How to measure access to cash? Methodology and evidence from France

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Abstract

We present a methodology to measure access to cash using granular geo-spatial data. Inspired by the existing measures used in other fields, we propose a distance-weighted index of access that accounts for the volume of cash access points in a given area. We apply this methodology to French data at a municipality level and describe the properties of the index. Finally, we offer avenues for further research by elaborating on the municipalities' characteristics that exhibit correlation with the access index.

Keywords: Access to cash; spatial measure; Financial inclusion;

JEL Codes: E42, R11, C21, G21, O18.

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1. Introduction

Banking sector has experienced significant digitisation in the recent years; banks have started to offer their standard services online such that it is no longer necessary to be physically present at a bank office to perform a payment or a wire transfer. At the same time, households have become less reliant on cash switching to credit card payments in their daily operations. This two tendencies have naturally fostered banks to reduce the size of their branch network. This has had detrimental implications for access to cash. This development exacerbates the problem of financial inclusion in the otherwise disadvantaged territories that might not have access to stable internet connection and digital payment services, and heavily rely on cash for their daily economic activity.

This paper, using a novel geo-spatial granular dataset on mainland France, studies the access to cash. First, we introduce an index that allows to measure access to cash accounting for the geo-spatial dimension. Second, we apply this index to the data on cash access points in mainland France emphasising the importance of the spatial dimension. Third, we correlate the index of cash access to demographic and economic characteristics of French municipalities.

Being able to robustly and effectively measure access to cash is imperative for policy making. An accurate measure of access to cash allows for a calculated policy intervention that would counteract the adverse implications of deteriorating cash access and provides a baseline for tracking progress.

Literature. This paper speaks to two broad strands of literature. First, this paper is related to the vast literature on geo-spatial access metrics. Second, we contribute to the literature on access to financial services.

The methodological literature on measuring access to a given service is vast and varied. Earlier studies would rely on a provider-to-population ratios (PPR) as in, for instance, Paez A. (2012). This simple metric consists in dividing the number of access points in a given territory by its population allowing for a tractable and meaningful measure of access yet has certain drawbacks. First, certain territories may have zero presence of the service of interest, which does not necessarily imply that the inhabitants of this territory do not have any access to the service. As a result, the metric is more suitable to assess presence of the service on the territory (when it is higher than 0) rather than the access to the service. For instance, in France, as we show below, around 80% of the city have no bank counter. So, the PPR in this case, is not relevant at all. Second, the PPR does not take into account the fact that inhabitants of one geographical area might move to a different area to gain access to the service. If someone lives in a city without the service, they might move to a nearby city to access the service. The question of accessibility, however, implies the need to not only study the extent to which the service is available in a given geographical location but also the accessibility of a given service in locations nearby.

More recently, the literature has attempted at addressing the shortcoming of the PPR by accounting for the spatial dimension. For instance, Neutens (2015) assesses accessibility in a minimum-distance measure framework. This metric captures the minimum distance one needs to travel to a given location where the service is available. This measure, however, does not account for spatial concentration of access points within a studied area. As we show further, around 20% of French municipalities have a cash access point. Thus, this metric will not allow us to distinguish between municipalities with low and high concentration of access points.

The most recent methodological advancements try to address these limitations and have been revolving around floating catchment area metrics. Two-step floating catchment area metric (2SFCA), most notably considered in studies of healthcare accessibility (Chen et al., 2020; Mao and Nekorchuk, 2013; McGrail and Humphreys, 2009), uses travel catchments, that are based on time or distance, constructed around supply and demand points. The 2SFCA metric can be broadly described as follows. At the first step, the demand from population $P_{k,j}$ that relates to service provider j is calculated by determining the size of the catchment are k given parameters that determine the size of a catchment area. The area can be determined by specifying the maximum travel time or distance. Then, supply-to-demand ratio R_j is determined by dividing supply capacity S_j by population $P_{k,j}$. At the second step, a catchment area for population demand i is calculated, denoted by k_i. The area is defined by either distance or maximum travel time. Final accessibility index is calculated summing all R_j that are within k_i. The 2SFCA approach does not take into account distances within the catchment area. In other words, the index is uniform across the population within catchment area. And, more specifically, those outside the catchment area get a uniform index of zero. We refer interested readers to Dai (2017) for an extensive treatment.

To remedy for these inaccuracies, an extended 2SFCA method, namely the E2SFCA, has been proposed. E2SFCA accounts for heterogeneity of access within the catchment area through a decay function employed at the second step of the original method. Notable examples include Luo et al. (2018), Luo and Qi (2009) in application to healthcare accessibility, Xing et al. (2020) in application to accessibility of parks, Yang et al. (2022) in application to various public service facilities. There is, however, no consensus on appropriate functional forms of the decay functions. See, for example, J. Bauer (2016). We refer the reader interested in an exhaustive treatment of different floating catchment area methods to Langford et al. (2020).

The second strand of literature we speak to is related to access to financial services. Earlier papers would mostly take a descriptive approach and document the evolution of geographic presence of financial services. Leyshon and Thrift (1995) study the evolution of financial exclusion in the US and the UK over the second half of the XX century documenting a decline in presence of bank branches. Pollard (1996) studies the impact of banking regulation on accessibility of banking services in Los Angeles and find a decline in financial access in the wake of regulatory change. Morrison and O'Brien (2001) studies the distribution of financial services access points in New Zealand. In contrast to the previous papers, they estimate a model of spatial interactions between bank branches and population to infer the impact of closing one branch. French et al. (2008) focuses on studying the historical aspect of political debate on financial exclusion documenting the decline in the financial services availability in the UK. Leyshon et al. (2008) studies whether bank closures in the UK disproportionally affected otherwise disadvantaged neighbourhoods documenting a decline in presence of bank and building societies branch offices.

More recently, the literature has focused on documenting geographical disparities in financial access and rationalising them. Alamá and Tortosa-Ausina (2012) studies the effects of the Great Recession on the the geographical distribution of banks in Spain. They find that the Great Recession has had a detrimental and uneven impact on the presence of banks but concludes that establishing a pattern in the geographical redistribution is not straightforward. Similar results are obtained in Martin-Oliver (2018). Dunham and Foster (2014) studies patterns of financial services distribution in Pennsylvania and finds that banks are more likely to be found in the communities with high income, whereas alternative financial institutions are closer to the disadvantaged communities.

Whilst most of the papers would focus on the local scale, others would deviate from that approach and consider financial inclusion at the state level and use its synthetic measure to correlate it with economic development and other characteristics. Park and Mercado (2015) and Park and Rogelio Mercado (2018) look at a panel of economies and find a link between financial inclusion, income inequality, and poverty. They conclude that higher financial inclusion is associated with lower inequality and poverty levels.

In measuring financial access, this paper tries to amend for the limitations in the literature outlined above. First, we allow for geographical accessibility considerations. If one is to consider a generic population centre that is one kilometre away from a bank branch, the distance will not have the same impact on accessibility in an environment where good transportation is available and where it is not. We, hence, take into account the actual time one needs to travel to a given financial service venue. Second, we allow for distance decay. As one is getting further from a bank branch, accessibility decreases non-linearly in the transportation time. Third, we do not limit our study to a city or a specific region, but do it on a national scale whilst preseving data granularity.

To measure access to financial services we employ an enhanced two-step floating catchment area method, a spatial analytical approach similar to that used in Langford et al. (2022). The output of this method is a supply-demand ratio that allows to analyse the accessibility of financial services that depends on population density, number of bank branches within catchment area, and travel time. This method has been originally used to analyse accessibility to healthcare and other public services to address the shortcomings of other spatial analytical methods that outlined above.

The rest of the paper is structured as follows. First, Section 2 introduces the index to measure access to cash accounting for the geo-spatial dimension. Section 3 presents the French data which we use for the calculation of the index of cash access. We discuss the property of the calculated index and compare it to two alternative specifications accounting for population. Section 5 presents an econometric analysis of correlation between the index and the characteristics of the municipalities. Section 6 concludes and presents avenues for future research.

2. Index of access to cash

The methodology we use to measure the access to cash stems from the Extended Two-Step Floating Catchment Area (E2SFCA) method presented above. In this section, we elaborate on the way we calculate the index.

Index definition. To measure cash access, we define the following index

$$CASH_i = \sum_{j=i}^{J} \frac{log_2(Equip_j + 1)}{\alpha^{d_{i,j}}} \Bigg|_{j \in d_{i,j} \leq \gamma} \tag{1}$$

where $CASH_i$ is the index of cash accessibility for a given territory i, J is the total number of territories j in the vicinity of the territory i, $Equip_j$ is the number of cash access points in the territory i allowing cash withdrawal and in each of the j territories located nearby, $d_{i,j}$ is the distance between the territory i and each of the j territories in the vicinity, and γ is a parameter for determining the distance delimiting the j territories around the territory i. We apply the distance condition for taking the neighbouring territories j into account in the calculation: its distance from i must be less than the chosen maximum distance γ. In other words, γ implicitly defines J and the j territories included in the calculation around i.

Breaking down the index. Several elements of Equation 1 shall be clarified for a better understanding of the index.

First, we use the logarithm of the number of cash access points rather than the gross number to accommodate for declining marginal benefit of an extra unit of service. We assume that, for a consumer the presence of an additional cash access point becomes less attractive as the number of access points grows.

Second, parameter α introduces distance decay. This assumption implies that as the distance between municipality i and the cash access venue in municipality j increases, it is more difficult to access it. The functional form that we use implies that cash access venues located in i are not subject to distance decay when measuring the index for the municipality i. Distance decay $\alpha^{d_{i,j}}$ is required to be an increasing function of distance, hence, we require that $\alpha > 1$. As α increases, the difference in impact on the index between the closest venues and those the furthest away is magnified.

Third, we restrict attention to neighbouring municipalities within a distance threshold governed by parameter γ; this parameter governs the size of catchment area. Since we are taking into account the cash access venues of neighbouring municipalities, we shall, for reasons of both computational economy and theory, choose which neighbouring territories to include in the measure.

Illustrative example. Consider three representative territories to illustrate the proposed metric, *CASH*: a central town, a peripheral town, and an isolated rural town. The characteristics of each of the three hypothetical towns are given in table 1.

Table 1. Score of cash access ($CASH_i$) for three hypothetical territories

Variables and parameters	City		
	Urban centre	Urban periphery	Rural isolated
$Equip_i$	30	5	0
$Equip_j$ for $\gamma < 10$	10×5	10×5	5×0.2
$d_{i,j}$ for $\gamma < 10$	3	5	9
$Equip_j$ for $\gamma < 20$	10×2	8×2	5×1
$d_{i,j}$ for $\gamma < 20$	12	15	19
$\mathbf{CASH_i}$	**8.7**	**5.1**	**0.3**

Note. We use Equation 1 to calculate $CASH_i$

The first city is an urban centre, that is very well endowed with cash access points. The surrounding areas are numerous but less well equipped than the centre. Furthermore, the number of facilities in these areas decreases as you move away from the centre. In the first radius, there are 10 towns with an average of 5 facilities located an average of 3 km away. In the second radian, there are still 10 towns, but they are less well served, with 2 services accessible on average, and those further away, located 12 km on average. One should note that the distances between the areas are short, as the urban density is higher. As a result, the *CASH* of this city is 8.7.

The second city is an urban town located in the periphery, with lower quantity of cash withdraw facilities that is equivalent to that of the surrounding areas of the first radian [1]. The areas are a little further apart and fewer in

[1] It is assumed that the town centre of this area is located in the vicinity of the town studied.

number than for the first type, because we arrive more quickly from the urban periphery to the suburbs, which are also less well served.

Finally, the third type of city is an isolated rural commune with no facilities on its territory. There are few communes in the surrounding area (5 in each radius), as the rural communes are larger and further away. These surrounding municipalities are also poorly served (0.2 and 1 service on average per municipality).

Eventually, the hierarchy between the three cities in terms of cash access is clearly illustrated by our score. The central urban area scored an *CASH* of 8.7, compared with 5.13 for the peripheral city and 0.27 for the isolated rural city. These differences provide a first illustration of the sensitivity of the cash access indicator to the characteristics of the area.

In Appendix A, we provide comparative statics to illustrate the evolution of the score with respect to the different elements of its calculation. To sum up, the relationships are as follows. First, *CASH* is increasing in the number of cash access points in the municipality with the marginal increase of *CASH* related to a one-unit increase of the facility is decreasing.

About the two elements related to the distance, there is a reduction in score when one increases the average distance of the territories included in the calculation of the index. The value of the index decreases very quickly with the growth of the parameter α. Lastly, we observe that the score increases with the radius γ that defines the catchment area.

Accounting for demand. So far, we have abstracted from accounting for population in the calculation of the index of access to cash. Now, we calculate the index of access taking population into account which could be seen as a proxy for potential congestion effects; Holding the number of cash access points fixed, the more people use them, the longer it takes one to access them and, thus, the quality of cash access decreases.

To account for demand, we divide the number of cash access points, $Equip_j$, by the total population within the defined catchment area, $\sum_{j=i}^{J} Pop_j$. The score then reads

$$CASH_i = \sum_{j=i}^{J} \frac{log_2\left(\frac{Equip_j}{\sum_{j=i}^{J} Pop_j} + 1\right)}{\alpha^{d_{i,j}}}\Bigg|_{j \in d_{i,j} \leq \gamma} \quad (2)$$

Compared to the index defined in (1), Equation 2 explicitly accounts for population within catchment area as a proxy for demand for cash.

3. Application to French data

In this section, we apply the index to the French data. We calculate the spatial accessibility index using a novel granular municipality-level data set.

3.1. Data and index composition

Data. To calculate the index of cash access, we use geo-spatial data at municipal level on ATMs, bank branches, post offices, and population. The data on ATMs[2] and bank branches is sourced from the French interbank network, *Groupement des Cartes Bancaires CB*, and is proprietary. Data on post offices that allow cash withdrawals is obtained from the French Postal Service, *Groupe La Poste*. The data on intercity distances is obtained via Google Maps API; we define distance between two given municipalities as a distance between their geographical centres. Population data is sourced from the French Bureau of National Statistics, *INSEE*.

By default, the cash access indicator is calculated based on the data for municipalities in mainland France and the island of Corsica. Due to data availability, we cannot calculate the indicator for overseas territories. Following the official geographical definition of 2022, we work on the data for all 34,835 municipalities.

[2]We restrict attention to ATMs deployed by banks. Other non-bank operators that deploy ATMs throughout the country exist. The number of such ATms is limited and is not considered in this paper.

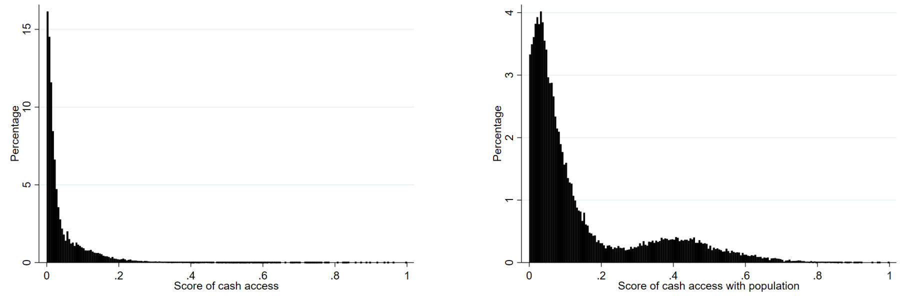
Index composition. The number of cash access points in a given city in our baseline calculation of the index is given by the sum of ATMs, bank counters, and post offices. Even though all of these venues offer cash access, it is not universally accessible. Whilst all ATMs can be used by the population holding a French-issued card, the post offices and bank branches offer a more restricted access to cash. First, bank branches offer access to cash only to their clients. Second, post offices restrict cash access to inhabitants of their municipality or to clients of *La Banque Postale*, French public bank managed by the national postal agency. In this section, we include all these cash access points in the calculation of the index. We relax this assumption and look into the drivers of the index of cash access by cash distribution venue type in Section 4.

Spatial distribution of ATMs, bank counters and post offices is rather concentrated; more than 80% of the French municipalities do not have an ATM, a bank counter, or a post office. We provide related figures in the Appendix (A.8, A.9, A.10). This fact can be explained by small size of French municipalities and their large number. This spatial concentration further motivates our choice to consider catchment areas and account for distance decay thus allowing for potential population travelling around their municipality of residence.

We calibrate the elasticity of the index with respect to distance, α, to 1.3, and γ, the catchment area size, to 30 minutes. Distance is measured as travel time in minutes, as defined by the Google Maps API, rather than as-the-crow-flies distance or route distance in kilometres. This measure of distance allows to better reflect the relevant travel conditions. Particularly, in isolated territories, physical distance might not be a good proxy for the travelling conditions. Similarly, for each municipality, the index calculation is based on the municipality geographical centre as defined by French National Geographic Institute, *IGN*.

In addition, we normalise the indix values for each municipality using min-

Figure 1. Scores of cash access in France (2022)



A. Without the population B. With the population

Note. The score is defined in the text for 2022. The left panel displays the score without taking into account the city population, the right panel does by integrating the population. The raw score is min-max normalized.

max normalisation as follows

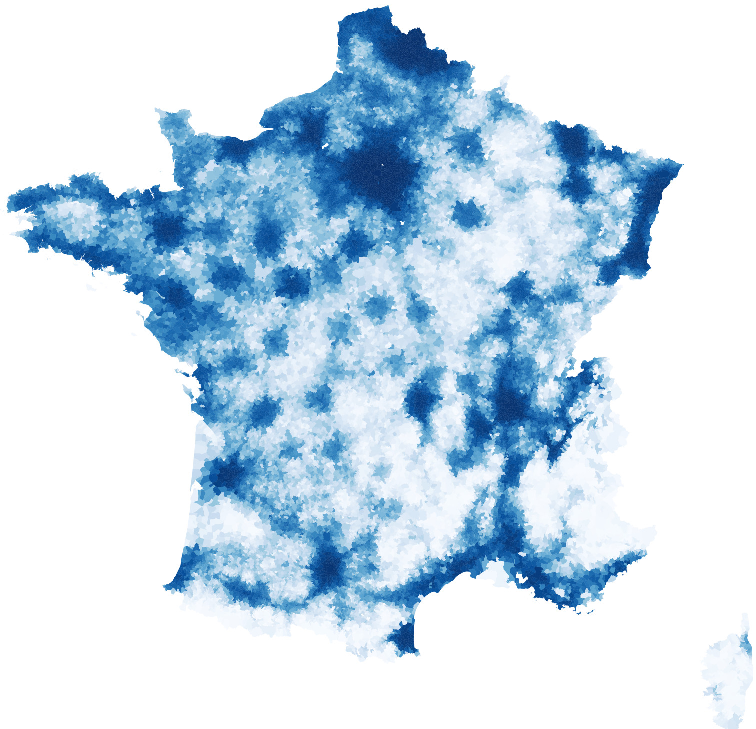
$$CASHnormalised_i = \frac{CASH_i - \underset{i}{Min}(CASH_i)}{\underset{i}{Max}(CASH_i) - \underset{i}{Min}(CASH_i)}. \tag{3}$$

We use this normalisation to allow for a more straightforward ranking of municipalities according to cash access.

Index presentation. We calculate the normalised index of cash access for 34,835 French municipalities. The left panel of Figure 1 depicts the distribution of the index. One can see that the distribution of the index is right-skewed implying that most municipalities have relatively low access to cash. The right panel shows the distribution of the index calculated according to (2). Accounting for population shifts the distribution to the right and makes it less concentrated. The mean increases from 0.05 to 0.15, and the variance increases from 0.005 to 0.029.

Map 2 offers an illustration of the spatial heterogeneity in cash access in France. Clearly, the index of cash access is driven by the French urban structure and the travel axis. In the large urban units and in highly urbanised regions, such as North and Alsace at the German border, the municipalities

Figure 2. Score of cash access by city in France (2022)



Note. See the text for the score definition. The raw score is min-max normalised and goes from 0 to 1. White colour denotes a low score of cash access, dark blue colour does a high score.

have a high degree of accessibility of financial services. The further one moves away from large cities, the lower is the cash access index. In addition, the variance in the score depends on the quality of highway network; rural and mountainous municipalities exhibit a low score of cash access.

Sensitivity analysis. We analyse the sensitivity of the index values to our calibration choice. Table 2 displays the changes in α in the top panel and in γ in the bottom panel.

Distance decay sensitivity, α, induces a significant change in standard deviation of the index. The higher the value of the parameter, the stronger are

Table 2. Score of cash access ($CASH_i$) and parameters values

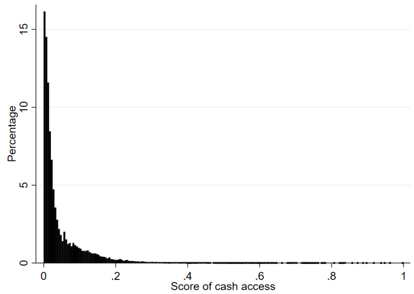
Parameters α	γ	Mean	S-D	Skewness	Kurtosis
1.1	30	0.050	0.070	5.756	50.371
1.2	30	0.047	0.067	5.234	45.311
1.3	**30**	**0.048**	**0.073**	**3.968**	**28.553**
1.4	30	0.052	0.088	3.027	16.267
1.5	30	0.058	0.106	2.616	11.280
1.3	10	0.045	0.078	3.217	19.326
1.3	20	0.047	0.073	3.892	27.583
1.3	**30**	**0.048**	**0.073**	**3.968**	**28.553**
1.3	40	0.048	0.073	3.974	28.625
1.3	60	0.048	0.073	3.974	28.626

Note. See equation 1 for the calculus of $CASH_i$. α has no dimension, γ is defined in minute of travel. The bold line is the baseline calculated score.

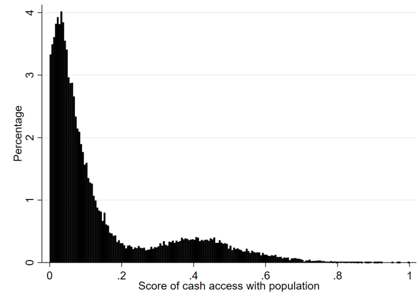
the effects of distance decay which, in turn, make isolated municipalities more isolated with respect to cash access. Thus, any existing disparity in the number of cash access points is amplified compared to baseline.

The size of the catchment area, γ, has a slight positive impact on the distribution mean which vanishes when all municipalities within 30 minutes of travel distance fall in a catchment area. This is due the fact that the two parameters have similar impact; one could interpret γ as binary distance decay; all territories outside the catchment area contribute zero to the index. At the same time, α could be seen as continuous distance decay; territories further away contribute less to the index as α increases. If α is rather high, distance territories already play a minor role for the index value, thus pruning them completely by setting low γ has relatively low impact. This explains why increasing γ has positive effects on the mean of the distribution up to a point, in our case the effect vanishes if catchment area is spans beyond a 30-minute travel distance.

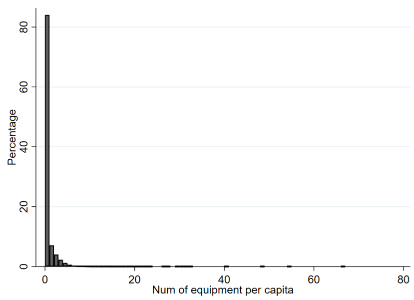
Figure 3. Various measures of cash access in France (2022)



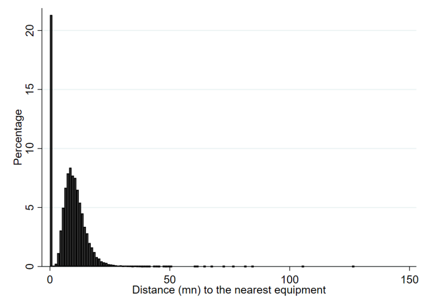
A. Score without population



B. Score with the population



C. Access points per capita



D. Distance to closest access point

Note. The score is defined in the text for 2022 and min-max normalised. The equipment per capita is calculated for 1000 inhabitants. The distance is calculated in minutes of car travel.

Alternative measures of cash access. We can compare our score, with population normalisation or without thereof, with two other simple measures of cash access that are frequently used in the literature: the number of access points per capita and the distance to the nearest access point. Figure 3 displays the distribution of the two alternative measures of cash access compared to the two indices that we have introduced above.

The ratio of cash access points to population presents no meaningful insights into the state of affairs in around 80% of French municipalities yielding the value of zero for them; 80% of municipalities do not possess any cash access points.

With the measure based on the distance to the nearest municipality with a cash access point, the problem is reversed. As 20% of the cities have at least one cash access point, the distance, and the corresponding value, is null. So, one can hardly infer anything about the level of cash access for the population living in these municipalities.

In contrast, our proposed score of cash access contains more information than the alternative measures because it accounts for information on both the cash access landscape in a municipality and its surroundings.

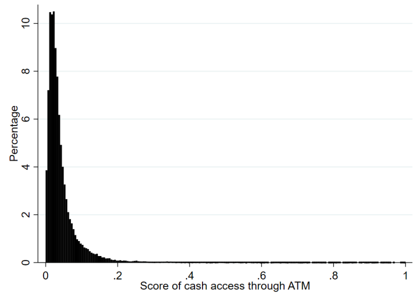
4. Score decomposition

In this section, we, first, look into the contribution of various sources of cash to the cash access index and, second, discuss the differences between private and universal cash access.

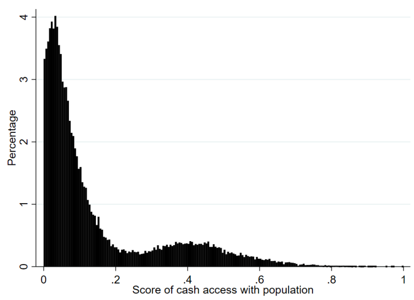
Channels of cash distribution. So far, we have considered three types of cash access points: ATMs, bank counters, and post offices. Now, we seek to understand the contribution of each component to the index. To do so, we calculate three indices using data on each of the three types of cash access points. Figure 4 displays the distribution of the three resulting indices.

First, the differences between the three distributions are significant. Compared to the bank counters (panel B), ATMs (panel A) and post offices (panel C) are more spatially concentrated, even though there are more ATMs than bank counters. In 2022, there were 50,518 ATMs and 29,199 bank counters. For the ATMs, their distribution is more spatially concentrated (see the detail in Appendix C.2). For instance, more than 20% of the municipalities with at least one ATM have 10 and more ATMs. By contrast, there are fewer cities with more bank counter. In contrast, there are more cities with a single bank counter and less cities with a unique ATM. As is intuitive, ATMs are most mostly located within or outside bank branches and a bank branch might have several ATMs. So, in addition to the isolated ATMs, a municipality would have multiple ATMs per bank counter, thus the difference. Out of the

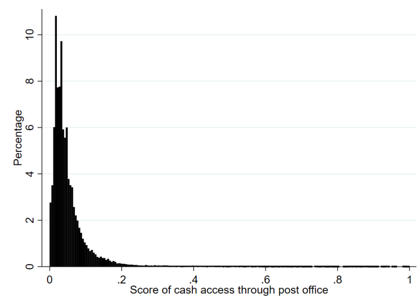
Figure 4. Score of cash access according to the type of equipment (2022)



A. Access through ATM



B. Access through bank counter



C. Access through post office

Note. The score is defined in the text for 2022 and min-max normalised. Here we apply the score to the three sources of cash: ATM only, bank counters only, and post office, instead of sum them in a set of equipment as before.

cities without ATM anything has a bank counter. Out of the cities without bank counter, 16% have at least one ATM. And out of the cities with at least one ATM and one bank counter, there are 1.5 ATM for one bank counter on average. Last, it is very rare that a city has more than one post office. It is the case only for very populated cities, which explains the shape of the score (panel (c) of Figure 4).

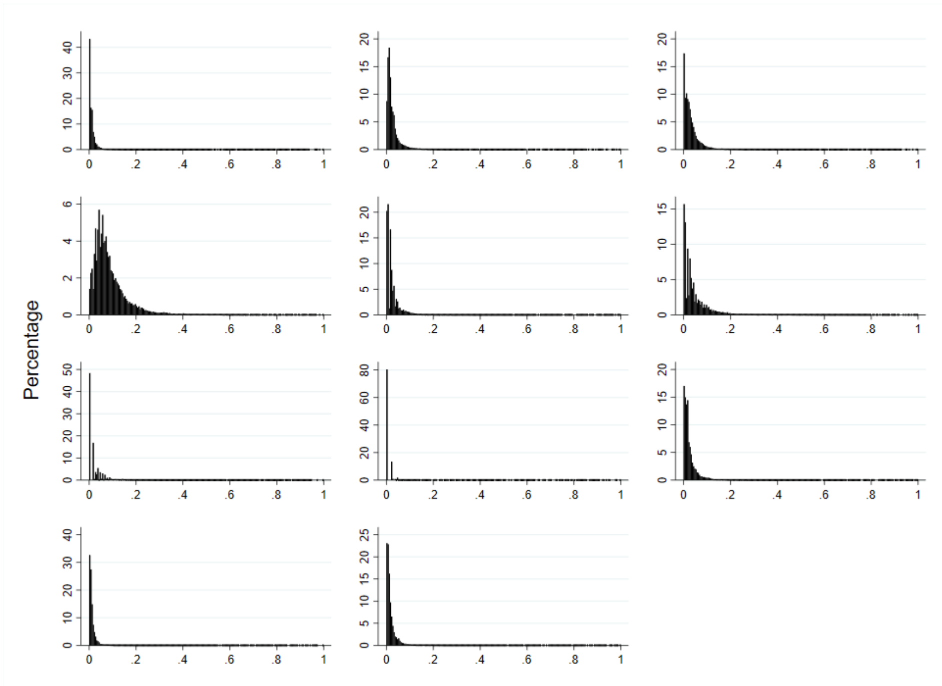
This explains the differences in distribution shown in Figure 4. The cash is more accessible through the bank counter than the ATMs or the post office, which it seems paradoxical but it can be easily explained. However, we do not mention the fact that the access to bank counter is more restrictive than the access to ATMs. Put differently, the access to cash is not universal according to the channel of distribution. We address this question in the next subsection.

Cash at bank counters. Previously, we looked at how different types of cash access points contribute to the index values. Now, we consider the bank branches specifically as they present another dimension, across which cash access is not universal. Normally, to withdraw cash at a bank counter, one needs to be client of a given branch.

Access to private cash may not be straightforwardly comparable between a municipality where all residents are clients of the sole bank with a local branch and a municipality where none of the residents are clients of the bank. Unfortunately, this information is unavailable, preventing us from determining the bank's market share at a refined geographical level. Nonetheless, we can compute the index of cash access for each bank network. In essence, we calculate eleven indices for cash access, each corresponding to a single bank network, based on a common facility, namely the bank counter.

For confidentiality reasons, we do not reveal the name of the network. In Figure 5, we see a large difference of index values across networks. Some have widely stretching presence, whereas others have limited presence, mainly in the largest cities. Whilst considering both the bank counter channel of cash distribution and the private access to cash, the effects on the index values are large. As a result, applying the scoring method necessitates a dual consideration — firstly, regarding the channel of cash distribution, and secondly, in terms of distinguishing between private and universal access.

Figure 5. Score of cash access through bank counters for the main French banking networks



Note. The score is defined in the text for 2022 and min-max normalised. Here, we apply the score to the bank counters of the eleven largest French banking networks. We do not indicate the network brand for confidentiality reasons.

5. Score of cash access and city characteristics

In this section, our focus is on understanding the correlation between the cash access index and diverse demographic and economic characteristics of municipalities.

Presentation of the estimation. We correlate access to cash score with four sets of municipality characteristics: population, tourism activity, location, and economic characteristics.

To measure the size of a municipality, we use log-transformed population. There could be a positive correlation between population and the cash access score, as we posit that more populated cities may have stronger endorsements in terms of cash access.

In examining tourism within the city, we utilise a singular variable that specifically addresses one aspect of tourism—the number of hotel rooms per inhabitant. This metric encompasses short-stay tourism from both within France and abroad. However, we exclude the stays of regular tourists who have a residence in the city, as these accommodations are occasionally rented out. Our assumption is that this type of tourism is more prevalent in small rural cities, making the variable likely redundant when used along with other characteristics.

To analyse the city's location, we incorporate three variables or sets of variables. Initially, we include the city's altitude in the specification, guided by a straightforward intuition. Cities situated in mountainous areas are assumed to be more isolated, implying longer travel times from other cities, and we assume they are likely to be less well served with cash access points.

Additionally, we consider the size of the urban unit to which a municipality belongs. While rural municipalities may not be directly relevant, we delineate six categories of size, including a specific category for the Paris area. Beyond the individual size, this information allows us to consider the broader urban structure in which a municipality is situated. For example, we expect that the access to cash for a city with a given population may vary depending on its position within the urban structure. If it is part of a large urban unit, its index value is expected to be higher than if it is part of a smaller urban unit.

This is particularly important in France, given the abundance of cities, which means that small cities can be situated within very large urban units. Additionally, we incorporate a set of dummy variables indicating the region of the municipality, specifically using the pre-2015 merger definition, as many banks still adhere to the former territorial organisation aligning more or less with the old regions. These variables aim to capture spatial differences in bank strategies. Despite national banks having a unified strategy of establishment, cooperative banks exhibit diverse strategies based on their local and regional branches.

Last, we gather two variables measuring various aspect of the economic conditions in a municipality. First, we introduce a number of new firms created in a municipality (in yearly average from 2012 to 2022 in order to smooth erratic evolution) to take into account economic dynamism. Second, territorial attractivity of the city is partly measured by the proportion of workers living outside the city and commuting daily.

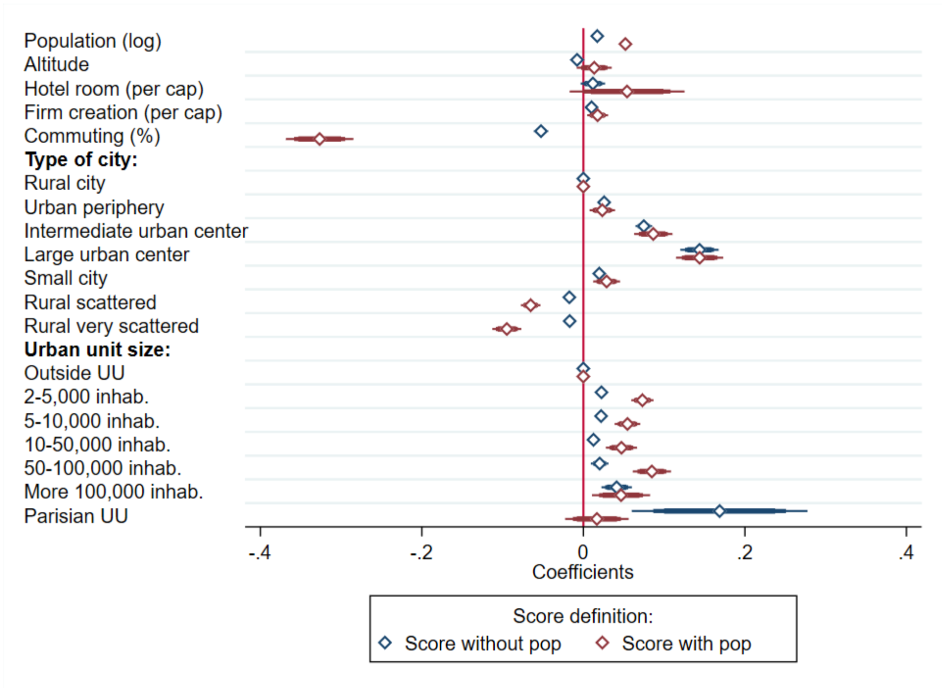
We estimate the coefficients with a standard OLS method, and we cluster the standard errors at the district (*département*) level in order to correct for the unobserved variance in the errors related to the spatial aggregation. We compare the significance of the coefficients for the score calculated without and with the population.

Estimations results. Figure 6 displays the correlation between the two cash access scores of the French cities and their characteristics. To begin with, we observe there is no large difference in the correlation according to the definition of the score. For all variables, we do not observe a change in the significance of the estimated coefficients between the two definitions. The correlations between the access to cash and the city characteristics are not affected by the definition of the score.

Among the variables, we observe several negative relationships. As expected, the altitude of a municipality is negatively correlated with the index. Moreover, compared to the rural municipalities, the rural territories have lower cash access.

Now, we turn to the positive relationships. First, population is positively correlated with the index; denser populated and larger municipalities have better access to cash. Cities that are more attractive in terms of employment opportunities and exhibit greater dynamism in terms of firm creation tend to have higher index of cash access. Second, certain types of municipalities have a positive relationship with the index. Compared to a rural municipality,

Figure 6. Estimations of the scores of cash access



Note. The scores are estimated using an OLS method. We also include region fixed effects. The s.e. are clustered at district (*département*) level. Displayed CI are 99%, 95% and 90%. N = 34,814.

a city in urban periphery, and intermediate urban centre, and a large urban centre have better access to cash. And finally, the cities of the two largest urban units, namely those of an urban unit larger than 100,000 inhabitants and those of the Parisian urban unit, experience a higher score of cash access. The cities of the other urban units are not significantly different from the city outside an urban unit. Third, we do not observe any correlation between the score of cash access and tourism activity, measured by the hotel rooms. Furthermore, small municipalities are not different from the rural ones in terms of cash access.

Notably, the observations we made are stable once we reduce the sample of cities to those having at least one bank counter or one ATM (see Figure A.11 in appendix).[3] The primary distinction lies in the absence of a correlation

[3] By doing that, we reduce the sample from 34,814 to 4,309 observations.

between the type of cities and the cash access score. When compared to rural cities, the only remaining significant coefficient pertains to cities classified as large urban centres. A second noteworthy difference is the lack of significance in the coefficient for the variable indicating if a city situated in an urban unit with more than 100,000 inhabitants. The consistent correlations reinforce our initial observations.

6. Conclusion

In this paper, we measure access to cash in France using a novel geo-spatial data on French municipalities. We present a suitable index of cash access that takes into account geographical considerations and allows for demand considerations. We use the proposed index to measure cash access in France at a municipality level. Then, we establish relationship between demographic and economic characteristics of municipalities and their cash access index.

First, we propose an index to measure cash access that integrates supply of cash access points, population, as proxy for demand, and a geo-spatial dimension of the two. The proposed index, having a tractable and intuitive functional form, allows to compare accessibility of cash across municipalities.

Second, we find that cash access, as measured by our index, is heterogeneous across France. The index distribution is highly concentrated and right-skewed indicating disparities in cash access.

Third, we find that access to cash is positively correlated with population mass, economic dynamism, and the position of a given municipality in the urban structure.

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Appendix

Appendix A. Illustration of the theoretical evolution of the score

To highlight the properties of the proposed index, we describe its elements and provide comparative statics below. To do so, we use the hypothetical setup described in Table A.1.

A.1. Baseline situation

The characteristics of this situation are then modified one after the other. The starting point is simple: there is a territory with 5 access points, we assume $\alpha = 1.2$ and the catchment area of 20km with average distance between municipalities equal to 5km. For tractability, the number of inhabitants is normalised to unity.

Based on this initial situation, we change the number of access points in the territory, the distance decay parameter α, the catchment area size, γ, and the average distance between municipalities.

Table A.1. Variables values for simulation

Parameters and variables	Starting situation	Changes in variables				
Access points: $Equip_i$	5	0	2	5	10	20
Distance decay: α	1,2	1	1,1	1,2	2	10
Catchment area (km): γ	20	10	20	50		
Distance (km): $d_{i,j}$	5	1	2	5	10	20

Furthermore, we incorporate heterogeneity of neighbouring municipalities. We assume three distinct types of municipalities according to their distance thresholds, γ,equal to 10, 20, and 50 defined in the Table A.1 :

- within 10 km distance, ($\gamma < 10$), there are 10 territories, characterised by an average distance of 5 km and a number of services $\sum Equip_j$ = 10 x 5;

- within 20 km distance, ($\gamma < 20$), there are 30 territories, characterised by an average distance of 15 km and a total number of services $\sum Equip_j$ = 30 x 5;
- within 50 km distance, ($\gamma < 50$), there are 90 territories, characterised by an average distance of 35 km and a total number of services $\sum Equip_j$ = 90 x 5.

Note that we are not varying the number of $Equip_j$ but rather setting it to the mean of 5 per municipality. Our goal is to visualise the effects of the gradual incorporation of the surrounding territories, regardless of the number of cash access points.

For our reference situation, i.e., the starting point, the *CASH* is equal to

$$
\begin{aligned}
CASH &= \frac{1}{1.2^0} \times log_2(5+1) + \frac{10}{1.2^5} \times log_2(5+1) + \frac{30}{1,2^{15}} \times log_2(5+1) \\
&= 1 \times 2.584962501 + 4.01877572 \times 2.584962501 + 1.947164146 \times 2.584962501 \\
&= 18.01 \approx 18
\end{aligned}
$$

A.2. Number of Access Points and Index Values

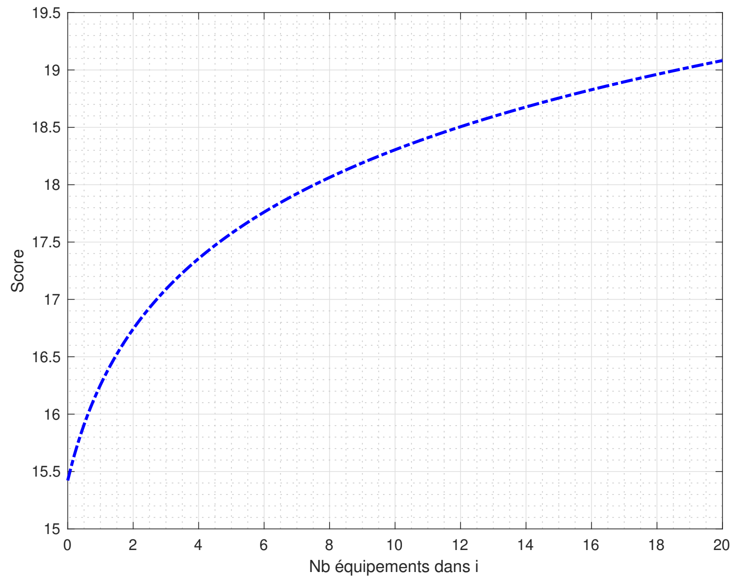
The first element we vary is the number of access points in the ith municipality. Figure A.1 describes the evolution of the cash access index, for th number of cash access points in i between 0 to 20.

Figure A.1 shows that *CASH* increases in the number of facilities in the municipalities, all else equal. Further, it highlights the concavity of the index of cash access with respect to the number of access points.

A.3. Distance and Index Values

To learn how the index changes in the average distance, we change the average distance of nearby territories, then the parameter α, and, finally, the two parameters together. Figure A.2 shows the reduction in the index values when the average distance of the territories within the catchment area increases. The most noticeable graphical pattern is the depressive effect of

Figure A.1. Changes in score ($CASH_i$) according to the number of facilities ($CASH_i$)



increasing distance on the index, with the reduction diminishing progressively in distance. In fact, the impact of distance weakens as it increases: walking distances become increasingly shorter, reflecting the idea that it is the first few kilometres that have a greater impact than subsequent ones on the accessibility of services.

Figure A.3 presents comparative statics with respect to α. We observe that the index values are decreasing and convex in α.

Finally, the simultaneous variation of the distance d and the parameter α provides an insight into the contribution of the geo-spatial component to the index (Figure A.4). First, one can observe that the score decreases in distance; all the curves for any value of α. Second, we observe that the choice of parameter α has a profound impact on the effect of distance. With $\alpha = 1$ (the highest blue horizontal curve on the graph), distance has no effect on the index; all surrounding access points contribute equally to the score with no distance decay. As α increases, the index decreases: the curve shifts

Figure A.2. Changes in score ($CASH_i$) according to the distance $d_{i,j}$

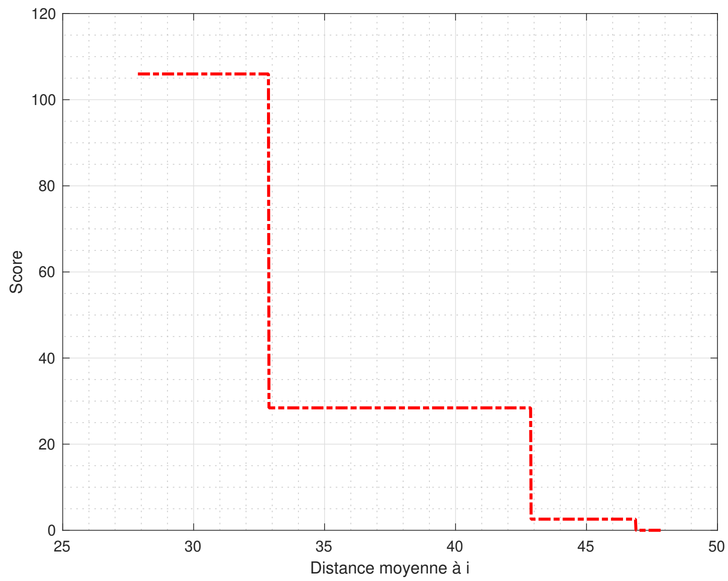
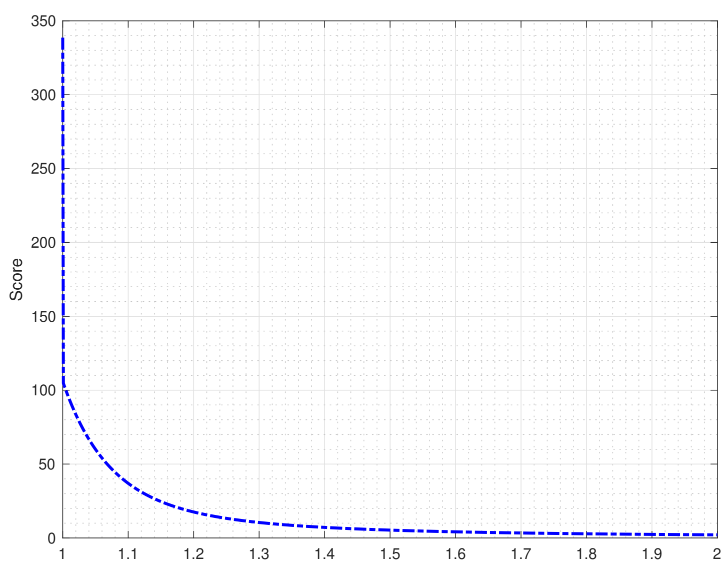
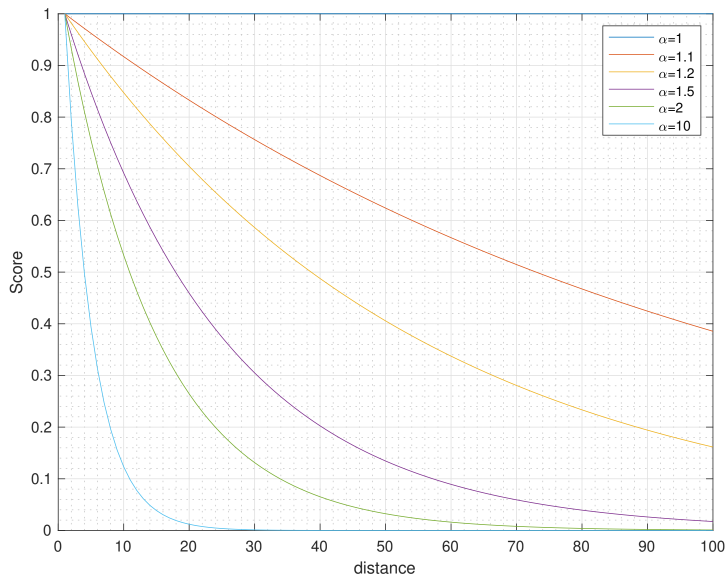


Figure A.3. Changes in score ($CASH_i$) according to the distance parameter (α)



downward. Further, as the effect of distance is not linear, the curves become increasingly more convex as α increases. This underscores the importance of the choice of the value of α.

Figure A.4. Changes in score ($CASH_i$) according to the distance $d_{i,j}$ and the distance parameter (α)

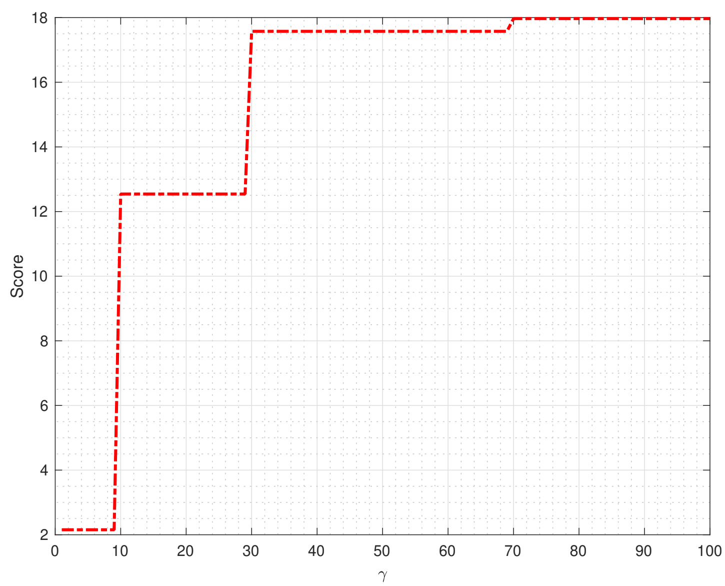


A.4. Catchment Area Size and Index Values

Last, we consider comparative statics with respect to the catchment area size, γ.

Figure A.5 illustrates the impact of taking into account the supply of banking and financial services of catchment areas of different sizes. From the first set of territories included in the catchment area, $\gamma < 10$, to the second with$\gamma < 20$, the index value increases from two to more than 12. However, with the addition of new territories that are increasingly distant, there is a noticeable positive impact on the score, which continues to grow. This phenomenon mirrors the concept that incorporating more distant territories,

Figure A.5. Changes in score ($CASH_i$) according to the radius (γ)



with greater distances denoted by $d_{i,j}$, results in the integration of more services into the index calculation. Consequently, as γ increases, so does the score. Additionally, it's worth noting that the increase in the index becomes progressively smaller over time.

Appendix B. Sources and treatment of the raw data

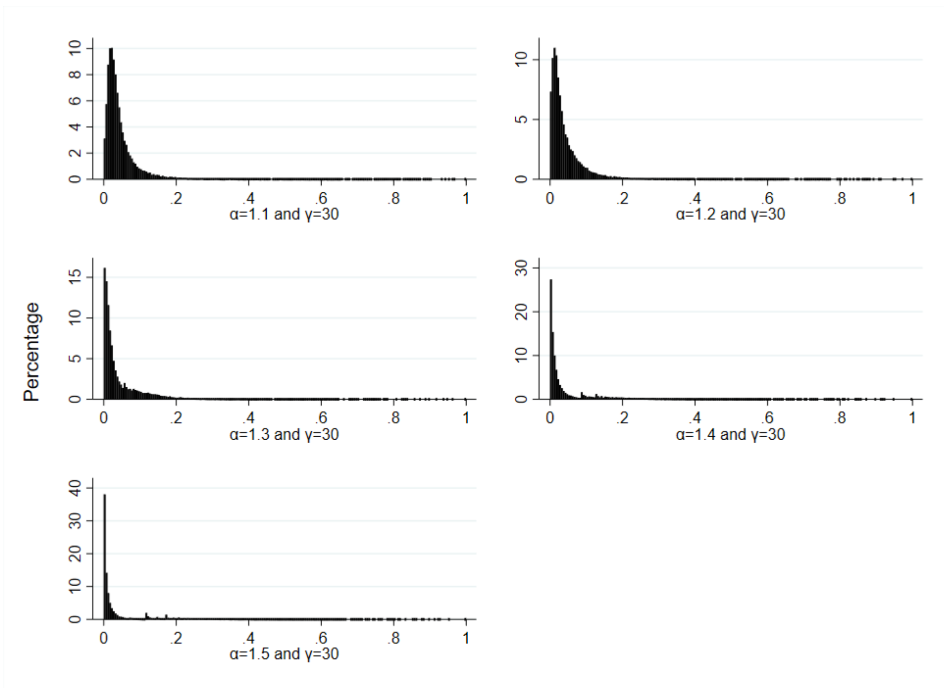
Here, to make a presentation of how we treat the raw data to obtain the variables used to calculate the scores

Here, to give the original sources

Appendix C. Additional information on French data

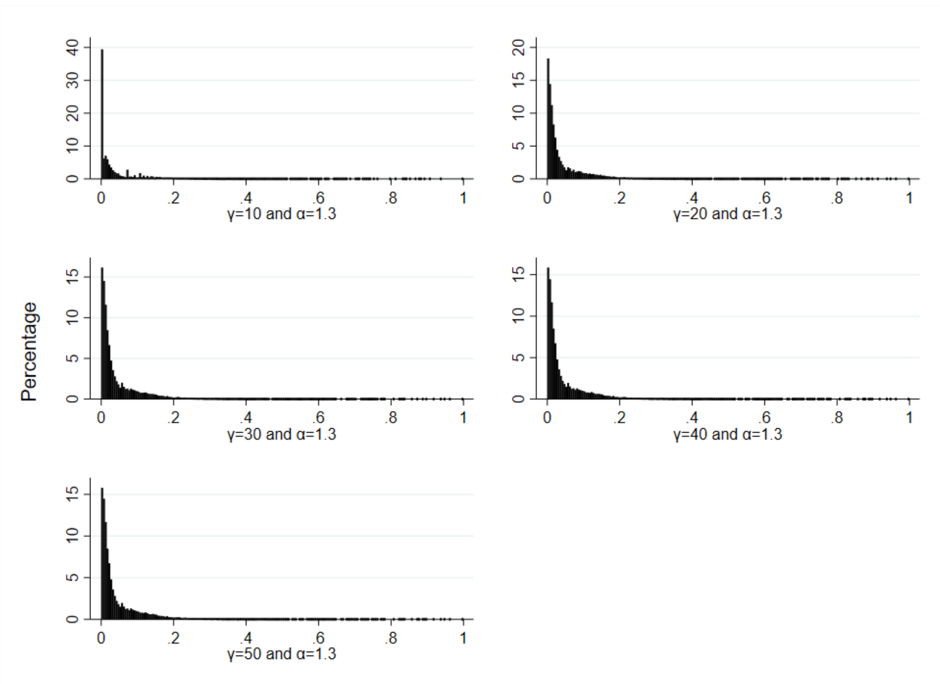
C.1. Calibration and Index Distribution

Figure A.6. Score distribution according the values of α



Note.

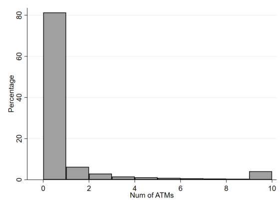
Figure A.7. Score distribution according the values of γ



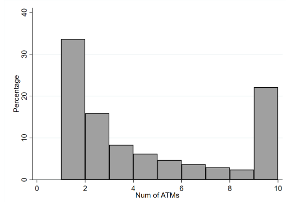
Note.

C.2. Distribution of French cities according to the number of equipment

Figure A.8. Distribution according to the number of ATMs

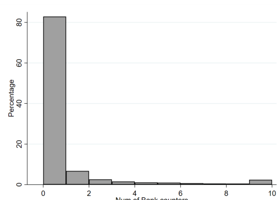


A. All cities

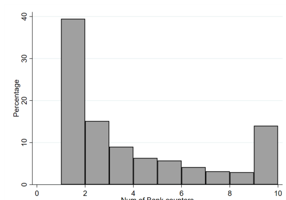


B. Cities with at least one ATM

Figure A.9. Distribution according to the number of bank counters

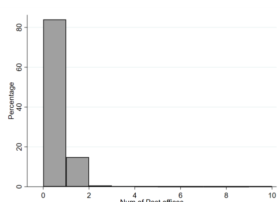


A. All cities

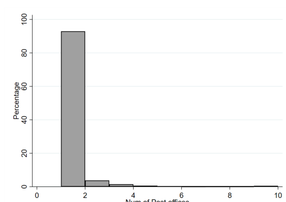


B. Cities with at least one bank counter

Figure A.10. Distribution according to the number of post offices



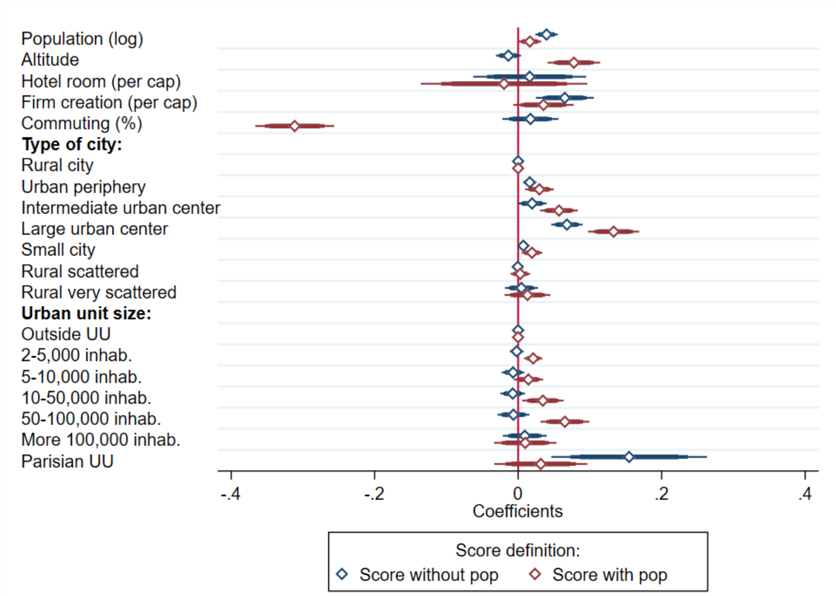
A. All cities



B. Cities with at least one post office

C.3. Additional estimations

Figure A.11. Estimations of the cash access score for the cities with at least one bank counter or ATM



Note. The scores are estimated using an OLS method on a sub-sample of the French cities that have at least one bank counter or ATM. We also include region fixed effects. The s.e. are clustered at district (*département*) level. Displayed CI are 99%, 95% and 90%. N = 4,309.