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Urban sprawl processes characterize the landscape of the areas surrounding cities. These landscapes show different features according to the geographical area that cities belong to, though some common factors can be identified: land consumption, indifference to the peculiarities of the context, homogeneity of activities and building typologies, mobility needs exasperatedly delegated to private cars.

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Contents

TeMA

Journal of
Land Use, Mobility and Environment

TeMA

Journal of
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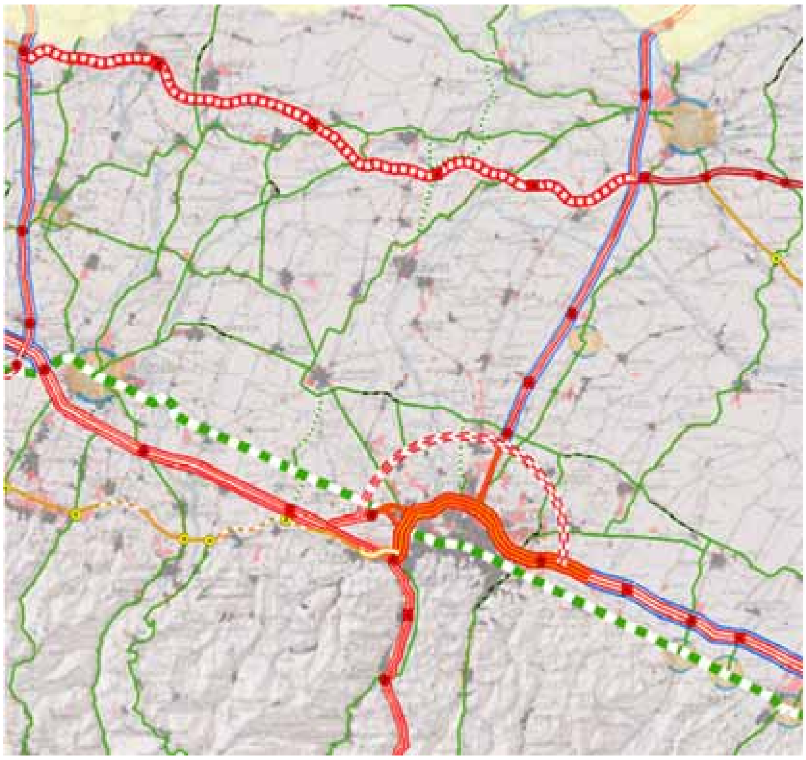

THE NEW CISPADANA MOTORWAY

IMPACT ON INDUSTRIAL BUILDINGS PROPERTY VALUES

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ABSTRACT

Infrastructures, through externalities, modify the territorial status quo: by creating advantages and disadvantages, they lead to inequalities and territorial cohesion problems. In this paper, the estimation of the costs and benefits generated from the building of the new Cispadana regional motorway (Emilia-Romagna Region, Italy) is described. The study focuses on the price variations of the industrial buildings property values in the real estate market after the new motorway will be built. Thanks to the hedonic pricing method, using a multiple linear regression model based on ordinary least squares method (OLS), the contribution of the accessibility on the industrial buildings' pricing has been isolated; it was then possible to forecast the rise in the industrial buildings prices that will be due to the accessibility variation produced by the new infrastructure. The purpose of such a procedure is the setup of equalization mechanisms, which can re-balance the territorial effects though he so-called "land value capture" tools. Thanks to a relatively quick phase of development and implementation, the described application could be used both as a tool for the ex-ante evaluation of different infrastructure projects and as an ex-post analysis tool for the monitoring of an existing infrastructure. Furthermore, thanks to the chance to understand the contribution of each territorial feature to the final price of the good, this application could provide a common knowledge base which could be used to support the public administration's capability of negotiation with the private partner, both in the participatory planning processes and in the public-private partnership procedures.

KEYWORDS:

Transport externalities, hedonic price, land equalization, land value capture

1 INFRASTRUCTURES AND EXTERNALITIES

An infrastructure has multiple impacts on the place where it is built, producing a complex relationship with the territory, which is defined by several factors. The generated phenomena are different by typology, origin, diffusion, length and place, linked with a complicate interaction of causes, actors and systems which are themselves different in terms of interests, background and activities (Maibach, 2007; May, 2006, Wegener-Fürst, 1999). Among all these impacts, this paper focuses on the so-called "externalities". An externality is defined as an effect sustained by a subject (receiver) due to an unintentional action made by an another subject (emitter) (Ceriani, 2006).

The externalities include both benefits (i.e. reduction of road congestion, trip-length, transport's generalized cost, road accidents, ...) and costs (i.e. environmental costs, as air pollution, noise, vibrations, but also others kind of costs like urban or territorial segregation, ...) variously distributed by time and space (Ceriani, 2006; Ferri, 2006). Costs and benefits are reflected in the political, administrative, economic and fiscal areas of all the institutions involved in the phenomenon, not strictly limiting themselves to the territory physically concerned by the infrastructure; they affect policy targets and decisions and they spread out over different time horizons. It is possible to regard transport infrastructures as a means for territorial externalities and fiscal interdependences, for development opportunities or threats, in relation to the dimension of positive and negative effects which are generated for each local authority (Ceriani, 2006).

The first attempts to quantify the externalities were made in France at the end of the sixties (Plassard, 2003), first by using cost-benefit analysis techniques, then using traffic forecasts and estimations of the saved time; however, it soon became clear that a huge transport investment could not be properly evaluated considering just its users' interests. There was a need for more complex analysis involving also the effects whose value could not directly be evaluated and, even if no successful practices of quantification of these effects were developed, the idea of structuring effects started to assert itself – also due to a period of major growth of the construction sector. These structuring effects were defined as some indirect effects, concerning the improvement of local development and wealth, which were supposed to be automatically generated after building an infrastructure in any area (Plassard, 2003). Nowadays, the "structuring" effect could be accounted as nothing but a kind of "political myth" (Offner, 1993), which could not be a valid reference for a technical-scientific viewpoint. One needs to talk about complex system (Plassard, 2003; Eboli-Forciniti-Mazzulla, 2010): any infrastructure must be considered to be part of a transport network, which in turn is a small part of a complex social and economic system, belonging to a specific historical period and shaped by many pre-existing structural trends. Here, causality is not the main topic anymore; one needs to focus on "congruence" (Offner, 1993) between territory and infrastructure, which consists of a mutual and multi-articulated adjustment. A valid representation of that complex scene is given by the Swiss model TRIPOD (ARE, 2007), which is based on three fundamental principles (transport effects, potentials, actors) that are interdependent and cyclically interconnected, whose output is a full set of territorial effect.

From the above, it is clear that infrastructures, through externalities, modify the territorial status quo (Ferri, 2006). By creating advantages and disadvantages, that is disparity, building infrastructures lead to inequalities and territorial cohesion problems, calling for a setup of territorial equalization mechanisms (Adobati-Ferri, 2009). They consist usually of economic tools which are used to compensate the higher costs (or the lack of benefits) borne by some actors because of some definite planning actions, through benefits (i.e. usually a surplus of income) which are enjoyed by some others actors because of the same planning choices; in the end, they allow to achieve a substantially equalized situation among all the various areas and all the involved stakeholders. (Bruzzo-Fallaci-Guaragno, 2004). First of all, to carry out these compensatory arrangements, it is necessary to establish if the externalities are produced and then, in that case, the generated costs and benefits need to be quantified and georeferenced (Ferri 2006, Adobati-Ferri, 2009).

In this paper, the estimation of the costs and benefits generated from the building of a new infrastructure is described through the case study of the Autostrada Regionale Cispadana (Emilia-Romagna Region, Italy), a new regional motorway currently at the design stage. We focused on the price variations of the industrial buildings in the real estate market after the new motorway will be built, aiming at developing a forecasting method, which could be repeatable and applicable to other kinds of externalities. Thanks to the hedonic pricing method, which is recurring in transport literature (Camagni, 2003; Camagni, 2004; De Ciutiis, 2008; Pavese, 2007; Cervero-Murakami, 2009, Hess D.B., Almeida T.A, 2007), using a multiple linear regression model based on ordinary least squares method (OLS), the contribution of the accessibility on the industrial buildings' pricing, has been isolated; it was then possible to forecast the rise in the industrial buildings prices that will be due to the accessibility variation produced by the new infrastructure. Once the price differentials are estimated, conclusions have been drawn at the end of this paper and a few hypotheses have been suggested about the feasible equalization mechanisms, focusing on value capture tools (Smith-Gihring, 2010; Milotti-Patumi, 2008; Scopel-Beria, 2010) and on a set of best practices (Buchanan, 2007; Greater London Authority, 2010; Milotti-Patumi-Sumiraschi-Vaghi, 2007; Milotti-Patumi, 2008; Scopel-Beria, 2010, Sumiraschi, 2010).

2 THE CASE OF THE NEW CISPADANA MOTORWAY IN EMILIA-ROMAGNA REGION

The Autostrada Regionale Cispadana will be a toll-motorway placed in the northern part of Regione Emilia-Romagna (Italy), planned to be a west-east link in order to improve the existing motorway network (A13, A22). The road layout is about 67 Km long, housing 6 toll gates, crossing 13 Municipalities belonging to 3 Provinces. As of today (April 2011), the administrative course and the whole project are at an advanced stage, and the General Contractor has been entrusted with the project.

To thoroughly analyze the spatial effects, the study area had to be extended in order to include a wider area, rather than just the directly concerned territories (Ferri, 2006; Plassard, 2003; Ferri-Adobati, 2009; Ceriani, 2006); thus, the study area has been extended to 50 Municipalities, classified in nodal-Municipalities (the ones where toll gates will be located), crossed-Municipalities (the ones which will be physically crossed by the motorway), first-belt-Municipalities (the ones which will contiguous to the first two typologies of Municipalities) and external-Municipalities (the ones which will be contiguous to the first belt ones or which will be even more distant from the infrastructure), as shown in figure 1.

Aiming at determining if and how the accessibility affects the industrial buildings prices (that is the testing territorial effect), the hedonic pricing method has been applied, as above mentioned. This method can break down the value of a composite good, like a building, into the value of its constituent characteristics, allowing to understand the contribution which each feature brings to the final price of the good itself. Moreover, the hedonic price method makes it possible to point out the contribution of those characteristics which cannot be quantified monetarily (Camagni, 2003). Here in this paper, a multiple linear regression model is used, which is based on the following equation: $y_j = \beta_0 + \beta_1 \cdot x_{j1} + \beta_2 \cdot x_{j2} + \ldots + \beta_n \cdot x_{jn} + \varepsilon_i$ [1] where β_0 = constant term, β_i = explanatory coefficients of each independent variable, y_j = dependent variables x_{ji} = independent variables, ε = error term, j = (1, 2, ..., m) number of distinct observations of the representative sample, i = (1, 2, ..., n) number of independent variables.

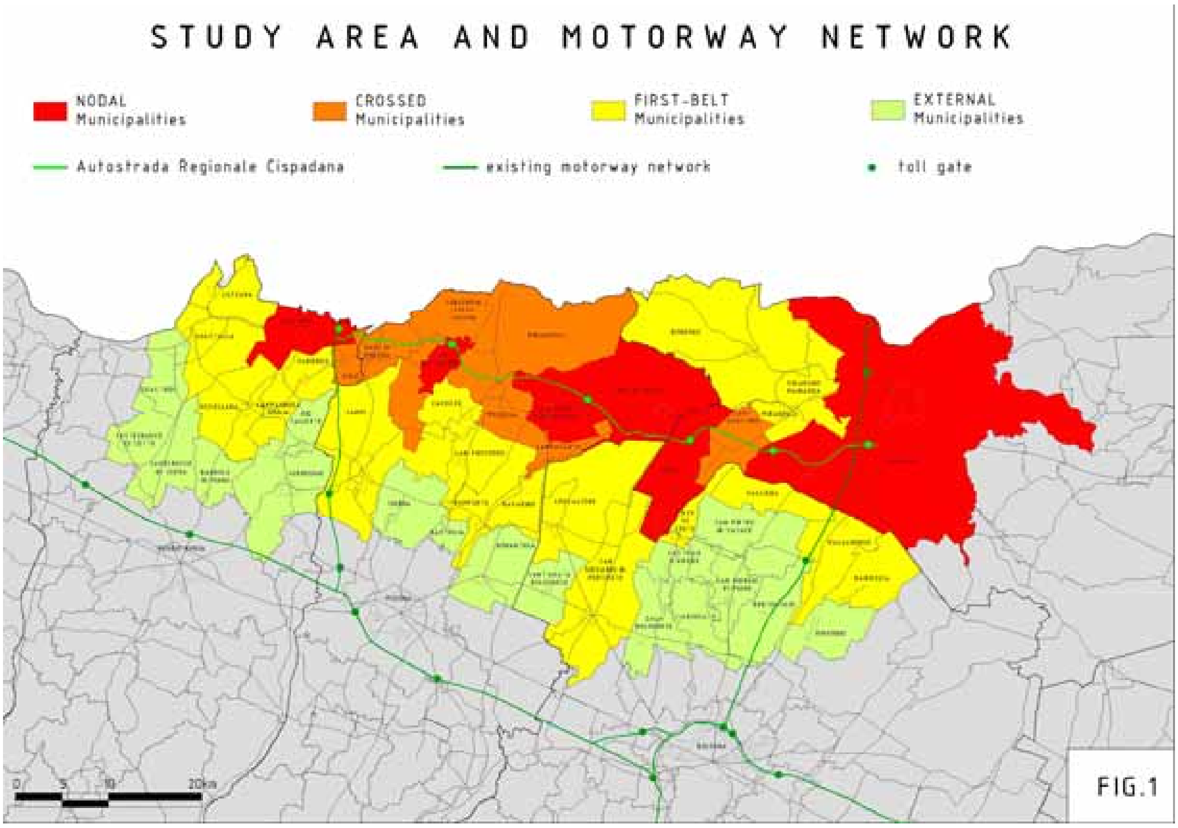

Fig. 1 Study area and motorway network

Once the values of the dependent and independent variables are obtained from the j-observations, by solving the equation [1] it is possible to know the values of the β_i coefficients; once assumed the price of the industrial buildings as dependent variable, the economic meaning of those β_i coefficients is the contribution to the formation of this price of each feature (i.e. each dependent variable) which has been supposed to be explicative of the price itself (Camagni, 2003).

The equation solution, that is the determination of the vector β consisting of the β_i coefficients, is the following one: $\beta = (X' \cdot X) \cdot X' \cdot y$ where: y = $(m \cdot 1)$ vector of the m observation of the dependent variable, X = $m \cdot (n+1)$ matrix of the m observation of the n independent variables, β = $(n+1) \cdot 1$ vector of the β_i coefficients to be estimated. This method is called Ordinary Least Squares (OLS) (Simonotti, 1997).

This solution has to be verified by performing some tests, which ensure the statistical significance of the results. In this work, the following tests have been performed: Student's t-test, the p-value, the Variance Inflation Factor (VIF), the coefficient of determination R^2, the adjusted coefficient of determination R_c^2 and the Fisher's F-test (Simonotti, 1997; Realfonzo 1994; Cottrell, 2005). The data processing was made with the open-source software Gretl (*Gnu Regression, Econometrics and Time-series Library*), using the White's HC0 correction to avoid the heteroscedasticity in the error's terms (Cottrell, 2005).

Due to the regional scale of the study, the reference territorial unit is the Municipality; the 6 variables used in the regression model are referred to this unit dimension:

1. PRICE – DEPENDENT variable – average price per square meter for industrial buildings [EUR/m^2]. Source: quotation price from the National Observatory of real-estate market, base period: 1st semester of 2010.
2. PLAN_FEES – INDEPENDENT variable - Planning fees for new industrial buildings [EUR/m^2]. Source: parametric regional charts, implemented by each Municipality through town council resolutions.

3. SERV_DENS – INDEPENDENT variable – density of business services, defined as the ratio between number of services units and population, for each Municipality. Source: Emilia-Romagna Region GIS database (base date: December 31st, 2009) for services units, Istat - National Institute of Statistics data (base date: January 1st, 2010) for population.
4. ENTERPR_DENS – INDEPENDENT variable – density of enterprises of Industry and Construction sectors, defined, for each Municipality, as the ratio between number of employed workers and number of firms. Source: SMAIL Emilia-Romagna - Regional Monitoring System for enterprises (base period: December 2009)
5. KM_HUB – INDEPENDENT variable – length of the shortest way from each Municipality to a regional road-rail distribution hub [Km] Source: Google Maps online cartography, to search for the shorter trip to the two main regional intermodal transport hubs (Interporto di Bologna and CePIM - Interporto di Parma), as prescribed by the Regional Transport Plan (PRIT)
6. ACCESSIBILITY – INDEPENDENT variable – shortest access time from each Municipality to get to a motorway toll gate, calculated in the current road network scenario [minutes]. Source: traffic simulation model of Emilia Romagna Region, D.G. Network Infrastructure, Logistics and Mobility System, Transport Planning Office.

2.1 RESULTS

The regression model's results are shown in table 1:

	β	std. error	t test (|t|<2)	p-value (<0.05)	VIF (<10)
const	215.675	76.950	2.803	0.008	...
PLAN_FEES	23.923	7.601	3.147	0.003	1.620
SERV_DENS	3.612	1.040	3.473	0.001	1.624
ENTERPR_DENS	9.897	3.858	2.565	0.014	1.089
KM_HUB	-1.058	0.359	-2.949	0.005	1.188
ACCESSIBILITY	-2.435	0.694	-3.509	0.001	1.224
coefficient of determination	R^2 = 0.705 R_c^2 = 0.672				
Fisher's F-test	F(0.05, 5, 44) = 23.246 > Ft (0.05, 5, 44) = 2.427 P-value(F) = $2.39*10^{-11}$ < 0.05				

Tab.1 Regression model's results

Each variable passes the control tests, ensuring their statistical significance. By substituting the value of the β coefficient in the equation [1], it is possible to get the regression equation for the case study:

$PRICE_i$ = const + 23.923 * $PLAN\_FEES_i$ + 9.897 * $ENTERPR\_DENS_i$+ 3.612 * $SERV\_DENS_i$ – 2.435 * $ACCESSIBILITY_i$ – 1.058 * KM_HUB_i + ε_i

Focusing on the average values, it is possible to split the average price as shown in table 2.

Therefore, it is possible to analyze the contribution of each characteristic to the final price of the industrial buildings. The variables ACCESSIBILITY and KM_HUB present a negative value, which means that they are inversely proportional to the dependent variable PRICE. The constant term (named "const"), which is the portion of the price not explained by the five independent variables, is about the 40% of the average price of the representative sample.

	β	Average value	β * average value	% (elasticity)
PRICE	...	543.784 EUR/m^2	...	...
const	215.675	1	215.675	39.66%
PLAN_FEES	23.923	8.372 EUR/m^2	200.276	36.83%
SERV_DENS	3.612	52.624 enterprise/1000 people	190.065	34.95%
ENTERPR_DENS	9.897	28.860 min	-70.268	-12.92%
KM_HUB	-1.058	42.592 km	-45.077	-8.29%
ACCESSIBILITY	-2.435	5.366 workers/enterprise	53.113	9.77%
		TOTAL	543.784 EUR/m^2	100.00%

Tab.2 Decomposition of the average price

This quite high value is related to the regional scale of the study, which does not allow to identify a set of specific features for each building impacting on prices (i.e. manufacturing and structural characteristics, measurements, residual service life, facilities and systems supplied, etc.). However, the aim and regional perspective of this study make it possible to deem the regression model and the estimated β-coefficients reliable. The β-coefficient for the ACCESSIBILITY variable, as shown above in table 2, is equal to 2.435: the motorway accessibility effect is 2.43 EUR/m^2 for every minute saved to get to a motorway toll gate (in relation to an average distance of 28.860 minutes for each Municipalities of the representative sample). This value is the so-called hedonic price of the ACCESSIBILITY variable.

After having estimated the hedonic price, the effect that the construction of the Autostrada Regionale Cispdana will have on the average price of the industrial building has been estimated by using the following equation (Camagni, 2004):

Hedonic price [EUR/m^2*min] * Variation of accessibility [min] = Variation of the building's average price [EUR/m^2] [2]

The accessibility variations were calculated comparing the results from the traffic simulation model, which was run for both present and future scenario. In the future scenario, all other variables were kept constant to the present values so that it was possible to value the effect of the variation of accessibility only.

As shown in figure 2, in view of 11 Municipalities (22%) which do not show any prices variation, since their access time to a motorway toll gate did not change, the others 39 Municipalities (78%) face a rise of the value of the industrial buildings. More specifically, 8 of them (16%) report increases over 10% and others 3 Municipalities show a rise of industrial buildings prices over 17%.

The average variations are reported in table 3, in relation to each typology of Municipality (nodal, crossed, first belt, external).

The global average variation of the price of the industrial buildings is +5,24%. By subdividing the results over the four typologies of Municipalities, it is shown that the farther Municipalities are from the motorway (the external ones and the first belt ones), the lesser the benefits, when compared to the closer ones (crossed and nodal Municipalities); the last two typologies' growth is near twice than the average value. Contrary to what it would be expected, the crossed-Municipalities get an higher benefit than the nodal-Municipalities, which were supposed to be the greatest recipients, because of the presence of a motorway's access point.

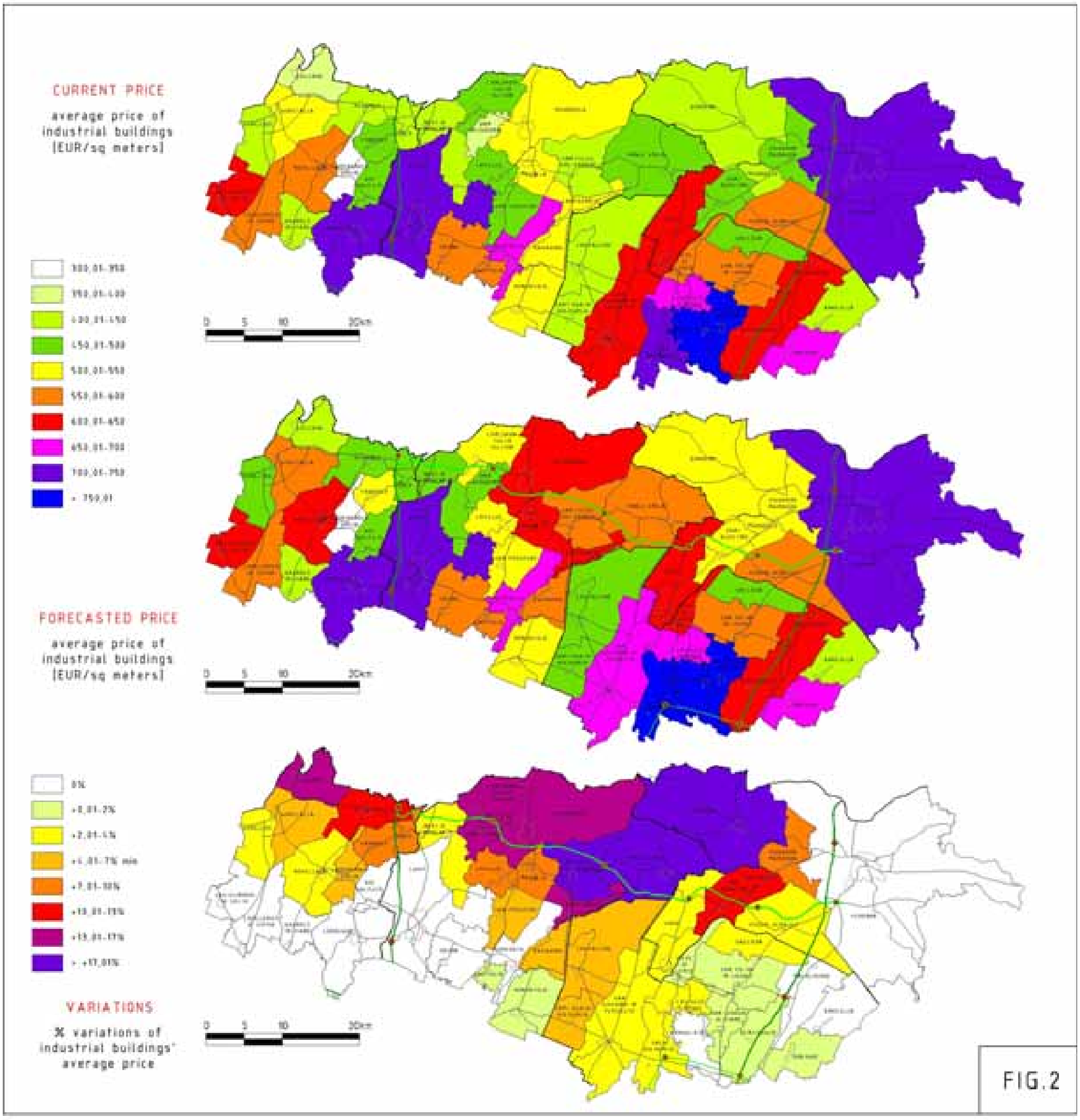

Fig. 2 Forecast of the rise in prices of the industrial buildings

Municipalities	present accessibility [min]	future accessibility [min]	variation [min]	present price [EUR/m^2]	future price [EUR/m^2]	variation [EUR/m^2]	variation [%]
TOTAL	28.72	16.38	-12.34	543.78	573.83	30.05	+ 5.24%
NODAL	29.57	8.14	-21.43	525.47	577.65	52.17	+ 9.03%
CROSSED	32.16	9.00	-23.16	478.46	534.87	56.41	+ 10.55%
FIRST BELT	32.33	19.19	-13.14	511.52	543.52	32.00	+ 5.89%
EXTERNAL	22.31	19.06	-3.25	618.64	626.56	7.91	+ 1.26%

Tab.3 Forecasted average value by typology of Municipality

This is due to two key factors: 1) boundary conditions; in the present scenario, the crossed Municipalities face a worse accessibility condition (they have an average accessibility of 32.16 minutes, against 29.57 minutes of the nodal Municipalities); therefore, the future presence of a closer toll gate (even if not in their municipal territory) will bring a higher benefit with regards to saved time. 2) the presence of the city of Ferrara among the nodal-Municipalities; Ferrara is the only nodal-Municipality which already has a toll gate of an existing motorway (A13). Because of that, the Municipality of Ferrara will not get any benefit regarding motorway accessibility (and so it will get no rise of industrial buildings' prices) and it contributes to reduce the average value of gained accessibility for all the nodal-Municipalities. Indeed, if the average values are calculated without counting the city of Ferrara, the nodal Municipalities gain the biggest benefits, as it is shown in table 4.

Municipalities	present accessibility [min]	future accessibility [min]	variation [min]	present price [EUR/m^2]	future price [EUR/m^2]	variation [EUR/m^2]	variation [%]
TOTAL	28.72	16.38	-12.34	543.78	573.83	30.05	+ 5.24%
NODAL (w/o Ferrara)	33.83	8.83	-25.00	553.80	553.80	60.87	+ 10.99%
CROSSED	32.16	9.00	-23.16	478.46	534.87	56.41	+ 10.55%
FIRST BELT	32.33	19.19	-13.14	511.52	543.52	32.00	+ 5.89%
EXTERNAL	22.31	19.06	-3.25	618.64	626.56	7.91	+ 1.26%

Tab.3 Forecasted average value by typology of Municipality, excluding the city of Ferrara

The small difference in benefit between the nodal-Municipalities and the crossed ones is due to the short distance among the nodal points of the new motorway (the average distance is about 11 km), so that the segregation effect for the crossed territories is weak. In other words, the polarization of the benefits around the access points of a transport infrastructure, that is the "tunnel effect" created due to the refraction law (Plassard, 2003), is essentially absent.

3 CONCLUSIONS

Through the hedonic price method, which was developed using a multiple linear regression model based on ordinary least squares method (OLS), it was possible to value the effect of the motorway construction on the industrial buildings' pricing by isolating the contribution of accessibility and then calculating the rises in the industrial buildings prices, due to accessibility variations produced by the new infrastructure. It is clear that the work which was developed and shown above, it is only a partial analysis. Indeed, a more complete analysis should take care of the dynamic aspect of land value and price's variations. To get over the static perspective here adopted, it would be necessary to include the time variable and the mutual variations: for example an increase of price of more accessible areas could be accompanied by a progressive decrease in price of marginal areas. Moreover, to have a full picture (qualitative, quantitative and georeferenced) of the territorial effects, it would be necessary to repeat a similar analysis for all the externalities typologies; only then it will be possible to determine the "receiver-Municipalities", the ones which will bear the costs generated by the new infrastructure, and the "payer-Municipalities", the ones which will get some benefits in comparison with the whole sample's average.

Anyway, the achieved results make it possible to make some considerations about the benefits of the described model , with particular regard to its application in urban planning context. The purpose of such a procedure is the setup of equalization mechanisms, which can re-balance the territorial effects. Generally, the so-called "land value capture" tools are adopted (Smith-Gihring, 2010; Cervero-Murakami, 2009, Milotti-Patumi, 2008; Hong, 1998): they consist of a set of actions which aim at recovering some of the produced generated benefits, by introducing some duties and taxation, which will be applied on the increased property values. This paper does not intend to enter into the details of the operational instructions, which will need to be set up in detail for every single case, by considering the specific legislative and fiscal background. However, it is possible to point out some general guidelines.

Nowadays, because of the general lack of public resources, it seems necessary to introduce a clause about the tax revenues' use, ensuring that the tax revenues will actually fund the equalization actions and that they won't be used for any other purpose of the Local Authorities. The taxable basis should be defined so that the tax will weigh as much as possible upon the beneficiaries only. Moreover, a taxation proportional to the benefits should be appropriate; in such a way, the tax would be diversified in order not to be too damaging for the payers. For this reason, the introduction of a threshold value for the taxation could be an useful tool, as seen in London's Crossrail Link project (Greater London Authority, 2010; Buchanan, 2007). In that case, the only taxed properties are the non-domestic ones which exceed a fixed threshold of rateable value. In such a way, the taxation weighs only on those enterprises which have a dimension that easier allows to face the additional charge. We also need to focus on the time variable, especially on the revenues' cash flow. In general (even if it could be considered as a necessary but not sufficient condition) the most successful experiences are characterized by the presence of a definite time and work schedule; for example, in the case of the Copenhagen Metro, the success of the project was reached also thanks to a straight planning the whole intervention in harmony with the different time schedules of each element (Milotti-Patumi, 2008). On the other hand, the lack of accurate time constraints and the non-compliance with the scheduled times have often main obstacles to the implementation of a value capture tool; this is evident, for example, in the case of the Quadrilatero Marche-Umbria project (Corte dei Conti, 2009).

In the end, thanks to a relatively quick phase of development and implementation, the described application could be used as a tool for the ex-ante evaluation of different projects and as an ex-post analysis tool for the monitoring of an existing infrastructure. Finally, thanks to the chance to understand the contribution of each territorial feature to the final price of the good, this application proved to be very useful in participatory planning processes (Urbani, 2001). Indeed, the tool discussed in this paper allows to deal with some very complex phenomena, as the interactions between transport infrastructures and territory, and it allows to synthesize them in a clear and explicit way, showing the existing mutual interrelationships. For this reason, this tool could provide a common knowledge base which could be used to support the public administration's capability of negotiation with the private partner, both in the participatory planning processes and in the public-private partnership procedures. In fact, it could be used to provide members of the public with the information they need to understand the project and decision process; furthermore, the use of a mathematical tool supports the transparency and clarity of the procedure with respect to every involved actor, and could help in regulating their contribution according to the benefits they'll gain form the new infrastructure and could support the Public Administration in carrying on negotiation processes with private stakeholders.

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Fig. 1 and 2 are from the Authors.

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