

Is a Nudge Enough? Evidence from Environmental Compliance in Chile's Industrial Wastewater Regulation

XVII Encuentro Sociedad Chilena de Políticas Públicas

Pablo Aguirre-Hörmann (PUC/SMA) - pjaguirr@uc.cl

Francisco Donoso (SMA), Cristóbal de la Maza (USS), Patricio Domínguez (PUC) & Enzo Sauma (PUC)

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Motivación y Contexto

Datos y Estrategia Empírica

Resultados

Discusiones / Conclusiones

- Superintendencia del Medio Ambiente (SMA): autoridad nacional de fiscalización y sanción.
- Mandato: promover el cumplimiento de la normativa ambiental vigente.
- Problema: Principal-Agente / Limitaciones presupuestarias.
- Incumplimiento por decisiones racionales (e.g. Becker, 1968) y/o por complejidades normativas (e.g. Spence, 2021; Stafford, 2006).
- Literatura extensa sobre mecanismos de disuación y cumplimiento (Gray and Shimshack, 2011; Shimshack, 2014).
- Potencial de intervenciones conductuales para influenciar y mejorar resultados (Haynes et al., 2013; Telle, 2013; Sunstein, 2014; Benartzi et al., 2017; Loewenstein, 2017; Meiselman, 2018; Thaler, 2018; Gillitzer and Sinning, 2020; Earnhart Ferraro, 2021; Del Carpio, 2022; Benami et al., 2023).

Normativa de Residuos Industriales Líquidos (RILES)

- Dos decretos regulan las descargas de RILES: **D.S. 46/2002** (aguas subterráneas) y **D.S. 90/2000** (mares, ríos, lagos).
- Auto reportes mensuales a través de sistema informático de la SMA.
- Muestreos se realizan por laboratorios (terceros) aprobados por la SMA.
- **Obligaciones:** (i) Entrega dentro de plazo; (ii) Frecuencia de muestreo; (iii) Parámetros exigidos; (iv) Caudal bajo resolución; (v) Parámetros bajo norma.
- Informes de fiscalización (IFA).
- Resultado de evaluación normativa vía publicación en SNIFA de los IFA sin hallazgo (sin notificación directa) o a través de notificación en caso de iniciar un proceso sancionatorio.

Intervención: avisos automatizados y personalizados

- Desde **mayo de 2020**, la SMA comenzó a enviar **correos mensuales** desde una cuenta oficial a cada instalación regulada.
- Evaluación de cumplimiento a nivel de ducto.
- El primer correo (mayo) evaluó los envíos de abril; no hubo anuncio previo.

Figure D1. Example of a customized monthly email notification
Informa INCUMPLIMIENTO de Norma de Emisión (RET 10012)



Estimado Titular:

Junto con saludarle, en el documento adjunto se informa el resultado de la revisión de los autocontroles reportados para el mes de **Mayo de 2020** bajo el código RETC **10012** conforme a la Norma de Emisión de Residuos Industriales Líquido (Riles).

Al respecto, se le informa que **esta Superintendencia ha detectado incumplimientos**, cuyo detalle se encuentra en el adjunto. Esta información se pone en conocimiento de Ud. para que tome en el más breve plazo las **medidas correctivas necesarias para retornar al cumplimiento**. Ello, sin perjuicio de las acciones que pudiera seguir esta Superintendencia en el marco de sus competencias. Se le recuerda que cada incumplimiento **puede implicar multas que van de 1 a 10.000 UTA**.

Si considera que la información presentada no es correcta, por favor comuníquese al siguiente correo: rlas@sma.gob.cl

Superintendencia del Medio Ambiente,
Gobierno de Chile
Teatinos 280, piso 8 y 9 - Santiago de Chile

Figure D2. Example of a customized attached file

The figure shows a screenshot of a document titled 'REPORTE DE CUMPLIMIENTO AUTOCONTROL DE RILES' from the SMA. It includes a table with columns for 'Código de Emisión', 'Descripción de la infracción', and 'Monto de la multa'. The table lists several violations with their corresponding fines. To the right of the table, there are two red boxes with text, likely providing instructions or additional information regarding the violations and the required corrective actions.

Las notificaciones cambiaron la forma de comunicación hacia el regulado hacia una postura proactiva, disponiendo información de forma oportuna y de fácil lectura.

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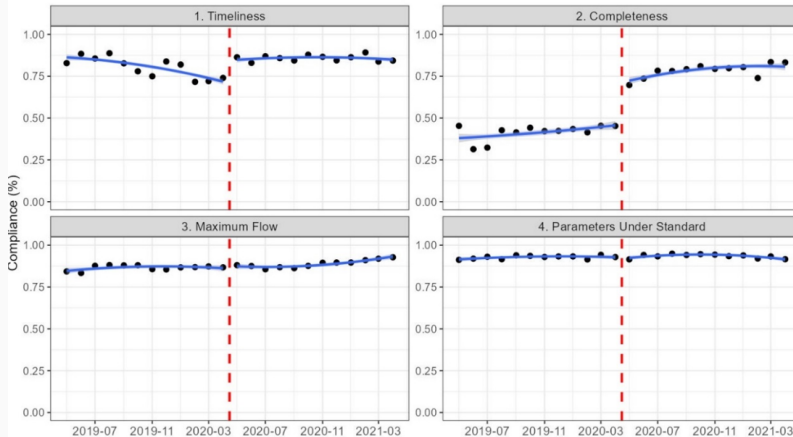
Discusiones / Conclusiones

Información disponible

- Periodo de estudio: mayo 2019 – abril 2021.
- Universo: 665 instalaciones, 803 ductos regulados.
- Observaciones (mes-ducto): 17.625.
- Variables dependientes (binarios):
 - **Entrega dentro de plazo:** envío a tiempo.
 - **Compleitud:** frecuencia requerida y parámetros obligatorios reportados.
 - **Caudal bajo resolución:** caudal de descarga no supera límite máximo.
 - **Parámetros bajo norma:** todas las concentraciones dentro de los límites.
- Covariables: sector económico, región/municipio, cuerpo receptor, inversión (capacidad), densidad poblacional, nivel (meses) de operación, denuncias/inspecciones/sanciones (exposición) en el período previo, propiedad, cumplimiento base.

Niveles mensuales de cumplimiento en el tiempo

Figure 1. Discontinuity plots for four regulatory obligations



Notes: Points represent monthly percentages of pipes that comply. Regression lines use a quadratic polynomial and are fitted using the pipe-month observations of compliance for each obligation.

Estimar la discontinuidad en el punto de corte considerando la implementación común en mayo de 2020.

$$y_{ijt}^{(o)} = \phi \text{Post}_t + \beta_1 f(t - c) + \beta_2 \text{Post}_t f(t - c) + \eta_j + u_{ijt} \quad (1)$$

Analizar la trayectoria del cumplimiento bajo el régimen de notificaciones mensuales con un diseño tipo estudio de eventos.

$$y_{ijt}^{(o)} = \delta_\tau \sum_{\tau=-4}^{\tau=3} \text{Post}_t + \text{month}_t + \eta_j + u_{ijt} \quad (2)$$

Calcular probabilidades de transición de ingreso (NC→C) y salida del cumplimiento (C→NC).

$$\text{Ingreso: } P(y_{ijt}^{(o)} = 1 | y_{ijt-1}^{(o)} = 0) = \alpha_0 + \alpha \text{Post}_t + \text{month}_t + \eta_j + u_{ijt} \quad (3)$$

$$\text{Salida: } P(y_{ijt}^{(o)} = 0 | y_{ijt-1}^{(o)} = 1) = \alpha_0 + \alpha \text{Post}_t + \text{month}_t + \eta_j + u_{ijt}$$

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Respuesta inmediata (RDD)

Las obligaciones administrativas suben inmediatamente en el corte; las obligaciones sustantivas no

- **Entrega dentro de plazo:** +13 a +18.5 pp (17–24.5% sobre la línea base).
- **Compleitud:** +23.1 a +28.5 pp (54–66% sobre la línea base).
- **Caudal máx. y Parámetros:** cerca de cero en el corte.

Table 3. Regression discontinuity estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RD in <i>Timeliness</i> (ϕ^T) (pre-intervention avg: 0.75)	0.130*** (0.022)	0.136*** (0.022)	0.185*** (0.029)	0.185*** (0.028)	0.143*** (0.016)	0.138*** (0.016)	0.146*** (0.024)	0.150*** (0.023)
Number of obs.	8795	8795	8795	8795	17625	17625	17625	17625
RD in <i>Completeness</i> (ϕ^C) (pre-intervention avg: 0.43)	0.261*** (0.025)	0.259*** (0.024)	0.239*** (0.030)	0.231*** (0.029)	0.285*** (0.023)	0.283*** (0.023)	0.265*** (0.025)	0.260*** (0.025)
Number of obs.	6039	6039	6039	6039	12170	12170	12170	12170
RD in <i>Max. Flow</i> (ϕ^M) (pre-intervention avg: 0.86)	0.006 (0.013)	-0.003 (0.013)	0.016 (0.016)	0.015 (0.016)	-0.013 (0.010)	-0.017 (0.011)	0.016 (0.013)	0.015 (0.014)
Number of obs.	6048	6048	6048	6048	12181	12181	12181	12181
RD in <i>Parameters U.S.</i> (ϕ^P) (pre-intervention avg: 0.93)	-0.007 (0.012)	-0.005 (0.012)	-0.018 (0.021)	-0.013 (0.020)	0.006 (0.010)	0.005 (0.010)	-0.002 (0.014)	0.001 (0.014)
Number of obs.	6048	6048	6048	6048	12181	12181	12181	12181
Bandwidth (months)	12	12	12	12	24	24	24	24
Pipe FE	Y	N	Y	N	Y	N	Y	N
Ec. Sector FE	N	Y	N	Y	N	Y	N	Y
Region FE	N	Y	N	Y	N	Y	N	Y
Discharge body FE	N	Y	N	Y	N	Y	N	Y
Polynomial	Linear	Linear	Quadratic	Quadratic	Linear	Linear	Quadratic	Quadratic

Notes: This table presents regression discontinuity (RD) estimates, ϕ , for the four evaluated normative obligations under different model specifications. Columns (1), (2), (5), and (6) use a linear polynomial, while columns (3), (4), (7), and (8) use a quadratic polynomial. Fixed effects for pipe are considered in columns (1), (3), (5), and (7) while fixed effects for economic sector, region, and discharge body are considered in columns (2), (4), (6), and (8). Columns (1) through (4) employ a 12-month bandwidth, whereas columns (5) through (8) use a 24-month bandwidth. Standard errors (in parentheses) are clustered at the facility-level. Pre-intervention average for each obligation considers the prior six months' compliance level for each pipe.

Significance levels: $p < 0.10$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

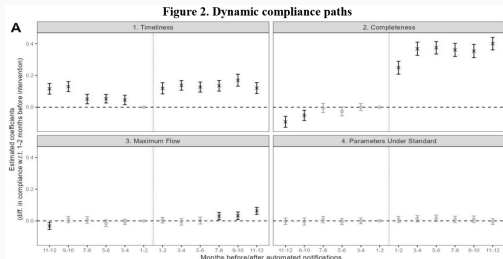
Efectos dinámicos (estudio de eventos) y probabilidades de transición

Efecto sostenido en obligaciones administrativas,
aumento tardío en cumplimiento con caudal máximo

- **Entrega dentro de plazo:** +12 a +17 pp a lo largo de 12 meses posteriores.
- **Compleitud:** +25 a +40 pp a lo largo de 12 meses posteriores.
- **Caudal máximo:** se vuelve positivo después de 7 meses (+3 a +6.3 pp en los meses 11–12).
- **Parámetros bajo norma:** sin cambio agregado.

Probabilidad de salir de incumplimiento con caudal
máximo aumenta

- **Entrega Dentro de plazo:** mayores salidas desde NC (+9.3 a +21.5 pp) y menores entradas a NC (3.4 a 9.5 pp).
- **Compleitud:** salidas +28.6 a +32 pp; entradas 8.2 a 11.6 pp.
- **Caudal máximo:** salidas desde NC +7.9 a +32.8 pp; entradas pequeñas/insignificantes.
- **Parámetros bajo norma:** cambios promedio pequeños/imprecisos.



- **Bajo cumplimiento pre intervención** $\Rightarrow$ mayores ganancias en esa misma obligación.
- **Exposición previa** $\Rightarrow$ efectos atenuados en cumplimiento de Entrega y Caudal.
- **Operación continua** $\Rightarrow$ diferenciales positivos en cumplimiento de Caudal.
- **Menor capacidad** $\Rightarrow$ mayores cumplimiento en Entrega

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- Notificaciones mejoraron de forma inmediata y persistente el cumplimiento administrativo.
 - La dinámica mensual respalda esto: más salidas desde no cumplimiento y menos entradas a incumplir.
 - El patrón observado es compatible con reducción de fricciones de información y coordinación.
- No se observan cambios agregados en concentraciones; el caudal máximo sí muestra mejoras, pero con rezago (ajustes operacionales toman tiempo).
- No puede descartarse manipulación, pero la evidencia apunta a mejoras genuinas.
- Potencial de uso de tecnología e intervenciones de bajo costo para complementar otras acciones.
- Próximos pasos: mecanismos de acción; "bundles" de acciones; análisis costo-beneficio; manipulación estratégica de datos.

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Número de ductos e instalaciones

Table 1. Number of discharging pipes and facility per sub-group in the dataset

Subgroup	Pipes	Facilities	Subgroup	Pipes	Facilities
Pipe discharge to			Pipe's facility has complaints pre intervention?		
... <i>Lake</i>	39	33	... <i>No</i>	540	477
... <i>Ocean</i>	202	163	... <i>Yes</i>	97	71
... <i>River</i>	366	330	Pipe's facility has on-site inspection pre intervention?		
... <i>Aquifer</i>	30	25	... <i>No</i>	501	451
Pipe located in			... <i>Yes</i>	136	97
... <i>North</i>	34	25	Pipe's facility had an on-going <i>RILES</i> sanction procedure pre intervention?		
... <i>North-Center</i>	30	21	... <i>No</i>	604	523
... <i>Center</i>	273	230	... <i>Yes</i>	33	25
... <i>South-Center</i>	265	238	Municipality population density at pipe site		
... <i>South</i>	35	34	... <i>Below median</i>	304	265
Pipe belongs to economic sector			... <i>Above median</i>	333	283
... <i>Agroindustry</i>	145	139	Pipe's facility capacity (env. permit investment)		
... <i>Energy</i>	59	26	... <i>Small project (below median inv. or no permit)</i>	342	316
... <i>Equipment</i>	12	9	... <i>Big Project (above median inv.)</i>	295	232
... <i>Forestry</i>	16	13	Pipe's facility is a public firm?		
... <i>Manufact. Fac.</i>	58	50	... <i>No</i>	628	540
... <i>Mining</i>	18	15	... <i>Yes</i>	9	8
... <i>Fishing & Aq.</i>	286	257			
... <i>Env. Sanitation</i>	29	27			
... <i>Other</i>	14	12			

Cumplimiento pre intervención

Table 2. Compliance levels pre-intervention

	May 2019 – Apr 2020	May 2019 – Oct 2019	Nov 2019 – April 2020
<i>Timeliness</i>	0.78 (0.92)	0.84 (1.00)	0.75 (0.83)
<i>Completeness</i>	0.40 (0.13)	0.39 (0.17)	0.43 (0.17)
<i>Max. Flow</i>	0.86 (1.00)	0.86 (1.00)	0.86 (1.00)
<i>Parameter U. S.</i>	0.92 (1.00)	0.92 (1.00)	0.93 (1.00)

Notes: Pipe-level compliance averages and medians (in parentheses) are constructed using the specified period in each column. Column 1 considers all 12 months before May 2020, Column 2 the first 6 months of the pre-intervention period, and Column 3 the last 6 months.

RDD - cumplimiento pre intervención

Table 4. Regression discontinuity estimates for pre-intervention compliance splits

	Lower 50% of pre-May 2020 compliance with <i>Timeliness</i>		Lower 50% of pre-May 2020 compliance with <i>Completeness</i>		Lower 25% of pre-May 2020 compliance with <i>Max. Flow</i>		Lower 25% of pre-May 2020 compliance with <i>Parameters U.S.</i>	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
RD in <i>Timeliness</i> for reference group	0.057*** (0.021)	0.074*** (0.026)	0.139*** (0.024)	0.167*** (0.029)	0.134*** (0.026)	0.176*** (0.031)	0.121*** (0.026)	0.162*** (0.030)
Differential RD effect in <i>Timeliness</i>	0.191*** (0.018)	0.247*** (0.021)	0.010 (0.018)	0.029 (0.021)	0.029 (0.019)	0.023 (0.022)	0.066*** (0.020)	0.065*** (0.023)
RD in <i>Completeness</i> for reference group	0.301*** (0.031)	0.282*** (0.036)	0.008 (0.019)	-0.021 (0.027)	0.276*** (0.027)	0.247*** (0.032)	0.281*** (0.027)	0.255*** (0.032)
Differential RD effect in <i>Completeness</i>	-0.077* (0.041)	-0.096** (0.044)	0.533*** (0.031)	0.542*** (0.033)	-0.050 (0.046)	-0.032 (0.049)	-0.082* (0.046)	-0.083* (0.049)
RD in <i>Max. Flow</i> for reference group	0.013 (0.017)	0.008 (0.018)	0.014 (0.014)	0.006 (0.016)	-0.032** (0.015)	-0.011 (0.016)	0.005 (0.014)	0.008 (0.017)
Differential RD effect in <i>Max. Flow</i>	0.006 (0.018)	0.017 (0.016)	0.004 (0.017)	0.021 (0.017)	0.223*** (0.032)	0.124*** (0.033)	0.056** (0.027)	0.044* (0.025)
RD in <i>Parameters U.S.</i> for reference group	0.001 (0.015)	-0.020 (0.023)	0.001 (0.015)	-0.012 (0.023)	-0.006 (0.014)	-0.023 (0.021)	-0.030** (0.013)	-0.049** (0.022)
Differential RD effect in <i>Parameters U.S.</i>	-0.006 (0.011)	0.002 (0.015)	-0.003 (0.011)	-0.014 (0.015)	0.021 (0.015)	0.018 (0.020)	0.153*** (0.022)	0.160*** (0.032)
Bandwidth (months)	24	12	24	12	24	12	24	12

Notes: This table presents regression discontinuity (RD) estimates and the differential RD (RD DD) estimates, for the four evaluated obligations, considering pre-intervention levels of compliance. RD DD is the post-intervention difference for pipes in the lower pre-intervention compliance group (as the define in the headline of each column) while RD is the discontinuity estimation for the pipes in the higher pre-intervention compliance group. That is, we interact $Post_t$ in Equation 1 with the corresponding indicator variable. Columns (1), (3), (5), and (7) consider a 24-month bandwidth, while columns (2), (4), (6), and (8) consider a 12-month bandwidth. All specifications are estimated using a quadratic polynomial for the running variable and pipe-level fixed effects. Standard errors (in parentheses) are clustered at the facility level.

Significance levels: $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

Table 5. Regression discontinuity estimates for subgroups of the population

	Previous enforcement exposure		Operated the entire pre-intervention period		More than one pipe per facility		Lower capacity facility		Low population density municipality		Aquaculture facility	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
RD in <i>Timeliness</i> for reference group	0.160*** (0.025)	0.201*** (0.029)	0.158*** (0.028)	0.203*** (0.033)	0.155*** (0.022)	0.201*** (0.027)	0.123*** (0.025)	0.150*** (0.031)	0.145*** (0.028)	0.192*** (0.033)	0.152*** (0.025)	0.198*** (0.030)
Differential RD effect in <i>Timeliness</i>	-0.044* (0.025)	-0.050* (0.029)	-0.027 (0.021)	-0.037 (0.024)	-0.031 (0.032)	-0.058 (0.036)	0.043** (0.021)	0.063*** (0.024)	0.002 (0.021)	-0.013 (0.024)	-0.012 (0.021)	-0.028 (0.024)
RD in <i>Completeness</i> for reference group	0.270*** (0.030)	0.247*** (0.034)	0.278*** (0.043)	0.254*** (0.048)	0.258*** (0.026)	0.237*** (0.031)	0.281*** (0.033)	0.261*** (0.038)	0.258*** (0.031)	0.224*** (0.035)	0.275*** (0.029)	0.228*** (0.034)
Differential RD effect in <i>Completeness</i>	-0.015 (0.044)	-0.024 (0.045)	-0.018 (0.047)	-0.022 (0.050)	0.030 (0.060)	0.008 (0.063)	-0.030 (0.041)	-0.042 (0.044)	0.014 (0.041)	0.031 (0.043)	-0.023 (0.041)	0.025 (0.044)
RD in <i>Max. Flow</i> for reference group (γ)	0.038*** (0.014)	0.028* (0.017)	-0.014 (0.019)	-0.011 (0.020)	0.022 (0.015)	0.023 (0.017)	0.018 (0.018)	0.018 (0.019)	0.012 (0.015)	0.018 (0.017)	0.013 (0.016)	0.014 (0.017)
Differential RD effect in <i>Max. Flow</i>	-0.070*** (0.018)	-0.039** (0.016)	0.043** (0.018)	0.039** (0.018)	-0.027 (0.021)	-0.031** (0.016)	-0.004 (0.018)	-0.004 (0.016)	0.008 (0.018)	-0.005 (0.016)	0.006 (0.018)	0.004 (0.016)
RD in <i>Parameters U.S.</i> for reference group	-0.005 (0.013)	-0.024 (0.022)	-0.014 (0.015)	-0.029 (0.024)	-0.003 (0.014)	-0.024 (0.023)	0.005 (0.015)	-0.004 (0.022)	0.000 (0.015)	-0.011 (0.023)	0.004 (0.015)	-0.011 (0.023)
Differential RD effect in <i>Parameters U.S.</i>	0.012 (0.012)	0.016 (0.018)	0.017 (0.011)	0.015 (0.016)	0.007 (0.011)	0.026 (0.019)	-0.013 (0.011)	-0.028* (0.015)	-0.004 (0.011)	-0.015 (0.015)	-0.013 (0.011)	-0.016 (0.015)
Bandwidth (months)	24	12	24	12	24	12	24	12	24	12	24	12

Notes: This table presents regression discontinuity (RD) estimates and the differential RD (RD DD) estimates, for the four evaluated obligations, considering different subgroups of the population studied. RD DD is the post-intervention difference for pipes having each of the six characteristics in the first row while RD is the discontinuity estimation for the pipes that do not belong to those subgroups. That is, we interact $Post_t$ in Equation 1 with the corresponding indicator variable. Columns (1), (3), (5), (7), (9), and (11) consider a 24-month bandwidth, while columns (2), (4), (6), (8), (10), and (12) consider a 12-month bandwidth. All specifications are estimated using a quadratic polynomial for the running variable and pipe-level fixed effects. Standard errors (in parentheses) are clustered at the facility level.

Significance levels: $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

Probabilidades de transición

Table 6. Changes in monthly compliance entry/exit hazards

		<i>May 2019 – Apr 2021</i>			<i>May 2019 – Nov 2020</i>			<i>Oct 2019 – Nov 2020</i>		
		Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
<i>Timeliness</i>	Exit (NC $\rightarrow$ C)	0.420	0.538	0.119*** (0.032)	0.449	0.543	0.093** (0.047)	0.373	0.588	0.215** (0.097)
	Entry (C $\rightarrow$ NC)	0.120	0.072	-0.048*** (0.007)	0.113	0.079	-0.034*** (0.008)	0.154	0.059	-0.095*** (0.024)
	N at risk (Exit/Entry)		2841/13981			2317/10703			1807/7662	
<i>Completeness</i>	Exit (NC $\rightarrow$ C)	0.058	0.356	0.299*** (0.026)	0.068	0.355	0.286*** (0.028)	0.042	0.362	0.320*** (0.044)
	Entry (C $\rightarrow$ NC)	0.127	0.045	-0.082*** (0.01)	0.139	0.022	-0.116*** (0.014)	0.064	0.055	-0.008 (0.02)
	N at risk (Exit/Entry)		4545/6602			4055/4664			2537/3691	
<i>Max. Flow</i>	Exit (NC $\rightarrow$ C)	0.170	0.271	0.100*** (0.03)	0.171	0.25	0.079** (0.036)	0.034	0.362	0.328*** (0.09)
	Entry (C $\rightarrow$ NC)	0.025	0.028	0.003 (0.004)	0.024	0.034	0.01* (0.005)	0.031	0.028	-0.002 (0.012)
	N at risk (Exit/Entry)		1398/9761			1163/7566			821/5417	
<i>Parameters U.S.</i>	Exit (NC $\rightarrow$ C)	0.489	0.596	0.107** (0.051)	0.484	0.625	0.142 (0.089)	0.491	0.600	0.108 (0.202)
	Entry (C $\rightarrow$ NC)	0.041	0.036	-0.005 (0.004)	0.041	0.032	-0.009 (0.006)	0.051	0.027	-0.024* (0.014)
	N at risk (Exit/Entry)		770/10389			608/8121			416/5822	

Notes: Each cell reports the monthly transition probability in the pre and post May 2020 periods for the indicated window and the difference (post – pre). C: Compliance-NC: Non-compliance. All specifications are estimated using pipe-level fixed effects. Standard errors (in parentheses) are clustered at the facility level.

Significance levels: $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

Fechas de intervención placebo

Table B2. Placebo test

	3 months before	2 months before	1 month before	Real date of intervention	1 month after	2 months after	3 months after
Placebo RD in <i>Timeliness</i>	-0.053*** (0.017)	0.025 (0.017)	0.094*** (0.021)	0.146*** (0.024)	0.048** (0.019)	0.036** (0.015)	-0.001 (0.014)
Placebo RD in <i>Completeness</i>	-0.012 (0.013)	0.048*** (0.014)	0.115*** (0.018)	0.265*** (0.025)	0.132*** (0.018)	0.048** (0.019)	-0.032** (0.015)
Placebo RD in <i>Max. Flow</i>	0.008 (0.01)	0.014 (0.01)	0.014 (0.012)	0.016 (0.013)	-0.002 (0.012)	-0.015 (0.012)	-0.003 (0.01)
Placebo RD in <i>Parameters U.S.</i>	-0.004 (0.01)	0.018 (0.014)	-0.002 (0.013)	-0.002 (0.014)	0.022* (0.012)	0.013 (0.011)	0.019* (0.01)
Placebo RD in <i>Frequency</i>	0.013 (0.012)	0.088*** (0.013)	0.149*** (0.018)	0.277*** (0.026)	0.146*** (0.018)	0.063*** (0.018)	-0.016 (0.013)
Placebo RD in <i>Parameter Completeness</i>	-0.012 (0.013)	0.048*** (0.014)	0.115*** (0.018)	0.265*** (0.025)	0.132*** (0.018)	0.048** (0.019)	-0.032** (0.015)

Notes: This table presents regression discontinuity (RD) estimates for the four evaluated normative obligations, and the two components of *Completeness*, artificially changing the intervention date between three months before and after the real date when automated reports started being sent (May 2020). The model specification for all estimations considers quadratic polynomial for the running variable, pipe fixed effects, and a 24-month bandwidth. Standard errors (in parentheses) are clustered at the facility-level.

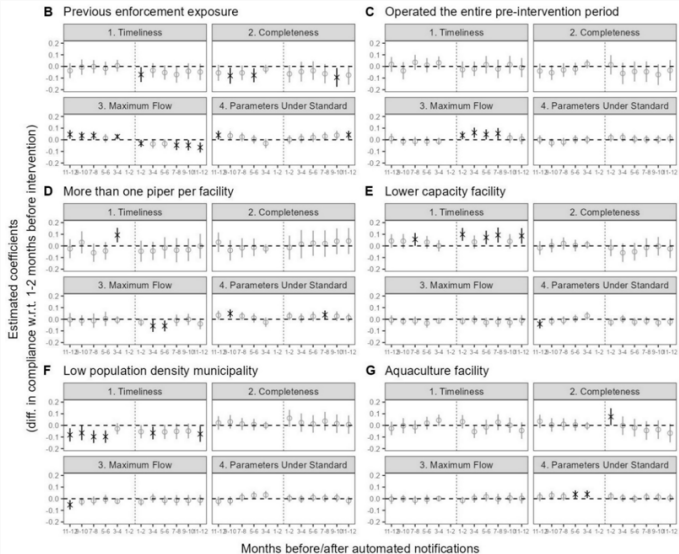
Significance levels: $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

Table B3. Donut Regression Discontinuity

	<u>All sample</u>	Removing 1 period before/after cutoff	Removing 2 periods before/after cutoff
RD in <i>Timeliness</i>	0.146*** (0.024)	0.164*** (0.035)	0.185*** (0.046)
RD in <i>Completeness</i>	0.265*** (0.025)	0.287*** (0.032)	0.339*** (0.044)
RD in <i>Max. Flow</i>	0.016 (0.013)	0.016 (0.020)	0.012 (0.030)
RD in <i>Parameters U.S.</i>	-0.002 (0.014)	0.011 (0.019)	0.043 (0.032)
RD in <i>Frequency</i>	0.277*** (0.026)	0.331*** (0.033)	0.439*** (0.045)
RD in <i>Parameter Completeness</i>	0.265*** (0.025)	0.287*** (0.032)	0.339*** (0.044)

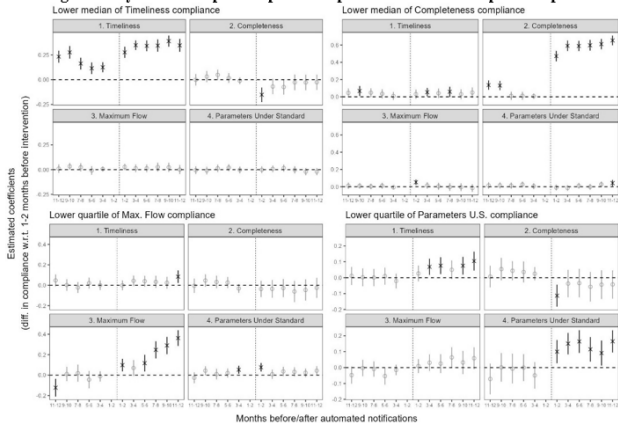
Notes: This table presents regression discontinuity (RD) estimates for the four evaluated normative obligations, and the two components of *Completeness*, removing observations from periods before and after the date when automated reports started being sent (May 2020). The model specification for all estimations considers quadratic polynomial for the running variable, pipe fixed effects, and a 24-month bandwidth. Standard errors (in parentheses) are clustered at the facility-level. Significance levels: $p < 0.1$ (*), $p < 0.05$ (**), $p < 0.01$ (***).

Heterogeneidad - Estudio de eventos (i)



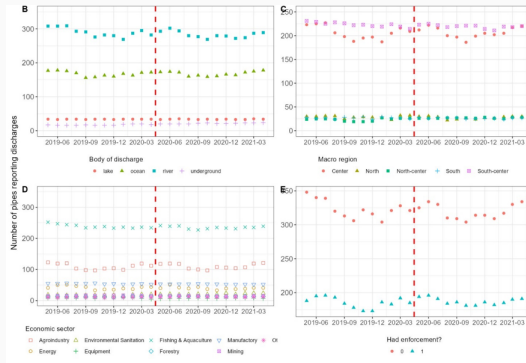
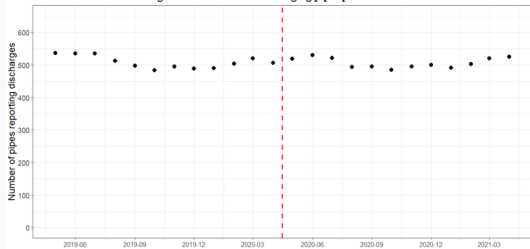
Heterogeneidad - Estudio de eventos (ii)

Figure 3. Dynamic compliance paths for pre-intervention compliance splits



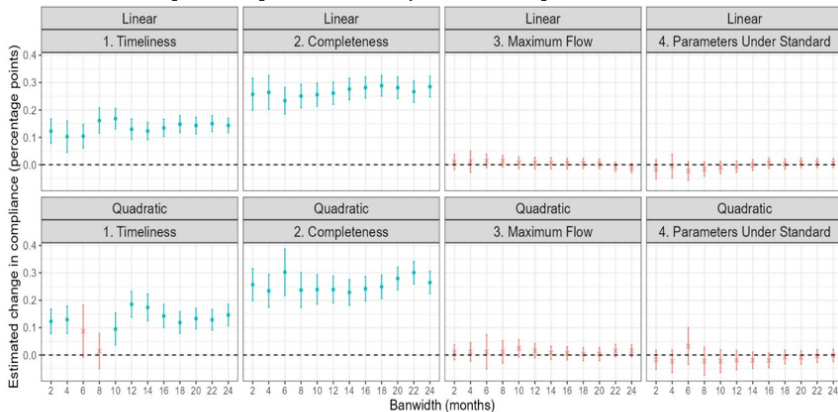
Ductos activos en el tiempo

Figure A1. Number of discharging pipes per month



Heterogeneidad - Estudio de eventos (ii)

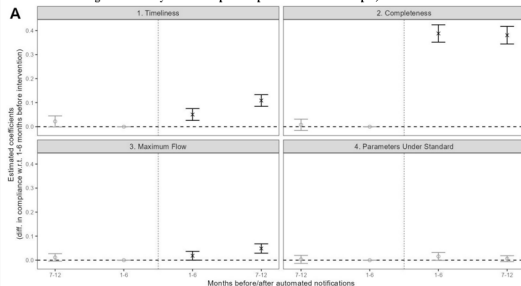
Figure A2. Regression discontinuity estimations using different bandwidths



Notes: This figure presents regression discontinuity (RD) estimates for the four evaluated normative obligations considering different bandwidths around the date when automated reports started being sent (May 2020). The model specification for the first row considers a linear specification for the running variable while the second row uses a quadratic polynomial, all include pipe fixed effects. Clustered standard errors at the facility level are used to estimate 90% confidence intervals. Point estimates with a cross represent non-significant values.

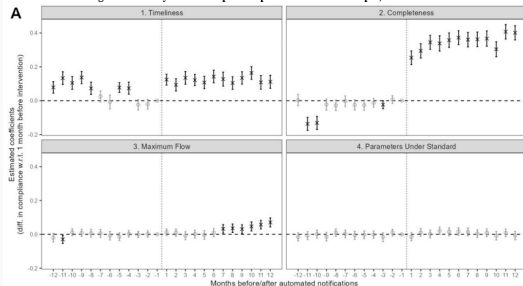
Estudio de eventos - distintos bins

Figure A6-A. Dynamic compliance paths for overall sample, 6-months bins



Notes: The X-axis indicates different periods before and after the implementation of the automated notifications. We consider compliance levels 1-6 months before the intervention as the reference group ($t = -1$). Thus, $t \in (-2, 0.1)$ respectively refers to 7-12 months before the beginning of the new regime notifications, and 1-6 months, and 7-12 months post action. The figure shows the estimates for the entire sample. 90% confidence intervals are estimated using clustered standard errors at the facility-level. Point estimates represented by a "X" show statistically significant estimates.

Figure A6-B. Dynamic compliance paths for overall sample, 1-month bins



Notes: The X-axis indicates different periods before and after the implementation of the automated notifications. We consider compliance levels 1 month before the intervention as the reference group ($t = -1$). The figure shows the estimates for the entire sample. 90% confidence intervals are estimated using clustered standard errors at the facility-level. Point estimates represented by a "X" show statistically significant estimates.