Do city dwellers care about periurban land use? The case of environment-friendly agriculture around Milan

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Forthcoming in
Journal of Environmental Planning and Management
Accepted on July, 16th, 2020

Abstract

Undeveloped land adjacent to urban areas has a strong potential to generate high amenity values to urban dwellers via the adoption of environment-friendly agricultural practices. Yet, there is a lack of specific policy measures tailored to unlock such potential and a scant knowledge of the preferences of the main beneficiaries. Analysis of data from a Choice Experiment in the municipality of Milan based on current policy deliverables shows that a large share of the urban population is willing to pay for specific ecological benefits linked to agricultural practices. Organic farming and land strips sown with wildflowers are the two practices whose ecological benefits are found most desirable. Willingness to pay for a policy intervention is shown to significantly correlate with income class, with low-income recipients being more interested in organic farming while those with middle and high income deriving higher benefits from planting fast-growing trees.

Keywords: periurban agriculture; agri-environmental policy; choice experiment; random parameter logit model; random utility in WTP space.

JEL Code: Q18, Q57, C35

1. Introduction

The urban sprawl of recent decades has seen rural areas surrounding cities being gradually included into urban borders. The resulting landscape of periurban areas has been shown to be shaped by several factors, such as the presence of highways and road networks, which fosters the urban sprawl (Garcia-López, 2019), land planning, as well as of agricultural activities. This process has affected most of the largest cities in Europe and in areas within a short distance from the original city centres has given rise to the so-called "urban-rural continuum". Agricultural activity is one of the main forces at work in shaping the landscape of the "periurban fringe", which is where urban and rural features intermingle (Llausàs et al., 2016). Due to its proximity to urban centres, periurban agriculture (PUA) is greatly influenced, and sometime threatened by urban sprawl. Expanding urban boundaries increase the speculative value of adjacent rural land due to the scarcity effect, and periurban agriculture must produce significant returns in order to survive (Bigelow and Plantinga, 2017). On the other hand, the environmental sensitivity of urban dwellers has also been growing (Baró et al., 2017) with an increasing interest in recreational and learning activities taking place in farms located in the periurban fringe (Zasada, 2011a). Given the pressure for residential development on undeveloped agricultural land proximate to cities, in order to survive peri-urban farmers cannot focus only on crop production; they must also find a suitable adaptation strategy by developing local public goods. For example, by increasing farm multifunctionality and by providing urban dwellers with ecological, cultural and social services. All these local public goods must inevitably rely on local public expenditure and require the development of adequate policy measures.

Zasada et al. (2011b) identify three types of adaptation strategies for periurban agriculture: (a) specialisation in high-value cropping systems, (b) adoption of environment-friendly practices and (c) provision of recreational and cultural services. The literature shows that many periurban regions in North America and Europe focus on high-value produce (e.g. horticultural and fruit) and that relative to other rural areas further away from urban centres, the adoption of environment-friendly practices tends to be higher (Zasada et al., 2011b). The presence of organic farming in periurban areas is controversial: some studies find a higher rate of adoption than elsewhere (Ilbery et al., 1999), while others find a lower one (Zasada, 2011a). The provision of recreational and cultural activities by farms is widespread in many periurban areas (van Zanten, 2014), that are often taking advantage of off-farm income opportunities. Adoption of multifunctional farming practices represents an opportunity for periurban farmers to both diversify their activity and simultaneously generate benefits for urban dwellers. Ives and Kendal (2013) find that Melbourne dwellers attach a value to many multifunctional components of PUA. Their work advocates the need to account for these components when planning land-use policies.

Developing multifunctional agricultural systems means supporting the provision of locally valued ecosystem services from agriculture. Ecosystem services include goods and services supplied by the agricultural landscape (van Zanten, 2014, Bernués et al., 2019), which can be classified into commodities and non-commodities and services (environmental, cultural and social goods and services). Missing markets for non-commodities produced by ecosystem services are known to lead to a sub-optimal level of provision of these local public goods and services. Thus, policy measures are required to correct spontaneous market allocation and guarantee that these services are provided at their socially optimal levels.

Over the last decades, agricultural policy in the European Union (EU) has been paying increasing attention to ecosystem services provided by selected agricultural practices. In the '80s the EU Common Agricultural Policy (CAP) introduced agri-environmental measures (AEMs) across the Member States as policy options. Since the early 90's, with Council Regulation 2078/92—the so-called "Mac Sharry reform"—such measures have been compulsory for all Member States. AEMs are measures specifically targeted to pay farmers who subscribe, on a voluntary basis, to environmental commitments for at least five years, to protect the environment and preserve the countryside. The payment aims at compensating farmers for the additional costs and the income loss resulting from the adoption of environment-friendly practices. AEMs are defined at the regional level to account for the regional specificities and are co-financed by the EU and the Member States. They are a section of the Rural Development Programmes (RDPs), which are regional programmes belonging to the CAP with the aim of supporting the development of rural areas. In the 2007-2013 budget framework, the EU expenditure for AEMs amounted to nearly 20 billion euro, 22% of the EU overall expenditure in the RDPs. Approximately 25% of the EU Utilised Agricultural Area (UAA) is under AEMs (European Commission, 2017).

In the periurban area of Milan farmers' participation in AEMs is rather low, although local urban dwellers could greatly and promptly benefit from environment-friendly practices, given the proximity of PUA to the city. This suggests a mismatch between what is on offer by local authorities in terms of policy measures and what is demanded in terms of ecosystem services provision by the local population. Indeed, no study exist on the preferences of the main beneficiaries, which can be used to direct a better policy design. In this study, we assess preferences of the population of city residents within the municipality of Milan for those ecological benefits provided by an increased provision of selected environment-friendly agricultural practices in the periurban area of the municipality. All practices analysed here are listed as AEMs included in Lombardy's RDP. The reason for restricting our focus to existing AEMs lies on the intention to use the existing policy framework to evaluate the potential benefits derived from an improvement of its application. Willingness to pay (WTP) measures from the estimated preference structure can indicate the social benefits generated by a marginal rise in the adoption of those practices.

Although an extensive literature exists on the economic valuation of landscape and recreational services (van Zanten, 2014), only a few studies investigated the economic value of the ecological benefits provided by some environment-friendly agricultural practices. Jensen et al. (2019) assess the impact on economic welfare of three nitrogen abatement measures affecting recreational and aesthetic values. Varela et al. (2018) elicit the social demand for increasing species richness in the forest path in the Flanders and the Picardie region. They find that respondents attach higher values to diversity enhancement where the landscape is more spoiled, but their willingness to pay estimates are statistically insignificant. Novikova et al. (2017) apply a choice experiment to investigate the preferences of Lithuanian dwellers towards environment-friendly agricultural practices and find that dwellers are particularly interested in biodiversity enhancement. Their choice experiment estimates environmental benefits but not the agricultural practices necessary to produce such benefits. We are aware of only one study (Sanyé-Mengual et al., 2018) that assesses these ecological benefits when specific agricultural practices are adopted in the urban area. However, that study has a broader scope on preferences towards different types of urban agriculture and its services, rather than a direct focus on ecological benefits. A novel contribution of the present study to the existing literature is its specific focus on agri-environmental practices implementable in the peri-urban area in relation to the willingness to pay by Milan residents for the ecological benefits these practices can provide.

We developed a survey-based choice experiment (CE) and administered it to a sample of 600 city residents. In the questionnaire, respondents were provided with a description of selected agricultural practices and their respective ecological effects. Respondents may not be aware of the relationship between agricultural practices and environmental consequences. So, providing detailed information about the ecological effects generated by each practice is central to our study. The study is designed to elicit preferences and stated WTP estimates for each sustainable agricultural practice based on their environmental consequences when implemented in the specific context of periurban areas. CE data are analysed using Random Parameter Logit (RPL) model with utility parametrised in WTP-space, such that the well-known drawbacks of deriving random WTP estimates from random coefficients of utility functions are avoided (Train and Weeks, 2005).

A further empirical contribution is our focus on the existence of spatial dependence on the distribution of individual WTP for each agri-environmental practice. We compute the Moran's index of spatial autocorrelation to assess the existence of spatial clustering in the WTP in specific neighbourhoods of the municipality. Evidence of spatial clustering would indicate that the benefits of AEMs are larger in some areas of the municipality and that the policy instruments should be calibrated accordingly.

The remainder of the paper is structured as follows. Section 2 provides a brief overview of the AEMs we consider in this study and their potential ecological benefits in the context of the Milan periurban area. Section 3 illustrates the methodological approach, while Section 4 introduces the study design and the sample data. The empirical results are presented in Section 5. Section 6 provides a discussion of these results and draws some conclusions and policy implications.

2. Periurban agriculture and agri-environmental practices

Agricultural activity in the periurban area of Milan is mainly concentrated in the south and west sides of the city (Figure 1). Together rice and corn crops dominate the land use, as they represent 75% of the utilised agricultural area (UAA), followed by grassland (7.5%) (Istat, 2010). Agriculture in this area can be classified as intensive, and the costs of compliance with the AEMs are comparatively high. This might explain the low adoption rate of environment-friendly measures. Doubts about the current effectiveness of the AEMs have been put forward (Arata and Sckokai 2016) as their application within a region currently ignores the heterogeneity of the agricultural conditions. This "flat rate" application of the policy is likely to imply that areas where the costs of compliance with the measures are low (e.g. marginal areas) register a high rate of adoption and a large windfall effect (Chabé-Ferret and Subervie, 2013). This because the measures would have been adopted even in the absence of payments. On the other hand, areas where the costs of compliance with AEMs are high (e.g. intensive agricultural areas) experience a low rate of adoption. However, it is worth noting that AEMs compliance costs to farmers are likely to be unrelated to their social desirability. There may exist some areas where the adoption of AEMs is highly desirable from a social perspective, but their adoption rate is low because of the high cost of compliance.

A noticeable exception around Milan is represented by an area of approximately 90 hectares in the south side of the city, corresponding to the Ticinello Park. There is only one farm in Ticinello Park, and its management focuses on the provision of environmental services such as hedgerows, ponds, and rows of trees. However, this focus is justified by the farm area being embedded within the boundaries of a park, which is an environmentally protected area. In the periurban area of Milan, outside Ticinello Park, the majority of farms providing ecosystem services are focused mainly on the provision of recreational and cultural activities, such as walking trails, agro-tourisms, recreational events, as well as direct sales of mostly locally grown farm produce. Most of these recreational ecosystem services generate an economic incentive for farmers in the form of payments by visitors for access and participation to such services. On the contrary, the ecological benefits provided by farmers through the uptake of sustainable agricultural practices generate an insufficient economic incentive for them to change practices and thus, in order to induce change, commensurate public subsidies are required. However, in such area the payments for the AEMs may be too low to fully compensate farmers' costs of environmental compliance. Indeed, the per hectare subsidies level for AEMs are defined at the regional level in an undifferentiated manner. Hence, they ignore the specificities of periurban agriculture, and the volume of local public good values delivered to the urban population.

Our study considers four environment-friendly agricultural practices and their related ecological benefits, all of which are included in the AEM framework of the RDP of the Lombardy region and thus are all eligible for a per hectare compensating payment. Specifically, the practices we assess, and their corresponding main ecological benefits, are:

(1) (*org*) organic farming– ecological benefits: reduction in nitrogen leaching and nitrous oxide emissions;

(2) (*fore*) fast-growing trees plantation on agricultural land– ecological benefits: increase of carbon sequestration, shadowing and cooling functions;

(3) (*strips*) field margins management – ecological benefits: positive effect on biodiversity (farmland bird population and pollinators);

(4) (*covercr*) cover crops – ecological benefits: reduction in nitrogen leaching.

The selection of the four environment-friendly agricultural practices and their levels was carried out in focus groups participated by local farmers and in consultations with experts. The latter, together with a literature review, have also identified the ecological benefits associated with each of these practices. Among other benefits, organic farming significantly decreases nitrogen leaching in the watershed, as well as the nitrous oxide emissions, which produce a greenhouse effect 298 times stronger than carbon dioxide (Tuomisto et al., 2012). Fast-growing tree plantations, such as poplars, contribute to carbon sequestration and cool the air by providing shadow during hot seasons (Palma et al., 2007). Biodiversity-strips consist of land strips located between the main crop and the field border. They are specifically targeted to increase biodiversity and its connectivity (e.g. by providing nectar to pollinators and nesting site and seeds for some species of birds). It has been shown (Vickery et al., 2009) that depending on the management of the strips, different effects on biodiversity are produced. Finally, cover crops are crops planted in the fallow period and are left unharvested because their main aim is to fixate nitrogen and make it available in the soil, thereby reducing nitrogen leaching and water contamination. Constantin *et al.* (2010) show that planting cover crops may reduce nitrogen leaching by between 30% and 60% of the leaching level in the absence of cover crops.

At the time of the survey, organic farming and fast-growing trees plantations are implemented only marginally in the periurban area of Milan (land under organic agriculture is 3% of the farmland and land planted with fast-growing trees is 0.5%), while biodiversity-strips creation and cover crops are completely absent. The reasons for such a low level of adoption for the four AEMs selected for this study may be twofold. Firstly, compensating payments may often be insufficient to cover the loss in farm income due to the adoption. This is more likely the case for organic farming and biodiversity-strips, where the income loss is expected to be higher compared to the other two practices. Secondly, the low level of adoption of planting fast-growing trees and cover crops is likely to be mainly linked to a lack of information between farmers or too strong inertia in their adoption. Farmers, in this case, may perceive the payment as insufficient to cover the additional time and effort needed to carry out the paperwork and the other bureaucratic activities involved in the application for support to set up these measures. There might also be some reluctance to commit land for long period of times.

Given the low level of adoption of these four practices at the time of the survey, it is worth assessing how much Milan city-dwellers, who are the main beneficiaries of local externalities, value the ecological benefits associated with increased adoption of each of these measures. This evaluation informs on the additional economic welfare that may be generated by improved adoption of the four AEMs in the periurban area. Such improvement can be achieved by developing agricultural programmes specifically targeted to the periurban rural area, which are currently missing.

3. Methodology

In the last two decades, there has been a sharp increase in the application of discrete choice experiments (CE) for the economic valuation of environmental goods. Environmental goods are often multi-attribute goods, and potential beneficiaries may prefer more provision of some attributes than others. CE allows researchers to disentangle preferences towards each attribute as the approach is rooted in Lancaster's theory (Lancaster, 1966), which states that the utility an individual derives from a packaged good depends on the utility s/he derives from each of the good's attributes. In a CE survey, respondents are asked to repeatedly choose the alternatives they prefer among experimentally designed sets, where each alternative represents a specific combination of attribute levels of the good. In each set, the individual is expected to choose the alternative providing the highest utility among all the mutually exclusive alternatives in the set. CE is suitable for our purpose as we assess four agri-environmental practices, which can be thought of as the attributes of agri-environmental policy. The information retrieved by CE is analysed using Random Utility Theory (McFadden, 1974), which states that researchers can interpret individual utilities from an alternative as composed of a deterministic additive term (V_{nj}), which depends on the attributes of the good to be evaluated and individual characteristics of the respondent, and a second random additive term (ε_{nj}), which is unobserved by the researcher, but is known to the respondent:

$$U_{nj} = V_{nj} + \varepsilon_{nj} \tag{1}$$

where *n* indicates the individual and *j* the alternative.

Assuming ε_{nj} is distributed extreme value type I (or Gumbel) delivers the well-known conditional logit model (CL). This model dominated the discrete choice modelling (DCM) literature for decades as its closed-form solution and global concavity on the parameter space make the estimation via maximum likelihood easy through simple gradient-based methods. Despite these advantages, the CL model carries three main limitations: it cannot represent random taste heterogeneity, it implies a rigid substitution pattern among alternatives, and it is unable to deal with correlation over choices by the same individual in the random part of the utility function. In order to overcome these drawbacks, panel (or repeated choice) mixed logit models (MXL) have been developed (Revelt and Train 1998, Train 1998) and have progressively grown in popularity. MXL encompass a wide range of different panel models, whose probabilities of a sequence of choice is the integral of the logit probability over parameters density function. The RPL panel model is a type of MXL where the utility of individual *n* is:

$$U_{nj} = \beta' \ x_{nj} + \eta_n' x_{nj} + \varepsilon_{nj} \tag{2}$$

where x_{nj} is the vector of attributes levels in alternative *j* for the good in question, β is the vector of expected values of the parameters associated with each attribute, η_n is the vector of individual-specific zero-mean random deviations from the expected values β, and ε_{nj} is the random component that has an extreme value Gumbel distribution with variance $\frac{\pi^2}{\lambda^2 6}$ where λ is the scale parameter of the error distribution.

In many applications λ is set equal to 1 because unidenti. Thus each individual has a specific value for each parameter, $\beta_n \ = \beta + \eta_n$ and the unconditional choice probability of individual *n* for the observed sequence of $t \ldots T$ choices is the integral of the product of the logit probabilities over all possible values of β_n (Train, 2009):

$$P_{njT} = \int_\beta \ \prod_t \frac{\exp(\beta_n' x_{njt})}{\sum_i \exp(\beta_n' x_{nit})} f(\beta, \delta^2) d\beta \tag{3}$$

where *j* is the alternative chosen in the choice occasion *t* by respondent *n*, $f(\beta, \delta^2)$is the probability density function (normal in our case) for the preference parameters β_n with standard deviation δ. In order to estimate a RPL model, it is necessary to make an assumption about the distribution of the

β_n parameters in the population. Equation (3) does not have a closed-form solution, but this can be approximated by simulations (Train, 2009). The RPL model allows accounting for taste heterogeneity not linked to observed variables and introduces flexible substitution patterns among alternatives. However, in order to account for the potential correlation in the error structure among utilities, an error component must be introduced. Error component (EC) model (Scarpa et al, 2005) decomposes the random part of utility into two parts:

$$U_{njt} = \beta_n' x_{njt} + \mu_n' z_{njt} + \epsilon_{njt} \tag{4}$$

where μ_n is a vector of random terms with zero mean and whose variance must be estimated, z_{nj} is a vector of observed variables related to alternative j and ϵ_{njt} is the extreme-value Gumbel distributed part of the error term. The variance of μ_n measures the magnitude of the correlation across alternatives.

The combination of RPL and EC results in a probability of individual n choosing the sequence of choices t:

$$P_{njT} = \int_\beta \int_\mu \prod_t \frac{\exp(\beta_n' x_{njt})}{\sum_i \exp(\beta_n' x_{nit})} f(\beta, \delta^2) \varphi(0, \sigma^2) d\beta d\mu \tag{5}$$

Where, $\varphi(0,\sigma^2)$ is the probability density function for the error component parameter β, δ^2, and σ^2 are the parameters to be estimated.

One of the most suitable applications of an EC model is to analyse data from a CE where in each choice set the status quo alternative is included. The status quo is an alternative which displays for each attribute the attribute's level that is currently observed. Indeed, it has been shown that the attitude people have towards the status quo is different from the attitude towards hypothetical designed alternatives (Kahneman et al., 1991). While people are familiar with the status quo the other alternatives are unfamiliar because they are just hypothetical changes. As such they are conjectured in an idiosyncratic manner rather than in a systematic one (Marsh et al. 2011). This real versus hypothetical alternative likely implies a larger variance of the error term for the hypothetical alternatives compared to the status quo and introduces a correlation in the error structure among hypothetical alternatives. An EC model allows accounting for that by setting $z_{nj} = 1$ if j is the non status quo alternative and $z_{nj} = 0$ if j is the status quo alternative. Scarpa et al. (2005, 2007) and Campbell (2007), amongst others since then, show that the error component model with alternative specific constant (ASC) for the status quo outperforms a CL model with ASC. Indeed, an EC model with an ASC allows capturing both systematic status quo effects (through the inclusion of ASC) and a correlation structure among the random part of the utility (through the error component).

As the preferences of Milan's city-dwellers towards the ecological benefits generated by sustainable agricultural practices are likely to be heterogeneous across the population an RPL model is adopted for analysing the data of our CE. In addition, the status quo alternative enters the choice sets in our CE, thus we opt for introducing an error component in the RPL model.

In most environmental economics studies the main interest is to estimate the willingness to pay (WTP) of the individuals for marginal improvements in each attribute. This is carried out by taking the ratio of each 'non-cost' attribute estimated coefficient by the cost coefficient. When the model setting is an RPL, WTP must be approximated by simulations. Daly et al. (2012) outline the importance of choosing a proper distribution for the cost attribute coefficient as many random attribute parameter distributions may lead to a marginal WTP distribution with infinite moments. The authors provide a theorem that allows analysts to check for each possible distribution of the cost coefficient whether the resulting marginal WTP distribution has finite moments. The theorem allows us to state that while the lognormal and Johnson's *Sb* distributions (Train and Sonnier, 2005) always have inverse moments, the existence of the inverse moments for all the other distributions can be assured only by setting bounds to prevent non-zero density around zero.

The ratio of two random coefficients is also a random value, but it might take unrealistic values and hence generate an overly large variance, implying that a share of people is willing to pay an extremely large amount of money to have a marginal improvement in an attribute (Thiene and Scarpa, 2009). In order to avoid this drawback and when the main interest is to derive the WTP estimates, Train and Weeks (2005), following the seminal work by Cameron and James (1987) in discrete choice contingent valuation data analysis, propose re-parameterising utility directly in WTP space, rather than in preference space. This re-parametrisation avoids the problems related to the ratio of two random coefficients. Utility specified in WTP space is:

$$U_{njt} = (\omega_n \alpha_n)' x_{njt} + \epsilon_{njt} \tag{6}$$

where $\alpha_n = \frac{\theta_n}{\lambda_n}$ is the cost attribute coefficient divided by the scale parameter, $\omega_n = \frac{\theta_n}{\theta_n^{cost}}$ is the vector of marginal WTP (henceforth mWTP) parameters directly estimated in the model and ϵ_{njt} is the extreme value Gumbel distribution with variance $\frac{\pi^2}{6}$.

In an RPL model, utility specified in WTP-space requires the researcher to assume the distribution of the WTP for each attribute rather than the distribution of each coefficient of the linear preference-space model. Train and Weeks (2005) compare a model in preference-space (i.e. a model where the parameters are the marginal utilities for each attribute and the WTP are derived taking the ratio) with a model in WTP-space using Bayesian estimation methods and find that the model in preference-space fits the data better than the model in WTP-space. Nonetheless, the model in preference-space implies an unreasonably large variance for the marginal WTP distributions. Scarpa et al. (2008) compare the performance of a preference-space model and a WTP-space model to analyse the choice for outdoor activities destinations in the Alps by using revealed preferences data. Their study shows that WTP-space model outperforms preference-space model both in terms of fitting the data and in terms of avoiding an unreasonably large variance for WTP estimates. The study is also the first application of the simulated maximum likelihood estimator to a WTP-space model. Thiene and Scarpa (2009) show how hypotheses on the size of the variance of random mWTP can be directly tested in simulated maximum likelihood estimation using restrictions on the values of the standard deviation parameters testable with any of the classic specification tests for ML estimators (likelihood ratio, Lagrange Multpliers and Wald tests).

Despite its interesting features, and their recent endorsements, applications of the WTP-space model for the economic evaluation of environmental goods are still less popular than those with preference-space models. As the main goal of our study is to assess the WTP of Milan's city-dwellers for improvement in the adoption of environment-friendly agricultural practices, the WTP-space model represents the most suitable model specification. Thus, our model framework is a RPL-EC model estimated in WTP-space where all the attributes and the error component are assumed to be normally distributed.

Additionally, we perform spatial analysis to check the potential relationship between the individual WTP for each practice and the area where the dweller lives. The idea is to find whether there exists some clustering for WTPs according to the distance between the living area and the periurban area. For each respondent in the sample, we first obtain the individual-specific mean of the mWTP distribution for each of the four practices. Then we match them with the geographical coordinates of the place of residence of the respondent[1] and conduct a spatial analysis of the individual estimates. The spatial distribution of the mWTP is examined using the Moran's index of spatial autocorrelation (Moran, 1950) employing a connectivity matrix that is based on the *k*-nearest (with *k*=5) criterion to define geographical continuity. That is, we assume that each unit has 5 neighbouring units that are the units with the minimum distance to it. As usual, the choice of the criterion for contiguity is at the discretion of the researcher, but in this case, we prefer the *k*-nearest criterion because it results in a uniform distribution of the connections, contrary to minimum-distance methods that result in a distribution in which central observations are overconnected and peripheral ones are isolated[2].

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[1] The database does not allow tracking information on the geographical location of the workplace to complement the analysis.

[2] We tried also the alternative of minimum distance, allowing a threshold distance, such that each unit has at least one neighbour, and the results are robust.

4. Experiment Design and Data

The four environment-friendly practices subject of this investigation represent the four attributes used in the CE. The status quo level of adoption for each practice, together with the analysed improvements and the consequent ecological benefits, are listed in Table 1. For organic farming, besides the current level of adoption (3% of the UAA), we consider a level of 10% and of 20% of the UAA. Currently the percentage of periurban UAA covered by fast-growing trees is 0.5%, and we introduce the possibility to increase it to 2% and 5%. No farm in the periurban area of Milan has planted biodiversity-strips, thus the status quo level is the absence of such strips. In the experiment, we consider the option of having strips between the main crop and the field border. These are either planted with the main crop, but imply a reduced amount of pesticides and fertilisers application, or planted with wildflowers beneficial to pollinators and to wildlife in general. The two levels associated with the cover crop attribute are either the status quo level (no adoption), or cover crop adoption.

The levels of each practice have been defined during focus groups involving local farmers from the periurban area of Milan and after consultations with agronomists. The focus group and the consultations ensured us that the attribute levels employed are reasonable and implementable in the area, adding realism to the proposed scenarios in the choice tasks. In the survey, each of the four environment-friendly practices has been described along with the ecological benefits it brings according to each level. In order to estimate the WTP, a monetary attribute has been added to the CE. Such attribute takes the form of a new local tax that each Milan resident over 18 of age must pay yearly, for seven years, the minimum duration of an agri-environmental policy measure. The proposed tax amounts used as levels were tested in a pilot study on a sample of Milan residents and were eventually set to 5, 15, 30, 50, 70 euro/person/year. The pilot study also allowed us to check the questionnaire's wording, length and coverage.

In the CE each respondent is asked to choose his preferred alternative in each choice task, which consists of three mutually exclusive alternatives, two of which generated using an experimental design, and the third representing the attributes as in the status quo. The alternatives represent a trade-off between the non-monetary attribute levels (the four environment-friendly agricultural practices and their related ecological benefits) and the tax amount the respondent would have to pay to have a policy implemented that can deliver those attribute levels. If the status quo option is chosen, no additional tax has to be paid, and no change in the environmental provision is implemented.

The questionnaire starts with a short introduction on agriculture in the periurban area of Milan together with a map illustrating such area. Respondents are then provided with a detailed description of the four agri-environmental practices, their status quo levels and their experimentally designed levels along with their expected ecological benefits. It is made clear that an improvement over the current level of the practices is conditional on the introduction of a new local tax. Such a tax will be used exclusively to compensate farmers in the periurban area for income foregone due to the adoption of the four sustainable agricultural practices, as described in the selected alternative profile.

In the second part of the questionnaire, survey respondents provide socio-demographic information and respond to questions testing their sensitivity to environmental issues, familiarity with the area under study (the periurban area of Milan) and opinions on the role of agriculture in the periurban area. Before showing the choice sets, an *honesty priming* task is introduced in order to reduce the hypothetical bias issue in the stated preference exercise. Indeed, it has been shown that in a hypothetical setting, individuals are likely to overstate their WTP. The application of honesty priming in CE was first introduced by De-Magistris et al. (2013), who borrowed it from the social psychological literature. Honesty priming aims at automatically activating some mental processes, which unconsciously influence people's perception and evaluation. In our specific case, before eliciting preference from the CE, we expose respondents to a scrambled sentence exercise. In this test, the respondents are asked to compose grammatically-correct and meaningful sentences using words supplied in random order. Such sentences are centred around the concepts of honesty, sincerity, fairness, and truth-revelation. De-Magistris et al. (2013) show that honesty priming outperforms other strategies (cheap talk and neutral priming) in terms of reducing the bias in the estimation of the WTP in a hypothetical CE. The performance of the honesty priming exercise was tested in a pilot study to include eight sentences in the final questionnaire eventually.

Full factorial design for our study implies 72,900 combinations $(3^3 \cdot 2 \cdot 5)^2$ of the attribute levels, which cannot be evaluated at our sample size. Hence, we used a fraction of the full factorial, selected using the criterion of minimising the expected *D*-error, a so-called Bayesian efficient design. Efficient designs aim at obtaining a fraction of the full factorial with a high probability of generating parameter estimates with low asymptotic variance (Hensher et al., 2015). Constructing an efficient design requires minimising some measure of the variance-covariance matrix of the estimator conditional on some prior knowledge of the values of the parameters being estimated. Ferrini and Scarpa (2007) show that, in the context of error component specifications and under the correct specification of priors, efficient designs outperform other common designs in terms of efficiency of the marginal WTP estimates. In our case, prior estimates are obtained from a pilot study and used to generate the efficient design[3]. Of course, the priors represent just a highly uncertain indication of the true parameter values, which remain the final goal of the choice survey. In order to account for the uncertainty of the priors around the true parameter values, we benefit from the Bayesian version of

[3] The experimental design of the pilot study is an optimal orthogonal in the difference (OOD) design, which aims at maximising the differences in the attribute levels across alternatives. OOD design are orthogonal within an alternative but there often exists a negative correlation across alternatives.

the efficient design, which requires researchers to assume *a-priori* the distributions around the unknown coefficients (Scarpa and Rose, 2008).

The final number of choice sets in our survey is 30, and we divide them into 5 blocks with 6 choice sets each. Choice task orders are randomised during the survey, such that two respondents facing the same block face the six choice sets of that block in a different order, so as to avoid position bias.

A market research company administered the questionnaire to 600 people living in the urban area of Milan by an online link, and it guarantees the sample to be representative of the population of Milan residents in terms of gender and income. Due to the online survey administration mode, the older age (>65 years old) is underrepresented, and this is a limitation of this study. Table 2 shows descriptive statistics for some socio-economic variables. Around half of the respondents in the sample are men, 46% hold a university degree, and 71% are employed[4]. The average number of family members in the sample is around three. We identify three income classes according to the ratio between family income and family size: in 45% of the respondents, the per capita income is between 700 and 1,400 euro/month (Middle-Income Class), while in 21% it is greater than 1,400 euro/month (High-Income Class). The remaining 34% of the population has a per capita income lower than 700 euro/month (Low-Income Class). Note that 13% of the respondents are members of an environmental association, denoting the sensitivity of the target population towards environmental issues. The share of respondents that lives in an urban area and visiting the periurban area for leisure is 66% and the average number of leisure visits in the last twelve months was eight. The share that transits through the area is 60%, and the average number of transits is twelve times a year; 37% of the respondents also indicated other reasons for going into the area.

The closing question of the questionnaire asked respondents to evaluate their perceived difficulty in answering it and in choosing the preferred alternative in each choice set using a Likert scale from 1 (easy) to 5 (difficult). The average evaluation was 2.78, indicating that respondents on average did not report substantive difficulty in understanding and compiling the questionnaire.

5. **Results**

5.1 Model 1 results

Table 3 presents the results for the RPL-EC model estimated in WTP space (Model 1). The socio-economic variables are interacted with the status quo, and thus the parameters for these variables denote changes in utility when choosing the status quo alternative compared to the other two

[4] Within Milan municipality the male population is estimated to be 49.7%, the estimated percentage with tertiary degree is 35%, and the estimated employment rate is 94%. Source: statistical office of the Milan municipality, year 2017, data available at http://sisi.comune.milano.it/.

alternatives. Respondents in the middle- and high-income classes and those who are part of an environmental association derive more utility from higher levels of sustainable agricultural practices compared to the status quo level, and this is consistent with other results from the literature (Baskaran et al., 2009). The same happens for men relative to women and those with larger family size. More educated and older respondents are negatively affected by departing from the status quo. On average, the utility of Milan residents is decreased by maintaining the status quo (the ASC parameter is -22.5, and it is statistically significant).

In estimation, all attribute levels are coded as dummy variables for medium and high levels of improvement, in order to capture a potential non-linear (piece-wise linear) relationship between utility and attribute levels. As the model is specified in WTP-space, the estimated coefficients can be directly interpreted as the annual mWTP for the ecological benefits generated by an improvement in each attribute level compared to the status quo situation. The mWTP for these improvements is found to be heterogeneous across respondents for all attributes except for cover crops, as its standard deviation estimate is statistically insignificant. This confirms the suitability of an RPL model, which captures heterogeneity in mWTP unaccounted for by socio-economic variables (unobserved heterogeneity). The standard deviation of the error component is also highly significant (at 1% significance level) indicating higher utility variance and a correlation across utilities from alternatives different from the status quo. Respondents evaluate their utility from experimentally designed alternatives and the status quo with vastly different variance, and this variation in perception concerns both the deterministic part of utility (the ASC is statistically different from zero) and the random part (the standard deviation of the error component is statistically different from zero).

The average annual mWTP is positive and significant at 1% for each attribute level, indicating that on average urban residents in Milan are interested in improving the ecological benefits derived from an increase in the adoption of environment-friendly agricultural practices in the periurban area. They display an mWTP for marginal improvement ranging between 5.6 euro/person/year (for having strips between main crop and field border with a reduced application of chemicals) to 16.3 euro/person/year (for having strips on the field border sown with wildflowers to support biodiversity). In addition, for the quantitative attributes that have three levels (organic farming and fast-growing trees), the average mWTP is higher when referred to the highest level of the attribute compared to the medium level, and this is consistent with the theory of increasing utility producing higher benefits. Additionally, according to the law of decreasing marginal utility, the average mWTP for improvement from the status quo level to the medium level of each attribute is larger than the mWTP for raising from the medium to the highest level.

These results are different from the one found in Sanyé-Mengual et al. (2018) analysing the preferences of the citizens of Bologna towards urban agriculture. Although Sanyé-Mengual et al. (2018) use a different methodology and their focus is broader than just the ecological benefits, their study concludes that residents in Bologna are more interested in the socio-cultural services provided by urban agriculture rather than in environmental services. In addition, they outline that Bologna residents seem more willing to buy produce from urban agriculture rather than from elsewhere.

In order to compare the welfare changes associated with simulated policy programmes, we use the compensating surplus formula:

$$CV = V^1 - V^0$$

where V^0 and V^1 are the deterministic part of the utility before and after the policy programme implementation respectively. Each policy programme is represented by a different combination of the attribute levels. The average mWTP (compensating surplus) to move simultaneously from the current level to the medium level of all the attributes is 39.8 euro/person/year on average. If we consider the WTP to simultaneously move from the current level to the highest level of all the environment-friendly practices, we obtain an average of 56.9 euro/person/year.

These numbers show that on average Milan dwellers derive rather high utility from the adoption of sustainable agricultural practices in the periurban area. Despite the difference in magnitude, an increase of all four practices analysed over the current level generates ecological gains representing substantial benefits to the city. It is plausible that benefits are also produced for those living outside the city.

Although the average mWTP for each attribute is positive and rather high, there are variations across respondents (the standard deviations are statistically significant for all the attributes except for cover crops). If we look at the share of the population with a positive mWTP (Table 4), we notice that more than 99.9% of the respondents is willing to pay for reducing nitrogen leaching, either by supporting an increase in the organic farming area up to 10% of the UAA or by supporting the cover crop adoption. The share of the population showing a positive mWTP for expanding the planting of fast-growing trees to 2% of the UAA is 99.8%, and the share in favour of promoting biodiversity strips by reducing the applied amount of chemicals is 91%. The other three attributes (20% of UAA under organic farming, 5% of UAA under fast-growing trees and biodiversity strips with wildflowers) are supported by a share of the population ranging between 77% and 79%. It can be observed that for the quantitative attributes with three levels (organic farming and fast-growing trees), while almost all Milan dwellers have a positive mWTP to improve up to the medium level, around 20%-22% of them experience a decrease in utility if the highest level is adopted. In both cases, this may be associated to the fear that converting 20% of UAA to organic agriculture and 5% to fast-growing trees may imply a drop in yield and thus less availability of locally-grown produce. This hypothesis may also explain why 21% of the population is unwilling to pay for biodiversity strips sown with wildflowers. The presence of cover crops does not compete with production, and thus more than 99.9% of the population is estimated to have a positive mWTP.

5.2 Model 2 results

We also re-estimated the model by including interaction terms between each attribute WTP coefficient and the dummies for income classes. The goal, in this case, is to check whether income per family member (calculated as the ratio between family income and family size) affects the average mWTP for each attribute while assuming the same standard deviation across the income classes. This is a validity check grounded on economic theory.

Results of this model (hereafter Model 2) are reported in Table 3. Most of the socio-economic variables show the same sign, statistical significance and order of magnitude as in Model 1. The only exception is represented by age, whose negative sign indicates that older respondents experience lower utility when the status quo is unchanged, which is the opposite finding with respect to Model 1. The first block of expected values for the attribute coefficients denote the estimated mWTP for respondents belonging to the low-income class. The mWTP of the other two income classes are obtained by adding to these expected values the corresponding average deviation of WTP reported under the headings "Interaction terms with the dummy for the middle-income class" and "Interaction terms with the dummy for the high-income class". The unobserved preferences heterogeneity is assumed to be the same across the three income classes; so, there is only one set of standard deviation coefficients. The variance of the error component is also assumed to be the same across income classes.

The mWTP of the low-income class is positive and significant for all attributes with the exception of having 2% of UAA under fast-growing trees, which is statistically insignificant. The highest mWTP is for the two attributes already estimated in Model 1: 20% of UAA under organic farming and biodiversity strips with wildflowers. The range of mWTP is between 4.2 euro/person/year (2% UAA under fast-growing trees) and 26.2 euro/person/year (20% of UAA under organic farming).

Middle-income respondents do not have the same preference rank as low-income ones. Indeed, for the two most preferred agri-environmental practices of the latter, the former are willing to pay almost 12 euro/year less on average (45% less) for raising organic farming up to 20% of the UAA and 6.6 euro/year less (35% less) for biodiversity strips with wildflowers. On the other hand, this group seems to be more interested in the ecological benefits provided by the fast-growing trees area as its mWTP for increasing to 5% the UAA under fast-growing trees is 74% higher than that of low-income respondents.

The high-income group also shows a lower preference for organic farming compared to the low-income one, as its mWTP for the ecological benefits of raising the UAA under organic farming to 20% is nearly 8 euro/person/year lower. Compared to the low-, the high-income respondents exhibit a more considerable increase in utility for fast-growing trees. Opposite to Model 1, in Model 2 the standard deviations of the coefficients for the 2% of UAA planted with fast-growing trees and for biodiversity strips without chemicals are insignificant. This suggests that the unobserved heterogeneity in WTP for these two attributes detected in Model 1 vanishes when allowing for the average mWTP to vary with income classes. The standard deviation of the error component is still significant.

In all the three income groups, more than 99.9% of the population has a positive WTP for the ecological benefits provided by cover crops (Table 4). 98.3% of the low-income population shows a positive mWTP for extending the UAA with fast-growing trees up to 2% and nearly 90% is in favour of having 20% of UAA under organic agricultural practices. More than 99.9% of Milan dwellers in the middle- and high-income classes have a positive mWTP for having a 2% of UAA under fast-growing trees and just below 90% for increasing this land use to 5% of UAA. For all other attributes, the share of the population with positive mWTP is between 70% and 80% in the three income groups. The only exception is the high-income group, which has a positive mWTP for biodiversity strips with the application of a reduced chemical in 64% of the population only.

5.3 Spatial analysis

The results from the spatial analysis are presented in Table 5 and suggest that there is no spatial autocorrelation in the data. The pseudo *p*-value is always larger than the standard threshold for significance (5%), and the hypothesis of spatial randomness in the distribution of the individual WTP can never be rejected. The result holds for all the four agri-environmental practices considered in the study. This suggests that proximity to the periurban area does not act a segregating variable in terms of the estimated mWTPs at the individual level. In practice, the perceived benefits from the proposed policy measures are not geographically clustered across the city.

6. Discussion and Conclusions

Our study aims at evaluating the marginal willingness to pay (mWTP) of urban dwellers in Milan for ecological benefits generated by farmers in the periurban area when they adopt specific environment-friendly agricultural practices. Specifically, we focus on ecological benefits that most of the urban residents should already be familiar with because they are prominent in the public debates (nitrogen leaching, carbon sequestration, biodiversity, etc.).

The four agricultural practices generating such benefits that we study are AEMs belonging to the RDP of the Lombardy Region, the local authority in charge of their implementation. To increase saliency and realism, we consider agri-environmental practices already included in the current regional policy programme because we intend to evaluate the support for the adoption of readily implementable practices in the periurban area of Milan. Indeed, from perspective of the city population's the four sustainable agricultural measures considered are currently under-adopted by periurban farmers, despite their availability as an option in the regional policy programme.

Our results suggest that most of Milan residents would clearly benefit from the ecological consequences of extending these measures, and most residents have a positive mWTP for supporting their adoption. In particular, the average mWTP ranges between 5.6 euro/person/year (for biodiversity strips with a reduced application of chemicals) to 16.3 euro/person/year (for biodiversity strips with wildflowers). Although some previous studies (Jansen et al., 2019; Novikova et al., 2017) showed the interest of urban dwellers towards agri-environmental practices, none of them focussed on the preferences towards ecological benefits provided by specific agricultural practices in the periurban farming area. Therefore, we cannot compare our results on mWTP with the literature and this represents the novelty of our study. We find that mWTP is heterogeneous across the population and, as expected, that respondents hold different perceptions of the status quo alternative and hypothetical alternatives. The use of an RPL-EC model was found to be a suitable specification to analyse the observed choice data obtained from the CE, while our focus on mWTP motivates the estimation of a model with utility in WTP-space. The estimated distributions of means of mWTP in the sample turn out to be correlated with per capita income. Indeed, respondents belonging to different income classes rank agricultural practices differently in terms of their benefits. Finally, the individual mWTPs do not show any systematic spatial correlation pattern, as the results of the Moran's index cannot reject the null hypothesis of no spatial autocorrelation for each of the practices, so they are geographically unclustered.

The evidence in this study points to the need for specific policy measures to support agriculture in urban and periurban areas and preserve the functioning of the ecosystem services it produces. The value of periurban farming areas and of their related agricultural activities is already broadly acknowledged, especially in relation to the services of food provision and to the recreational and cultural opportunities provided to the community (Zasada, 2011a). Such a value is easy to maintain notwithstanding the increasing pressures from urbanisation to which periurban areas are exposed, especially in metropolitan areas like Milan. That is, while farmers are rewarded for their food provision service, the provision of cultural and recreational activities is compensated typically by an entry fee (van Zanten, 2014; Ives and Kendal, 2013). In contrast, there is no market-related compensation for the mostly off-site ecological services provided, and the incentive currently provided by the existing policy instruments are obviously sub-optimal as they result in under-adoption of ecological practices.

By estimating the economic value that city dwellers derive from the ecological benefits produced by periurban farming, we want to emphasise the economic inefficiency of the current policy scheme, and call for a more refined spatial targeting of the farm policy. In our view, this could be achieved in two ways. The first is by local co-financing: Agri-environmental policies are co-financed by the EU, but their management is assigned to regions that define the measures to be adopted and the budget for their financing. Given the high interest of urban dwellers towards the adoption of these measures in the periurban farming area, policymakers could decide to integrate the financing of specific measures of interest in periurban farming areas through a local co-financing scheme for specifically approved projects. The second way is the design of measures with compensation values differentiated by area. In this respect, this study offers preliminary evidence about the economic benefits derived by city dwellers, while the incentives for farmers are only indirectly analysed. More research is needed, therefore, to first understand how much the benefits related to these practices vary between urban and non-urban dwellers and, second, to explore the willingness to accept of urban farmers for the adoption of specific agri-environmental practices and the action necessary o remove potential obstacles to their adoption.

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Table 1. Attribute definition, ecological benefits and attribute levels

Attributes	**Label**	**Ecological benefits**	**Attribute levels**
Organic farming (% of the UAA)	Org	Reduction in nitrogen leaching in the soil and reduction in the nitrous oxide emissions (greenhouse effect 298 times higher than carbon dioxide)	3% (status quo) 10% 20%
Fast growing trees plantation (% of the UAA)	Fore	Carbon sequestration, refreshing, shadowing	0.5% (status quo) 2% 5%
Biodiversity-strips	Strips	Effects on the farmland bird population and on pollinators	Absent (status quo) strips sown with the main crop but treated with a reduced amount of fertilisers and pesticides strips sown with wildflowers beneficial for the farmland birds and pollinators
Cover crops	Covercr	Reduction in the nitrogen leaching in the soil	Not adopted (status quo) adopted
Tax on each citizen older than 18 years (euro/person/year)	Tax		5 15 30 50 70

Table 2. Descriptive statistics

		Mean	standard deviation
Age		42.2	14.6
Male		0.52	0.50
University Degree		0.46	0.50
Middle-Income Class (family income/family size 700 -1,400 euro/month)		0.45	0.50
High-Income Class (family income/family size > 1,400 euro/month)		0.21	0.40
Employed		0.71	0.45
Family Size		2.9	1.2
Environmental Association Membership		0.13	0.34
Number of Visits in the area	For leisure	8.3	37.9
	For transit	12.2	54.6
	For other reasons	5.5	34.6

Table 3. Model parameters in WTP-space

	Model 1		Model 2	
	Estimate	Std. Error	Estimate	Std. Error
ASC (status quo)	-22.5	7.2 ***	25.4	8.9***
Age	0.2	0.1 ***	-0.4	0.1***
Degree	13.8	2.4 ***	8.9	2.6***
Occupied	2.2	2.6	-1.4	2.8
Family Size	-6.4	1.5 ***	-9.3	1.6***
Middle-Income Class	-14.4	2.9 ***	-30.5	5.5***
High-Income Class	-26.6	3.8 ***	-31.5	7.3***
Male	-21.1	2.5 ***	-15.2	2.3***
Number of Visits	0.0	0.0	-0.0	0.0
Env. Assoc. Membership	-19.0	3.3 ***	-21.5	4.5***
Expected values of the coefficients for the attributes				
10% UAA organic	13.5	1.5 ***	11.4	2.8***
20% UAA organic	15.8	1.4 ***	26.2	2.5***
2% UAA forest	9.0	1.5 ***	4.2	2.7
5% UAA forest	13.2	1.6 ***	10.9	2.9***
Biodiversity strips- reduced chemicals	5.6	1.5 ***	7.4	2.8***
Biodiversity strips- wildflowers	16.3	1.4 ***	18.6	2.9***
Cover crops	11.6	1.2 ***	16.1	2.3***
Interaction terms with the dummy for the Middle-Income Class				
10% UAA organic			-0.0	3.6
20% UAA organic			-11.8	3.0***
2% UAA forest			5.6	3.6
5% UAA forest			8.1	3.6**
Biodiversity strips- reduced chemicals			2.8	3.6
Biodiversity strips- wildflowers			-6.6	3.8*
Cover crops			-1.3	2.8
Interaction terms-with the dummy for the High Income Class				
10% UAA organic			2.1	4.3
20% UAA organic			-7.7	4.5*
2% UAA forest			16.6	4.8***
5% UAA forest			7.4	4.9
Biodiversity strips- reduced chemicals			-2.9	4.6
Biodiversity strips- wildflowers			-1.7	4.6
Cover crops			-1.3	3.6
Standard deviation of the coefficients for the attributes				
10% UAA organic	3.7	2.0 *	16.0	1.5***
20% UAA organic	19.8	1.6 ***	22.0	1.6***
2% UAA forest	3.2	1.9 *	2.0	1.7
5% UAA forest	17.5	1.6 ***	16.1	1.2***
Biodiversity strips- reduced chemicals	4.2	1.8 **	12.7	1.7
Biodiversity strips- wildflowers	20.7	1.6 ***	23.5	1.6***
Cover crops	2.4	1.5	0.5	1.3
Error component	74.1	4.7 ***	91.1	4.7***
Number of observations	*3600*		*3600*	
Log Likelihood	*-3019*		*-3007*	

***,**,* indicate 1%, 5% and 10% confidence level respectively

Table 4. Share of the population with a positive WTP

	Model 1	Model 2		
		Low Income Class	*Middle Income Class*	*High Income Class*
10% UAA organic	>99.9	76.1	76.1	79.93
20% UAA organic	78.7	88.27	74.2	79.65
2% UAA forest	99.8	98.27	>99.9	>99.9
5% UAA forest	77.4	75.169	88.07	87.26
Biodiversity strips- reduced chemicals	91	71.89	78.8	63.67
Biodiversity strips- wildflowers	78.5	78.5	69.49	76.1
Cover crops	>99.9	>99.9	>99.9	>99.9

Table 5: Moran's I of the individual WTP for different benefits of peri-urban agriculture

	10% UAA organic	20% UAA organic	2% UAA forest	5% UAA forest	Biodiversity strips-reduced chemicals	Biodiversity strips-wildflowers	Cover crops
I	0.0042	0.0169	-0.0145	0.0384	-0.0001	0.0155	0.033
(pseudo p-value)	(0.392)	(0.239)	(0.307)	(0.056)	(0.472)	(0.257)	(0.080)

Note: The expected value of the Moran's I, that depends uniquely on the sample size, is equal to -0.0017 in our case. The pseudo p-value refer to the null hypothesis of spatial randomness and is computed with the permutation procedure (Cliff and Ord, 1981).

Figure 1. Land use by main categories in Milan metropolitan area (municipality borders defined by the red line)