Measuring and evaluating the impacts of quality measures in TOD areas – a multi-approach evaluation method

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ABSTRACT

TOD (Transit Oriented Development) is a high density mixed area (residential and commercial) designed to optimize the access to public transport. These areas are located in the neighborhood of a high capacity public transport station. Its objectives are to promote the efficiency of human activity on both transport and activity location side, with the adoption of more sustainable measures leading to less motorized travels and space consumption. The objective of this work is to investigate about the assessment of TOD areas success/failure. In Portugal there are some urban areas around train stations that can be considered as TOD areas, but in most cases happened spontaneously, without background policies that can be called 'TOD measures'. In order to further evaluate the impact of quality measures in TOD areas, this paper proposes a methodology to explore the linkage between some variables associated with transport and some variables associated with land use, testing if these areas are in fact acting as TOD areas.
The example of a suburban train line station areas and a group of variables associated with its surroundings is presented and some of the relations between those variables are explored.

Keywords: TOD (Transit Oriented Development); TOD evaluation.

1. Introduction

The coordination between land use planning and transport system planning is crucial to a sustainable future of urban and suburban areas, in all its aspects: economic, social and environmental. Urban sprawl and automobilization led to an increase of journeys by private transport combined with the resulting increase in congestion and emissions of greenhouse gases, generating negative impacts on society, not only environmental, but also social and economic impacts. The future development and evolution of contemporary cities requires a perspective of sustainable development and integrated management of existing resources. Transit Oriented Development (TOD) is a tool to promote this integration.
This paper focuses on the measurement and evaluation of the impacts of quality measures in TOD areas, and explore grow trends due to public transport, in particular in suburban train line in Lisbon Metropolitan Area (LMA).

The document is structured in six main sections:

Section *1.Introduction*, which introduces the theme, states the main objective of the paper and displays paper´s structure;

Section *2. Framework* where a set of concepts, assumptions and practices are exposed in order to build a skeletal support used as the basis for the following sections. A literature review on TOD evaluation is also depicted in this section.

Section *3. Methodology*, proposes a methodology to explore the linkage between variables on the transportation and land use fields for the case study. In this chapter a preliminary characterization of the line is done, as well as a first analysis on the relations between indicators collected.

Section *4. Conclusions* encompass a summing up of the points and a statement of opinion or decisions reached;

Section *5.References* the bibliographic references list is shown.

2. Framework

2.1 TOD concept

TOD (Transit Oriented Development) concept arises in the 90s in the U.S. A., following the movements "smart-growth" or, Intelligent Urban Development and New Urbanism in an attempt to tackle the phenomenon of suburbanization ("urban sprawl") which began to be felt.
TOD definitions founded in the literature, namely in Cervero, R.; Kockelman, K. (1997) stressed the 3D's - Density, Diversity and Design - present in TOD areas, diversity in the form of mixed use development, density in form of residence and jobs, and design in the form of good street connectivity for pedestrians.
"TOD concept is an approach to expansion that aims to encourage the development of mixed use and compact, increasing the number of passengers of public transport and creating more livable communities." (Arrington, GB; Cervero, R., 2008). Thus, TOD or development in accordance with public transport is a planning approach targeted to high density mixed use development areas (residential / commercial / business) and high proximity to transport infrastructures (800m), along with public transport stations and corridors.
TOD has been planned or constructed around rail, light rail transit and bus transit stations and stops. Modal characteristics may be a factor in both the development feasible at the station and the ability of public transit to serve the travel markets created by the TOD. Although TOD around stations of light rail transit (LRT) and heavy rail (rail rapid) transit (HRT/Metro) have been the main focus in the literature, TOD can also be served by commuter rail (CRR), bus rapid transit (BRT), and good-frequency traditional bus services.

In relation to regional context, TOD may exist in a long-established city center or in a suburban context. Although locating TOD in either area type may result in boosted transit ridership and increased walking, the regional context plays a role in determining the overall traveler response. City center with TODs generally have higher levels of transit service, are available to more travel markets than suburban TODs and consequently have higher transit ridership generation potential. However, TOD represents a leap in the status quo in suburban contexts. This impact is more pronounced than in city center contexts, one of the reasons suburban applications receive more attention in the literature (John E. (Jay) Evans, I., et al. (2007)).

The main goal of TOD is to provide good public transport accessibility in order to reduce the number of trips by car (IT). Other benefits that occur when a TOD project is successful are reduced congestion and improved air quality, factors that are related to each other (Cervero, R.F., C; Murphy, S, 2002). Another benefit associated with the public good comes from the creation of pleasant areas, more livable communities, where pedestrian and cycle paths have some expression.

Transit Oriented Development has been increasingly promoted and implemented as a solution to the problems of urban growth mainly in the United States, Australia and Asia, being present some of its concepts in the planning process of cities in Europe for several decades, but not under this specific designation. TOD implementation does not always succeed as expected, once some of the expected results do not occur, such as modal split changes and real estate success (Lund, Hollie M; Wilson, Richard W (2005)). TOD projects or TOD areas evaluation cases are reported in next section.

2.2 TOD evaluation

There is substantial interest in identifying markers of successful TOD. This interest applies not only to evaluation assessments of existing TOD examples, but also especially to forward-looking design guideline, regulatory, and forecasting applications (John E. (Jay) Evans, I., et al. (2007)). A limited number of examples of studies on TOD analysis and evaluation are reported below.

The literature shows that the attention given to TOD outcomes is not a novelty. In *Travel demand and the 3Ds: Density, diversity, and design* (Cervero, R.; Kockelman, K. (1997)) a set of indicators, representing the 3D´s, was selected to pursue a regression analysis to evaluate the influence of built environment (3D's) on travel behavior. While the indicators can explain the relationship between land use and transport, they might not be sufficient to evaluate TOD. The objective of TOD is not only achieving sustainable transport; TOD provides people the opportunity to live, work, shop and relax. Hence, community development by providing affordable housing can be considered an essential part of TOD as well (Shastry, S. (2010)).

In Schlossberg, M., et al (2004) a series of spatial indicators is used to visualize and quantify eight transit-oriented development (TOD) areas in Portland and Silicon Valley. More specifically, this report uses a spatial-temporal analysis to measure transit usage, urban form, and socio-demographic change prior and subsequent to the incorporation of light rail and transit-oriented development policies in these two regions. A particular focus of this research is on the consistency of the urban mobility infrastructure with pedestrian access to the transit stops because the capacity for transit users to walk to and from their transit point of entry is a critical component of the overall TOD concept. Finally, this report makes extensive use of geographic information system (GIS) technology to both visually and quantitatively capture a series of phenomena related to TOD areas. Focus has been placed on representing the visual images in ways that can enhance a broad understanding of the issues and in an effort to enhance potential participation of a broader public into the smart growth policy making process–an area of policy increasingly pursued in communities throughout the United States.

A "Transit Oriented Development Index" as a potential device for considering the degree to which a particular project is intrinsically oriented toward transit was developed by Evans, Jay et al. (2007). The important elements of "successful" TOD would be captured in such an index. Suggested values for essential indicators of a "TOD Index" to describe development project "TODness" include:

- Centrally located transit with walking distances no more than 400m to 800m.
- Superior walkability with small blocks and pedestrian traffic management priority.
- Extended hours of highly-reliable transit service at 5- to 15-minute intervals.
- Land use mix to meet daily needs paired with good transit connectivity to other activities.
- Density sufficient to support cost-effective transit, retail services, and infrastructure.
- Managed parking with reduced supply relative to standard development.

This study integrates indicators for transport as well as land use. Thus, it adds one dimension to the 3D model of Cervero and Kockelman.
Reviewing proposed measures of TOD success was a useful starting point in visualizing a TOD Index. A national survey of 30 professionals highlighted fifteen success measures that were considered "very useful" by more than half of the respondents. A secondary ranking exercise, which added in findings from a literature and website review, brought out transit ridership as the most important indicator. The ridership indicator was followed by density, design quality, and pedestrian friendliness indicators; parking metrics; and economic indicators including tax revenue. Most of the indicators are suitable for use in either backward- or forward-looking approaches (Renne and Wells, 2005). Table 1 presents a summary of the identified key indicators as well as the rankings from the two exercises.

Table 1 - Useful Indicators for TOD Identified by 30 Professionals.

Indicator	Category	Percentage Identifying as "very useful"	Secondary Ranking
Transit ridership (e.g. boardings)	Travel behavior	70	1
Population/housing density	Built environment	67	2
Employment density (e.g. number of jobs per acre)	Economic/Built environment	53	2
Qualitative ratting of streetscape (i.e., pedestrian orientation, human scale)	Built environment	77	3
Mixed-use structures (number or square footage)	Built environment	60	4
Pedestrian activity counts	Travel behavior	77	5
Number of intersections or street crossings improved for pedestrian safety	Built environment	60	5
Estimated increase in property value	Economic	63	6
Public perception (e.g., administered survey)	Social diversity/ Quality	63	7
Number of bus, ferry, shuttle, or jitney services connecting to transit station	Travel behavior	63	8
Number of parking, spaces for residents, tenants, visitors, commuters, and shared	Travel behavior	53	9
Estimated amount of private investment	Economic	57	-
Number of convenience or service retail establishments (e.g., dry cleaners, video rental)	Economic	53	-
Estimated amount of private investment by type of land use	Economic	52	-

Source: Based on Renne and Wells (2005)

A more recent work, developed in India by Shastry, S. (2010) investigates primarily the existing development in Ahmadabad to determine if transit-oriented development (TOD) exists in some form. Secondly, what policy and planning measures can help improve the degree of TOD-ness in Ahmedabad? Indian cities traditionally have high density and mixed use type of development. In such a context, TOD might already be a reality in some form. The mentioned research investigates the concept of transit oriented development in an Indian context. A spatial multi criteria evaluation (SMCE) framework is used to develop a TOD score for the study area of Ahmedabad (the BRT corridor) using which it has been determined that greater portions of the city is already close to being TOD. Especially, the inner walled city with high density, mixed use type of development ranks very high on the TOD score (69%). The outer corridors on the other hand have a more or less suburban type of development and hence rank very low on the TOD score. These regions have great potential in terms of re-development.

It is believed that the brief cases here presented reflect a picture of the state of the art in TOD evaluation.

The literature reflect studies on the relationship between land use and transport integration (for example, Cervero, R.; Kockelman, K. (1997)), spatial indicators to visualize and quantify TOD (Schlossberg, M., et al (2004)), TOD indexes that represents the degree to which a particular project is intrinsically oriented toward transit (Evans, Jay et al. (2007)) and finally ways to determine if transit-oriented development (TOD) exists in some form and policy and planning measures to improve the degree of TOD-ness (Shastry, S. (2010)). It can be said that most of those studies represent an in-depth study on the relationship between land use and transport, but they might not be sufficient to evaluate TOD.

Currently there are no methodical form of assess this success/failure. The criteria for success seem to depend primarily on market in terms of household types, income levels, and regional locations as stated in several studies. Success in this endeavor will be, at least in part, a function of the connectivity, density, livability, and attractiveness created by careful physical planning and good urban design.

Measuring and evaluating the impacts of measures in TOD areas might be done using multiple criteria decision analysis. Multiple criteria decision analysis (MCDA) is an approach concerned with structuring and solving decision and planning problems involving multiple criteria. The purpose is to support decision makers facing such problems. Typically, there is not a unique optimal solution for such problems and it is necessary to use decision maker's preferences to differentiate between solutions. An example of MCDA software is MACBETH (Measuring Attractiveness through a Category Based Evaluation Technique), which enables the evaluation of options against multiple criteria. It permits the structuring of value tress, the construction of criteria descriptors, the scoring of options against criteria, the development of value functions, the weighting of criteria, and sensitivity and robustness analyses about the relative and intrinsic value of options (Bana e Costa C.A.; Vansnick J-C.(1999)).

For the correct definition of which variables to use in the construction of indicators and more specifically in the construction of the index, it is essential an exploratory study using some available variables and testing the relationships between them. This is the first phase of the study.

Next section encompasses the methodology used in this work, introduces the case study and the method to measure and evaluate the impacts of quality measures in TOD areas.

3. Methodology

3.1 Case study

The case study encompasses Azambuja Suburban train line stations, connecting Azambuja to Lisbon (Oriente), a service provided by Comboios de Portugal (CP). These train line stations represent a hypothetical TOD, as it configure an area with many TOD characteristics but where the implemented measures were not fully integrated. In terms of TOD corridor types the studied train line corresponds to a *Commuter corridor* as it connects residential peripheral areas to a Central Business District. The future study includes also an urban metro line, Lisbon metro red line, but for now the focus will be on Azambuja suburban train line.

Figure 1 – Scheme of the railway line
(http://www.cp.pt/ ,April 2012)

The methodology covers a collection and calculation of indicators, which encompasses four from those referred in Table 1. The fourteen studied stations that belong to Azambuja suburban train line are: Azambuja (terminal station), Vila Nova da Rainha, Carregado, Castanheira do Ribatejo, Vila Franca de Xira, Alhandra, Alverca,Póvoa, Santa Iria, Bobadela, Sacavém, Moscavide and Oriente.

3.2 Data collection

The chosen indicators, according to the literature review and the present case study, covers data on land use density, diversity and transportation, namely accessibility and public and private transport.

The spatial scale statistical to be used is the Geographic Information Referencing Base' (*BGRI*). Using BGRI´s statistical information, the spatial scale statistical used corresponds to the station catchment area, with 400m, 800m and 1200m radius. Within this area several data from different BGRI's was collected. Nevertheless, in this preliminary characterization study the indicators collected are those corresponding to a distance of 800 m as the service limit area. The 800m buffer was defined in accordance with the walking distances used to delimit service areas in most transit research, which are 400m for bus stops and 800m for rail stations (Zhao et al., 2003; Kuby et al. 2004). These values represent the maximum distance that most people are willing to walk to use transit. However, this distance threshold should not be considered as a hard standard, since it is area specific and mode specific.

The indicators used for the case study analysis are population density, building density, dwellings density, employment density, land use, transit ridership and several other variables, namely those related with accessibility.

Land use indicators such as population density, building density and dwelling density will permit ascertain about the attractivenessof each are to live, and the if there are growth trends in terms of densify the urban grid. Employment density indicator will allow envisaging generator poles of attractiveness. Indicators related with land use types will allow the understanding of the proportion of land uses mixes, like the indicator used by Martínez, L. M. (2010). Other composed variables, such as the relation between workers and students divided by the residents, will allow inferring for example that if an area is mostly residential, the value will be close to zero.

Subsequently a description of the indicators and their mode of calculation are presented.

Population density was calculated in inhabitants per hectare, based on BGRI´s census data of 2001 and 2011 (Statistics Portugal (INE)), dividing the population by the area of each catchment area station.
Building density and dwelling density were calculated as population density, described above. Using census data on building and dwelling characteristics at BGRI´s census level, for 2001 and 2011 and dividing the buildings and dwellings by the area of each catchment area for each station.
In relation to transportation indicators, train supply indicator was collected from CP suburban timetable schedules online in 2012 and relates to the number of suburban train connections per day, for a working day, for each train station.

Next section gives a preliminary analysis of the case study.

3.3. Analysis

The initial analysis encompasses the 14 already referred stations and gives a first characterization of the stations and an approach on the relations between some indicators gathered at this stage.
The train line connects the easternmost area of Lisbon, through its main train station - Estação do Oriente – to Azambuja, following along the Tagus river and crossing urban municipalities of Lisbon Metropolitan Area (LMA), such as Alverca and Vila Franca de Xira.
Table 2 shows indicators on population, land use and train supply for the 800m radius service areas of each station, sequentially displayed, from Azambuja to Lisbon.

Table 2 – Indicators on land use and transport (train supply) in a 800m radius of Azambuja train line stations.

Azambuja train line stations	Population_density (inhabitants/ ha)		Buildings_density (buildings/ ha)		Dwellings_density (dwellings/ ha)		Employment_density (employments/ ha)	train connections
	2001	2011	2001	2011	2001	2011	2009	2012
Azambuja	1,42	1,51	0,37	0,37	0,68	0,82	0,28	69
Espanadal da Azambuja	0,00	0,00	0,00	0,00	0,00	0,00	0,00	69
Vila Nova da Rainha	0,28	0,34	0,10	0,15	0,12	0,18	0,11	69
Carregado	0,19	0,13	0,08	0,04	0,09	0,07	0,08	69
Castanheira do Ribatejo	1,15	1,45	0,13	0,15	0,59	0,68	0,35	121
Vila Franca de Xira	4,01	4,01	0,70	0,66	2,13	2,46	2,60	122
Alhandra	2,64	2,72	0,45	0,46	1,31	1,44	1,63	122
Alverca	4,20	3,66	0,22	0,22	1,81	1,82	1,34	152
Póvoa	5,79	6,04	0,35	0,33	2,47	2,73	1,28	152
Santa Iria	2,17	1,91	0,20	0,22	0,93	0,98	0,50	152
Bobadela	3,78	3,31	0,37	0,35	1,63	1,66	0,78	152
Sacavém	2,50	3,41	0,21	0,27	1,19	1,98	1,18	152
Moscavide	9,68	11,72	0,56	0,64	4,64	6,44	4,11	152
Oriente	4,27	4,83	0,17	0,19	1,70	2,57	3,47	152

The studied areas constitute a consolidated urban network, mainly from Oriente to Vila Franca de Xira. Nevertheless, the obtained values for population, buildings, dwellings and employment densities are substantially low.

Castanheira do Ribatejo, Carregado, Vila Nova da Rainha and Azambuja are suburban areas with rural characteristics, evidencing the lowest values of the line stations. It should be noted that Espadanal da Azambuja station represents a way station which exists to serve an industrial area that is located in that region. So this station does not even match a village.

Azambuja station is a terminal station and presents density values superior to the preceding ones. One of the reasons for that might be explained by the fact that it is an interchange station and a terminal station. Terminal stations are more attractive because are the nearest stations for residents of a large area beyond the end of the line and people are willing to walk longer to reach this type of station (Gutierrez, et al (2011)).

Oriente station besides being located in an area considered as a CBD in Lisbon is an important pole that represents an interchange point between regional and local transport, presenting a large set of option to connect within Lisbon (bus, metro and rail) The literature states that interchange stations are more attractive for travelers than intermediate stations and tend to capture more riders, while intermodal stations also tend to have higher boardings, since they receive riders from other transport modes (Gutierrez,Javier et al (2011)).

Oriente station is form part of the most recently developed urban area in the case study, where the urban realm was take into account in its development. Oriente is provided of a wide network of footpaths, assuring comfortable pedestrian areas, and sense of security.

The data collected shows that stations with more train connections have bigger values of population, buildings and dwellings density, along with employment. Besides, land use indicators have rose (slightly) for almost all stations during the studied period. Nevertheless, this is not enough to test what stations are functioning as a TOD.

On a first approach, some exploratory regression studies were made, with the objective to evaluate some relations between the collected variables, in order to test some hypotheses about land use patterns close to TOD areas.

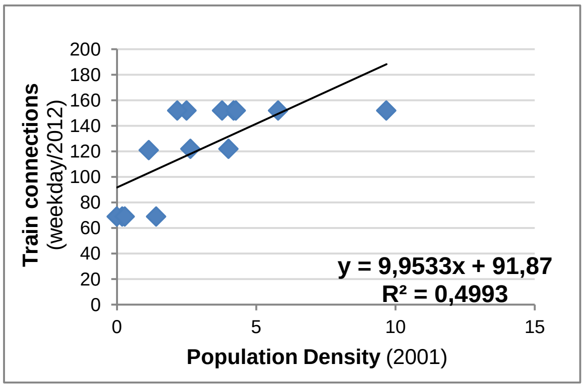
Regression analysis is used when two or more variables are thought to be systematically connected by a linear relationship. In simple regression, a variable y is "driven by" some other variable x, that is, y is called the dependent variable and x the independent variable. In addition, the relationship between y and x is basically linear, but is inexact: besides its determination by x,y has a random component ε, which is called "error".
The simple linear model assumes the form:

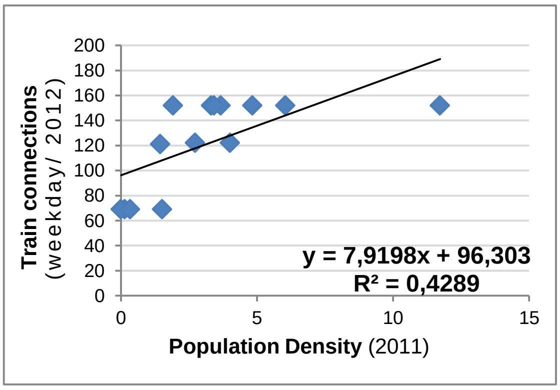
$$y = \beta 0 + \beta 1x + \varepsilon \qquad \text{Eq. (1)}$$

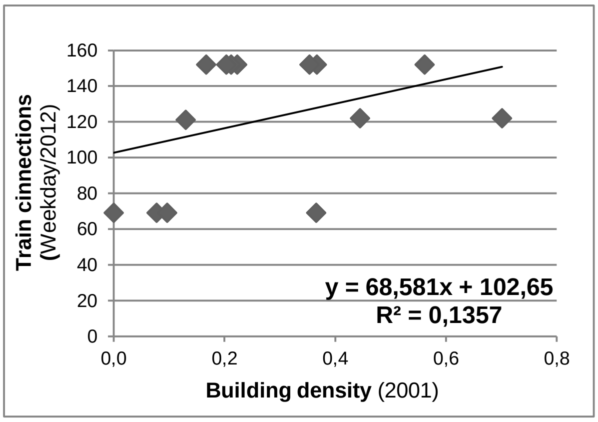
β0 is the intercept (or constant) and β1 is the x coefficient, which represents the slope of the straight line the equation describes.

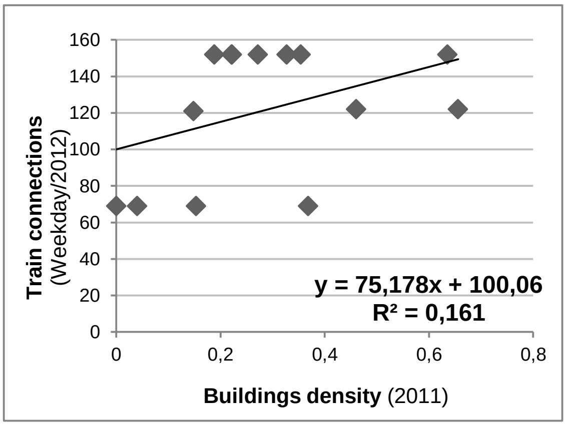
At a first stage a simple regression analysis was done relating land use variables -population density, buildings density, dwellings density and employment density - and transportation variables (train supply), choosing the transportation variable as dependent variable. The variables refer to the service area of 800m around the stations. Results are shown in Table 3.

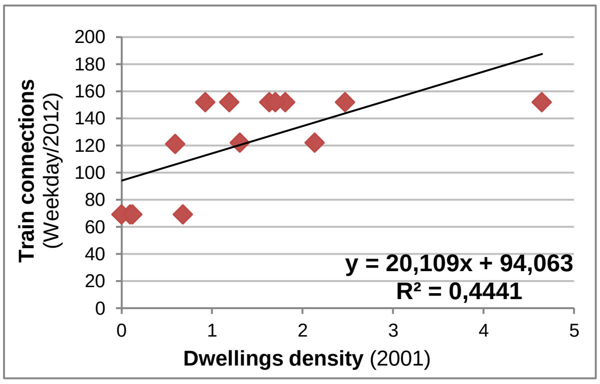
Table 3 – Simple regression analysis for the Azambuja train line stations.

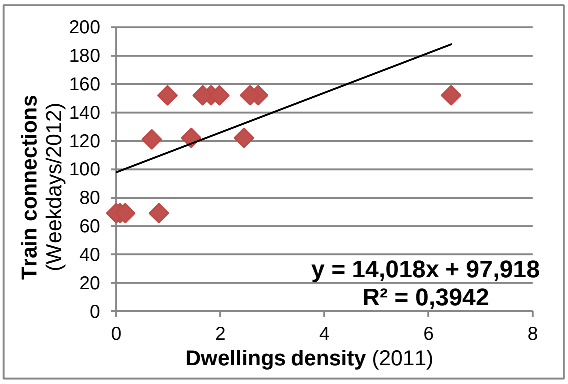


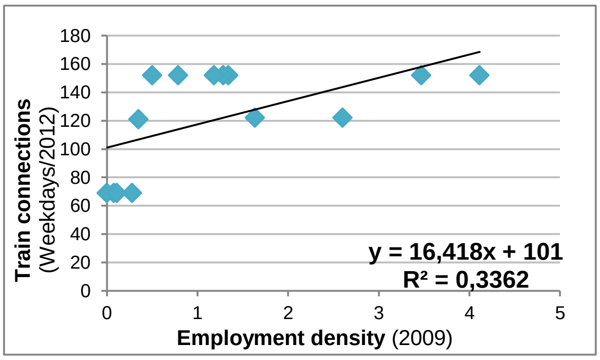












Correlation analyses and their associated graphics depicted above, test the strength of the relationship between two variables. Regression analyses, on the other hand, make a stronger claim; they attempt to demonstrate the degree to which one or more variables potentially promote positive or negative change in another variable.
The results expressed in Table 3 show positive relationships between the independent and dependent variable, in all cases, as it was expectable. However we must take into account that this sample is too small to reach the desired significant results. So this is still a very simple first approach that requires deeper studies on further stages. Nevertheless, we can observe that R squared, although with some expression, shows a week relation between transport and the other variables, and no relation at all in the case of the connection between the transport variable and buildings density. These results cannot be considered conclusive, but they show some tendencies that should be better explored with bigger samples and other variables.

The strength of the relationships could also be found through multiple linear regression model, a statistical procedure that attempts to assess the relationship between a dependent variable and two or more independent variables. The functional relationship that will be estimated by the multiple linear regressions involves a single dependent variable, train supply at each station, and four independent variables as is shown in Eq. (2):

$$Y = f\ (V1, V2, V3, V4) \qquad \text{Eq. (2):}$$

Where,
V1 = population density (2011)
V2 = building density (2011)
V3 = dwellings density (2011)
V4 = employment density (2009)

We are modeling transportation supply as a function of land use indicators. It is expected a positive relationship between transit supply and land use indicators. Table 4 and Table 5 displays the results of the multiple linear regression model.

Table 4 – Summary output of the multiple linear regression model.

Regression Statistics	
Multiple R	0,7143351
R Square	0,5102746
Standard Error	39,201092
Observations	15

The obtained values specify that 51% of the train supply is explained by the model and the correlation between independent variables and dependent variable is 71, 4%. As shown, these relations are still very week, what can be verified in Table 5.

Table 5 – Multiple linear regression model results.

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	72,978	18,659	3,911	0,003	31,404	114,552	31,404	114,552
V1 -Population density (2011)	56,699	35,779	1,585	0,144	-23,021	136,419	-23,021	136,419
V2 - Buildings density (2011)	54,978	82,922	0,663	0,522	-129,785	239,740	-129,785	239,740
V3 -Dwellings density (2011)	-103,201	74,441	-1,386	0,196	-269,066	62,665	-269,066	62,665
V4 -Employment density (2009)	16,614	19,223	0,864	0,408	-26,218	59,447	-26,218	59,447

Coefficients exhibit in Table 5 represent the strength and type of relationship the explanatory variables have to the dependent variable. Variables 1, 2 and 4 have a positive relationship with the dependent variable, while variable 3 has a negative relationship.

The p-value represents the probability of error that is involved in accepting our observed result as valid, that is, as "representative" of the population. The obtained P values are not encouraging. Those values suggest that independent variables do not have statistical significance. The higher the p-value, the less we can believe that the observed relation between variables in the sample is a reliable indicator of the relation between the respective variables in the population. Only variable 1 has an acceptable significance closer to 90% yet slightly less.

This first study has certainly many problems such as: omitted explanatory variables (misspecification), non-linear relationships, multicollinearity - one or a combination of explanatory variables is redundant-, spatially autocorrelated residuals and normal distribution bias are common and the model should be tested to avoid wrong interpretation of the results. There are tools more suitable than Excel to do the referred tests such as ArcGIS or GeoDA software's. Next steps along with the collection of more data envisage the use of these software's. Next chapter embraces the future developments of the work.

3.4. Future Steps

The indicators collected do not allow an in-depth analysis of the question under consideration: what are the relations between land use and transport that might allow to test if these areas are in fact acting as TOD areas.
In order to deepen and accurate this analysis a set of other indicators has to be collected or calculated, such as:

• Ridership data, for the studied stations and for buses in the service areas too if possible. Ridership is as seen in Table 1 one the most referred indicator to measure and test TOD, despite being difficult to obtain.
• Data regarding automobiles: Since automobile is a competing alternative to transits, data describing automobile ownership and usage may improve the explanatory power of the regression model. The data may include automobile ownership by block, traffic volume by street, street width, etc.
•Transit supply trends (train and bus).
• Land use data by type of activity.
• Park and ride data.
• Key urban design factors of TOD, such as: network continuity paths, existence of infrastructures for soft modes; qualitative ratting of streetscape, etc.
• TOD planning measures in municipalities Master Plans.

Adding the indicators mentioned above to the analysis, it will be possible to incorporate in the analysis the main variables referred in the literature and assess the three TOD components: Diversity, Density and Design.

4. Conclusions

Understand the relationship between transport and land use will allow the adjustment of TOD measures to the objectives set, contributing to develop the urban systems´ sustainability. Building a model capable of simulate the case study system will allow not only to measure the success of TOD measures but also get to know the system behavior towards certain policies, and understand the return on public investment.
More analysis must be performed in order to verify what stations show stronger TOD characteristics evidence. Temporal series analysis can be made in order to verify if the urban grow trends are dependent on Public Transport (PT) for the studied stations.
It is planned the use of Geographic Information Systems (GIS) and GeoDA software in order to do spatial analysis as spatial autocorrelation.
To found evidence of TOD characteristics in stations of the studied area, diligences will be carried out to assess and measure these characteristics using bigger samples and other variables. However, this study shows that probably the case study initially choose, might not be the best - because of the lack of density – to develop and apply transport and land use models.
This is an on-going research and it is expected, very soon, more conclusive results.

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