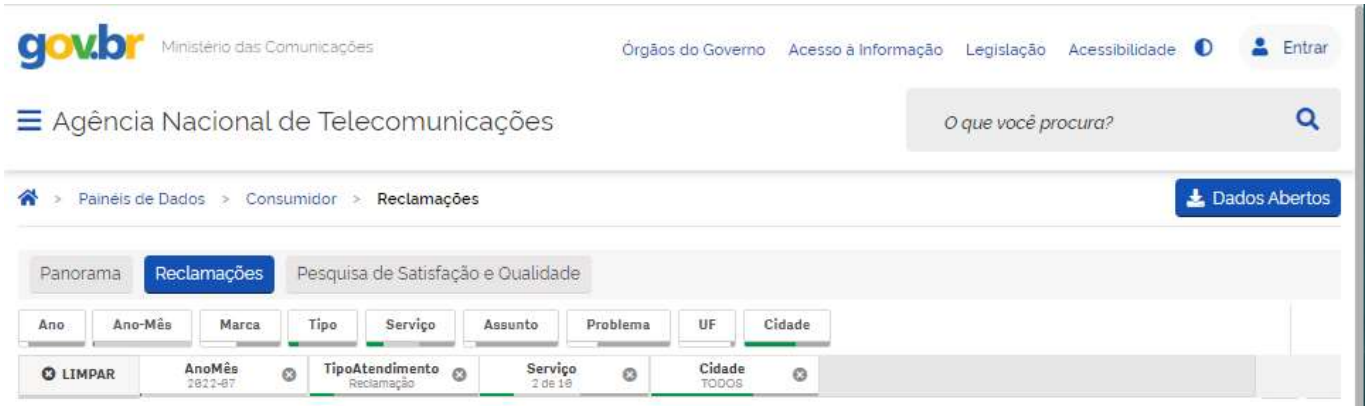
Support information for:

Principles, evaluation metrics and method for planned regulatory inspection targeting

In Section 5. Application of the Proposed Method, we used the number of consumer complaints referring to PCS in each municipality in Brazil (Anatel 2022), and the number of PCS consumers by municipality in Brazil (Anatel 2022a), to generate an initial average graph signal $\boldsymbol{u}(0)$, with $\boldsymbol{u}$ defined as $\boldsymbol{u}(n) = [u_1(n), u_2(n), ..., u_N(n)]^{\mathrm{T}} \in \mathbb{R}^{\mathrm{N}}$, where element $u_i(n)$ represents the average graph signal related to vertex v_i for inspection round n. $u_i(0)$ is the average consumer complaint rate of Brazilian municipality v_i on July 2022.

The Anatel's Consumer Complaints Data Dashboard are available in internet at this page. Figure S1 shows this dashboard and how to select the necessary data to generate $\boldsymbol{u}(0)$.

Figure S1. Selecting data in Anatel's Consumer Complaints Data Dashboard.

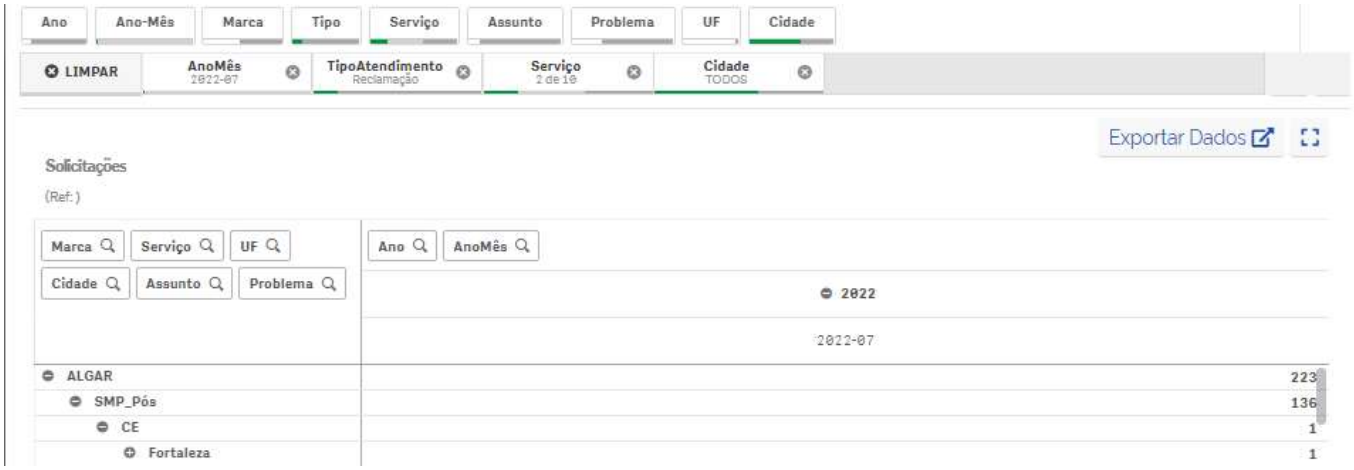


To properly select the data, we have chosen:

1. "Ano-Mês": "2022-07" (Year-Month: 2022-07)
2. "Tipo": "Reclamações" (Type: Complaints)
3. "Serviço": "SMP_Pós" and "SMP_Pré" (Service: PCS_postpaid and PCS_prepaid)
4. "Cidade": "Selecionar todos" (Municipality: Select all)

Figure S2 shows how to export the necessary data.

Figure S2. Exporting data from Anatel's Consumer Complaints Data Dashboard.



To properly export the data, we scroll down the page until “Solicitações” (Requests) and expand all filters but the municipality. After that, we click on “Exportar Dados” (Export Data). The data were downloaded in a .xlsx file with the format showed in Figure S3.

Figure S3. Format of consumer complaints data exported to a .xlsx file.

	A	B	C	D	E	F	G	H
1					**Ano**	2022		
2	**Marca**	**Serviço**	**UF**	**Cidade**	**AnoMês**	2022-07		
3		Totali				223		
4			Totali			136		
5				Totali		1		
6			CE	Fortaleza		1		
7				Totali		1		
8			DF	Brasília		1		
9				Totali		1		
10			ES	Vila Velha		1		

We sum the numbers of complaints, in column F, according state and municipalities, in columns C and D, to determine the total complains per municipality of Brazil.

The Anatel’s PCS Access Data Dashboard are available in internet at this page. Figure S4 shows this dashboard and how to select the necessary data to generate $\boldsymbol{u}(0)$.

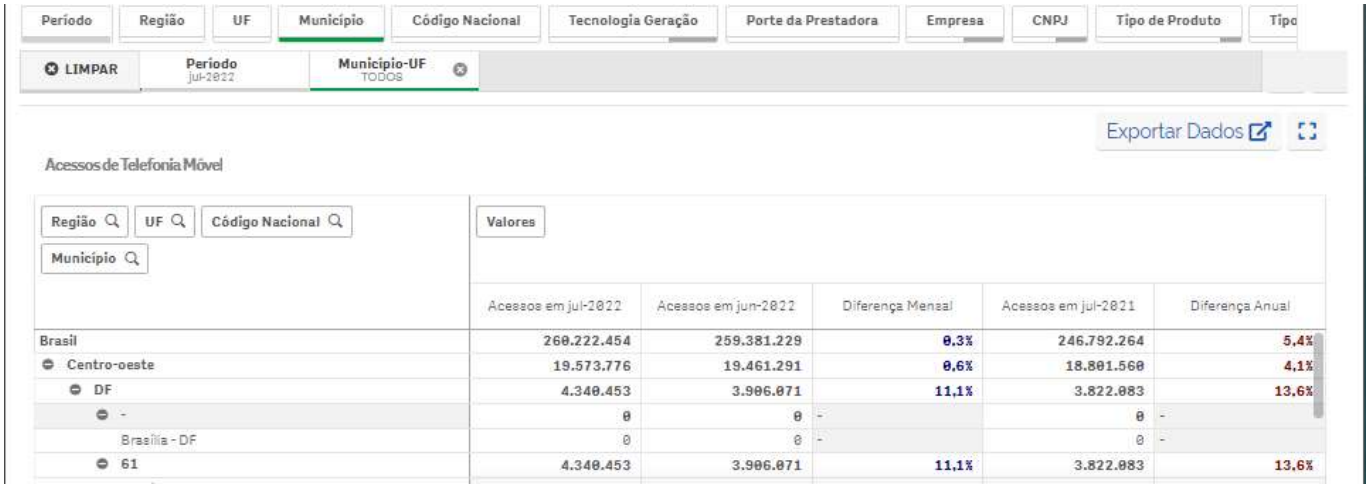
Figure S4. Selecting data in Anatel’s PCS Access Data Dashboard.

To properly select the data, we have chosen:

1. “Período”: “jul-2022” (Period: July-2022)
2. “Município”: “Selecionar todos” (Municipality: Select all)

Figure S5 shows how to export the necessary data.

Figure S5. Exporting data from Anatel's PCS Access Data Dashboard.



To properly export the data, we scroll down the page until "Acessos de Telefonia Móvel" (Mobile Phone Accesses) and expand all filters. After that, we click on "Exportar Dados" (Export Data). The data were downloaded in a .xlsx file with the format showed in Figure S6.

Figure S6. Format of PCS consumers data exported to a .xlsx file.

	A	B	C	D	E	F	G	H
1	Região	UF	Código Nacional	Município	Acessos em jul-2(	Acessos em jun-2	Diferença Mensal	Acessos em jul-2(Difer
2	Brasil				260.222.454	259.381.229	0,3%	246.792.264
3		Totais			19.573.776	19.461.291	0,6%	18.801.560
4			Totais		4.340.453	3.906.071	11,1%	3.822.083
5				Totais	0	0	-	0 -
6			-	Brasília - DF	0	0	-	0 -
7				Totais	4.340.453	3.906.071	11,1%	3.822.083
8		DF	61	Brasília - DF	4.340.453	3.906.071	11,1%	3.822.083
9			Totais		7.971.740	8.360.381	-4,6%	8.020.438
10				Totais	0	0	-	0 -
11				Abadia de Goiás -	0	0	-	0 -

We sum the numbers of PCS consumers, in column E, according municipalities, in column D, to determine the total number of PCS consumers per municipality of Brazil. Dividing the number of consumer complaints referring to PCS by the number of PCS consumers, for each municipality in Brazil, we generate $\boldsymbol{u}(0)$.

Still in Section 5., we need to model Anatel's expectation of PCS consumer dissatisfaction at each influenced municipality based on the PCS consumer dissatisfaction at their influencing municipalities. The adjacency matrix $\boldsymbol{W}$ of $\mathcal{G}$ was defined to adequately model Anatel's expectation.

Assume that Anatel's real expectation during the evolution of PCS quality is that:

a) For municipalities where the external search for goods or services is characterized by urban relations of proximity, the influences between municipalities must be proportional to the displacements of consumers from an influenced municipality to influencing municipalities in the search for goods and services in general, and;
b) For municipalities where the external search for goods or services is characterized by long-distance relations, the influences between municipalities must be proportional to the importance of the relations in public and business management.

In 2020, the IBGE published the study Areas of Influence of Cities 2018, in which it identifies and analyzes the Brazilian urban network, establishing the hierarchy and areas of influence of urban centers. The Brazilian urban network is characterized by small urban centers being influenced by one or more larger urban centers. To establish the hierarchy and areas of influence of urban centers, the IBGE considered the urban relations of proximity and the long-distance relations between these centers (IBGE 2020a).

For 5503 out of the 5570 municipalities in Brazil, the external search for goods or services is characterized by urban relations of proximity. For these municipalities, IBGE researched the relations in ten themes: clothing and footwear, furniture and electronics, low- and medium-complexity healthcare, high-complexity healthcare, higher education, cultural activities, sports activities, airport, newspapers, and public transportation. For these municipalities we used the available information in REGIC 2018 – Municipalities Connections and Attraction (IBGE 2020b) to calculate their received influences.

The REGIC 2018 – Municipalities Connections and Attraction data are available in internet at this page, and the file REGIC2018_Quest_Ligacoes_entre_Municipios.xlsx has the data of interest, with the format showed in Figure S7.

Figure S7. Format of REGIC 2018 – Municipalities Connections and Attraction data.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
1	ID	UF_ORIGE	MUN_ORI	MUN_OR	NOME_OF	POP2018_	COD_ARR	NOME_AR	HIERAR_M	HIERAR_C	NOME_HI	UF_DESTI	MUN_DES	MUN_DES	N
2	1,1E+13	RO	1100015	1100015	Alta Flore	23167			Centro Lo	5	Centro Lo	RO	1100049	1100049	Ca
3	1,1E+13	RO	1100015	1100015	Alta Flore	23167			Centro Lo	5	Centro Lo	RO	1100288	1100288	Ro
4	1,1E+13	RO	1100015	1100015	Alta Flore	23167			Centro Lo	5	Centro Lo	RO	1100205	1100205	Po
5	1,1E+13	RO	1100015	1100015	Alta Flore	23167			Centro Lo	5	Centro Lo	RO	1100122	1100122	Ji-
6	1,1E+13	RO	1100015	1100015	Alta Flore	23167			Centro Lo	5	Centro Lo	RO	1100189	1100189	Pi
7	1,1E+13	RO	1100015	1100015	Alta Flore	23167			Centro Lo	5	Centro Lo	RO	1100296	1100296	Sa
8	1,1E+13	RO	1100015	1100015	Alta Flore	23167			Centro Lo	5	Centro Lo	SP	3505500	3505500	Ba
9	1,1E+13	RO	1100015	1100015	Alta Flore	23167			Centro Lo	5	Centro Lo	RO	1100254	1100254	Pr

We calculated the influences in municipalities that search for goods and services in other municipalities as the estimated percentage of the participation (column AP) of the influencing municipality (which code is in column M) on the total displacements of consumers from the influenced municipality (which code is in column C).

For the remaining 67 municipalities, which tend to satisfactorily supply goods and services to the consumers who inhabit them, the external search for goods or services is characterized by long-distance relations. For these municipalities, IBGE researched the relations in two themes: public management and business management.

16 of these 67 municipalities are not the main municipality of the population arrangement to which they were grouped by the IBGE. We considered that all the influence received by these 16 municipalities comes from the main municipality of the arrangement to which they belong. For these municipalities we used the available information in REGIC 2018 – Population Arrangements (IBGE 2020c) to set their received influences.

The REGIC 2018 – Population Arrangements data are available in internet at this page. The data were downloaded in a .xlsx file with the format showed in Figure S8.

Figure S8. Format of REGIC 2018 – Population Arrangements data.

	A	B	C	D	
1	**Codmun**	**Nome do Município**	**Código do AP**	**Nome do Arranjo Populacional**	
2	3500105	Adamantina	3500105	Arranjo Populacional de Adamantina - Lucélia/SP	Arranjo popu
3	3540853	Pracinha	3500105	Arranjo Populacional de Adamantina - Lucélia/SP	Arranjo popu
4	3528908	Mariápolis	3500105	Arranjo Populacional de Adamantina - Lucélia/SP	Arranjo popu
5	3520806	Inúbia Paulista	3500105	Arranjo Populacional de Adamantina - Lucélia/SP	Arranjo popu
6	3527405	Lucélia	3500105	Arranjo Populacional de Adamantina - Lucélia/SP	Arranjo popu
7	4100202	Adrianópolis	4100202	Arranjo Populacional de Adrianópolis/PR - Ribeira/SP	Arranjo popu

We set the influences to 1 in that 16 of 67 municipalities using the code of the influenced municipality (column B) and the code of the main municipality of the population arrangement (column C).

36 of these 67 municipalities are the main municipality of the population arrangement to which they were grouped by the IBGE, but are not metropolises. It was considered that all the influence received by these 36 municipalities comes from the metropolis to which they are linked by IBGE. For these municipalities we used the available information in REGIC 2018 – Connection Between Cities (IBGE 2020d) to set their received influences.

The REGIC 2018 – Connection Between Cities data are available in internet at this page. The data were downloaded in a .xlsx file with the format showed in Figure S9.

Figure S9. Format of REGIC 2018 – Connection Between Cities data.

	A	B	C	D	E	F	G	H	I
1	id_reg	cod_ori	nome_ori	coduf_ori	uf_ori	nivel_ori	classe_ori	cod_dest	nome_dest
2	150140213	1501402	Arranjo Populacior	15	PA	1C	Metrópole	1302603	Manaus
3	150140223	1501402	Arranjo Populacior	15	PA	1C	Metrópole	2304400	Arranjo Populacional de Fortaleza/CE
4	310010431	3100104	Abadia dos Dourac	31	MG	5	Centro Lo	3143104	Monte Carmelo
5	150140226	1501402	Arranjo Populacior	15	PA	1C	Metrópole	2611606	Arranjo Populacional do Recife/PE
6	150140231	1501402	Arranjo Populacior	15	PA	1C	Metrópole	3106200	Arranjo Populacional de Belo Horizonte/MG
7	520010052	5200100	Abadiânia	52	GO	5	Centro Lo	5201108	Anápolis
8	150140233	1501402	Arranjo Populacior	15	PA	1C	Metrópole	3304557	Arranjo Populacional do Rio de Janeiro/RJ
9	150140235	1501402	Arranjo Populacior	15	PA	1C	Metrópole	3509502	Arranjo Populacional de Campinas/SP

We set the influences to 1 in that 36 of 67 municipalities using the information “sim” (yes) of the link (column O) according the code of the influenced municipality (column B) and the code of the metropolis to which they are linked (column H).

The last 15 of these 67 municipalities are metropolises. It was considered that the influences received by these 15 municipalities comes from the relations of public and business management. For these municipalities we used the available information in REGIC 2018 – Connection Between Cities (IBGE 2020d) to set their received influences. These relations between metropolises are set by IBGE from 0 to 3, meaning: 0 – no relation, 1 – first order relation, 2 – second order relation, and 3 – third order relation. The second and the third relations are equivalent, respectively, to 95% and 90% of the influence of the first order relation (IBGE 2020a). We calculated the influences on influenced municipalities that are metropolises (column B) as the average influence on public management (column W) and business management (column X) of influencing municipality (column H), that are also metropolis.

The average consumer complaint rate of Brazilian municipality v_i on July 2022 (the graph signal $\boldsymbol{u}(0)$), the influences between municipalities to model the Anatel’s expectation of PCS consumer dissatisfaction at each influenced municipality (the adjacency matrix $\boldsymbol{W}$ of $\mathcal{G}$), and the number of consumers per municipality, the vector $\boldsymbol{c} = [c_1, c_2, ..., c_N]^{\mathrm{T}}$, with $50.000c_i$ the number of consumers in municipality v_i, are already properly organized in the file data_for_print_simulations.npz, available at https://github.com/PRInT2023. File print_simulations.ipynb contains the script in Python language for reproduction of simulations, results and figures presented in article Principles, Evaluation Metrics and Method for Planned Regulatory Inspection Targeting.

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