Towards the massification of broadband internet access in Brazil: an application of alternative dispute resolution settlement of administrative proceedings.

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The National Telecommunications Agency (ANATEL)

1 February 2016

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Abstract

In 2012, the Brazilian Telecommunications Regulatory Agency (Anatel) ruled the Conduct Adjustment Commitment (TAC). It refers to an alternative dispute resolution mechanism that allows shifting pecuniary penalties into infrastructure investments. This case study approaches the setting up of strategic investment projects and the definition of a methodology framework set to maximize the benefits of resource allocation. To reach its objective 5,565 municipalities were divided in clusters and ranked according to priority destination for investments. Results include a short list of preferential projects focused on enhancing broadband infrastructure, encouraging the competition and to enhance quality of services performance. Outputs of the methodology suggest that municipalities located at the outskirt of metropolitan regions, evenly distributed throughout the country, with relative lower HDI and higher demographic density are the top ranked destination for investment.

Keywords: Alternative dispute resolution settlement; enforcement proceedings; cluster analysis; infrastructure investment.

1. Introduction: The origin of the problem

The privatization of the telecommunications sector in Brazil was followed by the accession of an extensive number of regulations handling virtually all aspects of services provision. With few exceptions these regulations are accompanied by enforcement requirements mainly constituted on the basis of pecuniary sanctions.

Now, after near 20 years of the privatization statistics for the sector indicate that existing regulatory and legal institutions did not succeed in identifying and resolving disputes efficiently and effectively. Instead, despite enormous sum of fines applied over years there is only elusive effect on the expectation for compliance with regulatory requirements.

In 2013, the National Telecommunications Agency (ANATEL) issued the Conduct Adjustment Commitment (TAC) regulation as an attempt to address alternative mechanisms for dispute resolution settlement of administrative proceedings (ANATEL, 2013). It follows successful experiences abroad and their reported advantages over traditional dispute resolution instruments (Bruce et al., 2004).

The American Federal Communications Commission (FCC) provides several examples of successful use of alternative dispute resolution to settle disputes in the telecommunications sector. Years of experience has turned these methods into preferential mechanisms for addressing administrative proceedings and those in which the Commission is a party.

Arguments underlying FCC approach include the recognition that complexity in clearing disputes in the sector is a major impediment to sector development and a critical element to efficacy of telecommunications infrastructure and services (Bruce et al, 2004)[1]. To FCC

[1] Further examples in using alternative dispute resolution mechanisms in the telecommunications sector are available in Bruce et al (2004).

simplifying dispute resolution can create favourable conditions for investment pushing the development of telecommunications and information industries to the new technology era.

Experiences with TAC in Brazil dates back to the beginning of the 1990s when the method was included in the Consumer Protection Code[2] (BRAZIL, 1990) inaugurating a new perspective for alternative dispute resolution settlement in consumers related issues. Expectation for reducing costs and length of administrative proceedings while protecting both collective and diffuse interests and rights and reducing demand over administrative offices, and eventually over the courts, turned it into a contemporary topic of interest by the main administrative offices in the country.

According to subsidiary analysis presented by the board of Anatel commissioners the TAC allows modernizing the sector tools of enforcement launching a new perspective on the issue of dispute resolution in administrative proceedings (Loureiro, 2013). Among other innovations it grants for reversing pecuniary penalties into investments in strategic infrastructure focusing on enhancing quality of service and experience of use while assuring compliance of service providers to regulatory obligations.

It must be noted that the TAC regulation operates on a request basis in which service providers have a definitive importance. It is up to the Agency to evaluate the eligibility of the proceedings to TAC after inspection of legal aspects, including the abdication of future appeal (ANATEL, 2013).

Following the approval of the TAC regulation in the Agency the board of commissioners issued a determination to the Agency´s technical office in duty to propose a subsidiary procedure approaching the design of a set of strategic projects and a methodology framework that permits maximizing the benefits of TAC while observing for transparency and nondiscriminatory rules, feasibility and independence from particular private and political interests.

This case study aims to present the fundamentals of the methodology framework elected by the Agency decision makers as the best choice for sharpening the focus of TAC. It attempts to clarify the main underlying discussion as well as the outline of the clustering analysis and ranking techniques deployed to arrange all 5,565 municipalities of the Brazilian federation into clusters and rank them according to priority destinations for investment.

The coming section introduces an overview of the regulation guidelines to project designing and methodology development. After, it is specified the formulation of the clustering analysis and the ranking procedure assigned to identify target municipalities. Finally, tests for the methodology consistence are presented followed by further determinations by the Agency decision makers for methodology further review.

2. Guidelines for project design and methodology framework

According to the TAC regulation available resources must be addressed to increase consumers' welfare through direct benefit to end users or investment in telecommunications infrastructure turned to increasing penetration of modern infrastructures to unserved population. The first choice comprises several arrangements ranging from direct discount on customers monthly bill to temporary gratuity of services. It is not the purpose of this article to present a complete account on the direct benefit to end users. Hence further details on this approach must be elucidated by Loureiro (2013).

Besides the recognizable importance of direct benefits to users, investment is taken as preferable destination for allocation of TAC resources (Freitas, 2015). This choice is coherent with the extensive debate on the theme carried out by the Agency decision makers[3] and detailed

[2] Federal Law n° 8.078/1990, article 113.
[3] *See*, for example, Freitas (2015) and Loureiro (2015).

commitment to the theme within the TAC regulation that contains a specific chapter for the theme detailing inceptives, obligations and conditions for investment disburse. It also delineates guidelines for project design that must observe simultaneously the modernization of infrastructure, reduction of social and regional inequalities, massification of the expected benefits and improvement of quality of service standards to residential customers, small businesses, and other end user customers such as schools, libraries and public facilities.

Requirement for project designing and to definition of methodology framework are defined in basic rules grounded in the Agency´s prior studies given as follows:

I. Provision of telecommunication network, capacity increase or capillarity to low economic and social development areas;

II. Regional inequality reduction;

III. Telecommunications network modernization;

IV. Increase of service quality standards to users;

V. Massification of networks and services access that support broadband internet access.

These conditions are coherent with the conduct adjustment effort which purpose is the improving of both the quality of service and experience by end users in areas known lower quality of service provision and outdated infrastructure. They are also aligned to current policy guidelines, oriented to development of broadband access (BRAZIL, 2015).

Regulators attempt to foster the modernization of network while pursuing access to uncovered population comprises some of most critical challenge to the sector. It is also consistent with current economic crises when investment in the sector withdrew to the lowest level since the privatization.

Ancillary references within the TAC regulation also comprise elements for the projects design and investment. Specifically, it defines that investments must be priority addressed to areas with lack or insufficient broadband infrastructure provision. It includes regions beyond the obligations specified in radiofrequency auctions for 3 and 4G services and the universalization policies focused on the universalization of fixed telephony.

The temporal boundaries for investment disburse consists in the main economic constraint to service providers willing to engage in TAC. Specifically, it implies that investments elected to TAC must be exhausted in four years span what, given the magnitude of investments, implies negative Net Present Value (NPV).

As compensation to the negative NPV the regulation establishes a social and regional discount factor. It refers to a multiplier factor ranging from 1 to 2 with the purpose of assigning different levels of discount according to the relevance of project and destination of investments. In practice multiplier 1 would be attached to low priority projects in non-priority municipalities while multiplier 2 would be assigned to high priority projects in top ranked destinations.

By applying the factor multiplier the estimated NPV of a given project may vary from the cost itself to its double. Since the total resource available is scarce, TAC signatories could reduce its debt whenever electing strategic projects and preferable target areas for investments with higher discount multiplier. A detailed set of multipliers distribution is provided in the results section.

Other important inceptive deals with the efficiency of the investment disburse. It is about the allowance to TAC signatories to retain the surplus of the projects implementation whenever the cost efficiency and demand overcomes the standards of costs and demand estimated by the Agency as input for the NPV calculation[4].

[4] Cost and revenue parameters for NPV valuation were established according to bottom up cost based model, sector´s WACC and time span available upon request to the superintendence of competition (http://www.anatel.gov.br/institucional/index.php/contato)

2.1. Priority projects

Regarding the project design a shortlist was chosen out of structured discussion with several interest groups. Fundamentally, discussions led to supplementary technical assumptions to maximize the benefits of the investments and to suit the projects to the agency oversight capacity. It deals with the compatibility of the project proposal to current network architecture, the priority of optical fiber over other alternative infrastructure deployed for broadband internet, spectrum optimization and the phase out of 2G mobile technology.

Therefore, selected priority projects are (a) transport infrastructure provided in optical fiber from the target locality to the nearby available backbone[5] and (b) provision of 3G and 4G services in municipalities without this service availability[6]. This set of strategic projects was elected as the fundamental infrastructure for broadband internet access, necessary to reach the under-served population allowing them to effectively engage in the modern communication era.

Focusing on development and availability of optical fiber is a fair recognition that broadband internet is the most important platform for innovation, free flow of knowledge, competition and economic growth in Brazil. It also reinforces the importance of mobile telephony and data use provided by 3G and 4G as immediate substitutes of wireline based services.

This shortlist is not exhaustive and is only meant to beforehand set priority projects that would ultimately allow expedite transaction. Hence, service providers willing to subscribe to TAC may come out with their own project proposals that must be submitted to the agency scrutiny in order to evaluate its eligibility respecting the conditions established in the TAC regulation.

2.2. Clustering procedure and the definition of priority areas for investment

The setting up of the clustering analysis and ranking of priority target areas for investment allocation was developed in three steps. First and foremost all 5,565 municipalities were characterized according to relevant and non-redundant socio-economic variables[7] that better approximate the conditions expressed in the regulation. Selected proxies are the availability of optical fiber, competition in broadband internet provision[8], the Human Development Index (HDI), revenue per capita[9], population density and distance between municipalities with and without optical fiber[10].

Since the presence of infrastructure is a basin condition for both the improvement of broadband internet speed and the proper development of other strategic projects, the database was split up into those with and without availability of optical fiber. This decision owes to easing of computation and for the sake of simplicity to expose the project to the board of decision makers. The two subsets were analyzed separately using the same parameter settings.

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[5] It also includes investments turned to shortening of fiber to the Curb (FTTC) in substitution to legacy copper network.

[6] Selected projects come out of a long list after extensive discussion with experts from the Agency and telecommunications service providers. The full set of considered projects and notes on the underlying discussion are available upon request.

[7] The decision for the selected variables comes out of a long list of potential variables related to the nature of the problem. The short-list refers those variables that displayed low degree of collinearity between them following lessons by Dolnicar and Grün (2009) on the theme of deciding the Clustering Variables.

[8] Herfindahl-Hirschman Index (HHI) is the competition proxy input considered for clustering process.

[9] Dataset were normalized by log ratio.

[10] O logaritmo da menor distância euclidiana entre municípios com e sem fibra. A distância entre municípios com e sem fibra foi utilizada apenas para o grupo de *clusters* sem fibra.

After characterizing all municipalities they were submitted to clustering procedure using a non-hierarchical method known as k-means (Macqueen, 1967). This method allows for partitioning the 5,565 municipalities into pre-defined number of K clusters.

The k-means algorithm uses the within-cluster variation as a measure to form homogenous clusters. Particularly, this procedure aims at segmenting the data in order to minimize the within-cluster variation (Milligan and Cooper, 1985).

Since the characteristics of the method allow pre-assigning the number of clusters it is expected that not all observations will naturally fit to the clusters immediately. Thus, the k-mean method uses a multi-iterative algorithm until all the observations get associated to the closest cluster (Bussab, 1990). It basically consists in assessing the (squared) distance from each observation to the center of the associated cluster. If the reallocation of an object to another cluster decreases the within-cluster variation, this object is reassigned to that cluster.

For the purpose of this study the clusters were set to five. Authors' judgment about the number of clusters included a close exam on the frequency distribution among clusters what would ultimately allow TAC signatories to expand their possibilities of project choice.

Based on the pre-defined number of clusters the algorithm randomly selects a center for each cluster. For the purpose of setting the distances from the cluster centers to every single object it was employed the Euclidian Distance Method. It refers to a geometrical measure in the multidimensional space between the center of a cluster $X=[x_1,x_2,\ldots,x_p]$ and municipality $Y=[y_1,y_2,\ldots,y_p]$ computed as follows:

(equation 1)

$$d_{xy} = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2 + \cdots + \left(x_p - y_p\right)^2} = \sqrt{\sum_{i=1}^{p}(x_i - y_i)^2}$$

Initial reference for defining cluster centroid follows the definition of what is conventionally called initial partition of the elements, or initial seed (Dubes and Jain, 1979). The initial seed refers to the mean values of the municipalities contained in the cluster regarding each of the selected variables. Each municipality is then assigned to closest cluster center.

Due to the multi-iterative algorithm the municipalities affiliation to one of the five clusters may change in the course of the clustering process following the objective of minimizing the within-cluster variation. For computing purpose it was done with the SAS Enterprise Guide, version 7.1[11]. Computed outcomes of the clustering procedure are summarized in the following tables 1 and 2.

Table 1: Clusters summary of municipalities with optical fiber availability

Cluster	Frequency	RMS Std. Deviation	Maximum Distance from Seed to Observation	Nearest Cluster	Distance Between Cluster Centroids
1	1,001	0.4624	1.7528	2	1.1732
2	864	0.4056	2.6996	1	1.1732
3	112	0.5981	2.6871	5	2.5424
4	160	0.4442	1.9149	1	2.0192
5	550	0.5339	2.6732	2	1.4633

Note: 2687 municipalities have availability of optical fiber.

Table 2: Clusters summary of municipalities without optical fiber availability

[11] The SAS program for clustering procedure is available upon request.

Cluster	Frequency	RMS Std. Deviation	Maximum Distance from Seed to Observation	Nearest Cluster	Distance Between Cluster Centroids
1	229	0.2646	0.9610	5	1.5815
2	987	0.2793	0.9605	4	1.3096
3	212	0.2120	0.8318	4	1.3940
4	1,429	0.2518	0.8416	2	1.3096
5	21	0.2271	0.8522	1	1.5815

Note: 2,878 municipalities do not have availability of optical fiber.

As expected, each cluster varies in frequency, depicting the diversity of the municipalities in Brazil. The root mean square standard deviation (RMS) measures the imperfection of the fit of estimator around the data. Higher values imply lower spread in the values around the regression line. By its turn the distance between cluster centroids is a distance reference that represents how distant the clusters are separated. Shorter average distances imply that the clusters are closely connected. These tests confirm the stability of the clustering models with a slightly better outcome for the clusters of municipalities without optical fiber availability.

Following step was to rank the clusters from higher to lower priority. Ranking was based on a two-step procedure that started by ranking individual variables within each cluster according to the average values per cluster. References for higher rank are lower HDI, higher population density, closer average distance from the center of the municipality to the nearby available optical fiber, higher average income and lower level of competition. Second step consisted in compiling the priority for all clusters considering the position of ranked variables. It implies that clusters with higher number of top ranked variables will be set as higher priority. The score assigned to HDI was assumed as tiebreaker criteria.

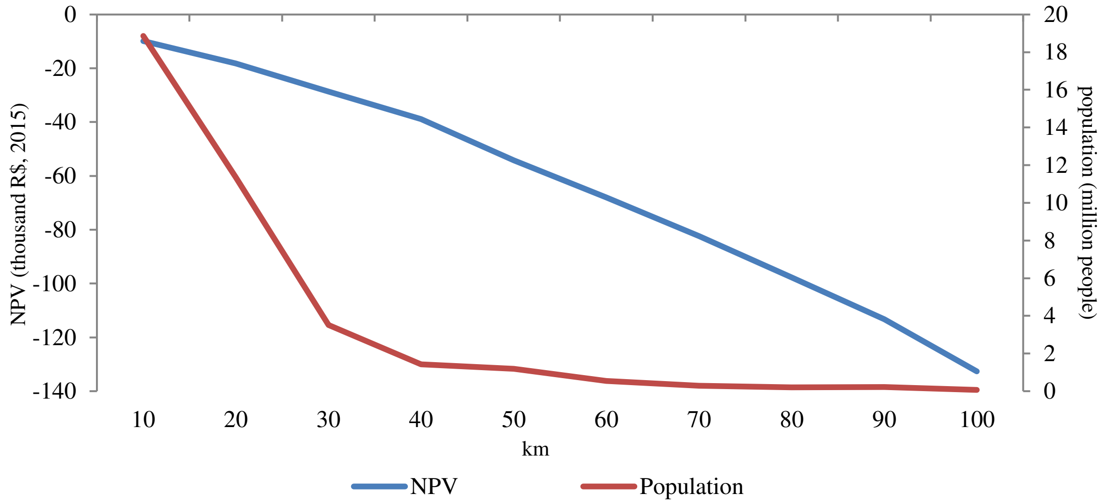
The choice for closer available infrastructure as higher score in the ranking procedure is justified by its natural extension of the available infrastructure. It represents a relevant aspect for potential TAC candidates since it respects the natural extension of infrastructure in compliance with technical particularities of available network.

The combined use of cluster analysis and ranking technique is a distinctive aspect of this proposal. The main competing schema was framed fundamentally on HDI ranking, with the single lower HDI municipality ranked with the maximum discount multiplier and so on.

Considering the economic conditions of these localities this would naturally reduce the attractiveness TAC signatory to go for projects due to the lower inceptives once a large parcel of the resources would be addressed to areas without economic attractiveness with a significant cost. The purpose of the TAC regulation would also be jeopardized under these circumstances given that localities with lower HDI are also those with lower population density.

In economic terms it is also against the expectation of efficient allocation since the municipalities with lowest HDI are located far distant from nearby available optical fiber network what leads to higher marginal cost for infrastructure development. A simulation of this evidence, exemplified by the cost of carrying optical fiber to farther localities, is summarized as follows.

Figure 1: Average NPV for optical fiber Project in municipalities located from 10 to 100km of the nearby available optical fiber network (simulation)[12]



Notes: Values in 2015 Brazilian Real (R$) were estimated according to expected demand and cost projections carried out by the technical body of the agency based on bottom up cost based model parameters.

Figure 1 shows the financial effort associated to the provision of optical fiber to localities outside the range of natural network expansion – an infrastructure which investment amortization requires intensive usage – in municipalities located from 10 to 100 km of the nearby available optical fiber network. For 100 km distance the cost for fiber provision is seven times higher than municipalities 10 km away of it. By the other hand the provision of fiber to closer municipalities cover, in average, 270 times more people than those 100 km far. Similar exercises for other strategic projects returns equivalent cost-benefit pattern.

It implies that few municipalities far from nearby available optical fiber would exhaust substantially more resources than others closed to optical fiber networks what would resume the whole TAC resources into few projects in isolated localities. Furthermore it would jeopardize the expectation for access massification, a fundamental condition of the TAC regulation.

The dilemma between massification and the haunting desire of some interest groups to focus on infrastructure universalization was taken as the major challenge for the present proposal. With this in mind it was fundamental to clarify that the attempt to TAC resources allocation does not confound with those of universalization policy which targets the entire population according to specific flow of universalization fund disburse and middle to long term implementation schedule.

Within the present proposal the clusters of municipalities allowed to balance a broader frequency of municipalities with similar levels of HDI but also considering incentives to attract investments, including the capacity of consuming, demographic density and levels of competition. Ultimately this choice permits maximizing the limited resources available while increasing the stimulus for service providers under the TAC condition.

Furthermore the choice for a multidimensional approach complies both to the guidelines and inceptives in order to induce TAC subscribers to choose the allocation of resources with priority projects *in lieu* of direct discount on the bill. It also dramatically increased the number of target municipalities assigned with higher discount multiplier, a characteristic absent in the main alternative proposals.

[12] Data and Program available upon request.

Third and final step of the methodology consisted in assigning the social and regional discount multiplier to each and all clusters. The multiplier factor ranges from 1 to 2 according to lower to higher priority cluster.

For the ranking process variables average were ranked according to the relevance defined within the regulation. Therefore, lower HDI, higher demographic density, closer distance to lighted optical fiber and higher income per capita were assigned with higher scores. Thus, clusters with higher scores were set with top priority and vice versa.

To be effective this proposal must allow each TAC signatory to freely choose the set of strategic projects and target municipalities that better fit its business plan and network architecture.

3. Database

Database considered in this study is arranged in cross-sectional structure of 6 variables for the year 2014[13]. Economic and social references were all obtained from the Census Bureau (IBGE, 2016) while references for competition and network availability are from Anatel (ANATEL, 2016)[14]. Following Tables 3 and 4 introduce the summary statistics for each dataset considered in the clustering procedure.

Table 3: Summary statistics of database of municipalities with optical fiber availability

Variable	Unit	Mean	Std. Dev.	Minimum	Maximum
HDI	0-1	0.70	0.06	0.47	0.86
Population Density	Pop/km^2	209.04	864.76	0.42	13,409.68
GDP per capita (R$) 2012	GDP/pop	18,888.67	18,202.78	3280.65	285,619.15
Population	Pop	61,877.85	3,081,32.38	836.00	11,967,825.00
Level of Competition	1-5	2.95	0.30	1.00	4.00

Notes: Summary statistics for all 5,665 municipalities considered in the study.

The summary statistics presented in tables 3 and 4 indicate that municipalities with available optical fiber exhibits higher average socio-economic performance compared to those without fiber. The same applies to competition in internet service provision, income and population density.

Table 4: Summary statistics of database of municipalities without optical fiber availability

Variable	Unit	Mean	Std. Dev.	Minimum	Maximum
HDI	0-1	0.62	0.06	0.42	0.79
Population Density	Pop/km^2	29.37	36.34	0.10	373.22
GDP per capita (R$) 2012	GDP/pop	11,165.46	14,139.08	2,720.32	511,967.24
Population	Pop	13,263.17	13,799.85	818.00	153,918.00
Level of Competition	1-5	3.66	0.47	3.00	4.00
Distance to nearby Optical Fiber network	km	13.47	17.27	0.33	212.68

Notes: For the HDI it was considered the last available references provided by the Census Bureau for 2010.

Despite the differences datasets provide, figure for average distance from the municipalities without optical fiber reveal how close, in average, they are. Results imply that majority of uncovered municipalities are located closer to available optical fiber.

[13] For the HDI it was considered that last available references provided by the Census Bureau for 2010.
[14] Data and Program available upon request.

4. Results

Following tables 5 and 6 summarize the key characteristics of the clusters. Table 5 deals with the dataset of municipalities with optical fiber already available, while Table 6 displays the statistics for clusters of municipalities without availability of optical fiber.

Table 5: Clusters of municipalities already attended with optical fiber availability

Cluster	Munic.	Variable	Mean	Std. Dev.	Minimum	Maximum
1	1,001	HDI	0.67	0.06	0.47	0.81
		Population Density	20.16	11.50	3.70	66.30
		GDP per capita (R$) 2012	13,186.71	7,176.30	3,280.65	57,513.15
		Population	18,421.59	28,777.44	1,098.00	502,748.00
		Level of Competition	3.02	0.15	3.00	4.00
2	864	HDI	0.73	0.04	0.55	0.83
		Population Density	53.47	26.17	13.48	182.24
		GDP per capita (R$) 2012	24,154.68	23,001.01	5,745.33	270,512.88
		Population	29,128.19	51,776.77	1,556.00	853,622.00
		Level of Competition	2.98	0.19	1.00	4.00
3	112	HDI	0.76	0.04	0.62	0.86
		Population Density	3,219.86	2,863.78	576.20	13,409.68
		GDP per capita (R$) 2012	31,436.71	34,048.01	6,343.95	285,619.15
		Population	606,922.85	1,331,271.58	8,429.00	11,967,825.00
		Level of Competition	2.41	0.69	1.00	3.00
4	160	HDI	0.67	0.04	0.54	0.76
		Population Density	2.77	1.37	0.42	7.02
		GDP per capita (R$) 2012	21,736.33	18,692.11	6,492.91	167,736.94
		Population	15,167.09	18,162.35	836.00	108,656.00
		Level of Competition	3.07	0.25	3.00	4.00
5	550	HDI	0.70	0.07	0.54	0.85
		Population Density	244.08	181.83	65.78	1,189.40
		GDP per capita (R$) 2012	17,610.15	14,867.24	3,670.34	174,372.58
		Population	95,012.57	181,392.32	3,139.00	2,914,830.00
		Level of Competition	2.87	0.39	1.00	4.00

Again, it is noticeable a strong correlation between competition and economic and social performance. Such condition is compatible with the economic appeal that drives service providers to invest in certain regions rather than others.

However, a close exam of following table 6 reveals the existence of clusters that despite their relatively lower economic attractiveness are closer enough to those listed in table 5 above. Thus, the effort to cover a broader region with optical fiber, focusing on certain clusters of Table 6 figures as a feasible choice for service providers given the incentives provided by the TAC Regulation. Focusing in these clusters have a crucial importance to narrow the divide between populations that have access to advanced digital services and those that do not, to reduce the social inequalities and ultimately maximizing the available resources.

Table 6: Clusters of municipalities without optical fiber availability

Cluster	Munic.	Variable	Mean	Std. Dev.	Minimum	Maximum
1	229	HDI	0.61	0.06	0.44	0.74
		Population Density	1.73	0.66	0.48	2.88
		GDP per capita (R$) 2012	16,454.54	16,114.00	3,222.53	142,974.33
		Population	12,572.13	14,387.41	818.00	116,186.00
		Level of Competition	3.68	0.47	3.00	4.00
		Distance to nearby Optical Fiber	32.90	34.07	0.39	181.89
2	987	HDI	0.63	0.06	0.42	0.79
		Population Density	9.03	3.71	2.90	15.84
		GDP per capita (R$) 2012	12,229.86	11,634.89	2,720.32	107,164.39
		Population	11,209.77	12,100.64	1,217.00	98,231.00
		Level of Competition	3.69	0.46	3.00	4.00
		Distance to nearby Optical Fiber	15.92	14.65	0.33	117.27
3	212	HDI	0.61	0.05	0.51	0.79
		Population Density	130.77	55.59	77.94	373.22
		GDP per capita (R$) 2012	7,955.81	6,086.58	3,199.11	60,883.74
		Population	21,676.81	20,064.78	2,930.00	150,431.00
		Level of Competition	3.60	0.49	3.00	4.00
		Distance to nearby Optical Fiber	6.60	7.90	0.74	104.86
4	1,429	HDI	0.63	0.06	0.48	0.77
		Population Density	33.23	15.22	15.90	77.56
		GDP per capita (R$) 2012	9,995.42	15,799.94	2,727.16	511,967.24
		Population	13,522.44	13,220.42	1,104.00	153,918.00
		Level of Competition	3.63	0.48	3.00	4.00
		Distance to nearby Optical Fiber	8.71	7.19	0.39	121.91
5	21	HDI	0.57	0.08	0.45	0.68
		Population Density	0.35	0.10	0.10	0.46
		GDP per capita (R$) 2012	15,483.16	17,488.22	4,399.71	79,590.81
		Population	14,728.57	10,864.43	2,284.00	43,094.00
		Level of Competition	3.90	0.30	3.00	4.00
		Distance to nearby Optical Fiber	79.69	58.34	15.03	212.68

Grounded on the characteristics of clusters for each dataset it is possible to categorize them according to the priority scores. Tables 7 and 8 provide the average characteristics of each cluster for both dataset with and without optical fiber availability and their respective position in the priority rank.

Table 7: Ranking of Clusters of municipalities with optical fiber availability

Cluster	HDI	Demographic Density	GDP Per capita (R$)	Level of Internet Competition	Municipalities	Priority
1	0.67	20.16	13,186.71	3.02	1,001	2°
2	0.73	53.47	24,154.68	2.98	864	3°
3	0.76	3,219.86	31,436.71	2.41	112	5°
4	0.67	2.77	21,736.33	3.07	160	4°
5	0.70	244.08	17,610.15	2.87	550	1°

Table 8: Ranking of Clusters of municipalities without optical fiber availability

Cluster	HDI	Population Density	GDP Per capita (R$)	Level of Internet Competition	Municipalities	Distance to Fiber (km)	Priority
1	0.60	3.41	9,540.25	3.77	442	30.87	5°
2	0.67	2.44	34,542.23	3.56	107	20.15	4°
3	0.71	15.37	37,595.34	3.23	164	6.81	3°
4	0.62	85.13	9,020.74	3.60	543	6.88	1°
5	0.62	20.96	8,111.89	3.69	1,622	11.16	2°

Taking together the top priority clusters of the two dataset cover 1,093 municipalities, with average yearly revenue per capita of R$13,300, above average demographic density and below average competition level. This area corresponds to municipalities without proper service provision but with potential consumption capacity to the added value services provided over optical fiber based infrastructure.

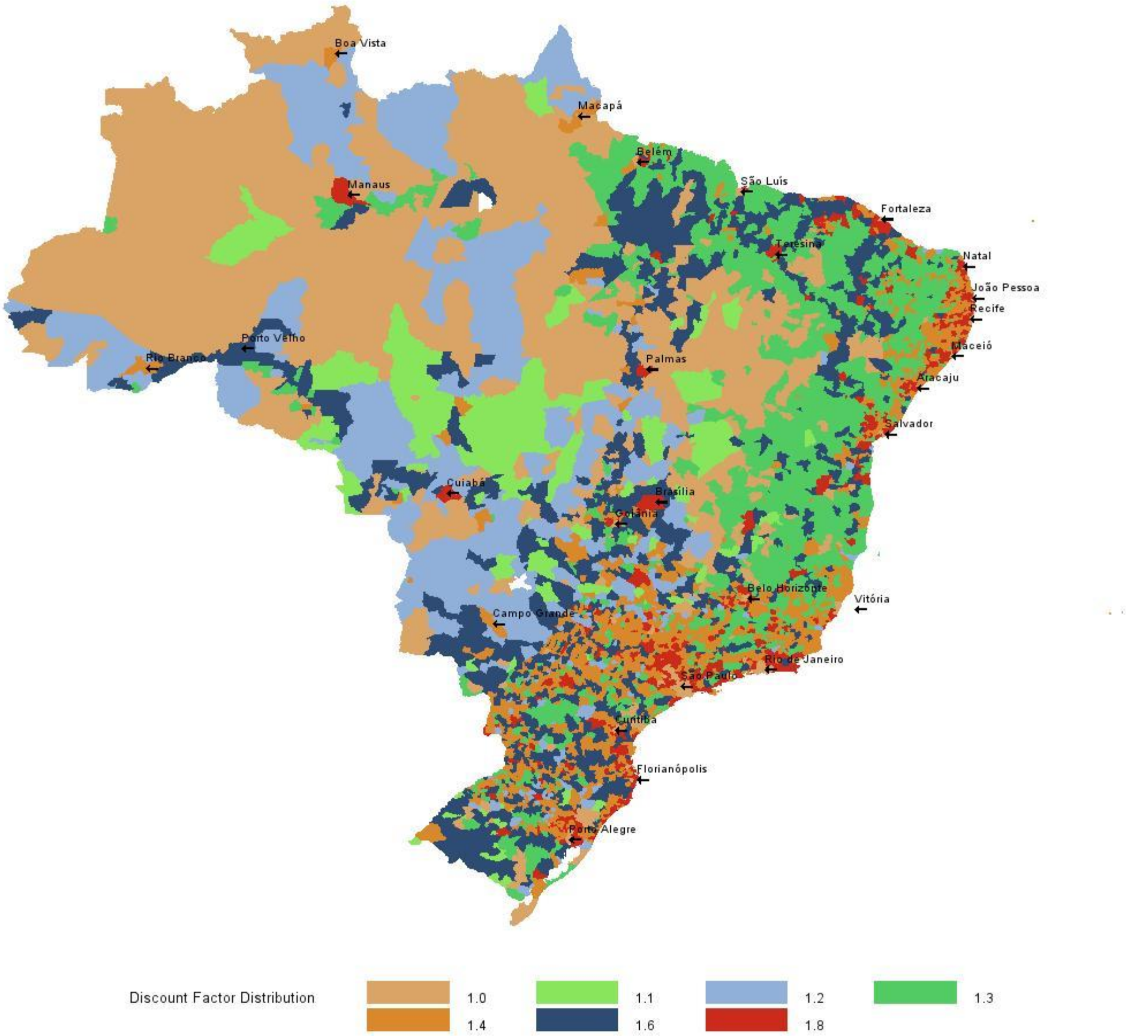
Finally, tables 9 and 10 describe the final proposal of discount factor for clusters of municipalities with and without availability of optical fiber, respectively.

Table 9: Summary of the discount factor multiplier for clusters of municipalities with optical fiber availability

Coefficient		Discount factor
(i)	*Cluster* 1: Priority 2	0.8
	Cluster 2: Priority 3	0.6
	Cluster 3: Priority 5	0.2
	Cluster 4: Priority 4	0.4
	Cluster 5: Priority 1	1
(ii)	Strategic Project	0.8
	Maximum out of (i) + (ii)	1.8

Amongst the clusters with available optical fiber, service providers would receive maximum 1.8 discount multiplier factor for developing strategic projects, except fiber, in municipalities classified in the top priority cluster. The outcome of this process is plotted over the Brazilian territory as shown in Figure 2.

Figure 2: Municipalities classification by discount factor multiplier with optical fiber availability



Meanwhile table 10 summarizes the discount factor multiplier for clusters of municipalities without availability of optical fiber.

Table 10: Summary of the discount factor multiplier for clusters of municipalities without optical fiber availability

Coefficient		Discount factor for optical fiber project *	Discount factor for strategic projects except optical fiber
(i)	*Cluster* 1: Priority 5	0.2	0.6
	Cluster 2: Priority 4	0.4	0.7
	Cluster 3: Priority 3	0.6	0.8
	Cluster 4: Priority 1	1	1
	Cluster 5: Priority 2	0.8	0.9
(ii)	Choice for a strategic project	1	0.4
	Maximum out of (i) + (ii)	2	1.4

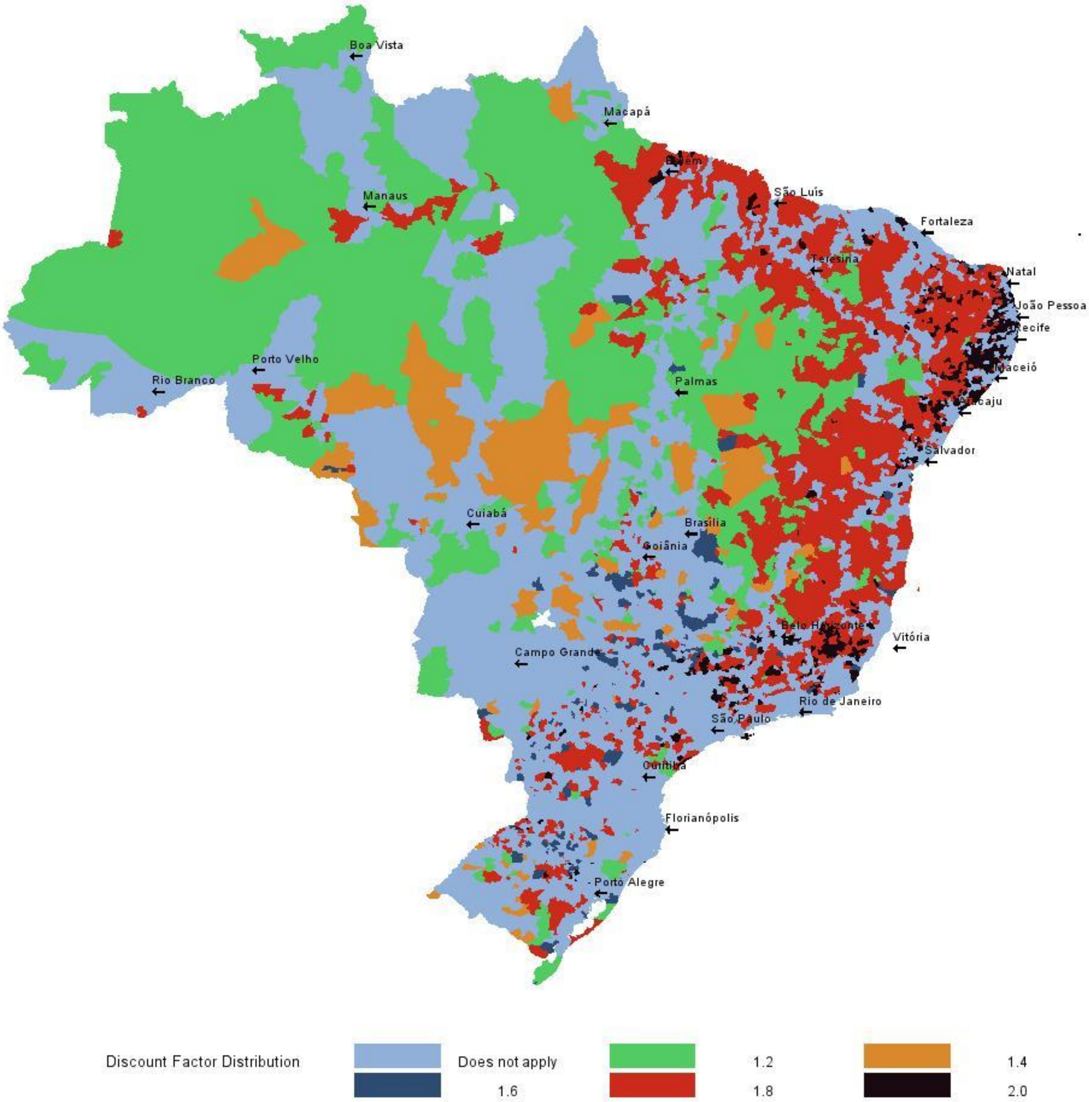
Notes: * Maximum multiplier factor also applies for combined investments that include optical fiber and other strategic projects altogether.

For municipalities without fiber availability the maximum discount factor reaches 2. Such combination occurs whenever the TAC signatories choose to invest in optical fiber project in the top priority cluster.

The discount factor distribution follows a priority hierarchy which is headed by optical fiber investment. In this way alternative investments will not receive the top multiplier unless it is combined with optical fiber. In other words, non-fiber projects turned to municipalities without fiber provision receive lower incentive amongst the other possible combinations.

The map is again useful for the purpose of illustrating the distribution of the discount factor throughout the Brazilian territory.

Figure 3: Municipalities classification by discount factor multiplier without optical fiber availability



The plot displays a concentration of higher discount factor in municipalities span in a large belt extending from north to southeast regions of the country. Detailed statistics of the outcome say that above 55.8% of the population from the lower developed north and northeast regions are located in municipalities contemplated with discount factor higher than 1.8, it corresponds to 43.7% of the municipalities of those regions. Besides that it provides a *prima facie* evidence of regular distribution of the top ranked discount factors throughout all regions of the country endorsing the accuracy of the model whenever considering municipalities with similar social and economic development standard.

Results show that municipalities located in the outskirts of major metropolitan regions, with relative lower HDI and higher market concentration are those with major priority. It also corresponds to the regions with higher demographic concentration and closer distance from available optical fiber. The final output of the study is summed up in one single matrix of municipalities and projects all assigned with a multiplier factor.

It is fundamental to recognize that the composition of target municipalities within the clusters is likely to change over time. The same applies to the list of strategic projects. It implies that reviewing the list and priority of projects and municipalities is an essential condition for its continuous improvement. Facing this condition the board of commissioners established the validity of the model for 2 years.

5. Conclusions

This case study approaches the first attempt to establish a coherent list of priority project and a methodology framework set to reversing pecuniary penalties into strategic investment in telecommunications infrastructure in Brazil. The proposal is backed up on national policies for the sector and in full compliance with the new regulation for alternative dispute resolution settlement in administrative proceedings carried out by the telecommunication regulatory authority.

Amongst the considered inputs for project design and methodology development it includes the modernization of infrastructure, reduction of social and regional inequalities, massification of the expected benefits and improvement of quality of service standard. Ultimately, the successful deployment of TAC aims simplifying the dispute resolution settlement procedures within the Agency while promoting investment, growth and development in the sector.

The proposal was submitted to review by the board of commissioners of the regulatory agency[15] resulting in unanimous approval with minor requests for future updates. Specifically, commissioners requested reducing the granularity of the target areas in order to extend the proposal to different regions within a single municipality (Loureiro, 2015).

Results suggest that the strategic projects and methodology framework is strongly aligned to the purpose of the TAC regulation and current public policies to the sector. Preliminary evidences demonstrate that target municipalities are evenly distributed throughout the country, mainly located at the boundaries of larger metropolitan regions. These regions are characterized by relative lower HDI, higher market concentration and average income average that would ultimately allow service providers to obtain returns over their investments.

Given the socio-economic conditions of these areas it is highly plausible that a large parcel of population will be able to reach broadband internet provided over modern optical fiber or mobile platforms operating in 3G or 4G technologies. To reach such objective services providers will incur in the challenge of developing business plans fit to this new market conditions.

Finally, notwithstanding the peculiarities of the Brazilian legislation and the jurisdiction of the regulatory agency, such experience may provide guidance and insight for public officials and private-sector executives around the world. This experience might be particularly beneficial for countries that have historically experienced a lack of investment and growth in their telecommunications sectors.

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[15] Video record of the deliberation meeting that approved the strategic projects and methodology framework is available at: https://www.youtube.com/watch?v=pjcYRK3-TbU

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