AND SHARE OF FINANCING FROM THE GENERAL ROYALTIES SYSTEM**



Source: Authors' calculations based on data from the National Planning Department.

participation, and good governance (Act 1530 of 2012). To achieve these goals, the monitoring, control, and evaluation system has a normative and procedural framework that covers activities centered on prevention. It also includes mechanisms that guarantee the provision of information on royalty-financed public investments in real time[8] and alert the need to sanction noncompliant institutions.

Characteristics of Royalty Investments before *MapaRegalías*

On July 15, 2014 (the last day that data were published before the intervention started), there were 4,508 projects funded with royalties in Colombia, of which 62.34 percent were in execution, 23.36 percent did not have a contract, and 14.29 were in the contracting process (Table 1).

As shown in Figure 3, the majority of the projects were located in the Caribbean region (23.76 percent). The least represented was the Eje Cafetero region (12.09 percent), as well as the projects specially designated for the Magdalena River.

TABLE 1. AVERAGE ROYALTIES AS A PERCENTAGE OF CAPITAL INCOME, 2014

Status of project	Quantity	Percentage
Project in progress	2,811	62.34
Projects without a contract	1,053	23.36
In contracting process	644	14.29

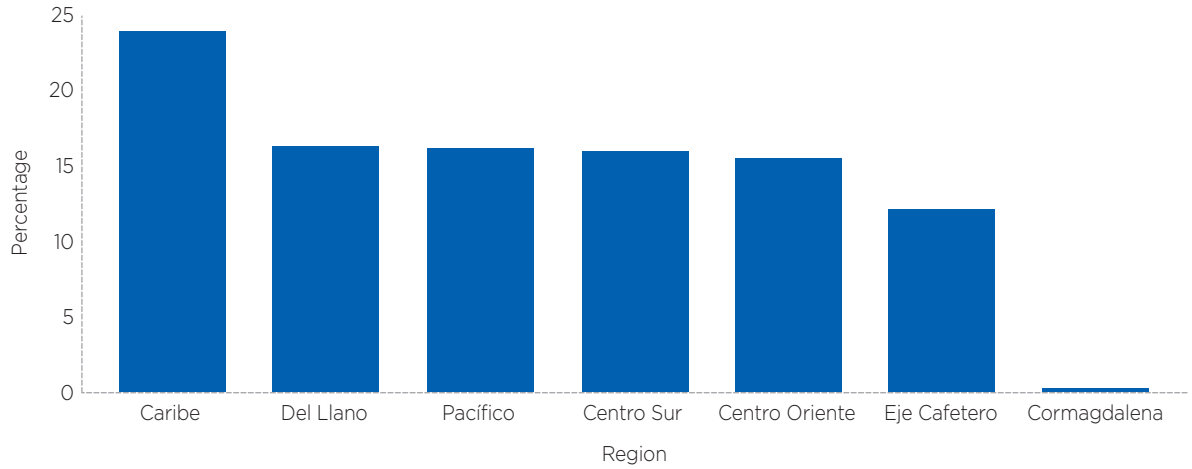
Source: Authors' calculations based on data from the National Planning Department.
Note: This analysis excludes completed and disapproved projects, among others.

Figure 4 shows the distribution of projects by department. The majority of the projects were in Antioquia, Meta, and Nariño, while Bogota, San Andres, and Vaupes, had the fewest.[9]

[8] One of those mechanisms is GESPROY, a software program that allows the implementer to manage and monitor execution of all projects funded with General Royalties System resources, providing information based on the project's goals, products, targets, and indicators.

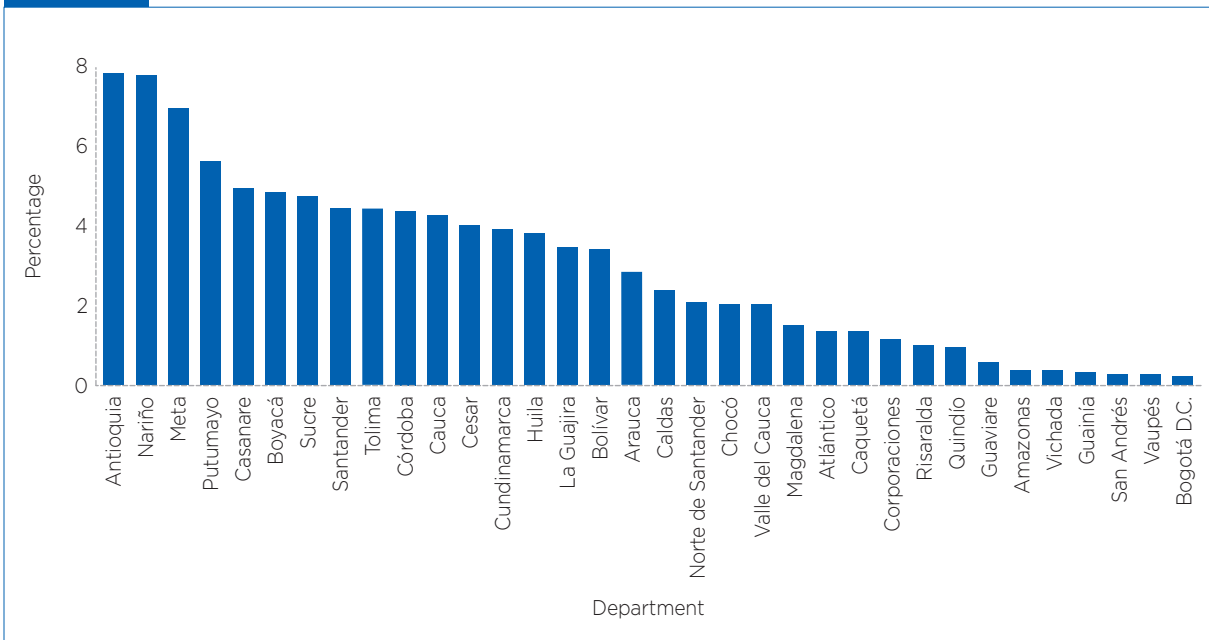
[9] Legally, Bogota is not a department. However, the National Planning Department considers it a department for the purposes of disseminating this information.

FIGURE 3 **PUBLIC INVESTMENT PROJECTS, BY REGION FINANCED BY ROYALTIES, JULY 2014**



Source: Authors' calculations based on data from the National Planning Department.

FIGURE 4 **PUBLIC INVESTMENT PROJECTS, BY DEPARTMENT FINANCED BY ROYALTIES, JULY 2014**

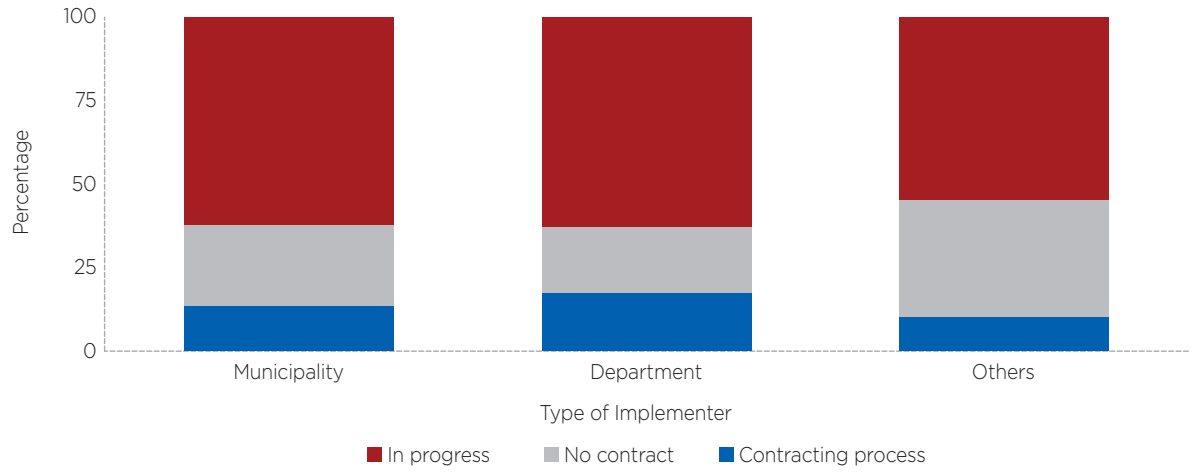


Sources: Authors' calculations based on data from the National Planning Department.

Similarly, the main type of implementing agency was municipalities (65.46 percent of the projects), followed by departments (28.35 percent). Other types of entities, such as autonomous corporations and others, implemented the remaining 6.19 percent of projects.

Figure 5 shows project status by type of implementer. Municipalities and departments

FIGURE 5 **PUBLIC INVESTMENT PROJECT STATUS, BY TYPE OF IMPLEMENTER, JULY 2014**



Source: Authors' calculations based on data from the National Planning Department.

have a similar percentage of contracts in progress (62.76 and 64.07 percent, respectively). The percentage of projects without a contract is larger for municipalities (23.92 percent compared to 19.48 percent for departments), while the percentage of projects undergoing a contracting process is larger for departments (17.45 percent, compared to 13.32 percent for municipalities).

Among the projects implemented by the municipality (2,925), most of the municipalities (85.98 percent) have population sizes below 10,000 inhabitants and have very low levels of revenue. Only a small fraction of municipalities has large populations and high levels of revenue.

Table 2 shows that the most important sector for the projects under analysis is transportation, which represents 27.15 percent of the total. This sector is followed by housing, city, and territory; agriculture; culture, sports, and recreation; and education. These five sectors make up 76.11 percent of the projects.

Figure 6 focuses on the main five sectors. The category "others" includes the remaining sectors. The sector with the highest percentage of projects in progress is transportation, while the agriculture sector has the highest percentage of projects without a contract.

On July 15, 2014, the average physical progress of ongoing projects (meaning that they had a signed contract and were in the implementation phase) was 21.34 percent, while average financial progress was 25.53 percent. Accounting for time, the average physical progress of ongoing projects was 12.24 percent for projects between 180 and 269 days and 30.83 percent for the most recently authorized projects (Table 3). Financial progress averaged 25.81 percent.

Table 4 shows the average physical and financial progress by type of implementer for ongoing projects.

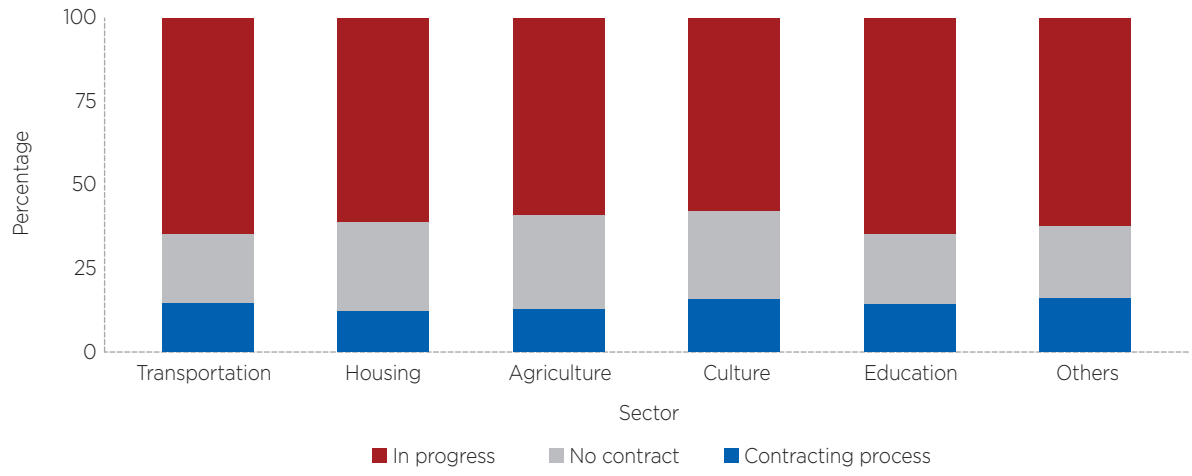
Table 5 shows that the sectors with the most average physical and financial progress are education and transportation, while the worst performers are housing and agriculture.

TABLE 2. NUMBER OF PUBLIC INVESTMENT PROJECTS FINANCED BY ROYALTIES, BY SECTOR

Sector	Number	Percentage
Transportation	1,224	27.1517
Housing, cities, and territory	647	14.3523
Agriculture	563	12.4889
Culture, sports, and recreation	504	11.1801
Education	493	10.9361
Social inclusion and reconciliation	233	5.1686
Science and technology	215	4.7693
Environment and sustainable development	166	3.6823
Health and social protection	155	3.4383
Mining and energy	146	3.2387
Commerce, industry, and tourism	47	1.0426
Planning	41	0.9095
Interior	27	0.5989
Labor	13	0.2884
Justice and law	11	0.2440
Communications	10	0.2218
Defense	9	0.1996
Statistics	3	0.0665
Foreign relations	1	0.0222

Source: Authors' calculations based on data from the National Planning Department.

FIGURE 6 **PUBLIC INVESTMENT PROJECT STATUS BY SECTOR, JULY 2014**



Source: Authors' calculations based on data from the National Planning Department.

TABLE 3. PHYSICAL AND FINANCIAL PROGRESS OF ONGOING PROJECTS FUNDED BY ROYALTIES, BY NUMBER OF DAYS SINCE AUTHORIZATION OF PROJECT

Number of days between authorization and July 15, 2014	Average physical progress	Average financial progress	Number of projects
0 to 89 days	30.83	34.38	24
Between 90 and 179 days	18.64	18.31	58
Between 180 and 269 days	12.24	14.36	274
Between 270 and 359 days	18.37	22.08	649
Between 360 and 449 days	20.63	27.12	541
Between 450 and 539 days	26.49	27.76	205
Between 540 and 629 days	24.44	30.46	577
Between 630 and 719 days	26.34	29.15	378

Source: Authors' calculations based on data from the National Planning Department.

TABLE 4. PROGRESS OF PROJECTS FUNDED BY ROYALTIES, BY TYPE OF IMPLEMENTER

Type of implementer	Average physical progress	Average financial progress
Municipality	23.60	27.86
Department	17.88	23.47
Others	13.13	9.27

Source: Authors' calculations based on data from the National Planning Department.

TABLE 5. PROGRESS OF PROJECTS FUNDED BY ROYALTIES, BY SECTOR

Sector	Average physical progress	Average financial progress
Transportation	24.32	29.21
Housing, cities, and territory	17.03	23.14
Agriculture	21.50	21.91
Culture, sports, and recreation	18.95	28.30
Education	26.30	28.56
Others	19.06	21.93

Source: Authors' calculations based on data from the National Planning Department.

2

MAPAREGALÍAS PLATFORM LAYOUT AND USER EXPERIENCE

The *MapaRegalías* website was launched in August 2014. The platform is laid out in the following way:[10]

Home

The Home page contains a map and tabs displaying information about projects, sources of funding, and levels of production of the natural resources whose royalties are allocated to public investment projects.

When the user scrolls across the interactive map, projects are displayed in a geo-referenced manner. Citizens can view each region or department to see how many projects were approved and the amount of each project or the total number per territory. Other details provided are the source of financing, the level of financial and physical progress, the beneficiary entities, the companies that were hired and even the names of the individuals acting as project supervisors or auditors at the local level. On the landing page and in all sections of the tool, the user can directly access GESPROY, the information system containing and distributing data about public investments carried out within the National Planning Department, to be redirected to the updated summary of execution of the projects approved at national level.

Projects

The projects tab opens to a map showing projects funded with royalties. The search can be done by layers of granularity: region, department, municipality, project status (approved, disapproved, not viable, not approved, updated, verified, feasible), project sector (e.g., agriculture), and period. The user can also directly search on the map for a specific region or department. Each project has an individual profile in *MapaRegalías,* with general and specific project data, such as information about the amount executed, funding sources, executing body, beneficiaries, contractors and auditors, and compliance goals. Moreover, all profiles have pop-up windows to share information on the projects on social media, send key information via email, or print it. Finally, the photo gallery allows the user to observe the actual level of implementation of projects and to clearly identify the types of projects under construction.

At the bottom of the project profiles, as well as in the rest of the portal components, there are two sections. The first section provides a table containing the source of data by type of information: projects, targets and compliance indicators, budget, drafts, hydrocarbon production, mining

[10] Appendix A shows figures of the platform's layout.

production, distribution, hydrocarbon control, mining control, and direct financial performance. It shows the source, the date that it was last updated, and the cut of the data to inform the user about the temporality of the same. The second section provides a hyperlink to the system of requests, complaints, and suggestions. Here users are redirected to the General Royalties System portal, where they can provide contact information and a message, as well as upload a file if necessary.

Resources

The resources tab shows the royalties received by each municipality or department, and the project in which they are invested. The search can be done through the map or through the available filters. The resources pages are very similar in information and functionalities to the project pages. In each expenditure period (year), the user can check the budget, distribution, rotation, approval, execution, and net royalties, among other data. Details about the source of the resources are available in each category, and monthly details are provided on the resources drawn down and the net royalties remaining.

Production

The production tab shows which hydrocarbons and minerals are produced in each municipality and department. They can be searched through the map that appears in the page or through the territorial filters available. Production can be explored by territory or project, and graphs are included. The corresponding royalties per resource are also listed.

Inspection

The inspection tab contains information on the activities carried out in the department, whether mining or hydrocarbons, to verify compliance with the rules and exploration and exploitation contracts. Data can be searched by year, type of mineral, number of projects inspected per mineral or territory, among other criteria. As an example, see Figure A5.

Internal dashboard

In addition to the sections mentioned above, *MapaRegalías* has an internal dashboard. To access it, the user must be authorized. Authorized users may access reports with more detailed information on the projects, total production, and settlement, as well as a summary of approvals and the rotation of resources. These reports are online files that consolidate the information available in *MapaRegalías,* and the information can be exported in Excel format for further analysis. Project implementers and citizens can contact the National Planning Department and request personalized reports. These reports are possible thanks to business intelligence components associated with the platform. The internal dashboard also has an updated control system, using traffic lights (yellow-green-red) to help monitor the status of projects.

The internal dashboard also facilitates the responsibility of the National Planning Department as a control entity and creates an incentive to improve efficiency and transparency in the country because it operates as a channel through which entities upload and update data on public investment projects. By legislative mandate, executing agencies are required to upload accurate information within the stipulated timeframe. Failure to comply with these requirements may lead to preventive measures (e.g., suspension of transfers of funds to the local level), or corrective actions and sanctions, such as imposition of fines or removal of projects (Sánchez, 2012). In 2016, 125 municipalities in Colombia were temporarily suspended from receiving funds from the General Royalties System because they failed to update project data on the National Planning Department's information platforms. Therefore, the internal dashboard creates an inter-institutional responsibility between the National Planning Department and governmental entities (Arisi and Gonzalez, 2014).

3

DATA, ECONOMETRIC MODEL, AND RESULTS

The most appropriate criteria for success are the project objectives. The degree to which these objectives are met determine the success of a project. For successful outcomes, management efforts tend to be restricted to cost, time, and quality/performance (De Wit, 1988). In the last 50 years, cost, time, and quality (the so-called "iron triangle") have become inextricably linked with measuring the success of project management (Atkinson, 1999). This study uses the projects' percentage of physical progress as a measure of efficiency.

The study uses monthly data on projects funded by royalties. Each project has a monthly time series indicating the percentage of physical progress, which is the outcome of interest. Projects that only have data after or before the release of *MapaRegalías* were discarded, since the analysis is only concerned with how the release of this platform impacted projects' physical progress.[11] The sample was restricted to an eight-month window around the release of *MapaRegalías* in August 2014 (that is, eight months before and after the release), to avoid contaminating the estimation of the effect by other events that took place well after or before the release (for a similar approach, see Munyo and Rossi, 2015). The final sample consists of 321 projects. Table 6 presents the summary statistics.

Even though the data consist of a panel of projects observed over time, a before-and-after approach is employed to estimate the effect of the release of *MapaRegalías* on the physical progress of the projects. This approach compares the outcome of interest (percentage completed of each project) after and before the intervention. The before-and-after approach is used since all projects are treated (that is, they are all uploaded to the *MapaRegalías* platforms), and all are treated at the same time. A linear monthly time trend and a quadratic monthly time trend are included to account for the evolution of the project's physical progress over time. The linear monthly time trend covers 17 months and the quadratic monthly time

[11] There were 18 projects discarded with a 100 percent completion.

TABLE 6. SUMMARY STATISTICS

Variable	Observations	Mean	Standard deviation
Percentage complete	1,637	47.801	35.728

Source: Authors' calculations based on GESPROY.

trend is the square of the linear monthly time trend.

Formally, the study estimates the following regression model:

$$PercentageComplete_{it} = \alpha + TimeTrend_t + \beta MapaRegalias_t + \varepsilon_{it} \quad (1)$$

where $PercentageComplete_{it}$ denotes the physical progress as a percentage of project *i* at time *t*, $TimeTrend_t$ is a time trend (including linear and quadratic trends), $MapaRegalias_t$ is a dummy variable equal to 1 after August 2014 and 0 otherwise, and ε_{it} is the error term. The parameter of interest is β, which indicates how the release of *MapaRegalías* impacted the project's physical progress. The observations are at the project-month level. The identification assumption of this strategy is that, conditional on the included controls (the time trend), the error term is uncorrelated with the treatment (the introduction of *MapaRegalías*).

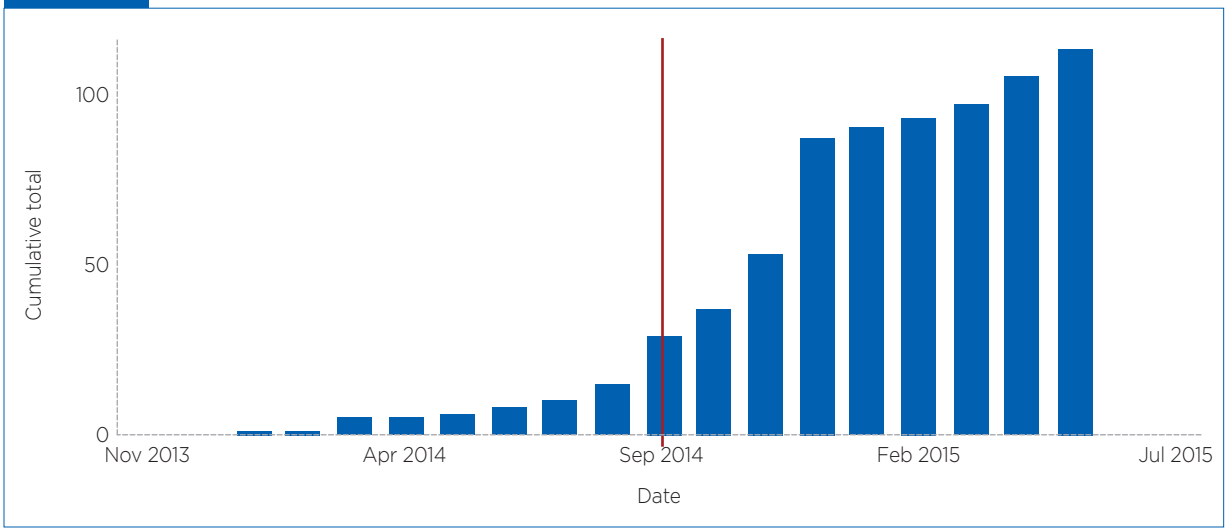
The standard assumption in econometrics is that errors are independent. In this particular context, however, there might be potential correlation between errors for the same project. Thus, in every regression, standard errors are clustered at the project level.

Figure 7 presents a preview of the main results. It shows the cumulative number of physically completed projects from the beginning of 2014 to the end of 2015. It is evident that the cumulative number of finished projects grows rapidly following the launch of the platform in August of 2014.

Table 7 reports OLS estimates of equation (1). Column (1) reports the estimates of the impact of the release of *MapaRegalías,* including a linear time trend. The estimated coefficient indicates that, after the release of *MapaRegalías*, projects show an average increase in its percentage physical progress of 16.389 percentage points, and this estimate is significant at the 1 percent level. Column (2) includes a quadratic time term, and the main result remains unchanged: the release of *MapaRegalías* is associated with a 9.882 percentage point increase in the project's physical progress, and this result is also significant at the 1 percent level.

Column (3) considers a linear time trend while including project fixed effects, and the main result remains: the release of *MapaRegalías* is associated with an increase of

FIGURE 7 **CUMULATIVE NUMBER OF COMPLETED PROJECTS**



Source: Authors' calculations based on data from the National Planning Department.

TABLE 7. MAIN RESULTS (*EFFICIENCY, 8-MONTH WINDOW*)

	Percentage complete				
Variables	(1)	(2)	(3)	(4)	(5)
MapaRegalías	16.389*** (2.808)	9.882*** (2.708)	11.079*** (2.118)	7.386*** (1.973)	7.996*** (2.053)
Quadratic trend	No	Yes	No	Yes	Yes
Project fixed effects	No	No	Yes	Yes	Yes
Election dummy	No	No	No	No	Yes
Observations	1,637	1,637	1,637	1,637	1,637
R-squared	0.103	0.134	0.296	0.314	0.315

Source: Authors' calculations based on GESPROY.
Notes: Standard errors clustered at the project level are reported in parentheses. All models include a linear time trend. The variable election dummy takes value of one after May 2014. *** p<0.01, ** p<0.05, * p<0.10.

11.079 percentage points in the project's physical progress, which is significant at the 1 percent level. This indicates that the rate of completion of a project increased faster after the introduction of *MapaRegalías,* controlling for the average trend in completion across all projects. Column (4) considers a quadratic time trend while including project fixed effects, and the main result remains: the release of *MapaRegalías* implies an increase of 7.386 percentage points in project physical progress, and this result is significant at the 1 percent level.

Finally, the preferred specification is shown in Column (5). It considers a quadratic time trend while including project fixed effects and an election dummy that takes the value of 1 after May 2014 to account for the possible effect of the presidential elections. The main result remains: the release of *MapaRegalías* implies an increase of 7.996 percentage points in project's physical progress, and this result is significant at the 1 percent level.

All of these estimates indicate that the release of *MapaRegalías* is associated with an increase in the physical progress of projects around a window of eight months before and after its release. In every regression, the estimated coefficient is positive and statistically significant, and the main findings are robust to the inclusion of a quadratic time trend, project fixed effects, and an election dummy.

As a robustness check, Table 8 presents the preferred specification for all the projects that started before *MapaRegalías* and finished or where they are ongoing afterward, for different month-window times. Column (1) corresponds to all projects that started before *MapaRegalías* and finished or were ongoing afterward. Column (2) corresponds to a nine-month window before and after the release of the platform, column (3) to a seven-month window, column (4) to a six-month window, column (5) to a five-month window and column (6) to a four-month window. All results remain the same.

The results present suggestive evidence that the release of *MapaRegalías* induced an increase in the physical progress of the projects compared to the trend before the intervention. Royalties rise and fall depending on external conditions. Thus, when commodity prices are high, it is plausible to assume that total public investment is also high, including public investment channeled to subnational governments.

TABLE 8. PREFERRED PROJECT SPECIFICATION: ROBUSTNESS CONTROL (*MONTHS-WINDOWS*)

	Percentage complete					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
MapaRegalías	10.309*** (2.017)	10.427*** (2.177)	5.058** (2.057)	2.882 (2.396)	6.044** (2.578)	6.755** (3.021)
Time	0.230 (0.614)	4.143** (2.031)	15.669*** (3.546)	23.652*** (5.997)	13.305 (8.454)	–2.533 (11.139)
Quadratic trend	0.009 (0.008)	–0.059 (0.038)	–0.259*** (0.066)	–0.408*** (0.112)	–0.225 (0.160)	0.087 (0.212)
Election dummy	14.060*** (2.654)	8.809*** (2.904)	–0.049 (3.163)	–4.521 (4.057)	–0.392 (4.590)	4.198 (4.766)
Constant	14.196 (9.013)	–30.054 (24.958)	–179.743*** (44.392)	–279.522*** (75.518)	–141.717 (106.356)	53.306 (140.977)
Observations	3,401	1,803	1,462	1,235	883	735
R-squared	0.306	0.307	0.341	0.315	0.221	0.203

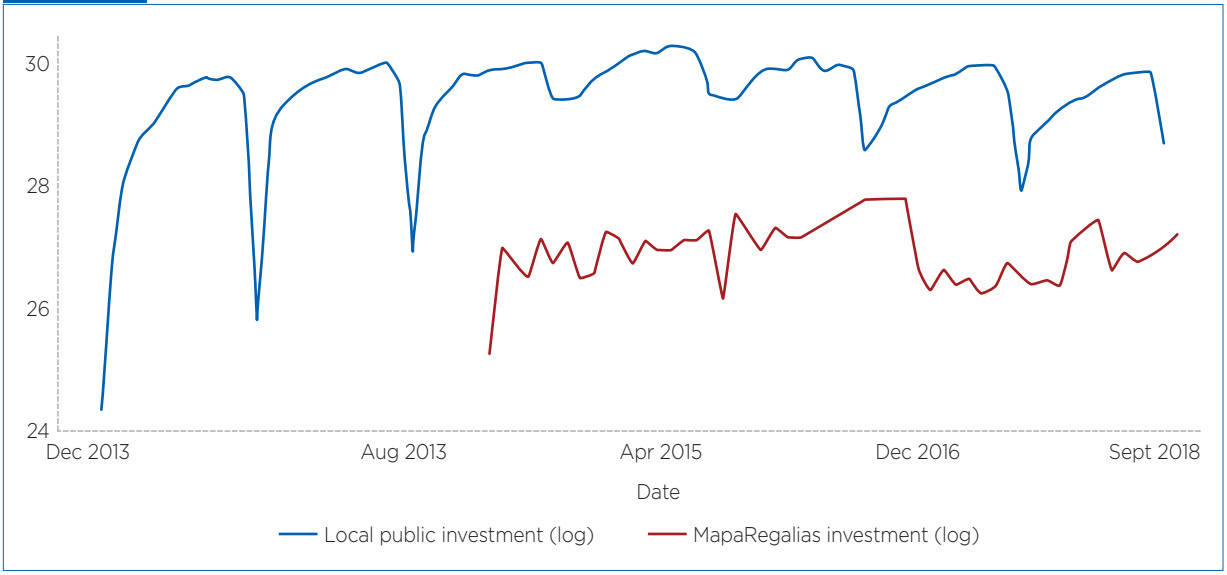
Source: Authors' calculations based on GESPROY.
Notes: Standard errors clustered at the project level are reported in parentheses. Column (1) corresponds to all projects that started before *MapaRegalías* and finished or were ongoing afterward. Column (2) corresponds to a window of nine-months previous and after the release of the platform, column (3) to a seven-month window, column (4) to a six-month window, column (5) to a five-month window and column (6) to a six-month window, All models include a linear time trend and project fixed effects. *** p<0.01, ** p<0.05, * p<0.10.

Similarly, when commodity prices fall, total investment also falls. If this is true, total projects could track royalties. In this scenario, it is possible to imagine that there would be a project backlog in the boom years, which would be executed during the bust years, mimicking the effect of the proposed intervention.

As *MapaRegalías* coincided with the end of the boom years in Colombia, as an additional robustness check, total national expenditure from the General Royalties System (accounted in *MapaRegalías*) was regressed to total national investments made by the National Planning Department for the period 2014–18 to rule out the interpretation that the increase in the efficiency of projects could be related to the backlog argument. The result was a negative and not statistically significant correlation between the two variables (see Table 9 and Figure 8). Thus, the overall evidence supports the argument that the monitoring effort is the underlying mechanism by which *MapaRegalías* has increased efficiency.

Another potential concern is the possibility that after *MapaRegalías* was released, there was an incentive for local officials to report greater physical progress, rather than actually executing more efficiently. Considering the administrative control systems in Colombia, this seems highly unlikely. The National Planning Department carries out several information verification procedures on registered or reported information. This includes inspections and visits to executing agencies. In addition, misreporting information is linked to a wide range of sanctions. Article 32 of Decree 0414, for example, stipulates that any record of information made by users in the integrated platform of the General Royalties System must be supported by legally issued documents. It empowers the National Planning Department as administrator of the System to define the requirements for verification and to

FIGURE 8 **CORRELATION BETWEEN LOCAL PUBLIC INVESTMENTS AND INVESTMENTS CHANNELED THROUGH *MAPAREGALÍAS***



Source: National Planning Department.

TABLE 9. CORRELATION BETWEEN LOCAL PUBLIC INVESTMENT AND INVESTMENTS CHANNELED THROUGH THE GENERAL ROYALTIES SYSTEM (*MAPAREGALÍAS*)

	Local public investment
MapaRegalías investment	–1.204 (2.255)
Observations	44

Sources: Local public investments: National Planning Department; investments channeled through *MapaRegalías:* General Royalties System.
Note: The period covered goes from July 2014 to December 2018. The observations are at the month level. The p-value is 0.596.

take control measures against legal breaches, including inconsistent reports. In addition, the administrative control within the National Planning Department is linked to the disciplinary control carried out by the Attorney General's Office and the fiscal control carried out by the Comptroller General of the Republic, two entities that use the reports submitted by executors, creating strong incentives for accurate and transparent self-reporting.

4

ANALYSIS OF MECHANISMS

This section explores underlying mechanisms that may explain the previous findings. First, it presents a stylized formal model that tries to capture the channels through which *MapaRegalías* could reduce corruption or increase the efficiency of investment projects. The model consists of two types of agents: a government (which need not be the central government; it could be a public official) and $n \geq 2$ monitoring agents (these can be either citizens or non-corrupt public officials, or both). The government decides how to allocate royalty resources between public goods and self-appropriation, the latter being this study's measure of corruption. Alternatively, this can be rationalized by saying that public officials must decide how to allocate their effort between the production of public goods and other personal (i.e., non-productive) activities, the latter being a measure of inefficiency.

The government is assumed to be interested in capturing resources and not in providing public goods. The monitoring agents receive utility from public goods and can exert costly efforts to monitor the government, which implies a probability of detecting government corruption or inefficiencies or both. Detecting corruption reduces the amount the government can appropriate for itself and can help to increase the amount allocated to public goods, which in turn has a correlate in better public services or greater efficiency in the provision of public services.[12]

Formally, the government decides the allocation of royalty resources (R) between public goods and self-appropriation. Specifically, it decides the share of royalty resources (α) that it will appropriate, with the remaining share ($1 - \alpha$) allocated to public goods. Appropriating royalty resources is assumed to have an increasing convex cost (for simplicity, a quadratic cost). This can capture, for example, how corruption can damage the government's image abroad, reduce the country's attractiveness for international investors, and reduce the chances of reelection. Similar effects would arise from being inefficient.

Each monitoring i can exert an effort $e_i \in [0,1]$ to monitor the government. It is assumed that an effort e_i implies a probability e_i of detecting corruption by the government. More generally, monitoring effort affects the probability of detecting inappropriate action on the part of public officials because of either corruption or inefficiency.

[12] To add realism to the model, it incorporates a parameter that reflects potential imperfections in the effectiveness of detecting corruption on actually reducing corruption.

If at least one agent detects corruption, the share that the government appropriates is multiplied by a factor $(1+\varepsilon)^{-1}$, where $\varepsilon>0$ captures how effective detecting corruption is at reducing government appropriation (note that an increase in ε implies that detecting corruption further reduces the amount that the government appropriates). The amount of royalty resources destined to public goods is split equally between the n monitoring agents. A quadratic cost of monitoring effort is assumed, and a multiplicative factor k captures the costliness of the effort. Within the model, the release of *MapaRegalías* is interpreted as a reduction in the parameter k, which reduces the cost of monitoring the government. The model assumes that the government and the monitoring agents choose their actions simultaneously. For simplicity, it assumes that both the government and the monitoring agents are risk-neutral. The government's payoff function is given by:

$$U_G = \alpha R \Pi_{j=1}^{n}(1-e_j) + \frac{1}{1+\varepsilon}\alpha R\left(1-\Pi_{j=1}^{n}(1-e_j)\right) - \frac{\alpha^2}{2} \quad (1)$$

where $\Pi_{j=1}^{n}(1-e_j)$ represents the probability of no monitoring agents detecting corruption.[13] Intuitively, the first term indicates that if no monitoring agent detects corruption, the government can keep the whole share α of royalty resources. The second term indicates that if at least one agent detects corruption, the share the government appropriates is reduced by a multiplying factor decreasing in ε, which measures the effectiveness of detecting corruption in reducing government appropriation.[14] Finally, the third term indicates the increasing cost of appropriating royalty resources. Rewriting (1) yields the following equation:

$$U_G = \alpha R\left[\frac{1}{1+\varepsilon} + \frac{\varepsilon}{1+\varepsilon}\prod_{j=1}^{n}(1-e_j)\right] - \frac{\alpha^2}{2} \quad (2)$$

The government's problem is:

$$\max\ \alpha R\left[\frac{1}{1+\varepsilon} + \frac{\varepsilon}{1+\varepsilon}\Pi_{j=1}^{n}(1-e_j)\right] - \frac{\alpha^2}{2}$$

The first-order condition that characterizes the solution yields the following best response function:

$$\alpha^{BR} = R\left[\frac{1}{1+\varepsilon} + \frac{\varepsilon}{1+\varepsilon}\prod_{j=1}^{n}(1-e_j)\right] \quad (3)$$

Monitoring agent i's payoff function is:

$$U_i = (1-\alpha)\frac{R}{n}\prod_{j=1}^{n}(1-e_j) + \left(1-\prod_{j=1}^{n}(1-e_j)\right)\left(1-\frac{\alpha}{1+\varepsilon}\right)\frac{R}{n} - k\frac{e_i^2}{2} \quad (4)$$

where the first term indicates that if no monitoring agent detects corruption, the share $(1-\alpha)$ will be destined to public goods, equally split between the monitoring agents. The second term indicates that if at least one agent detects corruption, the share the government appropriates is reduced by a multiplicative factor $(1-\varepsilon)^{-1}$. Finally, the third term indicates the quadratic cost of effort, with the parameter k measuring the costliness of the effort (increases in k imply a higher cost for the same effort). Rearranging (4), monitoring agent i's optimization problem is:

$$\max \frac{R}{n}\left(1-\frac{\alpha\varepsilon}{1+\varepsilon}\prod_{j=1}^{n}(1-e_j) - \frac{\alpha}{1+\varepsilon}\right) - k\frac{e_i^2}{2} \quad (5)$$

[13] Note that is the probability of monitoring agent i detecting corruption, so $(1-e_j)$ is the probability that monitoring agent i does not detect corruption. Thus, $\prod_{j=1}^{n}(1-e_j)$ represents the probability that no monitoring agents detect corruption.

[14] Note that $\varepsilon \to 0$ implies that detecting corruption does not reduce the amount the government appropriates, while $\varepsilon \to \infty$ implies that, upon detection, the government appropriates no resources.

The first-order condition is:

$$\frac{R}{n}\alpha\frac{\varepsilon}{(1+\varepsilon)}\prod_{j\neq i}(1-e_j)=ke_i \qquad (6)$$

The parameters of the model are assumed to be such that $e_i>0$, ruling out an equilibrium in which monitoring agents make no effort to monitor the government, since such a case is of little interest to analyze. Since the first-order condition is symmetric for every monitoring agent, the symmetry condition is imposed to find a monitoring agent-symmetric Nash equilibrium in which $e_j=e^*>0$ for every j. Given the complexity of the model, it is impossible to isolate e^* and write it explicitly. Thus, the Implicit Function Theorem is used to study comparative statics. Replacing every e_j with e^* in the best response function of the government of (3) yields the optimal share α^*. Replacing this α^* in (6) and rearranging yields the following expression:

$$\frac{R^2}{n}\frac{\varepsilon}{(1-\varepsilon)}\left(\frac{(1-e^*)^{n-1}}{1+\varepsilon}+\frac{\varepsilon(1-e^*)^{2n-1}}{1+\varepsilon}\right)-ke^*=0 \qquad (7)$$

which implicitly defines the equilibrium level of effort e^* as a function of the parameters of the model. The release of *MapaRegalías* is interpreted as a reduction in k, and it is interesting to understand how this affects the monitoring effort and how the government allocates resources in equilibrium. Using the Implicit Function Theorem yields the following results:

Result 1. The equilibrium monitoring effort is decreasing in the cost of monitoring $\left(i.e.\frac{\partial e^*}{\partial k}<0\right)$.

Proof.

By the Implicit Function Theorem:

$$\frac{\partial e^*}{\partial k}=-\frac{\frac{\partial(5)}{\partial k}}{\frac{\partial(5)}{\partial e^*}}$$

$$\frac{\partial e^*}{\partial k}=-\frac{e^*}{\frac{R^2}{n}\frac{\varepsilon}{(1+\varepsilon)}\left(\frac{n-1}{1+\varepsilon}(1-e^*)\to n-2+\frac{\varepsilon}{1+\varepsilon}(2n-1)(1-e^*)^{2n-2}\right)=k}<0$$

Since $e^*>0$, the sign depends on the denominator. Note that, since $\varepsilon>0$, $n\geq 2$, $e^*>0$, and $k>0$ the denominator is a sum of positive numbers, it is also positive. Thus, the negative sign turns the whole quotient negative, proving the result.

Result 1 indicates that increases in the cost of monitoring reduce each monitoring agent's monitoring effort or, conversely, reductions in the cost of monitoring induce an increase in the monitoring effort of each monitoring agent. Intuitively, as the cost of monitoring decreases, if the payoff for detecting corruption is held constant, monitoring agents have more incentives to actively monitor the government. Thus, with the release of *MapaRegalías,* monitoring agents would be expected to increase their effort to monitor the government's use of resources. Again, in reality this increase in monitoring how government officials use public resources can affect both corruption practices and efficiency.

Next, the effects of reducing the cost of monitoring on the government's allocation of resources are analyzed. Using Result 1 yields the following result:

Result 2. The share of resources appropriated by the government is increasing in the cost of monitoring $\left(i.e.\partial\alpha^*/\partial k>0\right)$.

Proof.

The government's optimal share of self-appropriation is:

$$\alpha^*=R\left[\frac{1}{1+\varepsilon}+\frac{\varepsilon}{1+\varepsilon}(1-e^*)^n\right]$$

Deriving and using the chain rule:

$$\frac{\partial \alpha^*}{\partial k} = -Rn\frac{\varepsilon}{1+\varepsilon}(1-\varepsilon)^{n-1}\frac{\partial e^*}{\partial k} > 0$$

Given that $\varepsilon > 0$, $R > 0$, $n \geq 2$, $e^* > 0$, and Result 1, the right-hand side is positive, proving the result.

Result 2 indicates that the share of resources appropriated by the government is increasing in the cost of monitoring. Thus, a reduction in the cost of monitoring would induce the government to reduce self-appropriation and increase expenditure on public goods (and efficiency). Intuitively, although the cost of monitoring does not enter directly into the government's payoff function, a reduction in the cost of monitoring increases monitoring agents' monitoring efforts (Result 1), which increases the probability of detecting corruption (or inefficient practices) by public officials. Since detecting corruption reduces the amount the government appropriates, the government has less incentive to incur the cost of appropriating resources.

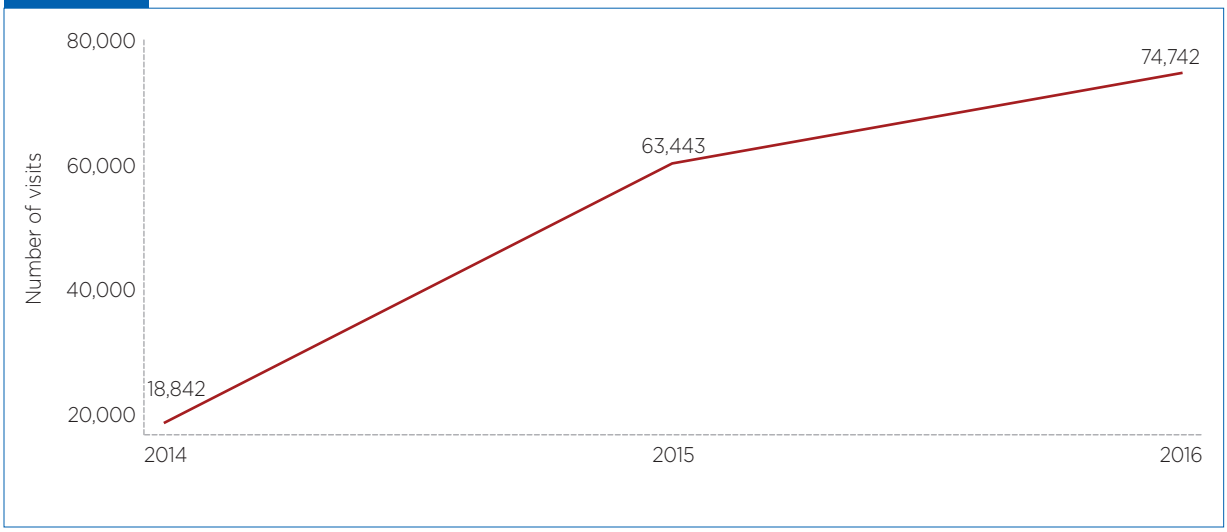
Thus, with the release of *MapaRegalías*, the government would be expected to reduce corruption or increase efficiency. Although reality would rarely behave so linearly, this simple model captures a mechanism through which *MapaRegalías* could reduce corruption or increase efficiency in a very stylized manner. Evidence that supports the proposed mechanism is provided below.

Empirical Evidence on Mechanisms

If the underlying mechanism by which *MapaRegalías* has affected efficiency is that citizens are exerting more monitoring effort, a necessary condition is that citizens must be using the platform. Figure 9 shows the number of visits to the platform in Colombia from 2014 to 2016. The number of visits increased sharply after the release of the platform. In 2014 there were 18,842 visits, and in 2016 the number of visits rose to 74,742.

This explanation would not hold in the hypothetical case that agencies in charge of the projects were not aware of the existence of *MapaRegalías.* If they were not aware of *MapaRegalías* and the fact that citizens have the possibility to access to this platform, they would not have the incentives to be more efficient.

FIGURE 9 **NUMBER OF VISITS TO THE PLATFORM**



Source: Google Analytics; data provided by the National Planning Department.

However, it is important to highlight that when preparing for the launch and implementation of *MapaRegalías*, the National Planning Department developed legal procedures and carried out a wide range of dissemination activities aimed at promoting the appropriation of the platform by subnational governments and other actors of the General Royalties System.

Furthermore, it is possible to prove a vast interaction between the National Planning Department and project executors, precisely to disseminate *MapaRegalías* since 2013. For example, Circular 066 encouraged public servants and agencies in charge of investment projects financed with General Royalties System resources to promote consultation and report inconsistencies.[15] This clearly understood the *MapaRegalías* platform as a tool to enhance transparency and citizen monitoring. In addition, it is important to highlight that in 2014, the General Royalties System issued Provision 023, setting the conditions, characteristics, and quality standards of the Integrated Platform *MapaRegalías*. This provision was communicated and disseminated to all General Royalties System actors through the trainings. According to official data from the National Planning Department, as many as 81 training sessions were held in 2014.

[15] This circular includes the following text: "As can be seen in the *MapaRegalías* application, reports of information will be available to citizens."

5

CONCLUSIONS

This paper analyzes the impact of the release of the *MapaRegalías* platform on the physical progress of public investment projects financed with resources from royalties. Using a before-and-after approach around an eight-month window before and after the release of *MapaRegalías*, public projects show an average increase in the percentage of physical progress of 7.996 percentage points.

The study also provides suggestive evidence that the introduction of *MapaRegalías* is linked to an increase in monitoring, which may be associated with the significant reduction in both the cost that citizens must incur to monitor the government's use of resources and the cost of monitoring efforts within the government. Thus, the results suggest that reducing monitoring costs has a significant impact on the efficiency of public investment projects. These findings are important from a policy perspective, and they suggest a clear path by which government can improve performance in the execution of public investment.

6

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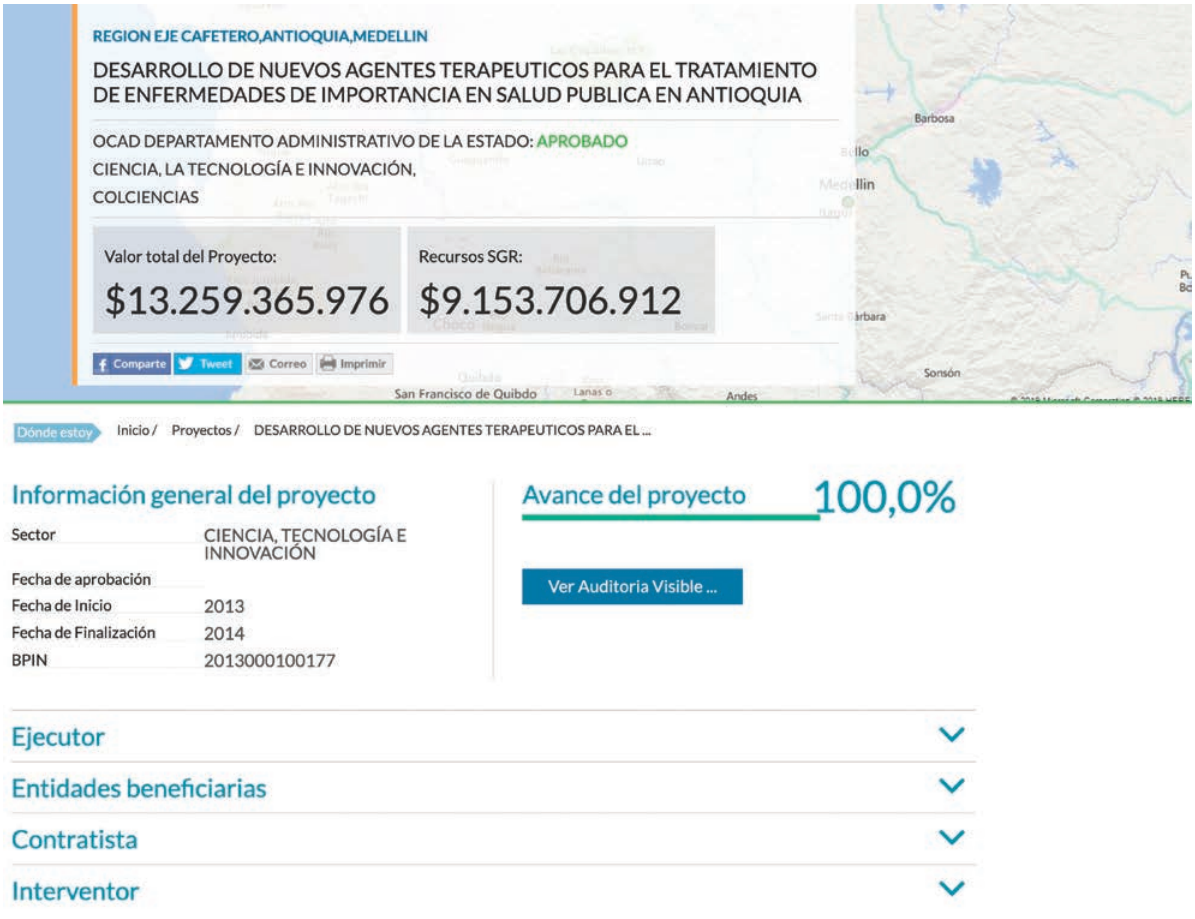
7

APPENDIX A: THE LAYOUT OF THE PLATFORM

FIGURE A1 ***MAPAREGALÍAS*** **WEBSITE'S HOME PAGE**

Source: MapaRegalías.

FIGURE A2A ***MAPAREGALÍAS* WEBSITE'S PROJECTS SECTION**



Source: *MapaRegalías.*

FIGURE A2B **PHOTO REPOSITORY IN THE PROJECT SECTION OF THE *MAPAREGALÍAS* WEBSITE**

Source: *MapaRegalías.*

FIGURE A3 ***MAPAREGALÍAS* WEBSITE'S RESOURCES SECTION**

Source: MapaRegalías.

FIGURE A4 ***MAPAREGALÍAS* WEBSITE'S PRODUCTION SECTION**

Source: *MapaRegalías.*

FIGURE A5 ***MAPAREGALÍAS* WEBSITE'S INSPECTION SECTION**

Source: MapaRegalías.


IDB