

Job hunting

Looking for the most suitable location of
public employment offices in Brazil

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Social Sector

Division of Labor Markets

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Abstract

The location of offices of public employment services matters. It can bring jobseekers and vacancies closer together to accelerate the matching process and make the best use of resources. In the case of Brazil, financial consolidation calls for better job placement and better spending of public resources. In this line, the Labor Markets and Social Security Division (LMK) in cooperation with the Ministry of Labor developed a tool to objectively identify where offices of public employment services (PES)¹ could be (re)located to spend resources more efficiently. Using a three-stage methodology, this technical note presents and discusses the tool to indicate where the most suitable locations for offices of employment services should be to increase the probability of finding a job and filling a vacancy. The first stage computes a ranking of PES offices employing variables of demand and supply of labor as well as the intermediation capacity of PES offices. The second stage replicates this index at a municipality level to determine the potential of municipalities to host PES offices. Finally, we combine both stage with georeferenced parameters such as distance to transport stations and capital cities to map where PES offices should be located, allowing end-users to control the influence of variables in determining spatial suitability.

JEL codes: J63, J61, J68

Keywords: job search, turnover, vacancies, suitable

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¹ The Public Employment Services (PES) in Brazil are referred to as the National System of Employment (SINE by its initials in Portuguese).

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I. Introduction

The location of offices of public employment services (PES)² is key to bring jobseekers and vacancies closer together to improve the matching probability and make the best use of resources. Brazil is seeking budget consolidation at all government levels that calls for the efficient placement of fewer vacancies and improving public spending (Almeida & Gasparini, 2016). In this line, the federal budget to finance the state and municipal agreements to support the offices of PES³ is undergoing a financial re-engineering process. In an attempt to prioritize spending in PES, the Department of Employment and Wages (DES by its initials in Portuguese) of the Ministry of Labor expressed interest in a study of spatial redistribution to identify which offices were candidates to be closed, kept opened or relocated to other available locations⁴⁵.

The technical note seeks to develop a tool to classify PES offices based on the internal aspects (customer service performance and technical efficiency) and external factors (supply of and demand for employment and physical accessibility) that affect the probability of finding a job and filling a vacancy. These criteria can help PES management identify the most suitable location of public employment offices in Brazil not aiming to prescribe a solution but rather supporting decision making objectively (Barbosa, 2008). It is expected that in this way the PES can spend resources more efficiently.

This technical note employs a three-stage methodology that combines different models to measure the suitability of geographical locations to host a PES office. The first stage uses the multi-criteria analytical tool Promethee II – Preference Ranking Organization Method for Enrichment Evaluation (Brans & Vincke, 1985). The Promethee II ranks and classifies offices as candidates to be closed, kept open or relocated to social security offices to cut costs according to their customer service performance and efficiency. The second stage consists of a multiple linear regression model that replicates the Promethee II to classify municipalities based on their potential to host PES offices. Lastly, the third stage combines the previous ones with georeferenced data such as distances to the transport stations and main urban centers to map

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² The Public Employment Services (PES) in Brazil are referred to as the National System of Employment (SINE by its initials in Portuguese).

³ The offices of Public Employment Services in Brazil offer at least three core services: job intermediation unemployment insurance and referrals to professional qualification courses. Then, depending on its size, geographical location and context of the local labor market, they can also offer issuance of the employment and social security booklet, professional counseling, entrepreneurship support, and information of labor rights and other social benefits of the federal government.

⁴ In this note we use the offices of the National Institute of Social Security as alternative to locate a SINE office. This exercise can be done with any other set of locations considered as alternatives to SINE offices. The National Institute of Social Security (INSS by its initials in Portuguese) is the public office that administers old-age, disability, and survivor pensions to workers, whether they were formally employed or not, and other related groups.

⁵ The tool presented in this technical note is part of a set of tools being developed by the Labor Markets and Social Security Division to support the strengthening of Labor Intermediation Services in the Region.

where PES offices should be located, allowing end-users to control the influence of variables in determining spatial suitability.⁶

The technical note is structured as follows. The first section briefly introduces the databases and the variables employed in the technical note. The following section presents in detail the three stages discussed above. Then, the third and fourth sections show the results of the analysis by model and describe an online tool developed to conduct the simulations. Finally, section six sums up the findings.

II. Databases and variables

We employ the following databases and variables to support the analysis:

A. Database of workforce Intermediation – PES office level

The database of workforce intermediation (BGIMO by its initials in Portuguese) is a daily administrative database compiled by the Ministry of Labor. It contains information of jobseekers and employers registered in PES offices. From the jobseekers' side, it includes data on the employment histories as well as their socioeconomic information (age, gender, education and employment status). From the employers' side, it contains their economic activity and listing of job vacancies. The database also includes data on the matching of the profiles of jobseekers with the requirements of vacancies, summons and referrals of workers to interviews based on matching results as well as the outcome of the referral. In this technical note, we use the following indicators:

- Number of services: Annual average of services delivered in PES offices.
- Number of intermediations: Annual average of services only related to intermediation (job seekers, employers, vacancies and referrals to job openings).
- Number of vacancies: Annual average of job positions offered in the year the vacancy was registered.
- Number of referrals: Annual average of workers referred to a vacancy.
- Number of registered job seekers⁷: Annual average of job seekers registered in the year disaggregated by occupation, economic activity and schooling.

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⁶ The note recognizes the idea that “everything is related to everything else, but near things are more related than distant things.” Tobler’s first law of geography (1970).

⁷ Using the Brazilian Classification of Occupations (CBO by its initials in Portuguese) and the National Classification of Economic Activities (CNAE by its initials in Portuguese).

- Variance of job seeker registration: Annual mean variance of workers registered among the different levels of schooling.
- Technical efficiency: Index ranking the decreasing returns to scale of outputs (placements) in terms of inputs (no. of vacancies, mean of PES agents, mean time of service delivery and no. of intermediations) using a data envelope analysis (DEA)⁸.

B. Annual Report of Social Information – Municipality level

The Annual Report of Social Information (RAIS by its initials in Portuguese) is an annual administrative dataset compiled by the Ministry of Labor. It contains information on employment and earnings of all the formally-employed workers of formally-registered firms in a given year. The RAIS includes detailed information on the employer, the employee, and the employment relationship (wage, tenure, type of employment, hiring and dismissal date, and reason for dismissal). In this technical note, we use the following indicator:

- Stock of workers: No. of workers in the year disaggregated by occupation, economic activity and schooling.

C. General Registry of Employees and Employers – Municipality level

The General Registry of Employees and Employers (CAGED by its initials in Portuguese) is monthly administrative dataset compiled by the Ministry of Labor. It was initially conceived as a database to collect information on the hiring and dismissals of workers to keep the unemployment insurance policy up to date. It therefore contains information on monthly employment and earnings of all the formally-employed workers of firms that at least hired or dismissed one worker in a given period. The CAGED includes data on the employer, the employee, and their employment relationship (wage, tenure, type of employment, hiring and dismissal date, and reason for dismissal). In this technical note, we use the following indicator:

- Net employment: No. of hired and dismissed workers in the year disaggregated by occupation, economic activity and schooling.

D. Layers of transport network – Georeferenced level

The road and transportation network as well as the map layer were obtained using Google Maps API, which allows you to extract existing georeferenced points which in this case were:

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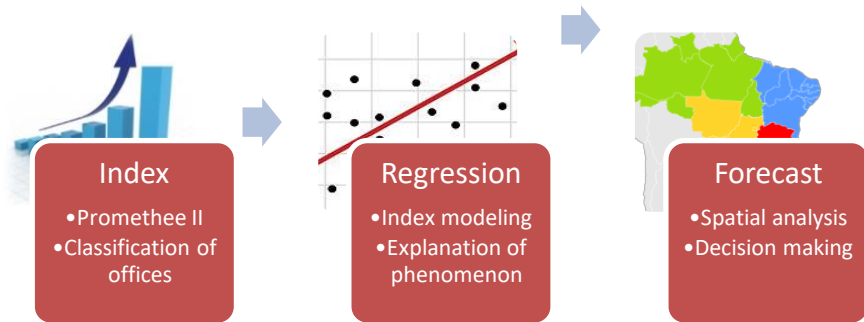
⁸ The data used for the Data Envelopment Analysis (DEA) was organized from the administrative microdata at office level.

- Transport stations: Main train, metro and bus stations including their intersections.

III. Methodology

The methodology used to build the model is based on a three-stage procedure as illustrated in **Figure 1**. This section will describe the stages taken in this technical note based on Roy & Vanderpooten⁹ to identify which offices are candidates to be closed, kept opened or relocated to neighboring social security offices. The first stage is to rank offices and municipalities employing multiple criteria. The second is to categorize offices (in three classifications) and municipalities (in 10 classifications)¹⁰ based on the distribution of their ranking performance. The final stage describes the analysis of the location suitability of PES offices in a systematic way so that the user can make a decision.

Figure 1. Development of the models



Source: Authors

A. Promethee II: Ranking of PES offices

The Promethee II is a multi-criteria analysis tool that employs a utility function to transform a multi-criteria problem (internal and external variables) into a single-criterion problem (ranking). There are other alternatives such as Analytical Hierarchical Process (AHP) and ELECTRE, but according to Brans & Mareschal (2005) the Promethee is more suitable when the problem is to rank spaces, which is the objective of this work. This type of analysis is part of the Multiple-Criteria Decision-Making (MCDM) field that studies problems in which there are alternative locations that must be ranked.

⁹ The Roy and Vanderpooten (1996) was one of the first articles to specify the steps that should be taken when a Multi-criteria decision problem is faced.

¹⁰ The 3 categories used for offices came as a result of the question posed by the government which wanted to identify which offices should be closed, relocated or kept opened. The 10 for municipalities was considered as categories based on the distribution's deciles to describe the percentage for which each municipality belongs to. It is a straightforward way to show the entire distribution splitting the total number of municipalities in 10 categories with approximately the same number of observations in each category.

In this exercise, the alternatives include existing PES offices or social security offices¹¹ (INSS by its initials in Portuguese) (MASSAM, 1988). The ranking is based on internal (service performance and efficiency) and external (supply of and demand for jobs) factors that explain the probability of finding a job and filling a vacancy¹². It is generated using a continuous index from 0 to 1 for all PES offices within a state while employing six criteria available in the BGIMO: number of services, referrals, vacancies, registered jobseekers, variance of jobseeker registration and technical efficiency. The index reflects the performance of a PES office in these criteria compared to the other offices in the state, with 1 indicating the best-performing office and 0 the worst-performing office.

In simple words, a PES office is defined as optimal if it features:

- ✓ A high mean of services delivered demonstrating its importance as a service provider in the state
- ✓ A high mean of vacancies offered indicating the capacity of the office to capture vacancies available in the area
- ✓ A high mean of workers registered reflecting the visibility of PES to attract interested jobseekers in the area
- ✓ A high mean of referrals indicating potential match of jobseekers to vacancies
- ✓ A high variance of registered workers as a proxy for continuous demand for jobs from job seekers from different educational profiles
- ✓ A high efficiency of the use of inputs to deliver intermediation services¹³

The first step is to build the index (Figure 2) is to assign the weights for each criterion (*Peso1, peso2, ..., pesoM*) based on the level of relevance from the user perspective. A criterion that receives a higher weight is considered more relevant in explaining the performance of a PES office. In the second step, the model establishes the level of preference for each criterion between the alternatives. That is, when comparing the performance of one PES office (*alternativa 1*) to another (*alternativa 2*), it can be established that ‘variance of job seeker registration’ (criteria 1) will have higher impact on the preference between the two offices than the ‘number of services’ (criteria 2).

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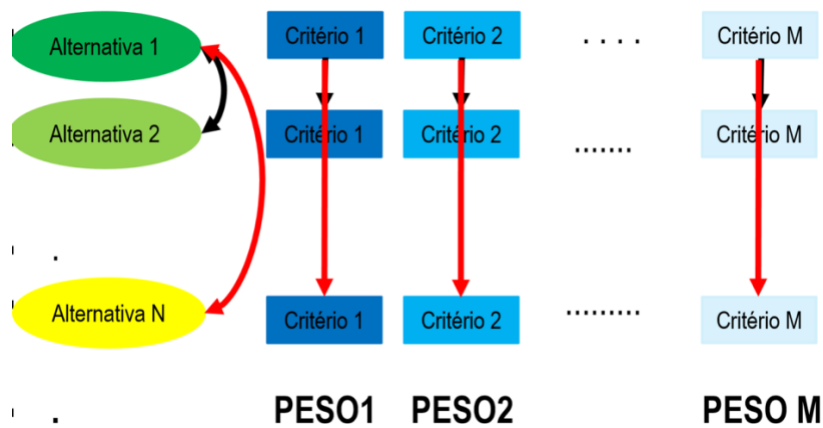
¹¹ The idea is to use as additional locations that can reduce the operational costs of public services. In this example, we use INSS social security networks as alternative. We could also have used the network of Social Assistance (CRAS, by its initials in Portuguese). This note only presents an example and the choice of INSS as additional locations is not linked to any suggestion that we should consider merging the networks.

¹² Promethee II has been used extensively to identify adequate use of spaces (Terrados, Almonacid, & Hontoria (2007), Eraslan, & Tansel (2011) e Téno & Mareschal (1998)). More details about the Promethee II is provided in the Annex.

¹³ Calculated using Data Envelopment Analysis (DEA), a model explained in Annex II.

In the second step, Promethee II employs a preference function to rank the PES offices using the parameters resulting from combining the weights and preferences mentioned above. In other words, to compare the performance between alternatives 1 and 2, Promethee II calculates the difference between each criterion (criteria 1) using the ordered preference function. If alternative 1 is superior to alternative 2 for criteria 1, then it is ranked above; otherwise, below. Next, the performance of criteria 2 is compared for the same office pair. The exercise is repeated subsequently for all the criteria and for each office pair until the ranking is generated.

Figure 2. Promethee II Model



Source: Authors

In the final step, the resulting ranking values are then used to build three categories (closed, open or relocated) employing cut-off points with a minimum internal variance and a maximum external variance. That is, the groups formed within the categories show characteristics that are very similar internally, but that differ greatly between the groups. Next, an index to municipalities is created building on Promethee II results.

B. Multilinear Regression: Ranking of municipalities

Now that we created a ranking of PES offices in the previous section, the objective of this section is to estimate the potential of municipalities to host PES offices by replicating the Promethee II index but at the municipality level. To do so, the first step is to calculate an estimated Promethee II index for each office¹⁴, using this time PES-level variables common at both municipality (i.e. stock of workers by educational attainment) and office level (i.e. registered workers by educational attainment).

¹⁴ The PES office is the spatial unit, for which there are 1,413 observations representing 97% of the entire universe of PES offices.

The second step is to run a Lasso regression. The Lasso regression minimizes the difference between the original Promethee II (the dependent variable) and the estimated Promethee II (calculated in the previous step). Since many of the variables considered here are proxies (stock of workers as proxy for registered workers), the Lasso regression was used to remove coefficients closed to 0 of workers with varying education attainment, as pointed by Nordhausen & Taskinen (2015, p. 236).

After running the regression, the third step is to collect the weights of only the municipality-level variables in the regression results. Finally, the last step is to replicate the index at the municipality level by multiplying the resulting weights with the actual values of the municipality-level variables.

The Lasso regression specification is as follows:

$$SQEp = \sum (y_i - x^t \beta)^2 + \lambda ||\beta||$$

where SQEp is a sum of squares of the errors $y_i - x^t \beta$; (y_i) is the actual values of the Promethee II; and ($x^t \beta$) is the Promethee II values estimated using PES-level data for variables common at both municipality and office levels. The term $\lambda ||\beta||$ instructs the model to keep only the variables at office levels that have a large contribution in the model. The λ is a term that penalizes the excess of variables that may not have explanatory power in the linear regression and $||\beta||$ is the L2-Regularization used to avoid the model overfitting. Then using the resulting weights β , a new index for municipalities is calculated. If the difference of the squared errors is small (high), it indicates that the municipality has high (low) potential to host a PES office.

C. Exploratory Spatial Analysis: Optimal location

The last stage of the analysis is to estimate the optimal geographical location to host PES offices based on georeferenced information. In this stage, the decision maker can conduct a simulation combining the indices of the offices (resulting from the Promethee II) and municipalities (resulting from Lasso regression) with the location of social security offices as well as the distances to bus, metro and train stations and urban centers. It can do so using Shiny, a tool that makes it easy to build interactive web applications using R package.

The combination of Promethee II and Spatial Analysis is not new. Marinoni (2005) shows how combining Promethee II in a Geographical Information System (GIS) allows decision

makers to assess alternatives spatially. In this case, to be considered an alternative office, a social security office must meet 3 conditions¹⁵:

1. Be located in a municipality with high potential to host a PES office:



2. Be situated within 500 kms of the capital city of the state:



3. Be within 50 kms of a bus, metro or train station:



Source: Authors, generated by Shiny using BGIMO

IV. Results

In the previous section, we rank in the first stage PES offices based on factors that determine the probability of finding a job and filling a vacancy. In the second stage we replicate the rank to municipalities to estimate their capacity to host a PES office. Finally, we combine the two rankings with georeferenced factors such as road and transportation networks to estimate the location suitability of a PES or social security office. The combination of these three stages generates a tool¹⁶ that contributes to a more objective decision making without giving up preferences of decision-makers. In this section, we present the results in four different formats: ranking of offices; distribution of offices by categories; map of offices; and map of transport network, ranking of municipalities and alternative offices¹⁷.

A. Ranking of offices

The **table 1** below contains the ranking of PES offices (index) and the variables used to create it, including the names and addresses of the offices. The ranking can be organized in descendant order – 1 being the office with the best performance and 0 the office with the lowest performance. In this case, we use the northeastern state of Pernambuco as an example¹⁸. In Pernambuco, the best-performing office is in the neighborhood of Boa Vista.

¹⁵ Potential cut-off points are set using the deciles of the index distribution. To be considered high potential, the municipality needs to have an index among the highest 10% of state distribution. The user can change the distance radius related to capital city and transport network.

¹⁶ It can do so using Shiny, a tool that makes it easy to build interactive web applications using R package.

¹⁷ The results can be made available in a web platform.

¹⁸ The tool was built at municipality level for all states of Brazil.

Table 1. Ranking of PES offices in Pernambuco

nome_municipio	nome_posto	postos2015	cep_posto	bairro_posto	endereço_posto	longitude	latitude	tot_atendimento	qtd_encaminhamentos	qtd_vagas	N_trab	Variability	CRS_TE3	Index
Recife	SINE RECIFE/PE	SINE RECIFE/PE	50050000	BOA VISTA	RUA DA AURORA, 425	-34.87592345	-8.053287819	44322	25009.2857142857	5605.14285714286	18079	7908746.45974026	0.2089673	1
Jaboatão dos Guararapes	SINE MUN JABOATÃO CENTRO/PE	SINE MUN JABOATÃO CENTRO/PE	54110000	CENTRO	AVENIDA BARÃO DE LUCENA, N 131, 131	-34.87737938	-8.047074229	21733	13512.4285714286	2068.71428571429	8414.42857142857	1906591.07272727	0.3643213	0.90214
Recife	SINE MUNICIPAL RECIFE/PE	SINE MUNICIPAL RECIFE/PE	50030310	RECIFE ANTIGO	AV RIO BRANCO, 155	-34.87237108	-8.062710877	18326.2857142857	10800.8571428571	1592	8167.57142857143	1700987.41558442	0.0748816	0.75748
Petrolina	SINE PETROLINA/PE	SINE PETROLINA/PE	56304190	CENTRO	PC DESEMBARGADOR JOÃO PAES, S/N, 1 PISO	-40.49246872	-9.398350071	10421.2857142857	5847.28571428571	814	5081	485915.150649351	0.8256069	0.53479
Paulista	SINE PAULISTA/PE	SINE PAULISTA/PE	53401250	CENTRO	PC CEL FREDERICO LUNDRENG, S/N	-34.85891018	-7.933862206	10253.5714285714	4928.28571428571	697.857142857143	5336.71428571429	824509.303896104	0.3888883	0.4408
Caruaru	SINE CARUARU/PE	SINE CARUARU/PE	55000000	MAUR.DE NASSAU	RUA PADRE ANTONIO TOMAZ, 127, CENTRO	-35.97106059	-8.277680889	10188	4815.42857142857	1449.57142857143	5488.85714285714	531727.423376623	0.1468293	0.43608
Olinda	SINE OLINDA/PE	SINE OLINDA/PE	53010120	PEIXINHOS	AVENIDA PRESIDENTE KENNEDY, 1001	-34.8946491	-7.999578657	10138.8571428571	2805	0	8312.28571428571	1561011.15064935	0	0.38549
Recife	SINE CORDEIRO/PE	SINE CORDEIRO/PE	50711000	CORDEIRO	AVENIDA CAXANGA, 2200	-34.92679371	-8.047266168	10569.4285714286	4205.71428571429	0	7876.42857142857	1123156.57662338	0	0.37442
Cabo de Santo Agostinho	SINE CABO DE SANTO AGOSTINHO/PE	SINE CABO DE SANTO AGOSTINHO/PE	54505330	CENTRO	RUA DR ANTONIO DE SOUZA LEAO, S/N	-35.03901081	-8.288464004	8250.28571428571	4124.28571428571	1022.57142857143	4597	649979.38961039	0.1548267	0.33737
Caruaru	SINE POSTO EXPRESSO CIDADÃO CARUARU/PE	SINE POSTO EXPRESSO CIDADÃO CARUARU/PE	55030200	INDIANÓPOLIS	CARUARU SHOPPING - AV ADJAR DA SILVA CASE 800	-35.97368914	-8.291946085	9125.14285714286	3002.14285714286	1	6597.57142857143	884191.916883117	0	0.28691

Source: Authors, generated by Shiny using BGIMO

The tool allows the user to modify the weights (**Figure 3**) given to the variables based on their perceived relevance and observe how the ranking varies. This allows users to assess the sensibility of the variables in formulating the index.

Figure 3. Variables and weights to create Promethee II index

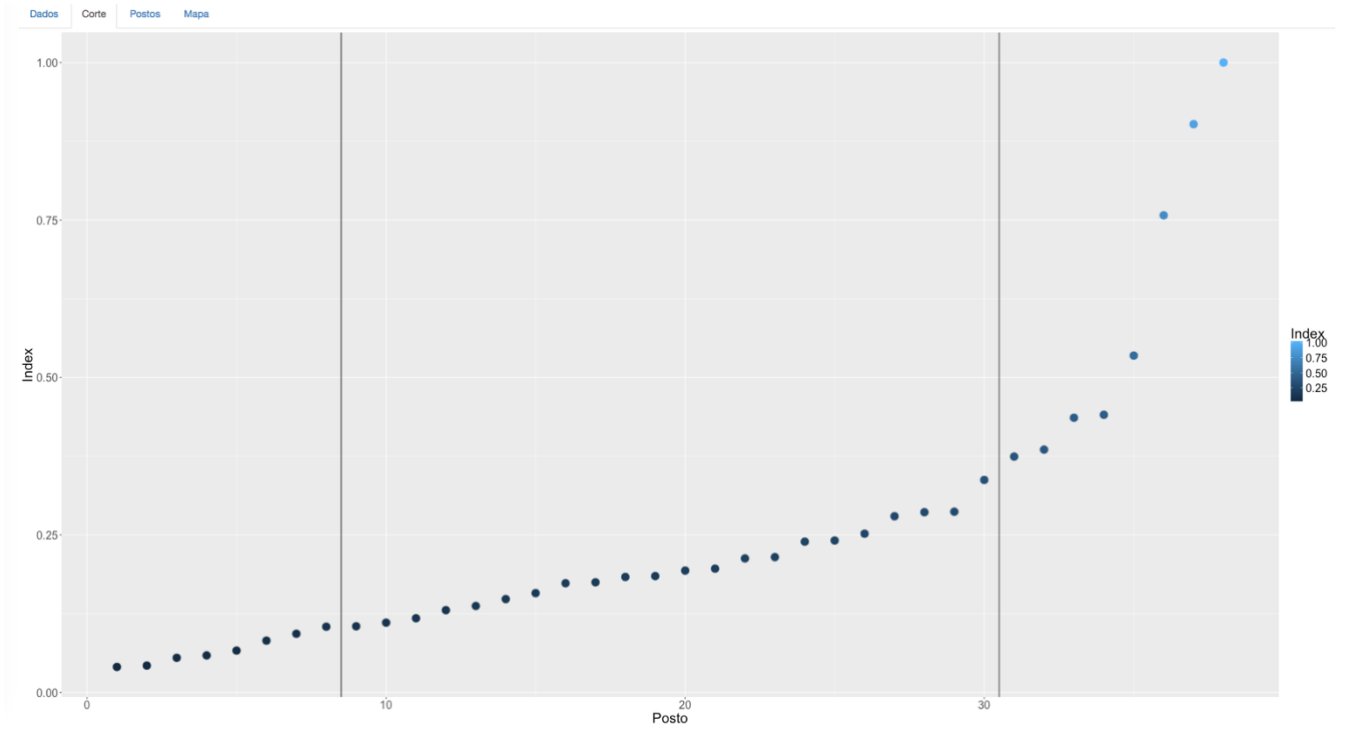


Source: Authors, generated by Shiny using BGIMO

B. Distribution of offices by categories

The graph in **Figure 4** presents the distribution of offices in three categories with similar characteristics within, but varying features across them. The first category (far right) represents the best performing offices which are candidate to remain open. The highest dot represents the same office in the neighborhood of Boa Vista, Recife mentioned above. The group in the middle contains the offices whose performance is average and are thus candidates for relocation. Finally, those offices in the third group (far left) are candidates to be closed.

Figure 4. Distribution of offices by categories and cut-off points in Pernambuco



Source: Authors, generated by Shiny using BGIMO

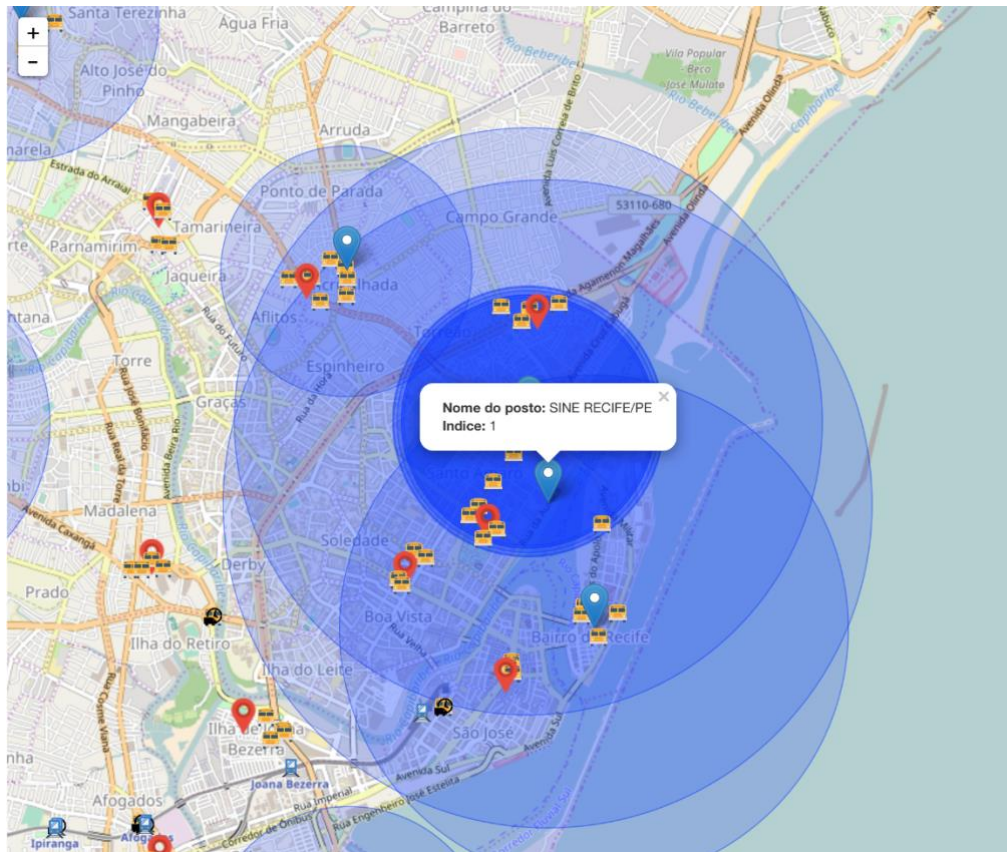
C. Map of offices

The map in **Figure 5** presents the PES offices (blue) in Pernambuco along with offices from the social security institute (red), considered as potential locations to host PES services in the state. It is possible to visualize the performance of a PES office by calculating the exponential of the PROMETHEE II index:

$$w_i = \exp \frac{I_i}{r} \quad (2)$$

where w_i is the performance of the PES office, I_i is the index and r is a measure of range. In this way, the user can visually observe which offices are the best and worst performing compared to the rest. We can observe below that office with the largest circle is the one in the neighborhood of Boa Vista, Recife.

Figure 5. Map of PES and social security offices in Pernambuco



Source: Authors, generated by Shiny using BGIMO

D. Map of offices, transportation network and ranking of municipalities

The map in **Figure 6** crosses the ranking of PES offices (Promethee II) and municipalities (Lasso regression) with the transport network and urban centers. In this way, the user can observe which municipalities have potential to host PES offices (darker color tones) and which not (lighter color tones). In this case, the green offices are located in municipalities with high potential to host PES offices and within a pre-determined maximum distance from the capital city and a transport station.

Table 2 – PES offices and transport signs

SINE offices are categorized as follows:		Transportation stations are illustrated as follows:	
	PES's Office.		Bus station.
	Social security office without potential to allocate a PES office.		Subway station.
	Social security office with potential to allocate a PES office		Train stations

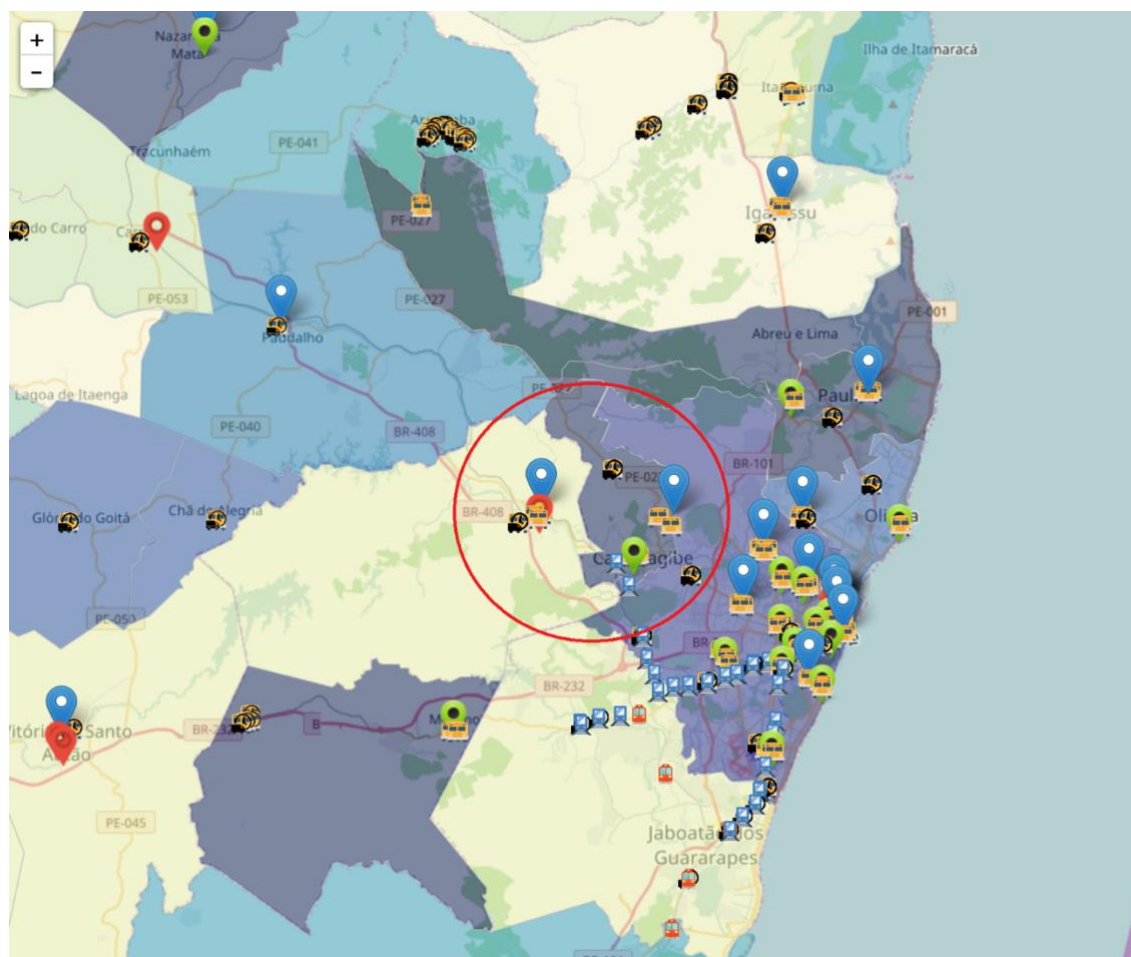


Integration between Bus, Subway and Train.

Source: Authors

In the example below (red circle), for instance, the PES office (in blue) located in the municipality with lower potential to host an office (in yellow) is a candidate to be relocated to the social security office (in green) in the municipality with higher potential to host an office (in purple). In other words, PES management can make better use of resources by moving the PES office in blue to the social security office in green which is relatively close and supported by public transportation. This note only evaluates the geographic location of PES and social security offices. It does not reflect the quality of services, customer satisfaction or promotion of equal access of vulnerable groups to better quality jobs nor does it assess the appropriateness of a social security office infrastructure to provide PES¹⁹.

Figure 6. Map of office, transportation network and ranking of municipalities of Pernambuco



Source: Authors, generated by Shiny using BGIMO

¹⁹ Also, this exercise is not based on any government indication that the PES and social security network should explore possible synergies. It is rather an exercise that indicates that this tool can be very useful to explore such synergies to improve the efficiency of network of public services.

V. Conclusion

This technical note presents for the first time an analysis of location suitability of Public Employment Services (PES) offices in the Latin America and Caribbean (LAC) context. It is part of larger efforts of the Labor Markets and Social Security Division (LMK) to provide solutions to PES seeking to allocate resources more effectively and efficiently. The tool created uses free software that can be adjusted and replicated to other PES whether they wish to open new offices, relocate existing ones or choose the best options between already defined locations.

In the case of Brazil, when PES offices need to spend limited available resources more efficiently, the tool can help PES management to identify which PES offices should be closed, kept opened or relocated to neighboring social security offices to use resources more efficiently. Using only intuition to close down PES offices may make matters worse. It may slow down the placement process in, for example, neighborhoods where jobs are now being created. The tool thus allows end-users to identify the most suitable locations to place PES offices at municipality level using a more structured decision-making process.

The tool does not plan to impose a rigid recipe towards a more efficient allocation of PES network by relocating and closing offices according to the results shown in the model. Rather, it seeks to provide inputs for a more objective planning process without giving up preferences. It enables policy makers to control the influence of variables based on their perception of what determines finding a job – from the perspective of jobseekers – and filling a vacancy – from the perspective of employers while addressing biasness.

The tool does not come without its limitations. It mainly focuses on the optimal location of PES offices in terms of an efficient allocation of inputs. It does not take into consideration the equity of access to better jobs for vulnerable groups. That is, it may not identify cases where an office with an inefficient use of inputs should remain opened given its effectiveness in generating access of good jobs to vulnerable groups. Neither does it incorporate information about the quality of services (sustainable job matches or low involuntary turnover) and customer satisfaction of stakeholders.

Finally, the tool could use its benchmark mechanism in the future to monitor discrepancies in the performance of the PES offices and identify solutions in high-performing units. The tool could also be further improved by including data available at lower administrative levels for more granular precision.

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Annexes

A. Models

I. Promethee II: Ranking of offices of public employment services

The Promethee II ranking is built upon the premise that multiple criteria, often non-compatible, must be compared simultaneously but to varying degrees (Albuquerque, 2015). In other words, to approximate the most optimal location for a geographical space, certain factors deemed key to define the suitability of the location need to be maximized or minimized. For example, if proximity to a bus station is considered a factor that better explains the performance of a given PES office because it attracts more qualified workers, then the user can give more weight to closeness to transport stations when ranking PES offices (Brans & Mareschal (2005).

This type of analysis is part of the Multiple-Criteria Decision-Making (MCDM) field. This field treats problems in which there are alternatives that must be ranked. Here these alternatives encompass PES offices or social security offices that have the potential to cut operational costs if merged in one location. However, while MCDM models allow for the calibration of weights, these are relatively more stable than compounded indices. This stabilization occurs because MCDM models do not allow the weights to alter extensively the ranking of alternatives. Given that users of the tool can manipulate the weights, its influence should not invert entirely the order of the ranking from best to worst alternatives. The MCDM models can measure the stability using the Kendall correlation index for different weights. If it is stable and robust, the Kendall index results in positive values closer to 1²⁰.

The Promethee II approaches the multi-criteria problem of maximization as follows (Brans et al., 1984):

$$\text{Max } \{f_1(a), f_2(a), \dots, f_h(a), \dots, f_k(a) | a \in A\} \quad (1)$$

where A is the set of alternatives f_h and $h = 1, 2, \dots, k$ and k are the number of criteria. The results from f_h are the values of the alternatives $a \in A$ of the defined criteria. Since $f(a)$ is the criterion to be maximized, for each alternative $a \in A$, $f(a)$ is an assessment of this alternative. Consider two PES offices a e b as two alternatives in set A (all PES offices in the state). The office a would dominate office b if $f_h(a) > f_h(b)$, for all the criteria h , where $h = 1, 2, \dots, k$. The order of superiority is considered only a partial relation in A . But when comparing two

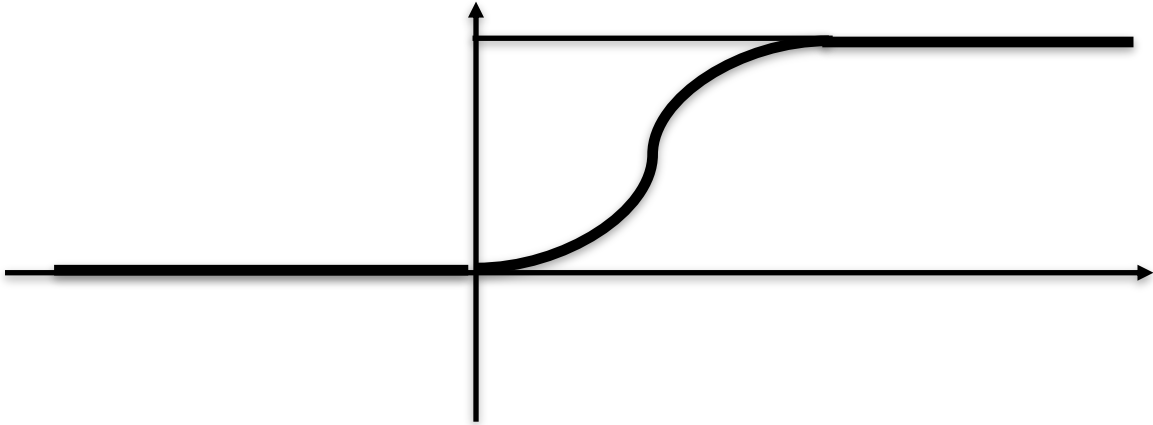
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²⁰ The Kendall index is a measure of rank correlation. It measures the similarity of the orderings of data when ranked differently. The rank between two variables will be positive and closer to 1 when they have similar ranks, or closer to 1 when the ranks differ greatly. The Kendall index is positive and close to one in our model.

offices a e b with respect to the criterion h , the results are also expressed in terms of preferences of the decision maker defined as the intensity of the preference of a over b .

With that in mind, we analyze the results of the preference function P . In case $P(a, b) = 0$, the office a is indifferent to office b . That is, there is no preference of a over b given their similarities are too closed to call. In case $P(a, b) \sim 0$, there is a weak preference of a over b ($f(a) > f(b)$), and if $P(a, b) \sim 1$, there is a strong preference of a over b ($f(a) \gg f(b)$). However, if $P(a, b) = 1$ there is a strict preference of a over b ($f(a) \gg \gg f(b)$). In this case, PES office a strictly dominates office b in all the criteria considered. In this way, each function of preference is an increasing function of the difference between two assessments, that is, $d = f(a) - f(b)$ and $P(a, b) = \mathcal{P}(d)$. For this reason, the slope of the preference function is in the positive axis as in Figure A.1 below:

Figure A.1 Function of Gaussian Preference



Source: Authors

In this analysis, we employ the Gaussian criteria as it is not necessary to define the sub-parameters for difference and indifference. The function of Gaussian preference is given by:

$$P(a, b) = P(d = a - b) = 1 - \exp \frac{d^2}{2 \sigma^2} \quad (1)$$

where σ^2 is the variance between the differences obtained for each criterion estimated based on historical data. The multi-criteria index of preference represents the intensity of the preference of the decision maker of a over b , considering all the criteria. It is calculated by the mean of the k values of the preference functions; that is, $\pi(a, b) = \frac{1}{k} \sum_{h=1}^k P_h(a, b)$. Aiming to assess all offices of PES (alternatives) from A using the over-qualification relations, the exit flow, $\phi^+(a) = \sum_{b \in A} \pi(a, b)$ and the entry flow $\phi^-(a) = \sum_{b \in A} \pi(b, a)$ are calculated. The

absolute flow is simply the different between the entry and exit flows; that is, $\phi(a) = \phi^+(a) - \phi^-(a)$ where $\phi(a)$ is the Promethee II index. This Promethee II index can be interpreted as a measure of the superiority of PES a over all other considered offices of PES.

II. Data Envelopment Analysis (DEA) for the efficiency index PES offices

We generate the efficiency index of PES offices, one of the variables used in the Promethee II model presented in this note, using the Data Envelopment Analysis (DEA). The DEA is a non-parametric method to estimate production frontiers where the structure of the production function is not assumed and the estimate is only based on observable variables. We use DEA to infer the efficiency frontier of PES offices and distinguish efficient from less efficient units. To do so, we compare the combination of inputs required to generate a defined output. Using the orientation of the inputs, this comparison generates an index from 0 to 1, where 1 indicates the offices producing the best outputs per inputs possible, and below 1 those with less efficient allocation of inputs.

The PES offices are compared using the Farrel efficiency concept for the public sector (Forsund, 2002). This concept consists of the ratio between the linear combination of outputs and the linear combination of inputs for each office. In this line, the DEA maximizes the ratio of the weighted sums of each unit compared to other units. Given that the maximization of these ratio can result in the generation of many optimal solutions, some restrictions in terms of the relationships between inputs and outputs (constant, increasing and decreasing returns to scale) need to be included. By adding hypotheses about returns to scale it is possible to create a problem of linear programming optimization.

Consider the $X_i = \{x_{i1}, x_{i2}, \dots, x_{ik}\}$ and $Y_i = \{y_{i1}, y_{i2}, \dots, y_{il}\}$ vectors of inputs and outputs, respectively for the i th office as well as $u = \{u_1, u_2, \dots, u_k\}$ and $v = \{v_1, v_2, \dots, v_l\}$ as a vector of positive weights associated with the inputs and outputs, respectively. The model of DEA will thus be:

$$\begin{aligned} & \max \frac{\sum_j^k u_j y_{wj}}{\sum_j^l v_j x_{wj}} \\ & s. a \frac{\sum_j^k u_j y_{ij}}{\sum_j^l v_j x_{ij}} \leq 1; \forall i \\ & \quad u, v \geq 0 \end{aligned}$$

In this case, our desired output is the no. of placements because it is a natural output of the processes of labor intermediation. The inputs associated to placements are the number of

vacancies, monthly mean of agents of PES, number of intermediations, and the mean time of service delivery from the registry of the vacancy to the referral of the candidate as shown in the table of correlations (**Table A.1**). The table shows that the inputs are positively correlated to the no. of placements and there exists a degree of linear dependency between the inputs employed.

Finally, to select the returns to scale method we chose to run an econometrics test proposed by Simar and Wilson (1998) to analyze the null hypothesis that technology has constant returns to scale against non-increasing returns to scale (NIRS) and variable returns to scale (VRS). Both tests show that NIRS and VRS are preferred with NRIS being more robust. Therefore, we restrict the DEA to decreasing returns to scale and the data for 2015, the last year for which there is complete data.

Table A.1 – Correlations of outputs and inputs

	nº colocações	nº intermediação	Média agentes	tempo médio cad_inter*	nº de vagas disponíveis
nº colocações	1.000				
nº intermediação	0.594	1.000			
Média agentes	0.533	0.492	1.000		
tempo médio cad_inter*	0.023	0.074	0.068	1.000	
nº de vagas cadastradas	0.355	0.374	0.609	0.053	1.000

Source: Authors using BGIMO