A spatial analysis of access to ATMs in Austria

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This paper sheds light on the geographical distribution of automated teller machines (ATMs) in Austria. Our results indicate that Austrians live within a travel distance of 1.2 km on average of an ATM, with travel times (by car) to the closest ATM averaging 2.9 minutes. A total of 82% of the population reside within a travel distance of 2 km of an ATM and 85% of the population travel less than 5 minutes to reach the next ATM. When comparing ATM access in urban and rural areas, we find that the average distance to the closest ATM ranges from 2.1 km in municipalities with less than 2,000 inhabitants to 0.6 km in larger cities.

Although our findings generally point to reasonable travel distances, on average, across Austria, a more disaggregated view allows us to identify areas where ATM access is more limited. 2.9% of the population (or some 260,000 residents) have to travel more than 5 km to reach the closest ATM. About 60% of these residents live in municipalities with less than 3,000 inhabitants and 80% in municipalities with less than 5,000 inhabitants. Municipalities with a high share of residents who have a travel distance of more than 5 km can be found in all of Austria's nine provinces (except Vienna). These municipalities have on average 840 inhabitants.

JEL classification: R12, E51, E41
Keywords: ATM network, cash access points, spatial analysis

This paper examines the spatial distribution of automated teller machines (ATMs) in Austria, providing information on how far Austrians have to travel, and how much time it takes, to reach the closest ATM.

There are two main reasons to conduct such an analysis. First, despite the broad availability of cashless payment options, cash still plays a significant role in Austria – both for everyday purchases and as a store of value (see Bagnall et al., 2016; Schautzer and Stix, 2019). Moreover, in Austria, the primary place to withdraw cash is the ATM.[2] For consumers, the cost of using cash is strongly associated with the time needed to reach the closest source of cash withdrawals.

Second, one of the key tasks of the Oesterreichische Nationalbank (OeNB) and its subsidiaries is to provide Austrian businesses and consumers with cash. Therefore, the OeNB has a keen interest in an efficient supply chain – from the production of cash to its distribution among the public. Furthermore, a broad availability of cash access points is key to ensuring that consumers are free to choose among payment methods (Deutsche Bundesbank, 2020). However, the increased closure of bank branches and ATMs in some countries has sparked a debate about how to safeguard

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[2] *88% of the population aged 14 and over use an ATM at least once a month, which compares with 43% for bank desks (Ritzberger-Grünwald and Stix, 2018). Results for withdrawal amounts are unavailable; yet, the results obtained by Brown et al. (2020) for Switzerland might be indicative for Austria. Hence, it can be expected that Austrians withdraw more than 90% of the total amount they withdraw at ATMs.*

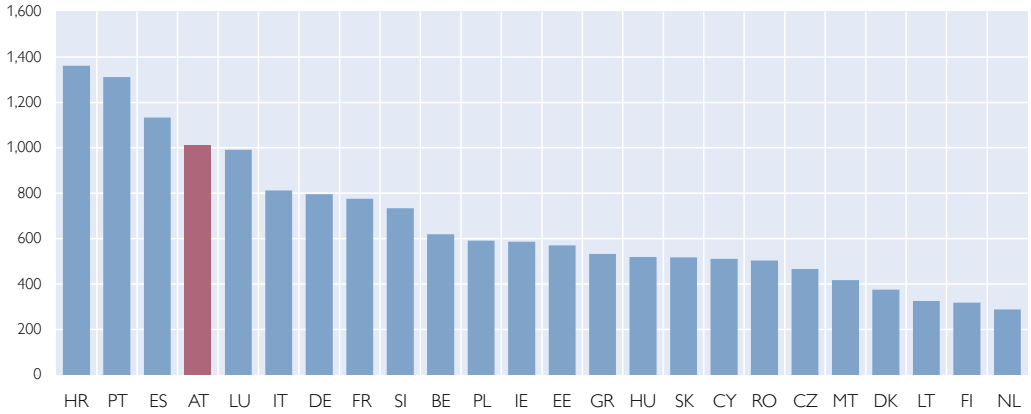
broad access to cash. In its Retail Payments Strategy, the European Commission "[e]xpects Member States to ensure the acceptance and accessibility of cash as a public good […]. One means whereby Member States might preserve access to cash could be to provide for minimum coverage of automated teller machines (ATM), or equivalent means of access, on their territory" (European Commission, 2020, p. 14). In its opinion on a Swedish initiative to set thresholds for the maximum distance to the nearest ATM, the European Central Bank states that "it [is] important that all Member States […] take appropriate measures to ensure that credit institutions and branches […] provide adequate access to cash services, in order to facilitate the continued use of cash".[3]

While several countries have seen a considerable fall in the number of cash access points, available figures suggest that the opposite seems to be true for Austria. In fact, the number of ATMs has increased over the past years – from about 7,400 in 2005 to about 9,000 in 2019[4]; moreover, in a European comparison, Austria is among the countries with the highest number of ATMs per capita (chart 1). However, such numbers only reflect averages across a country and may therefore hide regional differences in access to cash, in particular in rural areas. This seems to be particularly relevant for Austria where a large share of the population lives either in relatively small villages or in larger cities. More precisely, about 25% of Austrians live in municipalities with less than 3,000 inhabitants, while some 21% of the population reside in Vienna. Calculating an average across the entire country may therefore be uninformative about access to cash in rural areas.

Chart 1

Number of ATMs by country

Number of ATMs per million inhabitants



Source: ECB Statistical Data Warehouse.

Note: Values refer to 2019.

[3] *Opinion of the European Central Bank of 26 November 2019 on the requirement for certain credit institutions and branches to provide cash services (CON/2019/41) available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019AB0041&from=EN.*

[4] *Source: https://www.oenb.at/isaweb/report.do?report=5.4.1. The number of retail bank branches, in contrast, declined by about 1,000 over this period (see Stix, 2020 for a related paper on the geographical distribution of bank branches in Austria).*

The relatively high number of ATMs per capita is reflected in how Austrians rate their access to ATMs. The results of a survey conducted by the OeNB in 2016 among 1,700 Austrian residents show that 49% of respondents considered it "very easy" to find an ATM, another 47% "fairly easy." A mere 4% stated that it is "fairly difficult" or "very difficult" to access cash from an ATM.[5] A favorable rating was also observed for smaller municipalities with up to 2,000 inhabitants, where 95% of respondents said that it is "very easy" or "fairly easy" to get to an ATM.[6]

While the survey results and the data on the number of ATMs presented above provide first insights into the availability of ATMs in Austria, these data sources might be less suited to identify areas with poor ATM access due to the limited number of respondents in surveys. This is particularly the case for small areas and/or relatively small numbers of residents who have to travel larger distances to reach an ATM.

This is why this paper carries out a fine-grained analysis of the spatial distribution of ATMs in Austria, providing estimates about actual travel distances and times to the closest ATMs for small geographical areas and at the municipality level. These estimates can be used to assess the availability of ATMs in urban and rural areas and to identify areas with limited access. Moreover, they provide a benchmark for monitoring any future changes to Austria's ATM network.

When interpreting the findings of this paper, some remarks are in place. The paper provides a descriptive account of travel distances and times and tries to avoid, as much as possible, normative judgments, which would require a more elaborate analysis. This is well justified as we only focus on one aspect of accessibility, i.e. the physical distance to the next ATM. The same distance can have very different implications for different people, depending e.g. on their mobility, the availability of means of transport or whether or not they use digital payment instruments. Also, physical distances might be inconsequential if people stop at an ATM on their way to the city center, for example. These factors are not considered in the following analysis. Moreover, we do not take into account differences in ATM operating hours and other cash access points, such as grocery stores that offer cash-back. Finally, we would like to emphasize that the process of georeferencing ATM locations is prone to errors. Although thorough data checks were conducted, inaccuracies in the exact location of each ATM and their assignment to municipalities cannot be ruled out. Therefore, our results should be treated as indicative only.

We are unaware of recent studies that calculate travel distances and times to the closest ATMs based on actual road network distances. However, several recent studies adopt an approach based on straight-line ("as the crow flies") distances. As a case in point, the National Forum on the Payment System (NFPS, 2017) reports on the accessibility of ATMs and cash deposit machines in the Netherlands over the period from 2013 to 2017. Delaney et al. (2019) present a comprehensive analysis of how far Australians have to travel to deposit or withdraw cash. Sonea et al. (2019) conduct a spatial analysis of cash access points in the United Kingdom and develop indicators to identify the vulnerability of an area to the closures of cash

[5] *The results reported refer to the assessment of those respondents who typically use a specific ATM to withdraw cash.*

[6] *For a detailed description of the survey, see Rusu and Stix (2017). Esselink and Hernández (2017) report detailed results for the use of cash by consumers in the euro area. Their findings show, amongst other things, that Austrian consumers are among those most satisfied with the availability of ATMs. Deutsche Bundesbank (2020) draws an interesting comparison between the cash withdrawal behavior in urban and rural areas. Overall, respondents considered the effort involved in accessing cash to be low in both urban and rural areas, a finding similar to that for Austria.*

access points. Other interesting studies for France (Banque de France, 2019) and Spain (Gonzalo and Tejero Sala, 2018) adopt a somewhat more aggregated geographical perspective than in this paper, i.e. by mainly focusing on the availability of bank branches or ATMs at the municipality level.

The remainder of the paper is organized as follows: Section 1 presents the methodology used to assess ATM access in Austria and explains how the routes to ATMs were calculated. Section 2 discusses the key results broken down by municipality (population) size categories and provinces. In section 3, we adopt a more disaggregated geographical perspective by analyzing ATM access across Austria's municipalities. Section 4 presents some results based on straight-line distance measurements and section 5 concludes the paper.

1 Methodological remarks

In this section, we describe the dataset of ATM locations and explain how the routes to the nearest ATMs were computed.

1.1 A brief description of Austria's ATM network

In general, Austrian consumers have free-of-charge access to the vast majority of ATMs in the country, also when cash is withdrawn from ATMs run by banks other than their own. At end-2019, there were four ATM operators in Austria which provided a total of 9,058 ATMs. The majority of ATMs is operated by banks, with a significant share being located inside, or adjacent to, bank branches (especially in rural areas). As mentioned earlier, withdrawal fees are charged at a rather small share of ATMs. Since it is difficult to identify fee-charging ATMs, we did not exclude them from our analysis. However, we expect their exclusion to not have a significant impact on the aggregate results, as fee-charging ATMs are typically located at popular locations, such as train stations or touristic places, which have a rather high density of ATMs. Yet, since the number of fee-charging ATMs may be higher in touristic municipalities (e.g. in ski resorts), we expect their inclusion or exclusion to affect the results at the municipality level.

1.2 Collecting ATM location data

Data on the exact postal addresses of all ATMs in operation were provided by Austria's ATM operators.[7] For most ATM locations, we obtained georeferenced data; the remaining ATM locations were geocoded. Checks of all geocoded locations were conducted to ensure the correctness of the data. This was done by e.g. comparing the geolocations of ATMs with those of bank branches, as a large part of Austria's ATMs is located inside, or adjacent to, bank branches. Due to the high number of ATMs, however, errors in geocoded ATM locations cannot be ruled out completely. While any remaining errors are unlikely to significantly bias the results for Austria as a whole, they may affect the results at the municipality level. This should be considered when interpreting the results for individual municipalities.

Moreover, it should be noted that the number of ATMs varies throughout the year, with additional ATMs being put up e.g. at Christmas markets or in ski resorts during the winter season. These ATMs were not excluded from the analysis presented here, given the difficulties involved in identifying whether a specific

[7] *The author would like to thank all ATM operators for providing the respective data.*

location is seasonal or not. In addition to seasonal ATMs, we took into account ATMs with limited operating hours which are otherwise broadly accessible, i.e. ATMs located in local shops, grocery stores, gas stations, and other locations. ATMs located in discos or nightclubs, in contrast, were omitted from the analysis, as they are only accessible for a limited share of the population. Since we searched for these ATMs by manually checking the location name and the geolocations, we cannot guarantee that all ATMs of this kind were identified. In total, 62 ATMs were excluded, which brings the number of ATMs included in the analysis to 8,996.

1.3 Calculating the routes to the nearest ATM

Routes to the next ATM were calculated based on a road network analysis using a geographical information system. The road network analysis was conducted by an external company and was based on "TomTom" © maps. To account for the differences in how people travel in urban as opposed to rural areas, travel distances and times were calculated based on both traveling by car and on foot. The road network analysis was conducted on the basis of the fastest route in either transport mode. It should be noted that the fastest route is not always the shortest route, in particular when driving by car.

The analysis is based on a 100x100 m geographical grid of Austria. The center of each populated grid cell was used as the starting point to calculate the routes to the three nearest ATMs. More details on how routes were calculated are provided in box 1.

Box 1

How were routes to the nearest ATM calculated?

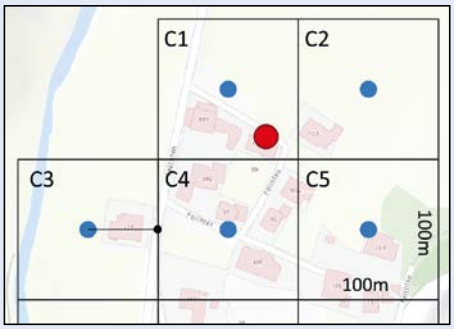
Route calculations are based on a 100x100 m geographical grid of Austria. Of the resulting number of grid cells, 580,995 grid cells were populated as of January 1, 2019. The center of each of these grid cells (blue dots) is used as the starting point for route calculations (see chart 1 – B1). More specifically, we measure the straight-line distance from the center of each grid cell to the nearest street, from where the routes to the three nearest ATMs (red dots) are calculated.

In grid cell C3, for example, the closest street is the one to the right. The straight-line distance from the center of the grid cell to the closest street is indicated by the black line. On average, straight-line distances to the closest street are rather small, except for a few outliers. Across all populated grid cells, the average (median) straight-line distance is 30 m (24 m). For 1.3% of grid cells, the straight-line distance is above 100 m, for 0.2% it is larger than 500 m. The maximum straight-line distance comes to 3.5 km. While the straight-line distances are included in the results for the shortest route, they are not included in the results for the fastest route (due to missing information on appropriate average speeds).

The route calculations are based on a number of assumptions regarding the two modes of transport:

Chart 1 B1

Minimum distance from starting point to nearest street



Source: Statistik Austria – data.statistik.gv.at. Map tiles© basemap.at.

- ***By car:*** *The reported travel times by car reflect pure driving times without accounting for the time needed to get to the car or find a parking spot. We take into account speed limits, one-way streets and turning restrictions; however, driving bans, e.g. in pedestrian zones, are ignored. Thus, average distances and driving times are somewhat downward biased, in particular in urban areas. Moreover, different average speeds are assumed depending on the type of street and whether the route is in or out of town. For example, an average speed of 65 km/h is assumed for main federal roads outside of towns, while an average speed of 40 km/h is used for roads in towns. Table A2 in the annex provides the full set of travel speed assumptions.*
- ***On foot:*** *For the calculation of travel times on foot, we only consider actual walking routes (it is e.g. not possible to walk on motorways). We assume an average walking speed of 4 km/h.*

Shortest and fastest routes: *For each grid cell, we compute the shortest (distance) and fastest (travel time) routes for each of the two transport modes.*

- *Shortest route = minimum distance (by car, on foot)*
- *Fastest route = minimum travel time (by car, on foot)*

Chart 2 – B1 shows the minimum travel times per grid cell. Grid cell C3, for example, is located rather close to an ATM, i.e. within a travel time of 5 minutes. The more remote grid cell in the lower right corner (colored in dark red) is more than 15 minutes away.

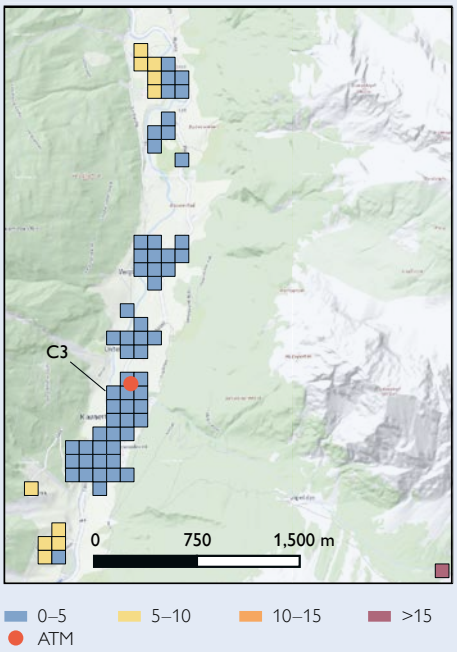
Imputation of empty grid cells: *For some grid cells, car routes cannot be calculated, as vehicle traffic is restricted for certain streets in these grid cells, mainly due to one-way street restrictions or turning restrictions in cities. For these cells, we impute the missing values by using the average of the values obtained for the nearest neighboring grid cells. This is done for 1,488 grid cells (0.26% of all grid cells).*

For some streets, e.g. in pedestrian zones, vehicle access is prohibited. If the starting point or end point of a route is located in a pedestrian zone, the corresponding car route cannot be determined. It is for this reason that pedestrian zones and driving bans are disregarded for the calculation of car routes.

Chart 2 B1

Minimum travel times to the nearest ATM by grid cells

Time to nearest ATM (walk or car) in min



Source: OeNB, Statistik Austria – data.statistik.gv.at. Map tiles© basemap.at.

Whether people choose to walk or to take the car to reach the next ATM depends on a number of factors, including personal preferences, impaired mobility, environmental conditions or whether or not they have small children. Moreover, people may stop at an ATM while out shopping. As these factors vary over time and as the corresponding information is unavailable to us, we cannot assign a preferred travel mode to specific geographical areas in Austria. Rather, we take an agnostic approach and compute the shortest route (in kilometers) to the nearest ATM irrespective of whether people choose to walk or go by car. In the same vein, we compute the fastest route (in minutes, see box 1).

For each grid cell, we furthermore collected data on the number of people who had their main residence in this cell as of January 1, 2019 (Source: Statistik Austria). This allows us to compute population-weighted summary statistics for different levels of agglomerations (such as municipalities or provinces). For example, the average distance to the nearest ATM for agglomeration j is computed as the weighted average of the shortest routes from all starting points i within this agglomeration, with the weights being proportional to the population residing at each starting point:

$$\text{Mean distance}_j = \sum_{i \in j} Shortest\ route_{i,j} * w_{i,j} \quad (1)$$

where i refers to the starting points in agglomeration j and w_{ij} denotes the population weights of grid cell i (population in grid cell i over the total population in agglomeration j). Similar computations were conducted for average (mean) travel times.

2 Average travel distances

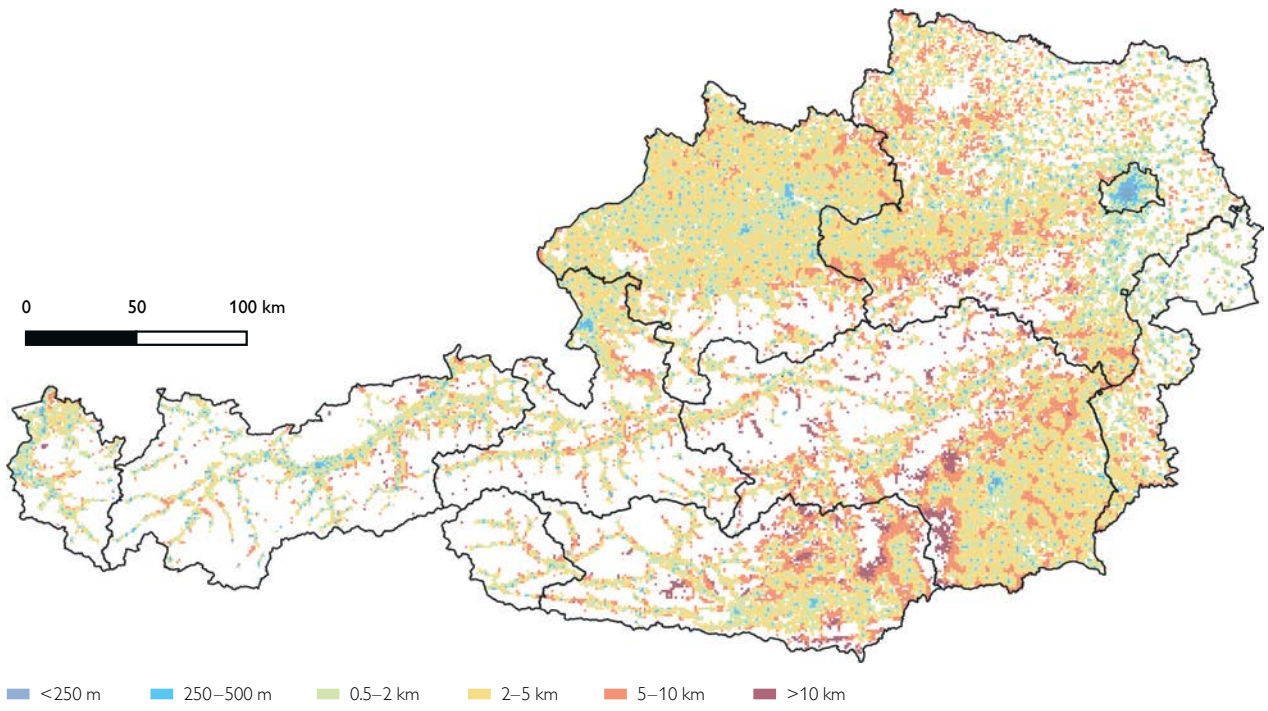
2.1 Average travel distances by grid cells

Chart 2 illustrates the average distances to the nearest ATM for all populated 1x1 km grid cells. The darker the color of a grid cell, the longer the average distance is to access the closest ATM. Most grid cells are colored in blue, light blue, green and orange, which means that the population living in these areas can reach the nearest ATM within distances of less than 5 km. Darker grid cells can be found in all of

Chart 2

Average distance to the nearest ATM by grid cells

Average distance to nearest ATM (1x1 km grid)



Source: Statistik Austria – data.statistik.gv.at, OeNB.

Note: The underlying data refer to a 1x1 km grid-cell level and were computed by averaging the results for the 100x100 m grid cells using population weights.

Austria's nine provinces, albeit at a higher frequency in Styria, Carinthia and Lower Austria.

These findings provide a first overview of how average distances vary across the country; yet, they provide relatively little information about which share of the population faces which distances. Many of the red grid cells, for example, are very sparsely populated. By calculating population-weighted average distances, these grid cells would contribute very little to the averages at the country or provincial level.

2.2 Travel distances and times to the nearest ATM

Table 1 summarizes average travel distances and times weighted by the total population of each grid cell. For Austrian residents, the average distance (fastest route) to the nearest ATM is 1.2 km. The median distance is 630 m, i.e. 50% of the Austrian population have to travel less far. In terms of travel time, we find that Austrians take 2.9 minutes on average to reach the nearest ATM, with the median value being 2.1 minutes. While the travel time calculations are based on realistic average travel

Table 1

Distance and travel time to the nearest ATM

	Mean	Minimum	P25	Median	P75	P90	P99
Distance (in km)	1.2	0.0	0.3	0.6	1.4	3.1	6.5
Travel time (in min)	2.9	0.0	1.1	2.1	3.7	6.0	12.2

Source: OeNB.

Note: Results are population-weighted. Total population: 8,858,775. "P25" denotes the 25th percentile, which means that 25% of the population have to travel less far or less long than the value specified.

Table 2

Distance to the nearest ATM by municipality size and province

	Mean	P25	Median	P75	P90	P99
	km					
by municipality size (number of inhabitants)						
up to 2000	2.1	0.6	1.4	3.1	4.7	8.6
2,001–3,000	1.7	0.6	1.1	2.5	4.1	7.0
3,001–5,000	1.6	0.5	1.0	2.2	3.7	6.8
5,001–10,000	1.3	0.5	0.9	1.7	3.1	6.2
10,001–50,000	1.0	0.4	0.6	1.1	2.0	6.0
50,001–1 million	0.6	0.3	0.4	0.7	1.1	2.8
>1 million (Vienna)	0.4	0.2	0.3	0.5	0.8	1.8
by province						
Burgenland	1.4	0.5	0.8	1.6	3.7	6.6
Carinthia	1.8	0.5	1.0	2.5	4.3	9.5
Lower Austria	1.5	0.5	0.9	2.0	3.8	7.1
Upper Austria	1.3	0.4	0.8	1.8	3.2	5.5
Salzburg	1.2	0.4	0.7	1.5	2.8	5.9
Styria	1.6	0.4	0.9	2.3	4.1	8.0
Tyrol	1.0	0.3	0.6	1.2	2.3	5.7
Vorarlberg	0.9	0.4	0.7	1.0	1.7	4.5
Vienna	0.4	0.2	0.3	0.5	0.8	1.8

Source: OeNB.

Note: Results are population-weighted. Total population: 8,858,775. "P25" denotes the 25th percentile, which means that 25% of the population have to travel less far or less long than the value specified.

speeds, the time it takes to get to the car or find a parking spot is not taken into account. This is likely to particularly affect the results for cities, where going by car turns out to be almost always faster than going on foot, which does not always reflect reality.

The results indicate that the domestic ATM network seems to be relatively dense, on average, across Austria. This is supported by the finding that 99% of the Austrian population live within a distance of 6.5 km or a travel time of 12.2 minutes from the nearest ATM.

Table 2 shows average distances to the nearest ATM broken down by municipality size categories and provinces. Corresponding travel times are summarized in table A2 in the annex. Travel distances and times decrease with the size of the municipalities, but even for smaller municipalities with less than 2,000 inhabitants the mean distance seems to be relatively modest (2.1 km). Substantial differences can be observed between small municipalities and Vienna, where 50% of residents live within less than 300 m of the nearest ATM.

When using the classification system for urban and rural areas provided by Statistics Austria, the mean distances range from 0.5 km in large urban centers to 1 km in regional centers, 1.4 km in rural areas surrounding centers and 1.8 km in rural areas.

When examining the population's access to cash, it is legitimate to ask whether one should also consider bank branches as a source of cash withdrawals. To account for this, we calculated travel distances and times to the closest ATMs or the closest bank branches. Our findings suggest that the corresponding averages are very similar. Specifically, the difference between the average travel distance to an ATM and the average travel distance to an ATM or bank branch is negligible.[8] This finding is in line with our expectations, as many bank branches have an ATM and as most bank-operated ATMs are located inside, or adjacent to, bank branches.

As an alternative to measuring average distances, one can also ask about which share of the population lives within a specific travel distance or time from the nearest ATM. The corresponding results are summarized in table 3. About 18% of Austrians have to travel less than 250 m to withdraw cash from an ATM; 66% less than 1 km. As many as 97.1% of Austrians (or 8,598,305 residents) live within 5 km of an ATM; in terms of travel time, 85% take less than 5 minutes to reach the closest ATM.

Table 3

Distance and travel time to nearest ATM

	Distance							Time			
	<100 m	<250 m	<500 m	<1 km	<2 km	<5 km	<10 km	<2 min	<5 min	<10 min	<15 min
Cumulative share of population	3.9	17.9	41.2	66.3	82.4	97.1	99.9	47.6	85.0	97.8	99.5
Number of inhabitants	341,127	1,587,914	3,653,691	5,870,139	7,296,667	8,598,305	8,846,475	4,218,739	7,533,353	8,667,441	8,817,924

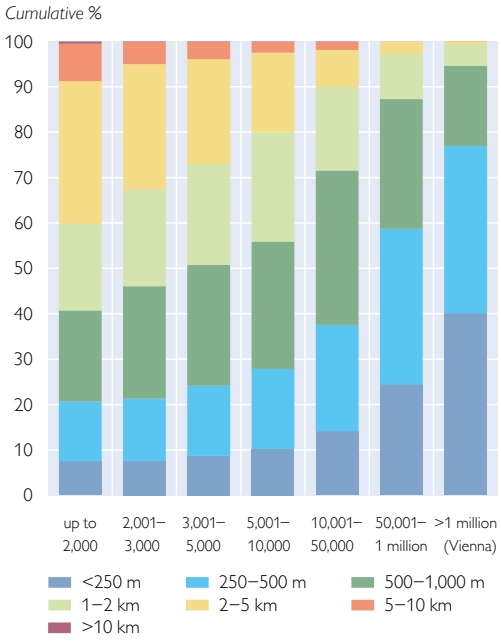
Source: OeNB.

Note: Results are population-weighted. Total population: 8,858,775.

[8] *Mean distances differ by about 30 m and median distances by some 14 m, while P90 values differ by 90 m and P99 values by about 160 m. The fact that average differences are rather small does not rule out that in some areas larger differences may be observed. For more details on the Austrian bank branch network from a spatial perspective, see Stix (2020).*

Chart 3

Distance to the nearest ATM by municipality size

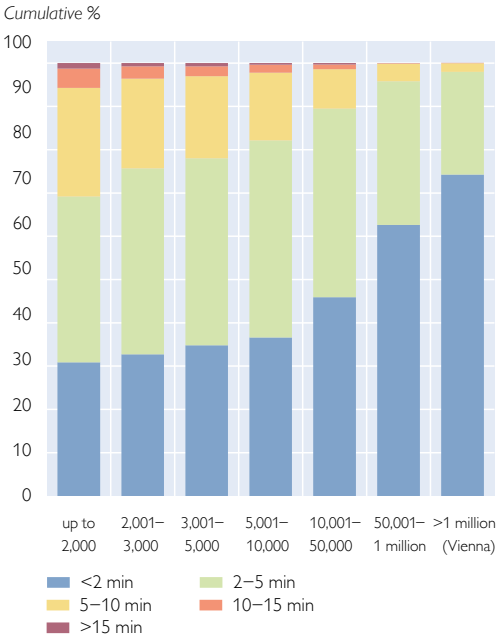


Source: OeNB.

Note: The chart shows how far which share of the population has to travel to reach the nearest ATM, broken down by municipality size categories, i.e. number of inhabitants.

Chart 4

Travel time to the nearest ATM by municipality size



Source: OeNB.

Note: The chart shows how long which share of the population has to travel to reach the nearest ATM, broken down by municipality size categories, i.e. number of inhabitants.

Chart 3 shows how the share of the population that lives within a certain distance of an ATM varies according to the municipality size categories. The blue bars represent the share of residents located within less than 250 m of an ATM, which stands at about 9%, or slightly below, in municipalities with up to 10,000 inhabitants. This share increases to about 25% in larger cities with more than 50,000 inhabitants and to 40% in Vienna. 95% of residents in Vienna and 41% of residents in small municipalities with less than 2,000 inhabitants live within a 1 km distance to the closest ATM (sum of the dark blue, blue and green bars).

Chart 4 displays the share of the population that lives within a certain travel time to the next ATM, again broken down by municipality size categories. As mentioned earlier, travel times by car only include actual driving times and may therefore be perceived as overly optimistic in cities in particular. As a case in point, we find that for 74% of residents in Vienna the nearest ATM is less than 2 minutes away. The more interesting finding, however, that we observe from chart 4 is that the majority of the population lives within 5 minutes of the closest ATM.[9] It is only in smaller municipalities with less than 10,000 inhabitants that a considerable share of people has to travel more than 5 minutes.

In general, it is difficult and highly subjective to define a threshold value that separates satisfactory from unsatisfactory ATM access, given differences in e.g. people's preferences, health, mobility and access to means of transport. In the

[9] *In the vast majority of cases, the shortest travel time refers to the one by car.*

Table 4

Number of inhabitants traveling more than 5 km or 10 minutes by municipality size

	Inhabitants	Inhabitants traveling more than 5 km		Inhabitants traveling more than 10 min	
	Number	*Number*	*%*	*Number*	*%*
Austria	8,858,775	260,470	2.9	191,334	2.2
by municipality size (number of inhabitants)					
up to 2000	1,333,610	114,857	8.6	76,584	5.7
2,001–3,000	927,388	45,163	4.9	33,109	3.6
3,001–5,000	1,209,729	47,141	3.9	36,522	3.0
5,001–10,000	1,146,491	28,362	2.5	25,265	2.2
10,001–50,000	1,283,163	24,583	1.9	17,869	1.4
50,001–1 million	1,060,888	356	0.0	1,083	0.1
>1 million (Vienna)	1,897,506	8	0.0	902	0.0

Source: OeNB.

Note: Results are population-weighted. Total population: 8,858,775.

following, we nevertheless focus on such a threshold value, namely on a 5 km distance, or alternatively, a 10 minute travel time.[10]

Overall, about 2.9% of the Austrian population (or 260,470 residents) are more than 5 km away from the nearest ATM, and 2.2% (or 191,334 residents) have to travel more than 10 minutes (table 4). These figures vary considerably across municipality size categories. In villages with less than 2,000 inhabitants, 8.6% of residents do not have access to an ATM within a 5 km distance. In larger cities with more than 50,000 inhabitants, the corresponding share is close to zero. Since long travel distances mainly concern residents of smaller municipalities, we have furthermore taken a closer look at municipalities with less than 1,000 inhabitants (not shown in table 4). There, about 14.9% of residents have to travel more than 5 km to reach the next ATM. When analyzing these results based on Statistics Austria's classification system, we find that 6.1% of residents in rural areas have a travel distance of more than 5 km. This share comes to 4.1% in rural areas surrounding centers.[11]

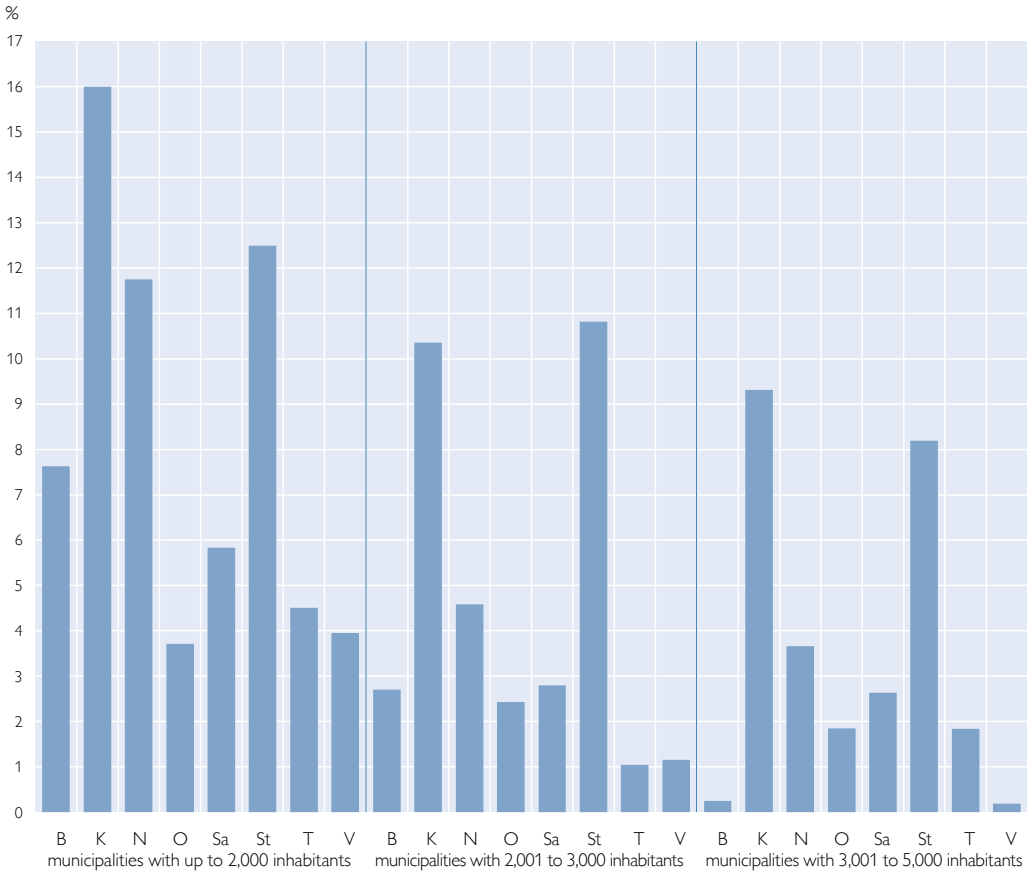
Marked differences can also be seen across Austria's nine provinces. However, a direct comparison between provinces might not be very informative due to e.g. differences in the size distribution of municipalities, their settlement structure or topology. To achieve a more meaningful comparison, we therefore look at specific municipality size categories and can thus control for one (but not for all) of the salient differences. Chart 5 depicts the share of the population that lives at an average distance of more than 5 km from the next ATM. In municipalities with less than 2,000 inhabitants located in Carinthia (K), Styria (St) and Lower Austria (N), more than 10% of residents have to travel more than 5 km. In Burgenland (B) and Salzburg (Sa), this share ranges between 5% and 10%. For municipalities with more than 2,000 and less than 3,000 inhabitants located in Carinthia and Styria,

[10] *NFPS (2017), for example, also applies a 5 km threshold value.*

[11] *Again, one might wonder how these numbers will change if we consider distances to the closest ATMs or the closest bank branches. The corresponding results show that the absolute number of people who live at a distance of more than 5 km decreases slightly to 240,525 or 2.7% of the population. In municipalities with less than 2,000 inhabitants, this share increases to 7.6%. Thus, the inclusion of bank branches does not affect the overall pattern of results qualitatively.*

Chart 5

Share of population traveling more than 5 km to the nearest ATM by province and municipality size



Source: OeNB.

Note: B = Burgenland; K = Carinthia; N = Lower Austria; O = Upper Austria; Sa = Salzburg; St = Styria; T = Tyrol; V = Vorarlberg.

the share of residents who do not have access to an ATM within a 5 km radius again comes to above 10%. By and large, these results mirror those shown in chart 2.

2.3 Density of Austria's ATM network

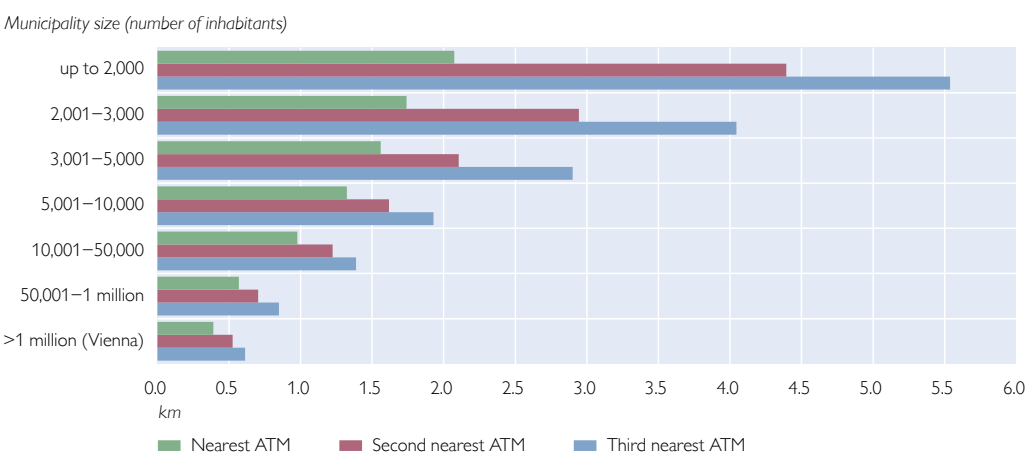
The density of the domestic ATM network is not only determined by the distance to the nearest ATM but also by the proximity of other ATMs. The latter is relevant if consumers have to find another ATM in case the nearest ATM is out of order or closed.

Chart 6 depicts the average distance to the three nearest ATMs broken down by municipality size categories.[12] Since average travel distances and times to the next ATM were found to be rather modest, we would also expect the distances to other ATMs located in the area to be short. This is true for towns with more than 10,000 inhabitants. In Vienna, for example, the average distance to the nearest ATM is 390 m. The second nearest ATM is located within 525 m on average, the

[12] *Note that the second nearest ATM can be at the same location than the nearest ATM. For example, this could be the case if several ATMs are located in one bank branch.*

Chart 6

Average distance to the three nearest ATMs by municipality size



Source: OeNB.

Note: The chart shows the average distance to the three nearest ATMs. Municipality size refers to the number of inhabitants.

third nearest within 612 m. Thus, the first and the second ATM are located just 136 m on average from one another, the first and the third ATM 222 m.

Moreover, chart 6 shows that the average distance between the first and the second ATM increases with the distance to the nearest ATM. In municipalities with less than 2,000 inhabitants, the average distance between the first and the second ATM comes to 2.3 km, meaning that the second closest ATM can often be found in the neighboring municipality. In municipalities with more than 3,000 inhabitants, the average distance between the nearest and the second nearest ATM is less than 550 m, which implies that the next ATM is usually located in the same municipality.

3 ATM access by municipalities

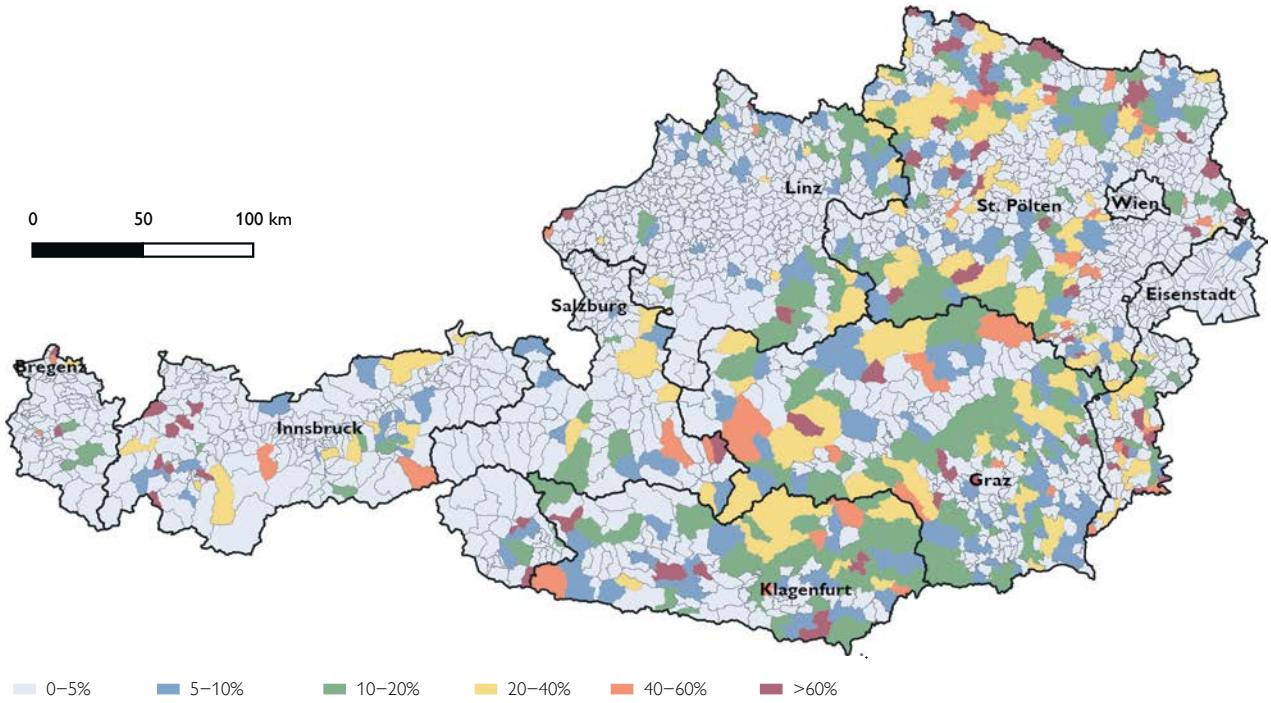
Up until now, we focused on municipality size categories and provinces to describe access to ATMs in Austria. In the following, we provide additional evidence at the municipality level by calculating key access indicators for each of the 2,096 municipalities in Austria.

For each municipality, chart 7 indicates the share of the population that has to travel more than 5 km to reach the nearest ATM. A corresponding map for travel times can be found in chart A1 in the annex. In line with chart 2, chart 7 shows that the ATM network seems to be relatively dense in many parts of the country, which is exemplified by a small share of residents who live more than 5 km away from the next ATM. However, there are also municipalities where ATM access seems to be more restricted. In 69 municipalities, for example, more than 60% of inhabitants have to travel more than 5 km. For an additional 39 municipalities, this share ranges between 40% and 60% of inhabitants. In other words, in 108 municipalities the share of residents who have a travel distance of more than 5 km stands at 40% or more. All of these 108 municipalities are classified as "predominantly rural" according to the classification of municipalities provided by Statistics Austria. They are rather small in terms of population size, with an average number of inhabitants of 836. Consequently, the absolute number of inhabitants who live at a distance of

Chart 7

Share of population traveling more than 5 km to the nearest ATM by municipality

Share of population in %



Source: Statistik Austria – data.statistik.gv.at, OeNB.

Note: Municipality borders as of 2019.

more than 5 km from the next ATM is low (e.g. 50% of 836). This is relevant if we consider the questions of whether access to cash can be improved by putting up an additional ATM and whether the additional ATM can be operated economically. These issues may be debatable for municipalities that consist of several clusters of smaller agglomerations which are spread out geographically. While answering these questions is beyond the scope of this paper, it would certainly be interesting to analyze in more detail the economic, social and topological characteristics of the municipalities with a more limited ATM access. The detailed results for Austria's municipalities provided in this paper may be used as a basis for such analyses.

3.1 Travel distances in municipalities with or without ATM access

In the following, we explore whether the availability of an ATM in a given municipality affects average travel distances. Our data reveal that out of Austria's 2,096 municipalities,[13] 316 municipalities (or 15%) are not equipped with an ATM. Given the close proximity of municipalities in certain areas of Austria, this does not necessarily mean that ATMs are far away. Table 5 shows that the average distance to the next ATM is 3.8 km in municipalities without an ATM compared to an average distance of 1.6 km in municipalities with an ATM. Similar results are obtained for the median

[13] *As of January 1, 2019.*

Table 5

Distance to the nearest ATM by municipalities with or without ATM access

	Municipality with ATM access	Municipality without ATM access	Difference
	(1)	(2)	(2)−(1)
(1) Average distance (in km)	1.6	3.8	2.2
(2) Median distance (in km)	1.0	3.6	2.6
(3) % of population traveling more than 5 km	3.0	25.8	22.8

Source: OeNB.

Note: The table shows how the distance to the nearest ATM varies between municipalities equipped with an ATM and those not equipped with an ATM. For comparison purposes, the results only refer to municipalities with less than 3,000 inhabitants. Results are population-weighted.

distances and the share of the population that has to travel more than 5 km, which is 23 percentage points higher than the share in municipalities with an ATM.

It is important to note that when comparing travel distances in municipalities with or without an ATM, one should also take into account other characteristics (e.g. population densities) of municipalities. To partly account for this, we also conducted conditional analyses in which we controlled for fixed effects for province x municipality size categories as well as for fixed effects for the urban/rural classification system provided by Statistics Austria. Quantitatively, the results are very similar, which suggests that the results described above are not driven by large selection effects.

4 A comparison with straight-line distances

From a methodological perspective, it is of interest to evaluate how actual road network distances compare with straight-line (Euclidean or "as the crow flies") distances which are considerably easier to compute and which represent an alternative and computationally efficient way of assessing ATM access. We expect the differences between the two distance types to be small when the ATM network is dense, i.e. when the distance to an ATM is low. This is typically the case in more densely populated areas.

To assess the differences between the two distance types, we computed the straight-line distances to the nearest ATMs. This allows us to determine coverage ratios, such as the share of the population that resides within a certain radius of an ATM. The results show that 75.1% of inhabitants live within a 1 km radius and 99.3% within a 5 km radius of an ATM (table 6). In villages with less than 2,000 inhabitants, the share of people living within a 5 km radius is slightly lower but still impressive (97.6%).

Three comments are warranted regarding these results. First, the straight-line distances can be compared internationally, at least roughly. NFPS (2017) reports, for example, that in 2017 99.7% of the population in the Netherlands resided within a radius of 5 km from an ATM, which is very similar to the ATM coverage found for Austria. Interestingly, in 2019, Austria had 3.5 times as many ATMs per million inhabitants as the Netherlands.[14] This suggests that unadjusted statistics,

[14] *See https://sdw.ecb.europa.eu/browse.do?node=9691546; entry "Number of ATMs – provided by resident PSPs – located in the reporting country – per million inhabitants;" Austria: 1,009; Netherlands: 288.*

Table 6

Share of population living within a straight-line distance of 1 km or 5 km of an ATM

	Within 1 km of an ATM	Within 5 km of an ATM
	%	
Austria	75.1	99.3
by municipality size (number of inhabitants)		
up to 2000	49.4	97.6
2,001–3,000	56.1	99.2
3,001–5,000	61.1	99.3
5,001–10,000	68.6	99.7
10,001–50,000	83.9	99.4
50,001–1 million	94.5	100.0
>1 million (Vienna)	98.3	100.0

Source: OeNB.

e.g. on the number of ATMs per capita, could be misleading (at least with respect to assessing ATM access), as factors, such as topology or population density, may bias comparisons between countries.

Second, the bias induced by straight-line distances can be substantial. Table 4 showed that 8.6% of the population of villages with less than 2,000 inhabitants have to travel more than 5 km to reach the nearest ATM. In contrast, the results based on straight-line distances suggest that this share is as small as 2.4%.

Third, box 2 presents a brief assessment of how straight-line distances differ from road network distances in the context of this study. Straight-line distances yield rather accurate results for average or median travel distances (table B2). For smaller travel distances, differences between the two distance types are not substantive and almost negligible (in absolute terms). However, as expected, the absolute bias induced by straight-line distances can become substantial for larger travel distances. For a straight-line distance of 10 km, the corresponding actual road network distance is estimated to be 4.5 km longer on average (chart B2). Overall, these results confirm the presumption that straight-line distances are reasonably appropriate for measuring smaller travel distances, i.e. for densely populated areas. However, when the goal is to identify areas with limited ATM coverage, straight-line distances may be less reliable.

Box 2

Comparing distance types

This box provides a brief comparison between straight-line distances and road network distances. Specifically, table B2 shows the differences between the summary statistics based on the two distance types broken down by municipality size categories.

At 0.3 km (0.2 km), the mean (median) difference between the two approaches is very modest (see table B2). This reflects the fact that the underlying travel distances were not large. However, the differences between the two distance types increase with the average straight-line distance to the nearest ATM. One way to illustrate this is to plot straight-line distances against the differences between road network distances and straight-line distances. We can then observe from chart 1 B2 that the absolute bias increases with the straight-line distances. For a straight-line distance of 0.5 km, for example, the predicted road network distance is 0.2 km longer, while the predicted bias for a straight-line distance of 10 km comes to about 4.5 km or 45%.

Table B2

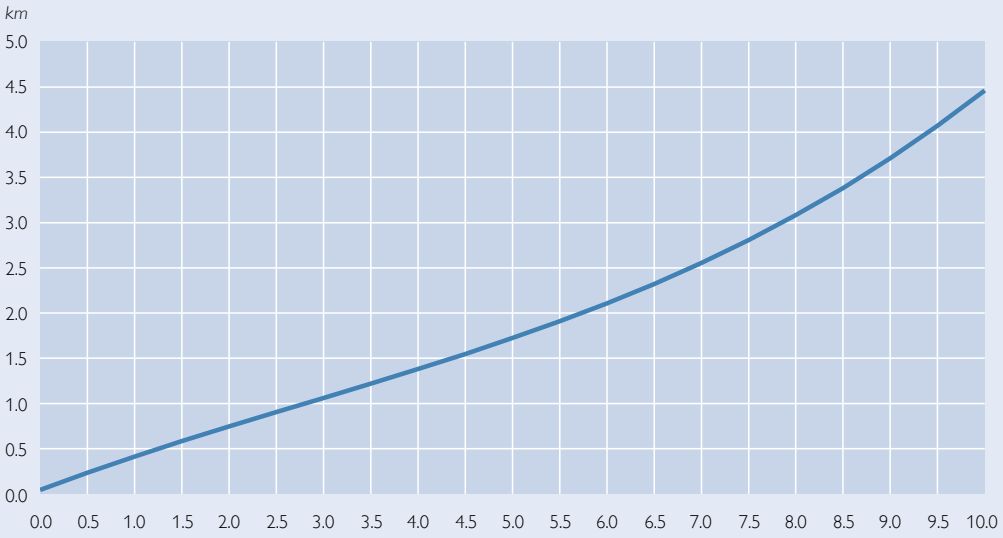
Difference between road network distances and straight-line distances

	Mean	Median	P95	P99
	km			
Austria	0.3	0.2	1.3	2.7
by municipality size (number of inhabitants)				
up tp 2,000	0.6	0.3	2.1	3.9
2,001–3,000	0.5	0.3	1.7	3.3
3,001–5,000	0.4	0.2	1.5	3.0
5,001–10,000	0.4	0.2	1.3	2.5
10,001–50,000	0.3	0.2	1.0	2.1
50,001–1 million	0.2	0.1	0.6	1.1
>1 million (Vienna)	0.1	0.1	0.4	0.8

Source: OeNB.

Chart 1 B2

Difference between road network distances and straight-line distances



Source: OeNB.

Note: Chart 1 B2 shows the difference between road network distances and straight-line distances (in km, y-axis) as a function of straight-line distances (x-axis). The results reflect predictions from an OLS regression in which the difference (in levels) is regressed on a third-degree polynomial of straight-line distance.

5 Summary and conclusions

This paper presents a first – and certainly incomplete – assessment of the Austrian ATM network from a spatial perspective. It provides detailed results on travel distances and times to the nearest ATMs for both small geographical areas and Austria's 2,096 municipalities. In doing so, this paper aims to contribute to the debate on access to cash and to provide a benchmark for international comparisons and for evaluating changes to the domestic ATM network.

There are two broader conclusions emerging from this study. First, although normative judgments about the quality of ATM access are problematic – owing to a lack of historical values and appropriate theoretical frameworks – our results suggest that travel distances to ATMs are, on average, reasonable across the country and its population. This assessment holds true for both small and large municipalities and is further supported by an OeNB survey which shows that 96% of Austrians consider it "very easy" or "fairly easy" to access ATM services. Second, our fine-grained geographical approach allows us to identify regions with higher shares of the population that have to travel larger distances to reach an ATM. Typically, these municipalities are rather small in population size (about 840 inhabitants on average).

Several directions may be pursued to extend our analysis. First, in addition to ATMs, further studies may also take into account cash-back services provided by retailers. Second, in contrast to focusing on only one aspect of accessibility (i.e. the physical distance to the closest ATM), further studies may consider more aspects. This could be done by combining the results obtained from this study with geographically fine-grained data on the socioeconomic composition of the population and on the structural characteristics of specific regions (i.e. by accounting for e.g. the proportion of older people in the population, the availability of public transport or the availability of high-speed internet, see Evans et al., 2020; Náñez Alonso et al., 2020). Such analyses could thus shed light on the demand for ATMs in areas where people have to travel larger distances and look into how ATM access in these areas may be improved. We hope that the results presented in this paper provide a useful basis for such analyses.

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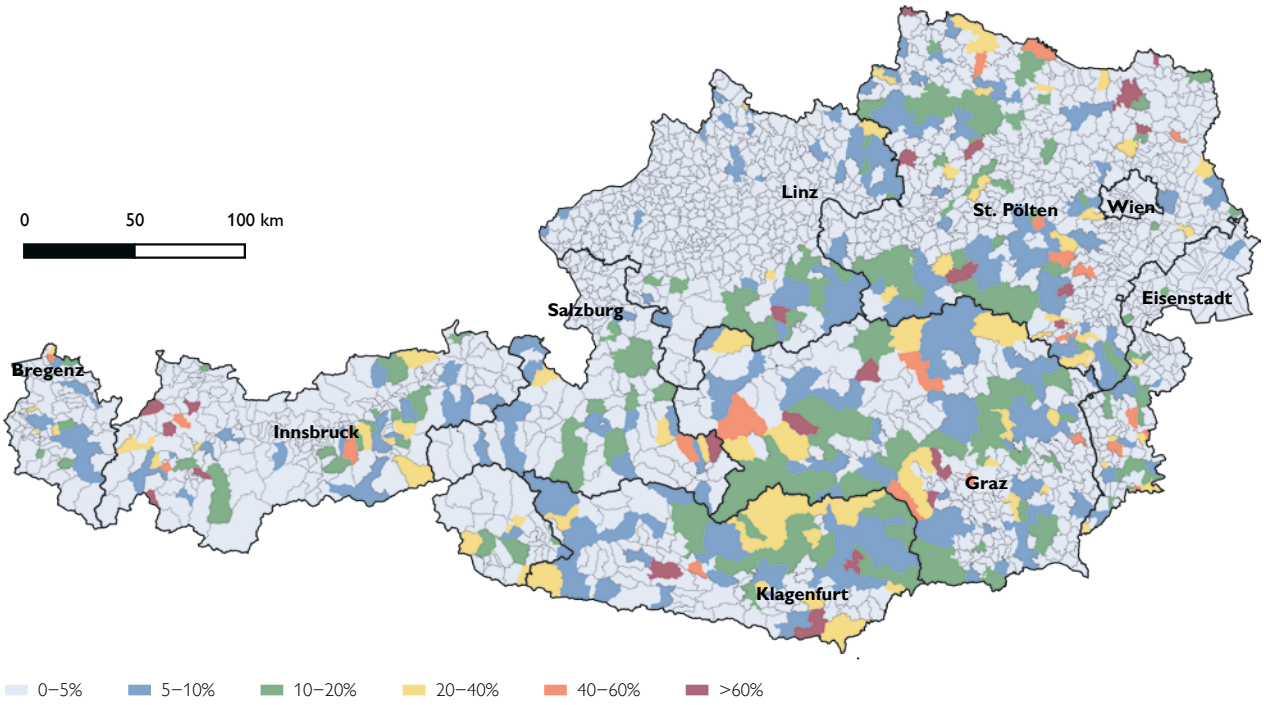
Annex

Chart A1

Share of population traveling more than 10 minutes to the nearest ATM by municipality

Share of population in %



Source: Statistik Austria – data.statistik.gv.at, OeNB.

Note: Municipality borders as of 2019.

Table A1

Overview of average travel speed assumptions for different street types

	Average speed in town	Average speed out of town
Street type	*km/h*	
Motorway	100	100
Main federal road	40	65
Federal road	40	55
State road	40	55
Connection road	25	45
Thoroughfare	25	45
Local street	15	30
Small street	10	15
Alley	10	10

Source: WIGeoGIS Softwareerstellungs- und Handelsgesellschaft m.b.H.

Table A2

Travel time to the nearest ATM by municipality size and province

	Mean	P25	Median	P75	P90	P99
	min					
by municipality size (number of inhabitans)						
up to 2000	4.1	1.7	3.2	5.7	8.5	16.0
2,001–3,000	3.7	1.6	2.9	4.9	7.4	13.8
3,001–5,000	3.5	1.5	2.8	4.7	7.0	13.8
5,001–10,000	3.2	1.5	2.6	4.3	6.3	12.2
10,001–50,000	2.7	1.2	2.1	3.4	5.1	11.0
50,001–1 million	1.9	0.9	1.6	2.6	3.8	7.3
>1 million (Vienna)	1.6	0.7	1.3	2.0	3.1	5.9
by province						
Burgenland	3.3	1.5	2.6	4.4	6.9	11.4
Carinthia	3.9	1.6	2.9	5.1	8.2	18.3
Lower Austria	3.4	1.5	2.6	4.5	7.0	12.3
Upper Austria	3.0	1.4	2.4	4.1	5.9	10.0
Salzburg	2.9	1.2	2.2	3.9	5.8	12.7
Styria	3.6	1.4	2.7	4.8	7.6	15.8
Tyrol	2.7	1.1	2.0	3.3	5.3	12.6
Vorarlberg	2.4	1.2	2.0	3.1	4.6	10.1
Vienna	1.6	0.7	1.3	2.0	3.1	5.9

Source: OeNB.

Note: Results are population-weighted. Total population: 8,858,775. "P25" denotes the 25th percentile, which means that 25% of the population have to travel less long than the value specified.