Applied Mathematics & Information Sciences

Volume 17
Issue 5 *Sep. 2023*

Article 17

9-1-2023

The Artificial Intelligence as a decision-making instrument for Modeling and Predicting Small Cities' Attractiveness: Evidence from Morocco

Sohaib Khalid
MASAFEQ Laboratory, National Institute of Statistics and Applied Economics, Morocco, sohaibxkhalid@gmail.com

Driss Effina
MASAFEQ Laboratory, National Institute of Statistics and Applied Economics, Morocco, sohaibxkhalid@gmail.com

Khaoula Rihab Khalid
LERSRG Laboratory,University of Sultan Moulay Slimane,Be´ni-Mellal, Morocco, sohaibxkhalid@gmail.com

Mohamed Salem Chaabane
Laboratory of Systems Engineering (LaGes), Research Team Geomatic Sciences (SGEO), Hassania School of Public Works, Morocco, sohaibxkhalid@gmail.com

Recommended Citation

Khalid, Sohaib; Effina, Driss; Rihab Khalid, Khaoula; and Salem Chaabane, Mohamed (2023) "The Artificial Intelligence as a decision-making instrument for Modeling and Predicting Small Cities' Attractiveness: Evidence from Morocco," *Applied Mathematics & Information Sciences*: Vol. 17: Iss. 5, Article 17.
DOI: https://dx.doi.org/10.18576/amis/170517
Available at: https://digitalcommons.aaru.edu.jo/amis/vol17/iss5/17

Applied Mathematics & Information Sciences
An International Journal

http://dx.doi.org/10.18576/amis/170517

The Artificial Intelligence as a decision-making instrument for Modeling and Predicting Small Cities' Attractiveness: Evidence from Morocco

Sohaib Khalid[1,*], *Driss Effina*[1], *Khaoula Rihab Khalid*[2], *and Mohamed Salem Chaabane*[3]

[1]MASAFEQ Laboratory, National Institute of Statistics and Applied Economics, Morocco
[2]LERSRG Laboratory,University of Sultan Moulay Slimane,Béni-Mellal, Morocco
[3]Laboratory of Systems Engineering (LaGes), Research Team Geomatic Sciences (SGEO), Hassania School of Public Works, Morocco

Received: 17 May 2023, Revised: 21 Jul. 2023, Accepted: 23 Aug. 2023
Published online: 1 Sep. 2023

Abstract: This study analyzes residential attractiveness in small Moroccan cities using statistical models. Net migration rates are commonly used to assess attractiveness. The study estimated net migration rates for each city and employed a structural econometric model with logistic regression to identify influential variables that affect the net migration rate. These variables were then used in a predictive model with an artificial neural network algorithm. The logistic model revealed insights, highlighting the complexity of residential attractiveness influenced by factors like job supply, accessibility, and housing conditions. The artificial neural network model provided accurate predictions (over 80%), aiding policymakers in decision-making and prospective analyses.

Keywords: Artificial neural network, binary logistic regression, residential attractiveness, R language

1 Introduction

Until the 20th century's turn, Morocco experienced only modest urbanization, hosting around 400,000 urban residents, a mere 8% of the nation's population. The urban landscape comprised small cities, each housing limited urban centers. However, the latest population census of 2014 indicates a remarkable shift in the urbanization rate, now surging to 60.3%. This surge has catapulted Morocco into sustained growth within a brief time frame. By way of comparison, Algeria boasts a 71.3% urbanization rate, Tunisia 67.05%, Mauritania 60.45%, whereas France, Germany, the United Kingdom, and Brazil exhibit 79.75%, 75.75%, 82.84%, and 85% respectively.

The task of developing Moroccan cities is complex and requires a comprehensive approach to understand the intricate urban dynamics. The urban structure is a network of interconnected hubs and territories that engage in intense exchanges, drive urban economies, and coordinate a complex network of actors and territorial systems [1].

Cities are important hubs where people, businesses, and social events come together in one place. They form complex systems with different parts that have specific functions and characteristics. These different parts interact with each other and with their surroundings in intricate ways, creating a web of relationships between cities. This makes cities important places for economic and social activity to thrive. Although small cities have not received as much attention from scholars and researchers, they play a crucial role in the development of their surrounding areas by directing population movements and spreading economic progress.

Smaller urban centers have a great potential to attract migrants due to the promising job opportunities, localized labor markets, and entrepreneurial potential that they offer. Furthermore, these enclaves provide a more affordable cost of living and a peaceful, friendly residential environment in comparison to larger cities. On the other hand, small cities also function as temporary stopovers for migrants who are transitioning between rural and urban areas.

Small cities play an important role in managing migration. They serve as temporary homes for migrants

* Corresponding author e-mail: sohaibxkhalid@gmail.com

who stop to find jobs and explore opportunities before moving on to their final destinations. Additionally, they can serve as bases for ”reverse migration,” where migrants return to their hometowns after gaining skills and experience. These smaller cities help direct migration flows, create economic opportunities, and provide a welcoming environment for migrants. They also serve as points of departure for those returning home and offer crucial services to refugees and asylum seekers. By fulfilling these roles, small cities help reduce migratory pressures on larger urban areas and promote social and economic unity in rural regions.

The goal of improving the attraction of small cities poses a challenge within this framework. This challenge goes beyond addressing issues of territorial balance and strengthening specific urban strata. It also involves a strategic dimension that impacts Morocco's future trajectory. This trajectory includes the country's integration into a comprehensive territorial economy, its vision for society and territory, and the principles of effective governance.

2 Definition and estimation

2.1 Target population

The idea of a small city is complex and cannot be defined by a single, universal endpoint due to the diverse territories and urban realities. There are various criteria used to define urban formations, such as administrative considerations like municipalities, towns, and agglomeration communities, functional perspectives based on employment hubs, and morpho-statistical approaches that consider the continuity of built-up spaces and population and density thresholds.

In this article, we use the morpho-statistical criterion to define small cities. The High Commission for Planning considers a small city to have a population of 1000 to 50,000 people. According to the latest census data from 2014, Morocco has **292** cities spread across 67 provinces. Of these, 144 are municipalities, making up 72.3% of the total, while the remaining 27.7% is made up of 148 urban centers [2].

2.2 Estimating the net migration rate

Cities experience expansion primarily through population dynamics driven by either natural births or immigration. The interplay of demographic and migratory forces, acting as catalysts for growth, assumes a pivotal role in shaping spatial configurations.

Unraveling the demographic history of cities necessitates a comprehensive examination of both natural and migratory equilibrium. These dual indices converge to unveil the comprehensive population fluctuations within a defined temporal framework, effectively mirroring the urban allure and vibrancy [3].

Amongst the array of metrics gauging the ebb and flow of residential migrations, the net migration rate emerges as a beacon of precision. Regrettably, the Moroccan High Commission for Planning abstains from disclosing its migration-related data. In view of this informational void, the estimation of the net migration rate becomes an imperative endeavor, serving as a reliable surrogate for gauging territorial attraction. This rate, encapsulating the discrepancy between the influx of newcomers and the exodus of residents, is computed as the differential quotient between the Overall Growth Rate (OGR) and the Natural Growth Rate (NGR). The latter, represented by the natural balance rate, embodies the surplus of births over deaths within a specific urban context. Its ascertainment was achieved by harnessing fertility and infant mortality statistics spanning the intercensal period between 2004 and 2014 [4]. The underlying equation for analytical estimation is articulated as follows :

For each city i:

$$Net\ Migration\ Rate_i = OGR_i - NGR_i \tag{1}$$

$$NGR_i = Rate\ Births_i - Rate\ Deaths_i \tag{2}$$

2.3 Mapping

Cartography is a valuable tool for visualizing and understanding the characteristics of a territory in terms of its attractiveness. It helps to identify the strengths and weaknesses of a territory by showing, for example, existing infrastructures, locations of economic activities, residential areas, and natural spaces.

Maps can also show how an area is connected to other areas, transport routes, and communication facilities, facilitating strategic planning for economic and tourism development. Maps can also be used for the promotion of an area by showing its attractive features, such as tourist attractions, festivals, and cultural events.

To sum up, mapping is a valuable tool for territorial attractiveness, helping stakeholders to understand the characteristics and assets of a territory, as well as promoting its attraction to potential immigrants.

In this context, we have chosen to map the attractiveness versus the repulsiveness of small cities by making use of the estimates of the net migration rate that have already been made. A small city is considered to be attractive if it has a positive net migration rate. If this is not the case, the city is considered to be repulsive.

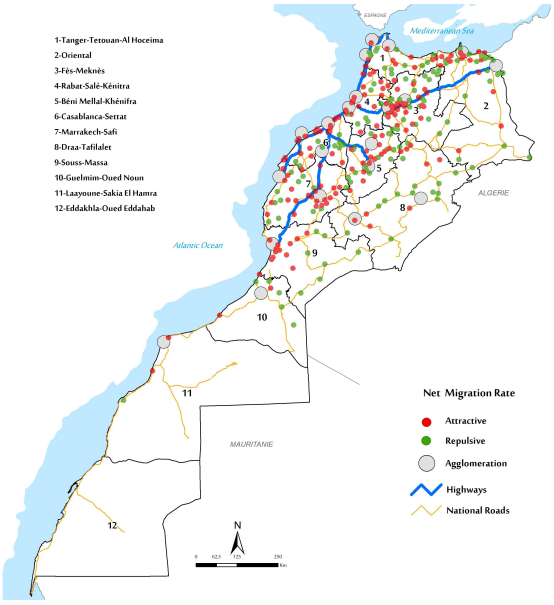


Fig. 1: Repulsive versus Attractive cities using net migration rate, Source: Author's manipulations using ArcGIS.

The cartographic analysis of the distribution of attractive cities shows that they follow a rather specific distribution. In fact, the attractive small cities are distributed along two main axes. The first axis is located on the coast and connects the main agglomerations of the country, meanwhile, the second is located in the interior of the country, connecting the second most important agglomerations of the country [5].

The visual analysis of the map shows that attractive unities follow the network of main roads, especially highways. This observation underlines the importance of connectivity and spatial proximity to agglomerations in addressing the issue of territorial attractiveness of small cities in Morocco.

3 Mathematical Modeling

3.1 Methodology

This work seeks dual exploration: structural and predictive modeling of Moroccan small cities' residential attractiveness.

Factors impacting residential attractiveness are distilled via logistic backward regression. This informs a synthetic reduced model.

Key variables from the first manipulation shape a predictive model, utilizing Artificial Neural Network. The method ensures utmost precision in predicting city attractiveness probability.

For all that follows, the probability of a city being attractive is defined as:

-y_i=1 ; if Net Migration Rate>0 (Attractive) ;

-$y_i = 0$; if Net Migration Rate<0 (Repulsive).

Note: No city obtained the value zero when estimating the net migration rate.

In the following, we will present the theoretical framework of the binary logistic regression, and then a brief explanation of the chosen variables.

3.2 Logistic regression

Binary logistic regression estimates the probability that a characteristic is present (in this case the probability of a city being attractive) given the values of explanatory variables. In logistic regression, it is not the binary response (attractive/unattractive=repulsive) that is directly modeled, but the probability of realization of one of the two modalities (attractive for example).

This probability of realization cannot be modeled by a straight line because it would lead to values outside the interval of a probability which is necessarily by definition bounded between 0 and 1.

An alternative solution is modeling this probability by a sigmoid curve, between 0 and 1. Let Y be a binary response variable such as:

-Yi = 1 If the trait is present in observation (city, territory, etc...);

-Yi = 0 If the trait is NOT present in observation i;

-X = (X1, X2,..., Xk) Be a set of explanatory variables which can be discrete, continuous, or a combination.

This sigmoid curve is defined by the logistic function, of the equation:

$$f(x) = P(X) = \frac{e^{X\beta}}{1 + e^{X\beta}} \tag{3}$$

Using the logistic link function, we obtain the following expression which expresses the probability of the occurrence of the event as the sum of the effects of the different explanatory variables.

$$logit(p) = \log\left(\frac{p}{1-p}\right) = \sum_{j=1}^{k} \beta_j X_{ij} \tag{4}$$

R code-Logistic Regression

```
library(readxl)
library(stargazer)
library(dplyr)
library(forestmodel)
Only_Numeric<- read_excel("C:/Users/HP/
    Desktop/ANN.xlsx",sheet = "Feuil2")
Only_Numeric$`Net migration rate`<-ifelse(
    Only_Numeric$`Net migration rate
    `<0,"0","1")
dta <- na.omit(dta)
dta$`Net migration rate`<-as.factor(dta$`
    Net migration rate`)
global_model<-glm(`Net migration rate`~.,
    data=dta,family = binomial(logit))
```

3.3 Stepwise regression

Stepwise regression is a statistical method for the selection of variables in a multiple regression analysis. In this method, the most significant variables are selected from many explanatory variables by means of an iterative approach.

The theoretical framework of stepwise regression assumes that some of the explanatory variables will have a significant effect on the dependent variable, while others will have no effect or a negligible effect.

Stepwise regression uses a variable selection approach based on how a multiple linear regression model performs. This method selects the variables that contribute most to the variation in the dependent variable. Variables that do not have a significant effect are eliminated.

Variable selection procedure is based on the Akaike information criterion (AIC) and the Bayesian information criterion (BIC).

R code-Logistic Regression-Reduced Model

```
reduced-model<-step(glm(‘Net migration rate ‘~.,data=dta,family = binomial(logit)), direction = "backward")
forest_model(step(reduced_model))
```

3.4 Artificial Neural network

Artificial Neural network algorithm is a machine learning method that simulates how the human brain thinks to solve complex problems. The basis of this method is the theory of connectionism, which is the idea that cognitive processes can be understood in terms of connections between neurons in the brain.

Neural network theoretical framework has three main elements: neurons, synapses, and architecture. Neurons are the information processing units of the neural network, which receive input signals, transform them, and transmit them to other neurons via synapses. Synapses are the connections between the neurons that allow the transfer of the input signals and the transmission of the results of the processing between the neurons. The architecture of the network is the configuration of neurons and synapses in the network. The architecture of the network is the configuration of the neurons and synapses in the network.

The neural network model is built using a learning algorithm that adjusts the network parameters in response to the input data. Network parameters include synaptic weights, neuron biases, and activation functions. Synaptic weights determine the relative importance of input and output signals, neuron biases determine the threshold for neuron activation, and activation functions transform the input signals. Natural neural network modeling has found many applications in areas such as pattern recognition, computer vision, time series prediction, classification, and speech recognition. This method has the advantage of being able to deal with non-linear and complex data, to adapt to input data of different sizes and formats, and to produce predictions that are accurate and reliable.

R code-Artificial neural network

```
train <- dta %>% sample_frac(.70)
test  <- anti_join(dta, train, by = ’id’)
set.seed(12345)
Train<-train %>% mutate(Net_migration_rate=ifelse(Net_migration_rate<0,"Repulsive","Attractive"))
Train$Net_migration_rate<-as.factor(Train$Net_migration_rate)
Test<-test %>% mutate(Net_migration_rate=ifelse(Net_migration_rate<0,"Repulsive","Attractive"))
Test$Net_migration_rate<-as.factor(Test$Net_migration_rate)
nn <- neuralnet(Net_migration_rate ~ ‘Ageing Index‘+Random_housing
                + Employment_rate  + Employee_in_the_private_sector+
Log_Distance_highway,data=Train, threshold=0.004, act.fct="logistic", linear.output=FALSE, stepmax=1e7)
pr.nn <- compute(nn,Test)
plot(nn)
Cross<table(Test$Net_migration_rate,c("Repulsive","Attractive")[apply(pr.nn$net.result,1,which.max)])
Cross
Accuracy<-sum(diag(Cross))/sum(Cross)
Accuracy
```

3.5 List of variables

Considering the complicated nature of the issue of territorial attractiveness, a comprehensive examination of literature and empirical studies is imperative to model this complex economic phenomenon. This investigation aims to identify important factors that can influence a region’s capability to attract people and their financial investments.

To properly execute our modeling attempt, a discerning selection of independent variables was conducted. Our investigation is based on a careful curation that considers both existing literature and the unique features of Morocco’s urban environment. We have identified thirteen key variables within our modeling framework that highlight Moroccan small cities’ attractiveness across six dimensions: **Economic and Housing Conditions**, **Demographic Dynamics**, **Education**, **Employment Availability**, **Spatial Patterns,** and **Territorial Connectivity**.

4 Results

Before proceeding with the ANN modeling, we should first determine key variables that influence a city's attractiveness. Therefore, we'll proceed with logistic regression analysis. The final model is considered after the application of the backward elimination method. The analytic formula of the global model is as follows:

-Global model:$Attractiveness\ probabilities_i = F\left(\sum_{j=1}^{k} \beta_j X_{ij}\right)$

-Reduced model: $Step(Globalmodel, direction = "backward")$

Where: $F(.)$is the logistic function previously defined; X_{ij} Independents variables of all dimensions previously explained.

4.1 Results of the reduced model

Using Stepwise backward regression on the global model that contains all explanatory variables , the results of the reduced model are as illustrated in the figure below:

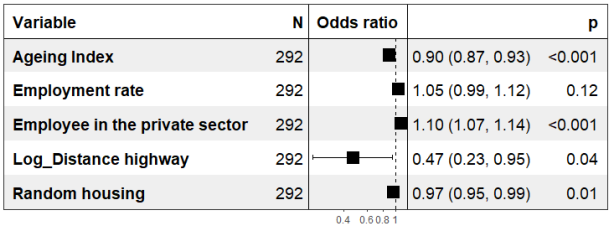


Fig. 2: Results of the reduced model using the "forestmodel" library, Source: Author's manipulations using R language.

Attractive cities are younger

Results of the reduced model show that a city's attractiveness declines as its population ages. Conversely, cities with a younger population tend to have more migration. This finding aligns with the current situation in Morocco, as young individuals are the demographic group impacted the most by migration.

Young people migrate for several reasons such as seeking better economic or educational opportunities in urban areas or other regions. Moreover, societal and familial pressures can influence their decision to move. However, young migrants often encounter difficulties such as discrimination, difficulty integrating, and social isolation.

To ensure that young migrants integrate successfully and flourish, it is crucial to comprehend the unique challenges they face. Armed with this understanding, we can provide them with the guidance and support necessary for success on their journey.

A job offer, a key factor of residential attractiveness

After analyzing the results of the reduced model, we found that only five variables were significant, two of which were related to labor supply. Of these two, one had statistical significance at the 5% level, while the other maintained its significance at the 15% level.

This discovery highlights the importance of labor supply, particularly in the private sector, as the driving force behind the attraction of small cities in Morocco. Interestingly, we noticed that every variable related to labor supply had a positive impact on the likelihood of small cities being appealing to their residents. This trend was seen not only in the reduced model but also in the global model containing all variables.

In conclusion, labor supply in the private sector is a significant determinant of the attractiveness of small Moroccan cities. People are drawn to places where they have employment opportunities and avenues for economic and social integration. This observation underscores the fact that migration to small cities is rooted in fundamental needs such as employment prospects and economic activities. Overall, this fact highlights a significant issue in small Moroccan cities - their lack of economic and social development. People continue to migrate to these places due to basic needs, which keeps them in a developmental paradigm characterized by a notable lag.

Enhanced Accessibility and Its Magnetic Effect

The correlation between a city's accessibility and its attraction is a well-established phenomenon. Research demonstrates that the distance separating a city from a highway exerts a notable influence on the likelihood of the city being considered attractive. This observation underscores the pivotal role that the city's proximity to a highway network plays in shaping its attraction to the population. In essence, this suggests that a city's boosted accessibility directly contributes to its heightened attractiveness, this fact is supported by Many Moroccan government documents [2].

Living Quality: A Catalyst for Migration Dynamics

The role of favorable housing conditions in elevating the attractiveness of urban landscapes, particularly cities, is paramount. Our model's outcomes substantiate this notion, revealing a convincing insight: there exists an inverse relationship between the prevalence of random housing within a city and its degree of attractiveness.

This empirical finding underscores the pivotal impact of favorable living conditions in supporting a city's attraction. It reinforces the core understanding that the quality of residential spaces significantly shapes a city's overall attractiveness. This principle reverberates as a central tenet in augmenting the allure of urban environments, thereby highlighting the integral role that well-maintained living conditions play in fostering the city's overall appeal.

4.2 Results of the ANN

Before delving into the evaluation of our model's performance, it is pertinent to revisit the segmentation of our data-set. This bifurcation entails the allocation of 70% of the data for model training, while the remaining 30% constitutes the testing subset employed for gauging predictive accuracy.

In quantifying the precision of our model, we employ the construction of a confusion matrix. This matrix, as elucidated in the context of binary classification, encompasses four distinct values that encapsulate the myriad combinations arising from the interplay between actual and predicted outcomes [6].

Table 1: Confusion matrix,Source: Author's manipulations using R language

	1-Attractive	0-Repulsive
Predicted(1)	37	5
Predicted(0)	6	40

The accuracy of the model is calculated as the fraction of the diagonal of the confusion matrix over the total of all cells:

$$Accuracy = \frac{37+40}{88} = 87,5\% \quad (5)$$

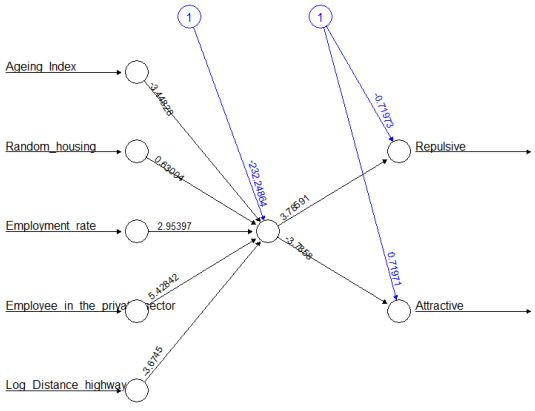


Fig. 3: The architecture of the Artificial Neural Network, Source: Author's manipulations using R language.

Note: We have calculated the accuracy in terms of prediction of both the logistic regression model and ANN algorithm. The accuracy of the natural network exceeds that of the logistic regression model (62%).

5 Discussion

Young people are more involved with migration:

Young people, especially the well-educated, tend to leave their regions. Policymakers are concerned about this migration dynamic and consider youth migration to be a major issue, threatening the economic development and reputation of the regions affected by it [7].

The phenomenon of youth migration to areas with employment opportunities is a global phenomenon and the Moroccan context is no different [8, 9]. Indeed, in Europe, rural areas are increasingly experiencing a decline in the youth population in general and in the highly educated youth in particular, and this decline in youth migration is a major factor contributing to the ageing of the population [10, 11].

The fact of youth migration is not confined to rural areas; it is also spreading to the periphery of agglomerations and employment basins. In the sense that areas close to large cities and agglomerations exert a centrifugal force that increasingly attracts migratory flows, especially those of young people. This trend of youth migration risks unbalancing territories and threatening the future economic and social development of youth exporting territories [12].

In general, the literature distinguishes between two main reasons for youth migration: the pursuit of education and the quest for decent work.

One of the main reasons for youth migration is education. Certainly, most rural areas do not support higher education, leaving young people with no choice but to leave their home area to continue their education [13]. The first choice is to leave one's home region to continue one's education, the second is to stay and abandon one's higher education [14, 15].

The Moroccan context is not immune to this sad dilemma, due to the simple fact that higher education is not widely available in rural areas, which means that young secondary school graduates who want to continue their education have no choice but to leave their areas and migrate to the nearest cities or small cities [16].

To sum up, the finding in this article that the most attractive small cities are those with the highest proportion of young people can be explained by two main influencing factors, namely the supply of jobs and the supply of education. The confrontation of these two reasons solves the puzzle of the Moroccan small cities in the sense that the most attractive small cities are those that guarantee both superior educational perspectives and decent employment opportunities. Employment opportunities are generally driven by the effects of the proximity of small cities to metropolitan areas and employment basins. [3].

Connectivity a major driver of territorial attractiveness:

The cartographic analysis of the most attractive small cities in Morocco shows that their distribution follows precise geographical trends. In fact, they tend to be close

to large agglomerations, while practically following the main road circuits as well as the highway [5]. Moreover, the results of the Statistical Modelling show that the cities closest to the highways are more likely to be attractive. These facts show that the distribution of attractive small cities in Morocco is quite selective and combinatorial. In Morocco, an attractive small city is both one that is close to the metropolitan area and benefits from the effects of proximity to jobs, mainly offered by the large employment areas, and one that is more accessible and better connected by roads. It is this specific and combined configuration of the most attractive small cities in Morocco that makes them the most suitable environment for the population, and in particular for young people, to choose as their place of residence.

Once again, the tendency to distribute according to a specific logic of the most attractive small cities is not a phenomenon exclusively linked to the Moroccan context. In fact, several authors have mentioned in their works that urban spaces, especially those of small size, follow a logic in their spatial distribution [17]. They tend to be organised according to a structure that he calls linear along a communication axis. This axis can be a main road, a railway, or a highway. In this context, the positive externalities of accessibility and proximity to this axis favour the attractiveness of urban spaces, especially the small's one [2].

Proper living conditions as an important determinant of the city's attractiveness:

Housing quality is an important factor in making places attractive to live in. The condition and design of housing can also influence migration patterns and shape the perception of the attractiveness of a place. Literature findings have identified different ways in which housing quality can affect territorial attractiveness. Indeed, research has shown that improving housing quality can have a positive impact on the attractiveness of a place. Indeed, a study by Glaeser et al [18] found that improving the quality of urban housing may increase population growth and economic development. Similarly, a study by Sánchez-Guevara et al [19] found that improving the quality of public housing in Madrid led to increased resident satisfaction and improved perceptions of the neighbourhood. Furthermore, poor housing can lead to various negative health outcomes, including respiratory, allergic and mental health problems [20, 21].

Conversely, good quality housing can promote physical and mental well-being and contribute to the overall quality of life in a place. The improvement of the well-being of the population has a profound impact on its quality of life, which also contributes to the promotion of territorial attractiveness. According to a European Commission study [22], 'quality of life' was one of the main factors attracting people to live and work in a particular region or city. Good housing is a key component of quality of life, as it provides a safe, comfortable and healthy living environment.

In addition to its direct impact on the attractiveness of an area, good housing can also be a contributor to other factors that are important in the attraction of residents and businesses. For example, good housing can help create a sense of community and social cohesion. This can be attractive to people looking for a place to live [23]. Places with substandard or overcrowded housing may experience social dislocation and other negative outcomes [24]. By contrast, high quality housing can lead to greater social cohesion and community involvement. It may also improve educational attainment and employment opportunities, which are important factors in business attraction [25].

However, it is important to note that the relationship between housing quality and territorial attractiveness is complex and compounded. For example, some researchers have argued that affordability is as important as quality in attracting residents [26]. Others have noted that certain types of housing may be more attractive than others, depending on factors such as location, design and amenities [27].

Overall, an understanding of the relationship between housing quality and the attractiveness of an area is important for policymakers and planners who are seeking to promote economic development and social well-being in their communities. By identifying the types of housing that are most attractive to different groups of people, they will be able to develop strategies to enhance these characteristics and make their communities more competitive in terms of attracting migrants and investment.

Once again, the Moroccan context confirms the key role played by the quality of housing in the channeling of migratory flows. The results of the statistical modeling clearly show the important role played by the quality of housing in the attractiveness of small Moroccan cities. In fact, it is arguable that the most attractive small cities in Morocco are those with the best quality housing conditions.

Artificial intelligence as a decision-making tool for territorial development:

In Morocco, detailed data on population and Housing are provided exclusively by the general population and housing census, which is scheduled every ten years. Consequently, the problem of slow updating affects the modeling of any territorial topics in Morocco.

The modeling of the territorial attractiveness by means of artificial intelligence tools has made it possible to estimate the territorial attractiveness of small cities without having to resort to the migration data that are exclusively available in the census data.

Indeed, our AI model can give an idea of the attractiveness of Moroccan small cities from a few simple indicators. These indicators can be collected through limited and inexpensive periodic surveys, unlike general censuses. This model is a useful, highly accurate decision-making tool for policymakers to target public interventions at the lowest cost.

6 Conclusion

Residential attractiveness is a highly intricate and multifaceted phenomenon that is contingent upon a multitude of factors, each of which plays a critical role in determining a city's level of attraction.

Research has shown that young people are particularly influenced by migration and that the quality and accessibility of housing plays a pivotal role in retaining residents. However, It is evident that the utilization of robust econometric manipulations showcases the point that job supply is unequivocally the most significant factor in determining the attractiveness of small cities in Morocco.

Using advanced methods of artificial intelligence, specifically ANN, this article has successfully developed a predictive econometric model for territorial attractiveness with an accuracy rate of over 80%.

This model is valuable because it serves as a reliable tool for decision-makers to predict the appeal of a small town or city. It does this by using simple indicators gathered from inexpensive surveys. This approach allows for an understanding of the city's attractiveness without having to calculate the net migration rate, which typically requires extensive data from the General Population and Housing Census.

Acknowledgement

The authors are grateful to the anonymous referee for a careful checking of the details and for helpful comments that improved this paper.

References

[1] D. Bell et M. Jayne, Small Cities? Towards a Research Agenda, Int. J. Urban Reg. Res., vol. 33, no 3, p. 683-699,2009, doi: 10.1111/j.1468-2427.2009.00886.x.

[2] M. of N. T. M. Moroccan State Document Urban Planning, National urban framework plan, 2017.

[3] K. Sohaib, E. Driss, et J. Youness, An Econometric Analysis of the Determinants of Small's Cities' Attractiveness: Evidence from Moroccan Case, in 2022 8th International Conference on Optimization and Applications (ICOA), Genoa, Italy: IEEE, p. 1-6,2022. doi: 10.1109/ICOA55659.2022.9934146.

[4] K. Sohaib, E. Driss, et M. S. Chaabane, The Artificial Intelligence for Modeling and Predicting SMALL's Cities Attractiveness, in Artificial Intelligence and Smart Environment, Y. Farhaoui, A. Rocha, Z. Brahmia, et B. Bhushab, Éd., in Lecture Notes in Networks and Systems, vol. 635. Cham: Springer International Publishing,p. 763-769,2023. *doi* : 10.1007/978 − 3 − 031 − 26254 − 8 − 110.

[5] M. of N. T. M. Moroccan State Document Urban Planning, Housing and Urban Policy (MATNUHPV), Competitiveness of small cities in Morocco,2020.

[6] L. Rasmy et al., Simple Recurrent Neural Networks is all we need for clinical events predictions using EHR data , 2019, doi: 10.13140/RG.2.2.13199.51368.

[7] A. Stockdale, Migration: Pre-requisite for rural economic regeneration , J. Rural Stud., vol. 22, no 3, p. 354-366,2006, *doi* : 10.1016/*j.jrurstud*.2005.11.001.

[8] A. Yassine et F. Bakass, Do Education and Employment Play a Role in Youth's Poverty Alleviation? Evidence from Morocco , Sustainability, vol. 14, no 18, Art. no 18,2022, *doi* : 10.3390/*su*141811750.

[9] A. Yassine et F. Bakass, Youth's Poverty and Inequality of Opportunities: Empirical Evidence from Morocco , Soc. Sci, vol. 12, no 1, p. 28, 2022, doi: 10.3390/socsci12010028.

[10] A. Findlay, C. Mason, D. Houston, D. McCollum, et R. Harrison, Escalators, Elevators and Travelators: The Occupational Mobility of Migrants to South-East England , J. Ethn. Migr. Stud., vol. 35, no 6, p. 861-879, 2009, doi: 10.1080/13691830902957676.

[11] R. King, Towards a new map of European migration , Int. J. Popul. Geogr, vol. 8, no 2, p. 89-106, 2002, doi: 10.1002/ijpg.246.

[12] F. Thissen, J. D. Fortuijn, D. Strijker, et T. Haartsen, Migration intentions of rural youth in the Westhoek, Flanders, Belgium and the Veenkoloniën, The Netherlands , J. Rural Stud., vol. 26, no 4, p. 428-436,2010, doi: 10.1016/j.jrurstud.2010.05.001.

[13] C. H. Mulder et W. A. V. Clark, Leaving Home for College and Gaining Independence , Environ. Plan. Econ. Space, vol. 34, no 6, p. 981-999, 2002, doi: 10.1068/a34149.

[14] T. Bjarnason et T. Thorlindsson, Should I stay or should I go? Migration expectations among youth in Icelandic fishing and farming communities , J. Rural Stud., vol. 22, no 3, p. 290-300, 2006, doi: 10.1016/j.jrurstud.2005.09.004.

[15] B. Jentsch, Young People in Rural Areas of Europe, 1re éd. Routledge, 2017. doi: 10.4324/9781315233307.

[16] T. Muilu et J. Rusanen, Rural young people in regional development—the case of Finland in 1970–2000 , J. Rural Stud., vol. 19, no 3, p. 295-307, 2003, doi: 10.1016/S0743-0167(03)00003-2.

[17] G. Veyret-Verner, Essai de définition et de classification des petites villes: leur insertion dans un réseau urbain , Rev. Géographie Alp, vol. 58, no 1, p. 51-66, 1970, doi: 10.3406/rga.1970.3458.

[18] E. L. Glaeser, J. Kolko, et A. Saiz, Consumer city, J. Econ. Geogr., vol. 1, no 1, p. 27-50, 2001, doi: 10.1093/jeg/1.1.27.

[19] C. Sánchez-Guevara Sánchez, M. Núñez Peiró, et F. J. Neila González, Urban Heat Island and Vulnerable Population. The Case of Madrid , in Sustainable Development and Renovation in Architecture, Urbanism and Engineering, P. Mercader-Moyano, Éd., Cham: Springer International Publishing,p. 3-13,2017. doi: 10.1007/978-3-319-51442-0-1.

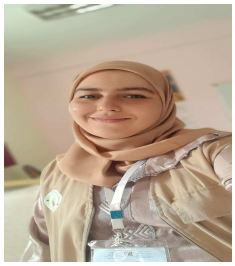
[20] E. Baker, L. H. Lester, R. Bentley, et A. Beer, Poor housing quality: Prevalence and health effects , J. Prev. Interv. Community, vol. 44, no 4, p. 219-232, 2016, doi: 10.1080/10852352.2016.1197714.

[21] S. C. Saegert, S. Klitzman, N. Freudenberg, J. Cooperman-Mroczek, et S. Nassar, Healthy Housing: A Structured Review of Published Evaluations of US Interventions to Improve Health by Modifying Housing in the United States, 1990–2001 , Am. J. Public Health, vol. 93, no 9, p. 1471-1477, 2003. doi: 10.2105/AJPH.93.9.1471.

[22] European Commission. Joint Research Centre., Handbook of territorial and local development strategies. LU: Publications Office, 2022. Consulté le: 27 avril 2023. [En ligne]. Disponible sur: https://data.europa.eu/doi/10.2760/57919.
[23] R. Van Kempen et G. Bolt, Social cohesion, social mix, and urban policies in the Netherlands , J. Hous. Built Environ., vol. 24, no 4, p. 457-475, 2009, doi: 10.1007/s10901-009-9161-1.
[24] D. E. Jacobs, J. Wilson, S. L. Dixon, J. Smith, et A. Evens, The Relationship of Housing and Population Health: A 30-Year Retrospective Analysis , Environ. Health Perspect., vol. 117, no 4, p. 597-604, 2009, doi: 10.1289/ehp.0800086.
[25] M. Desmond et T. Shollenberger, Forced Displacement From Rental Housing: Prevalence and Neighborhood Consequences , Demography, vol. 52, no 5, p. 1751-1772, 2015, doi: 10.1007/s13524-015-0419-9.
[26] B. P. Scafidi, M. H. Schill, S. M. Wachter, et D. P. Culhane, An Economic Analysis of Housing Abandonment , J. Hous. Econ., vol. 7, no 4, p. 287-303, 1998, doi: 10.1006/jhec.1998.0235.
[27] J. McCord, M. McCord, W. McCluskey, P. T. Davis, D. McIlhatton, et M. Haran, Effect of public green space on residential property values in Belfast metropolitan area , J. Financ. Manag. Prop. Constr., vol. 19, no 2, p. 117-137, 2014, doi: 10.1108/JFMPC-04-2013-0008.

Sohaib Khalid is a State Engineer in Statistics and Economics graduate from the National Institute of Statistics and Applied Economics,he is currently pursuing a PhD at the same institute in Rabat, Morocco. His research focuses on the fields of economics, econometrics, and territorial development. He has several publications in reputable journals, particularly in the areas of territorial development and attractiveness. On the professional front, he holds the position of State engineer within the Territorial Attractiveness Department at the Ministry of Land Planning, Urban Planning, Housing and City Policy. ORCID:https://orcid.org/0000-0003-2125-3480

Driss Effina is a highly educated individual with a PhD. in Economics, a degree in Statistical Engineering from the National Institute of Statistics and Applied Economics, and a Master's degree in Capital Markets. Currently, he serves as a higher education professor at the National Institute of Statistics and Applied Economics in Rabat. Driss Effina has extensive experience in strategy consulting and territorial development. He has participated in major strategic studies with various leading international consulting firms such as SCANDIA CONSULT, Deloitte, Counterpart International (USA), and many others. Additionally, he has worked for several ministries and public institutions, as well as for international organizations including the World Bank, UNDP, GIZ, FAO, OECD, MCA Morocco, the Islamic Development Bank, the African Development Bank, and the European Bank.



Khaoula Rihab Khalid boasts intriguing experience in project management, having achieved a Master's degree in Organizational and Project Management in 2017. Currently, she is furthering her studies through a PhD. program at the Faculty of Economics and Management in Beni Mellal, Morocco within the Laboratory of Economic and Management Sciences Studies and Research (LERSRG). Her specialization centers around the topic of territorial attractiveness.
ORCID:https://orcid.org/0009-0008-8415-1354

Mohamed Salem Chaabane is a Geomatics Engineer (2010) and PhD in geomatics applied to strategic urban planning (2019). Also, he is a BIM MANAGER certified by Building Smart International (2023). Currently, Mr. CHAABANE is an associate member of the Laboratory of Systems Engineering (LaGes), Research Team Geomatic Sciences (SGEO), Hassania School of Public Works. He is also a Temporary Professor in several renowned schools and scientific institutions: University mohammed VI Polytechnic, - UM6P, National School of Architecture of Rabat, Hassania School of Public Works -Casablanca, Faculty of Letters and Humanities -Mohammedia, Faculty of Science and Technology of Mohammedia, Moroccan School of Engineering - Rabat. On a professional level, Mr. CHAABANE is a head of Division of Territorial Observation Dynamics within the Ministry of Land Planning, Urban Planning, Housing and City Policy. He was also, a head of GIS Business Unit in the Urbanism Departement. ORCID: https://orcid.org/0000-0003-1267-2819