Firm survival and location preference: evidence from Mexico city

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1. Introduction

The aim of this research is to find if there is a relationship between firm location and road class, and whether location decisions regarding road class affect the probability of firm survival.

Location theory for firms has evolved since the early model of Von Thünen (1826) through Marshall’s industrial districts (1890), Weber’s location triangle (1909), and Christaller’s (1933) and Lösch’s (1940) central place theory. More recent models have deepened the knowledge of how businesses benefit from agglomeration economies (Siedschlag et al., 2013), and how these have an impact on the co-location of businesses in order to share both labor force and inputs for production. In this respect, agglomeration becomes a source of accessibility to local characteristics that either reduce costs or increase sales as well as production benefits as a result of synergy between firms; these, in turn, affect location decisions. For example, certain firms locate where there is a supply of local intermediary services (Henderson and Ono, 2008). High-tech firms tend to locate in the vicinity of universities to have access to knowledge sources (Audrestch et al., 2005), while businesses in the service sector are attracted by shopping centers (Romero, 2015).

In terms of transportation infrastructure, Tsou and Cheng (2013) have looked at how different configurations of the road and public transportation networks affect firm distribution. Nilsson and Smirnov (2016) measured how main roads positively relate to location, and Wang et al. (2014) determined the advantages of locating on central streets in terms of closeness (distance to central streets), betweenness (distance relative to two or more central streets) and straightness (difference between the distance to central streets using the road network and the Euclidean distance). Iacono and Levinson (2016) researched the relationship between the growth of the transportation network and economic growth, and Behrens et al. (2009) found that as transport supply increases and its fixed costs decrease, the relocation of businesses and consumers becomes easier. Biviera et al. (2016) argue that walking accessibility is the primary locational characteristic for supermarkets to survive.

There have been multiple examples of the effects of location on the survival rates of firms although there are conflicting findings. Wennberg and Lindqvist (2010) found that agglomeration economies increased the survival rate of firms, number of jobs, and wages, whereas De Silva and McComb (2011) found that a high density of similar firms in a small area decreases the probability of survival. Basile et al. (2017) also found agglomeration to have a positive effect on survival rates although only in the service sector, together with diversity in the type of businesses that locate together. Manzato et al. (2011) argue that different types of firms require different location characteristics in order to survive.

Although there are multiple characteristics that have been studied in terms of location and its effect on firm survival, there is little if any evidence on the nature of the relationship between road class and the location of businesses. Thus, our question is whether there are locational preferences of distinct business type towards specific types of roads and,
if so, whether location decisions regarding road class affect the probability of firm survival.

In order to answer this question, we look at the location of 35 selected kinds of businesses in Mexico City in four road classes. We develop a Location Preference Quotient (LPQ) that indicates whether the number of businesses that locate within a road class is above or below the expected number. With this calculation we are able to see not only what type of road each business type prefers, but also the degree of this preference. We find certain businesses to have a more homogeneous location preference, while others have a more heterogeneous preference. We then run a logistic regression model that predicts firm survival after a 5-year period. Among the independent variables considered, we find the one that most contributes to the probability of firm survival is its location on the road class preferred by that business type.

The rest of the article is divided into four sections: Section 2 describes our study area, its road network and the distribution of firms; Section 3 describes the methodology; in Section 4 we present the results of our analyses; and Section 5 presents conclusions and the limitations of our study.

2. Firms and roads in Mexico City

The study comprises firms of 35 selected economic activities (Table 1) located in the administrative area of Mexico City and its primary road network. The extent of the administrative area is 1,495 km², 48% of which is urban area. The population in 2015 was 8.8 million and gross urban density was 122 hab/ha (INEGI, 2010; INEGI, 2015).

Mexico City has a road network with a total length of 10,200 km. Road type is classified in 5 categories: (1) Arterial roads are grade-separated high-speed roads, similar to highways or motorways with no on-street parking, and no traffic lights in the central lanes. (2) One-way high capacity (OWHC) roads are known in Mexico City as ejes viales; they are roads that cross the city making up a grid. OWHC roads are one-way except for a dedicated lane for public transport that can be counter flow. Traffic lights are synchronized at 50 km/h. No on-street parking is allowed. (3) Major roads are streets of medium-high capacity with intersections that are controlled by traffic lights. Major roads connect economic centers of the city. No on-street parking is allowed. (4) Collector roads are secondary roads that link local streets with the primary road network. Collector roads may have high capacity, but they allow shorter travel distances than the other types described above. On-street parking is usually allowed. (5) Local roads are residential streets that allow parking and serve the local population. Only a limited number and type of firms are located in this category, and thus they are excluded from the analysis. Excluding local roads, the network’s length is 931 km (Figure 1) (Setravi cited in: GDF, 2002a and GDF, 2002b).

Of the four road categories used in the analysis, Arterials account for 11.7% (240.1 km), OWHC 17.4% (356 km), Main roads 30.3% (619 km), and Collector roads 40.6% (831 km) of the network.

According to the National Statistical Directory of Economic Units (DENUE), Mexico City had close to 395,000 firms in 2009 and just over 415,000 firms in 2014. Gross value added in 2014 was US$ 76 billion, 25% of the national figure. Employment rose to 3.6 million workers, 12% of the national figure (INEGI, 2014a; INEGI, 2014b). Table 2 shows the distribution of selected firms among 35 economic sectors and their associated road class. The selection includes 70,000 businesses, which employ 392,000 workers, and are the business types where Mexico City population dwellers spend 80% of their income in three-month period (Ruiz et al., 2014).

3. Methodology

Since the research question is whether there is a relationship between firm location and road hierarchy, our procedure involved two steps. The first step was to identify whether there is a road category in which selected types of firms prefer to locate; for this we use a Location Preference Quotient (LPQ). We also calculate the degree of homogeneity found in that preference; for this we use an Entropy Index. In a second step we evaluate whether firms that are located on their preferred road class, as measured by the LPQ, have a greater probability of survival than those that are located elsewhere.

Our main data source for the location of businesses was the National Statistical Directory of Economic Units (DENUE: Directorio Estadístico Nacional de Unidades Económicas) for years 2009 and 2014, which contains the location of all businesses in Mexico at the lot level. It also provides the name, address, economic activity (6 digits NAICS codes) and number of employees for each firm. This database includes the road network for the city and provides the road hierarchy classification.

Owing to the wide variety of firms, we selected 35 common types of business in which Mexican households spend most of their income according to Ruiz et al. (2014) (considered 25 economic activities; we added a further 10 to complement this list). Each firm was associated to the road class where it was located. If a firm touched more than one road, we used the street reported in the address attribute of our data base. For each type of business, the LPQ was calculated from Eq. (1). Analyses of preference took into account the proportion of firms in each of the 35 economic activities and the aggregate proportional length of roads of each of the 4 types, in order to control for differences in population size. The behavior of the LPQ is similar to that of a location quotient, in that those values above zero indicate the proportional preference of a firm in activity i to locate on a road of type j, while values below zero show that

### Table 1. Firm groups, name, and NAICS code in Mexico City, 2014.

| NAICS code | Name                        |
|------------|-----------------------------|
| 8114       | Appliance repair            |
| 522        | Banks                       |
| 7224       | Bars & night clubs          |
| 465312     | Bookstores                  |
| 5171       | Cable TV, Tel. & Internet   |
| 8111       | Car repair                  |
| 5172-5174-5179 | Cellphone shops          |
| 4632-4633  | Clothing                    |
| 236-237-238 | Construction industry      |
| 46111      | Convenience stores          |
| 551        | Corporate                   |
| 4622       | Department stores           |
| 46411      | Drugstores                  |
| 8122       | Dry cleaners & laundry      |
| 311830-46113-461121-461122 | Food stores (perishables)  |
| 466111-466112 | Furniture & appliances    |
| 468411     | Gas stations                |
| 81211      | Hairdresser                 |
| 43421-467111-467116 | Hardware & construction |
| 524        | Insurance                   |
| 561432     | Internet café               |
| 462112     | Mini markets                |
| 512130     | Movie theatres              |
| 465313     | News stands                 |
| 6211116-621113-621211 | Private doctor’s offices   |
| 611151-611161 | Private high schools    |
| 622111     | Private hospitals           |
| 61111      | Private preschools          |
| 6111121    | Private primary schools     |
| 611131-611141 | Private secondary schools |
| 611311     | Private universities        |
| 465211     | Record stores               |
| 7221-7222  | Restaurants                 |
| 433410-465311 | Stationery               |
| 462111     | Supermarkets                |

Source: Authors’ elaboration based on DENUE-INEGI, 2014a; INEGI, 2014b.
an activity $i$ will not usually locate on a road of type $j$, relative to the number of firms and the length of roads.

$$LPQ_{ij} = \frac{F_i}{F} \frac{V_j}{V} - 1$$ (1)

Where:

$LPQ_{ij}$ = Location preference quotient of firm type $i$ on road class $j$

$F_i$ = Number of firms in economic activity $i$ located on road class $j$

$F$ = Total number of firms

$V_j$ = Number of km of road class $j$

$V$ = Total number of km of roads

Once we had calculated each LPQ, we selected the road class with the highest coefficient as the preferred road for each economic activity. However, we noted a wide variation between business types. Some had very similar coefficients across categories (high variation), while others had very high coefficients on some categories and low coefficients on others (low variation), so an entropy measure was calculated to know the extent of the preference dispersion among road classes (Equation 2).

$$\varepsilon = (1 - \frac{1}{\log_{10} k} \sum_{k=1}^{k} P_i \log_{10} P_i)$$ (2)

Where:

$P_i$ = Proportion of LPQ in category $k$

$k$ = Number of categories

Finally, in order to ascertain whether the LPQ in fact denoted an advantage of location on specific road classes for each type of firm, we ran a logistic regression analysis to see whether firms that are located on their preferred road class (according to the LPQ) have a greater possibility of survival within a five-year period than do those that are not located on their preferred road class. In order to do this, we compared DENUE data for 2009 and 2014.

Given the nature of our data base, the process to determine if a firm survived the five-year period could not be automated and had to be done by observing each case in both time periods. Due to the large number of businesses, we decided to take a sample which we use only for the logistic regression.

The sample is a single-stage, stratified by type of road and firm, and with simple random probability without replacement. The size of the population corresponds to the total firms in 2009 (66,569), while the number of strata (140) results from the combination of business types (35) and the road classes (4). A relative error of +/- 15% was set, respect to $p = 0.0263$, with a confidence level of 95%. The sample was 5,519
cases, but with the adjustment in the strata, so that there are no categories with a single unit, \( n \) was established in 5,535 cases. Of the units selected for the 2009 sample, 97% survived (5,378) in 2014. The sample is calculated as follows (Equation 3):

\[
n = \frac{z^2 \cdot q}{r^2 \cdot p}
\]

Where:
- \( n \) = Sample size
- \( q = 1 - p \)
- \( r \) = Acceptable relative error
- \( z \) = Confidence level

As the total population of business is known, the calculation must be adjusted for a finite population (Equation 4):

\[
n' = \frac{n}{1 + \frac{z^2 \cdot q}{N}}
\]

Where:
- \( n' \) = Sample size adjusted for finite population
- \( n \) = Estimated sample size
- \( N \) = Total firms

The variables for the model can be classified as of two types, a) location variables that refer to the characteristics of the place where the firms are located, this group includes the LPQ; and b) synergistic variables that indicate the relationship that businesses have with other

### Table 2. Distribution of selected firms among road class in Mexico City, 2014.

| Firm type               | % Firms per road class | No. of firms | Total No. employees | Mean employees |
|-------------------------|------------------------|--------------|---------------------|---------------|
|                         | Arterial | OWHC | Main | Collector | Arterial | OWHC | Main | Collector | Arterial | OWHC | Main | Collector |
| Appliance repair        | 7.0      | 29.3 | 25.6 | 38.0      | 2,474  | 6,775 | 3   |
| Banks                   | 13.4     | 24.1 | 45.3 | 17.2      | 2,073  | 21,166 | 10  |
| Bars & night clubs      | 6.5      | 40.7 | 34.9 | 17.8      | 275   | 2,836  | 10  |
| Bookstores              | 7.4      | 35.5 | 37.5 | 19.5      | 256   | 3,005  | 12  |
| Cable TV, Tel. & Internet | 17.7     | 17.7 | 33.6 | 31.0      | 113   | 1,957  | 17  |
| Car repair              | 6.6      | 24.8 | 28.6 | 40.0      | 5,793 | 21,216 | 4   |
| Cellphone shops         | 9.9      | 23.0 | 36.5 | 30.6      | 395   | 5,618  | 14  |
| Clothing                | 9.6      | 46.2 | 22.7 | 21.5      | 7,134 | 25,331 | 3   |
| Construction industry   | 14.0     | 25.6 | 32.8 | 27.6      | 758   | 21,241 | 28  |
| Convenience stores      | 5.5      | 20.9 | 21.8 | 51.8      | 7,649 | 20,769 | 3   |
| Corporate               | 14.4     | 8.9  | 60.0 | 16.7      | 90    | 2,713  | 30  |
| Department stores       | 12.7     | 22.4 | 50.3 | 14.5      | 165   | 11,658 | 71  |
| Drugstores              | 7.5      | 25.5 | 27.7 | 39.2      | 2,427 | 11,001 | 5   |
| Dry cleaners & laundry  | 5.5      | 23.1 | 25.7 | 45.7      | 1,352 | 4,478  | 3   |
| Food stores (perishables) | 3.8    | 31.4 | 16.6 | 48.3      | 6,240 | 17,193 | 3   |
| Furniture & appliances  | 11.8     | 31.2 | 31.2 | 25.8      | 1,102 | 6,225  | 6   |
| Gas stations            | 17.7     | 32.3 | 33.2 | 16.8      | 232   | 5,610  | 24  |
| Hairdressers            | 5.3      | 23.4 | 25.7 | 45.5      | 4,030 | 12,457 | 3   |
| Hardware & construction | 6.3      | 28.5 | 27.9 | 37.3      | 2,429 | 12,871 | 5   |
| Insurance               | 14.7     | 23.4 | 43.3 | 18.7      | 402   | 15,648 | 39  |
| Internet café           | 5.5      | 21.2 | 22.5 | 50.8      | 1,412 | 3,792  | 3   |
| Mini markets            | 9.3      | 26.8 | 39.1 | 24.8      | 645   | 4,196  | 7   |
| Movie theatres          | 15.4     | 32.7 | 48.1 | 3.8       | 52    | 1,183  | 23  |
| News stands             | 12.2     | 38.4 | 29.6 | 19.8      | 1,347 | 3,524  | 3   |
| Private doctor's offices| 5.8      | 27.7 | 36.1 | 30.4      | 3,403 | 10,994 | 3   |
| Private high schools    | 18.1     | 29.8 | 31.9 | 20.2      | 94    | 3,380  | 36  |
| Private hospitals       | 11.1     | 25.4 | 34.9 | 28.6      | 63    | 2,587  | 41  |
| Private preschools      | 6.5      | 14.2 | 29.5 | 49.8      | 275   | 3,495  | 13  |
| Private primary schools | 4.4      | 19.4 | 27.5 | 48.7      | 160   | 3,678  | 23  |
| Private secondary schools| 16.2    | 29.7 | 10.8 | 43.3      | 37    | 1,295  | 35  |
| Private universities    | 13.8     | 29.8 | 30.9 | 25.5      | 94    | 7,162  | 76  |
| Record stores           | 6.3      | 46.8 | 23.6 | 22.9      | 301   | 1,512  | 5   |
| Restaurants             | 7.9      | 28.4 | 30.0 | 33.6      | 14,268| 82,351 | 6   |
| Stationery              | 5.0      | 19.8 | 22.2 | 53.0      | 2,500 | 10,717 | 4   |
| Supermarkets            | 14.2     | 29.4 | 33.8 | 22.5      | 204   | 22,792 | 112 |
| Total                   | 7.3      | 28.5 | 27.1 | 37.1      | 70,244| 392,415| 6   |
| Roads (%)               | 11.7     | 17.4 | 30.3 | 40.6      | -     | -     | -   |

Source: Authors' calculations based on DENUE-INEGI, 2014a; INEGI, 2014b.

### Table 3. Location Preference Quotient of selected firms in Mexico City, 2014.

| Arterial | OWHC | Main | Collector | Total |
|----------|------|------|-----------|-------|
| 5,143    | 19,996 | 19,048 | 26,057 | 70,244 |
| % Firms   |      |      |           |       |
| 7.3      | 25.8 | 27.1 | 37.1     | 100   |
| Total Roads (km) | 240 | 356 | 619 | 831 | 2,046 |
| % Roads   |      |      |           |       |
| 11.7     | 17.4 | 30.3 | 40.6     | 100   |
| Location Preference Quotient | -0.38 | 0.64 | -0.11 | -0.09 | 1 |

Source: Authors' calculations based on INEGI, 2014a.
Figure 2. Location Preference Quotients for all firms per road class, 2014. Art: Arterial road; OW: One way; MR: Major road; Col: Collector road. Source: Authors' calculations based on INEGI, 2014a.
| Category                  | Road  | Art | OW | MR | Col |
|--------------------------|-------|-----|----|----|-----|
| Food stores              | −0.68 (−0.38) | 0.80 (0.64) | −0.42 (−0.11) | 0.19 (−0.09) |
| Furniture/appliances     | 0.90 (−0.38) | 0.79 (0.64) | 0.03 (−0.11) | −0.27 (−0.09) |
| Gas stations             | 0.51 (−0.38) | 0.06 (0.64) | 0.10 (−0.11) | −0.59 (−0.09) |
| Hairdresser              | −0.52 (−0.38) | 0.22 (0.64) | −0.34 (−0.11) | 0.25 (−0.09) |
| Hardware & construction  | −0.46 (−0.38) | 0.64 (0.64) | −0.08 (−0.11) | −0.08 (−0.09) |
| Insurance                | 0.25 (−0.38) | 0.34 (0.64) | 0.43 (−0.11) | −0.54 (−0.09) |
| Internet cafe            | −0.53 (−0.38) | 0.22 (0.64) | −0.34 (−0.11) | 0.25 (−0.09) |
| Mini–markets             | −0.21 (−0.38) | 0.54 (0.64) | 0.39 (−0.11) | −0.39 (−0.09) |
| Newspaper stands         | 0.04 (−0.38) | 1.21 (0.64) | −0.02 (−0.11) | −0.51 (−0.09) |
| Private doctor’s offices | −0.50 (−0.38) | 0.59 (0.64) | 0.19 (−0.11) | −0.25 (−0.09) |
| Private high schools     | 0.54 (−0.38) | 0.71 (0.64) | 0.05 (−0.11) | −0.51 (−0.09) |
| Private hospitals        | −0.05 (−0.38) | 0.48 (0.64) | 0.13 (−0.11) | −0.30 (−0.09) |
| Private preschools       | −0.45 (−0.38) | −0.18 (0.64) | −0.53 (−0.11) | 0.20 (−0.09) |
| Private primary schools  | −0.63 (−0.38) | 0.13 (0.64) | −0.08 (−0.11) | 0.28 (−0.09) |

Figure 2. (continued)
business types, based on their proximity and, therefore, on the economies of agglomeration that they generate.

4. Results

4.1. Location preference

Table 3 shows firm distribution among four road classes as well as the actual distribution of roads both in absolute terms and in percentages. A general LPQ is calculated for all firms regardless of their economic sector. The logic underlying the LPQ is that if there was no location preference among road classes, the percentage of firms on each road class would be no different than the distribution of road classes themselves (in overall length). In that scenario, 11.7% of all firm types should be located on Arterial roads; 17.4% on OWHC, and so forth. However, we found significant deviations from this assumption.

Overall, businesses prefer OWHC (LPQ = 0.6). This LPQ value is interpreted as a 60% higher probability that a business will locate on an OWHC road. That is, 28% of all firms are located on OWHC roads while their share in the network amounts to only 17%. Arterial roads, in contrast, are the least preferred (LPQ = -0.4). Main and Collector roads have a share of businesses similar to their share of the network. There are, however, differences among business types (Figure 2).

As an example, corporate offices are more likely to locate on Main than on OWHC roads, convenience stores usually locate on Collector roads and have their highest LPQ on that type of road, and Cable TV firms are more likely on Arterials than on any other road class. Figure 2 also reveals any second and third preferred location, and demonstrates that some firms (e.g., secondary schools) have a more heterogeneous preference, while others such as clothing stores have a more homogeneous preference.

In Table 4 we summarize the percentage of firms that show positive preference (LPQ >0) for each road class as well as the percentage of firms that score their highest, second and third highest LPQs on each road class (there is always at least one negative category). Most firms have LPQs greater than zero on OWHC roads, and it is the preferred road class for 71% of all firms, while Arterials are the least preferred. The second most preferred are Main roads. However, these are generalizations and there is wide variation between firms.

For the entropy index of LPQ between road classes (Figure 3), values < 0 show homogeneity in road preference while values > 0 show a heterogenous road preference relative to the entropy index for the complete aggregation selected firms. We would expect business types showing high heterogeneity to perform better when they are not located on the road class on which they were most frequently found; to investigate this suggestion, we ran the logistic regression model.

4.2. Logistic regression

Most firms (97%) survived the 5-year period regardless of where they were located. However, 87% of the firms that did not survive were not located on the road class with the highest LPQ. If we run a simple Chi square test on firm survival as a function of them being in their preferred road class, the test result is significant (Table 5). However, we believe the relationship between these two variables to be more complex. Specifically, because, 68% of firms that did survive, were also located on a road class other than the one with the highest LPQ. Thus, a series of factors, other than road class location, would have to explain firm survival when location is a different to what we have defined as the preferred road class. The multivariate nature of the logistic regression model allows us to see these relationships.

### Table 4. Distribution (%) of preferences among firms for road classes, according to the Location Preference Quotient, 2014.

| Road Class | Arterial | OWHC | Main | Collector |
|------------|----------|------|------|-----------|
| % Firms with LPQ greater than 0 for each road class | 40 | 94 | 51 | 26 |
| % Firms with highest LPQ on each road class | 2.9 | 71.4 | 11.4 | 14.3 |
| % Firms with second highest LPQ on each road class | 25.7 | 20.0 | 37.1 | 17.2 |
| % Firms with third highest LPQ on each road class | 31.4 | 8.6 | 48.6 | 11.4 |

Source: Authors’ calculations based on INEGI, 2014a.

### Table 5. Firm survival and location Chi square test.

| Located on preferred road class | Survived | | Total |
|---------------------------------|---------|--------|-------|
| No                              | 136     | 21     | 157   |
| Yes                             | 3664    | 1714   | 5378  |
| TOTAL                           | 3800    | 1735   | 5535  |

Chi sq = 24.24; Sig. = 0.000

Source: Authors’ calculations based on INEGI, 2014a.
Table 6. Variables used in the logistic models.

| Variable | Description |
|----------|-------------|
| Firm is located on its preferred road class | Firm is located on the road class with the highest LPQ for the firm type |
| Distance to arterial roads (m) | Distance in meters from the firm to the closest arterial road |
| Distance to OWHC roads (m) | Distance in meters from the firm to the closest OWHC road |
| Distance to main roads (m) | Distance in meters from the firm to the closest main road |
| Distance to collector roads (m) | Distance in meters from the firm to the closest collector road |
| Distance to preferred road class (m) | Distance in meters from the firm to the closest road with the highest LPQ for the firm type |
| Urban ring | Urban ring where the firm is located (Belgardo, 1988) |
| Firm size (number of employees) | Number of employees in the firm |
| Population density in tract (hab/ha) | Population density in the tract where the firm is located |
| Marginalization score of tracts | Marginalization score for the tract where the firm is located. The construction of the index can be consulted in CONAPO, 2012 |
| Entropy index | Is the entropy index score of the firm type, heterogeneous (1) or homogenous (0) |
| Land use mix | Entropy index of land uses in the tract where the firm is located (Industrial, Commerce, Housing, Services) (Setravi, n.d.) |
| Distance to the nearest firm (m) | Distance in meters to the nearest firm |
| Distance to the nearest firm (same type) (m) | Distance in meters to the nearest firm of the same type |
| Firm density (Firms/ha) | Number of firms in a 20m² area from the firm of reference |
| Employee density (Emp/ha) | Number of jobs in a 20m² area from the firm of reference |
| Specialization coefficient (tract) | Location quotient in a 20m² area from the firm of reference; \( f_i / f_i / F \), where: \( f_i = \) Number of firms of type \( i \) in tract \( t \); \( f = \) Number of firms in tract \( t \); \( F = \) Total number of firms of type \( i \) in the study area |

Source: Authors' elaboration.

Table 7. Logistic regression, firm survival; full and reduced models.

| Variable | Description | Full model | Reduced model |
|----------|-------------|------------|---------------|
| Firm is located on its preferred road class (Latent category: Na) | | Beta (Sig.) | S.E. | Exp (B) | Beta (B) (Sig.) | S.E. | Exp (B) |
| Yes | 0.9068 (0.0007) | 0.2687 | 2.476 | 0.8993 (0.0003) | 0.2506 | 2.458 |
| Distance to arterial roads (m) | -0.0001 (0.0410) | 0.0001 | 1.000 | -0.0001 (0.0007) | 0.0000 | 1.000 |
| Distance to OWHC3 (m) | 0.0000 (0.6911) | 0.0001 | 1.000 | |
| Distance to main roads (m) | 0.0015 (0.0000) | 0.0003 | 1.002 | 0.0008 (0.0063) | 0.0003 | 1.001 |
| Distance to collector roads (m) | -0.0001 (0.7712) | 0.0002 | 1.000 | |
| Log distance to collector roads (m) | -0.0585 (0.0000) | 0.01316 | 0.943 |
| Distance to preferred road class (m) | 0.0001 (0.4907) | 0.0001 | 1.000 | |
| Urban ring (Latent category: Central City) | | | | |
| First urban ring | 0.5189 (0.0240) | 0.2229 | 1.680 | 0.4762 (0.0104) | 0.1858 | 1.610 |
| Second urban ring | -0.2050 (0.5130) | 0.3134 | 0.815 | |
| Third urban ring | 0.2806 (0.5550) | 0.4695 | 1.324 | |
| Firm size (number of employees) | -0.0016 (0.6793) | 0.0040 | 0.998 | |
| Population density in tract (hab/ha) | 0.0004 (0.7533) | 0.0013 | 1.000 | |
| Marginalization score of tracts (Latent category: high) | | | | |
| Low marginalized tract | 0.3427 (0.4246) | 0.4292 | 1.409 | |
| Medium marginalized tract | 0.2868 (0.4801) | 0.4054 | 1.331 | |

(continued on next page)

1 We use the marginalization index of the National Population Council (CONAPO, 2012) as a proxy for income since it strongly correlates with it. The marginalization index uses a principal components analysis (PCA) to extract common variance from 10 variables: 1) percent population between 6 and 14 years of age that does not attend school, 2) percent population 15 and more years old without pri- mary education, 3) percent population without health services, 4) percent infant deaths of women 15e49 years of age, 5) percent dwelling units without piped water, 6) percent dwelling units without sewage, 7) percent dwelling units without a WC, 8) percent dwelling units with dirt floors, 9) percent dwelling units that are overcrowded and, 10) percent dwelling units without a refrigerator- ator; the index uses the first component of the PCA as the marginalization index. All variables correlate positively with the index, such that as the index value increases, places are considered to have higher marginalization.

In the logistic model, the dependent variable is whether a firm survived as a function of location characteristics. The intent of the model is to ascertain whether, according to the location preference coefficient of each of the 35 selected firm categories, location on the preferred road class increases the odds of survival. Candidate control variables include distance from other types of roads, area of the city where the firm is located, firm size, nearby socioeconomic characteristics such as population and job density, marginalization as a proxy for income1, and synergy characteristics, such as firm density and distance from other firms. Table 6 shows the variables used, and their construction.

In a second, reduced, model (Table 7), non-significant variables were dropped. The pseudo R² of the reduced model is slightly higher (0.125) than that of the full model (0.099), and in the reduced model all variables are significant, and the AIC is lower. Thus, the reduced model is preferred.
In any case, the relationship of interest is whether the odds of firm survival increase when firms are located on their preferred road class. According to our model this seems to be true. In fact, odds of survival increase more than twofold when a firm is located on its preferred road according to the odds-ratio (Exp (B)) coefficient. According to this coefficient, road location is the most important variable in the model.

5. Conclusions

The main research question was whether there is a relationship between road hierarchy (i.e. road class) and the location of different types of economic activity. We have provided evidence that this relationship exists.

In the first analysis we used LPQ to show that different types of firms have a preference for different road classes, and that some firms have a higher probability of being found on one road type rather than others. This preference persists after taking into account that some road classes have a larger share of the road network. We also provide evidence that some firms have more heterogeneous preferences, with their distribution following more closely that of the road classes themselves, whereas other firms have a more homogeneous preference with concentration in a specific road class.

In the second analysis we test whether firms that are located on their preferred road class have a greater chance of survival in a 5-year period, controlling for a set of location characteristics and basic synergistic variables that relate to agglomeration externalities. Both the full and a reduced model show that the variable that has the greater odds ratio is our interest variable: in the reduced, more parsimonious model, odds of survival increase 2.4 times when a firm is located on the road class for which the business type show the highest LPQ. Although we anticipated that a more heterogeneous preference would imply better odds of survival, that variable did not prove significant.

This is not to say that agglomeration externalities do not play a role on location and firm survival. On the contrary, the logistic regression shows intuitive directions for control variables. Thus, in addition to the location and agglomeration characteristics that have been studied in the existing literature we propose that road class be also considered.

Our analysis is limited by the fact that data on firms are available for only two time periods. From 2009 to 2014 the total number of businesses increased by 8%. According to our sample, close to 3% of businesses did not survive in the 5-year period although they were replaced in the most part by new firms. This means that somewhere between 10% and 11% of businesses in the city were new in 2014. Since most firms survive, it is probable that we could find better evidence of the effect of location by road class if we were to work only with new firms, under the assumption that after a certain time threshold firms will survive more easily regardless of road class location.

Another limitation of our analysis, as noted by an anonymous reviewer, is that there are other factors that affect firm survival, such as overall economic conditions and cultural preferences. Unfortunately, knowing if the country’s economic performance in the period under study affects the analysis is beyond the scope of the article. We are also aware that the validity of our observations for cities in other countries could depend on cultural preferences that may relate to road class, such as transportation mode choice. This is the subject of further research.

Declarations

Author contribution statement

Victor Reyes & Manuel Suarez: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data associated with this study has been deposited at National Statistical Directory of Economic Units (DENUE), 2009 and 2009, INEGI at https://www.inegi.org.mx/app/mapa/denue/default.aspx.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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