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Editorial for the special issue entitled: New advances in spatial econometrics: Interactions matter

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Editorial for the special issue entitled: New advances in spatial econometrics: Interactions matter

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This Regional Science and Urban Economics special issue collects together a subset of contributions presented in the 15th edition of the *International Workshop in Spatial Econometrics and Statistics*, which was organized by the Department of Economics of the University of Orléans (Laboratoire d'Economie d'Orléans – UMR CNRS 7322) on May 26-27 2016.

This annual workshop series was inaugurated by Christine Thomas-Agnan in 2002 in the University of Toulouse-Capitole on a one-day basis and was composed of invited presentations only. The second edition was organized by Catherine Baumont and Cem Ertur in Dijon, under the same format. From the third edition held in Strasbourg in 2004, the workshop opened to unsolicited contributions, which quickly became a key event for interactions among senior researchers, junior researchers and PhD students interested in spatial econometrics and statistics. Its success, never denied since, compelled the organisers of the subsequent editions[1] to extend the initial length to a two-day meeting. Each year, some world-reknown keynote speakers were invited, which contributed to maintain the high-quality level of this workshop and provided outstanding opportunities for participants to discuss their research with worldwide specialists of the field of spatial econometrics. The keynote speakers of this 15th edition were Professors Lung-fei Lee (Ohio State University) and James LeSage (Texas State University). Thanks to their availability and involvement in the workshop, participants had been offered many occasions to benefit from their complementary approaches on spatial econometrics. Further, both Lung-Fei Lee and James LeSage had kindly made their contributions to this special issue.

On October 9, 2016, it was with much sadness to learn of the passing of Cem Ertur, a founding member of this annual workshop, due to a prolonged illness. Cem Ertur devoted his scientific career to the modeling of cross-sectional dependence (interactions between statistical units) in econometrics specifications. The methodological approach on which his research has been based is the spatial econometrics framework. Notably through Cem's work, this framework, originally confined to regional science, has spread to other fields such as macroeconomics, international economics, international finance or peer effects to name a few. Indeed, Cem has always been convinced that spatial autocorrelation (in the geographical sense) was only a particular case of cross-sectional dependence that could be modeled with spatial econometrics specifications. He believed that the spatial econometrics methodology has been designed to account for interactions between individuals (in a broad sense), with these interactions potentially being based on geographic proximity, economic, cultural, linguistic or institutional similarities. He would have liked to rename spatial econometrics as *econometrics of interactions*, to fully acknowledge the richness of this methodological approach in accounting for effects individuals may have on each other.

Cem Ertur's research on interactions between individuals (in a broad sense) started in the early 00's with papers dedicated to the economic convergence among European regions. In 2003, Cem Ertur and Julie Le Gallo performed an Exploratory Spatial Data Analysis (ESDA) on the distribution of regional per capita GDP in Europe over the period 1980–1995. This exploratory work has been extended to the enlargement process in a 2006 paper that Cem Ertur wrote with Wilfried Koch. In 2003, Cem Ertur also contributed to three chapters in the European Regional Growth book edited by Bernard Fingleton (Le Gallo et al., 2003; Baumont et al., 2003; Ertur and Le Gallo, 2003a). Coming back to 2006, jointly with Julie Le Gallo and Catherine Baumont, Cem Ertur analysed the presence of convergence clubs and the influence of spatial dependence over the European regional growth. This work has been pursued in 2007, with Julie Le Gallo and James LeSage, in a paper where a local model for European regional convergence is tested against a global alternative. Finally, in 2009, in a contribution with Julie Le Gallo, Cem Ertur studied the importance of spatial heterogeneity and spatial dependence to explain European regional growth. Having shown the important role that spatial dependence is playing in the growth process, Cem felt the need to integrate this cross-sectional dependence in macroeconomic theory models. In 2007, Cem Ertur and

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[1] Toulouse (2005), Grenoble (2006), Dijon (2007), Paris (2008), Besançon (2009), Orléans (2010), Toulouse (2011), Avignon (2012), Orléans (2013), Toulon (2014) and Paris (2015).

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Wilfried Koch introduced interactions between countries within the neoclassical growth theory model. In a 2011 paper, they included interactions between countries in the Shumpeterian growth model, which, among others, led to an econometric specification containing the neoclassical growth theory as a special case. Cem Ertur also contributed to the modeling of interactions in international economics. In 2012, Kristian Behrens, Cem Ertur and Wilfried Koch developed a quantity-based structural gravity equation with imbedded interactions in both trade flows and error terms. This paper is also a rare contribution in which the interaction matrix has been derived from economic theory.

Cem's research also focused on methodological development in spatial econometrics. In a 2005 paper, written with Catherine Baumont, Julie Le Gallo and Sandy Dall'erba, Cem Ertur studied the diffusion's properties of the spatial error model. In 2010, with Nicolas Debarsy, he developed Lagrange Multiplier statistics to help the applied researcher to choose between the spatial autoregressive and the spatial error specifications in a fixed effects panel data model, while in 2012, with Nicolas Debarsy and James LeSage, he proposed economic interpretations of the Spatial dynamic panel data model. Cem also focused on the relative role of the so-called strong and weak spatial dependence (see among others Pesaran and Tosetti, 2011; Chudik et al., 2011) in international technology diffusion. This question led to an article written with Antonio Musolesi in 2017.

In addition of having pursued a distinguished scientific career, Cem has always highly valued the academic institution. Soon after he arrived in the Department of Economics of Orléans in 2006, he joined the Department council. In 2013, he got elected as dean of the Faculty of Law, Economics and Management. As such, he has been acknowledged for his vision of the institution, the time devoted to listen each person's opinion and for his perpetual quest of the collective interest.

Cem has been a loyal, righteous colleague and friend. He loved to interact and confront his point of view while knowledge sharing was a fundamental feature of his scientific personality. Under his shell, he was a very empathic person, always supportive, respecting each person's individuality. He also was a brilliant mind, constantly preferring the general interest over individual satisfactions. He left no one untouched and he will be deeply missed by all those who once have had the privilege to meet him.

On March 1, 2017, we were also saddened to learn of the passing of Raymond Florax. Raymond contributed very frequently to the International workshop on Spatial Econometrics and Statistics and was invited several times as a keynote speaker. Raymond is an established and widely recognized researcher in spatial econometrics, for his high level and insightful publications, his pleasure and interest for discussions, and for his involvement in the regional science community by serving as editor-in-chief of "Papers in Regional Science" for a ten-year tenure. Raymond is a very accessible person and would always spend time for junior researchers. His passing causes an important loss to the scientific community but it does not compare in any way to the suffering of his relatives.

This special issue is dedicated to our two dear friends that passed away at a much too young age and to their family.

This special issue consists of a subset of papers that were presented in the 15th edition of the International Workshop on Spatial Econometrics and Statistics, which covers methodological as well as applied questions in spatial econometrics. All the papers included in this special issue were handled in an identical manner as any of the regular publications in the *Regional Science and Urban Economics*. We would like to take this opportunity to thank the Editor, Professor Daniel McMillen, for having accepted this special issue proposition, all the involved referees for their careful reading of the manuscripts, and all the authors for their scholarly contributions. The following gives a brief summary of each of the 10 papers contained in this special issue.

The paper by Shi and Lee (2018) develops asymptotic properties of quasi-maximum likelihood estimator of spatial panel data models with time-varying and endogenous connectivity matrices and unobserved common factors. This innovative contribution allows to solve simultaneously several important econometric issues applied researchers might face. First, it allows for common factors instead of individual time-constant and common time-varying effects. The literature has shown that common factors are a more flexible way to model unobserved heterogeneity as unobserved time factors are allowed to have a heterogeneous impact on each individual (heterogeneous factor loadings) (see Bai, 2009). Secondly, the specification allows for time-varying and endogenous connectivity matrix. This feature is no less important than the former as the use of spatial econometrics methods has spread to many economic fields, where the links (interactions) between individuals based on economic, cultural, institutional variables may be more meaningful than geographic proximity. For instance, in finance, interactions between financial institutions will be better apprehended when based on some economic variables, such as size similarity, portfolio composition rather than based on geographic proximity. However, these socio-economic based connectivity matrices may suffer from endogeneity, an issue also treated in the paper. The advantage of the proposed approach by Shi and Lee (2018), based on Qu and Lee (2015) is that no additional external instruments are required to obtain consistent estimators. In addition to deriving the asymptotic properties of their proposed specification, the authors present Monte Carlo results that show the good performance of their QML estimation method and empirically apply their model to examine the effects of house price dynamics on reverse mortgage origination rates in the United States.

Jin and Lee (2018) develop outer-product-of-gradient (OPG) tests for spatial autoregressive models, based on either the quasi-maximum likelihood approach (variant of LM statistic) or GMM (variant of the gradient test). In contrast to the traditional LM tests, the OPG-based tests are robust against distributional misspecifications and unknown heteroskedasticity. Born and Breitung (2011) and Baltagi and Yang (2013) were the first to introduce OPG variants of LM tests to spatial econometrics model, but they restricted their attention to simple scenarios where the model under the null hypothesis can be estimated by OLS.[2] This paper extends this approach to give tests for one type of spatial dependence allowing the existence of the other type in the model. For these hypothesis tests, the standard OPG tests are not valid as some orthogonality conditions are missing. Jin and Lee (2018) propose to use the formula of the $C(\alpha)$-type statistics (see Neyman, 1959) to derive systematically valid OPG variants of tests statistics for SARAR models with homoskedastic or heteroskedastic disturbances. Particularly, they derive score-based and gradient-based OPG tests for SARAR models with homoskedastic disturbances, and robust OPG tests for models with unknown heteroskedastic disturbances. Those OPG statistics are also distribution free and easy to compute. Their Monte Carlo experiments indicate that OPG tests with QML and GMM estimates have good size properties and are generally powerful.

LeSage and Chih (2018) concerns with Bayesian estimation of spatial panel models with spatially heterogeneous coefficients. Thanks to the greater availability of longer time data for panel models, the spatial econometrics literature has recently developed interests for heterogeneous spatial autoregressive panel data models. Aquaro et al. (2015) are the first to develop the quasi-maximum likelihood estimator of a heterogeneous spatial autoregressive (HSAR) panel data model. This HSAR specification allows all model parameters (i.e., the spatial lag parameter, the regression coefficients, and the error variance) to vary over individuals. In their paper, Aquaro et al. (2015) show the consistency of the developed estimators as well as their asymptotic normality. Still in the static spatial autoregressive panel data framework, Blasques et al. (2016) derive the asymptotic properties of a specifi-

[2] Born and Breitung (2011) and Baltagi and Yang (2013) consider LM tests for no spatial dependence in *(i)* a spatial lag dependence (SLD) model, *(ii)* a spatial error dependence (SED) model, or *(iii)* a linear regression with both SLD and SED (or a SARAR model).

cation where the spatial autoregressive parameter varies over time. LeSage and Chih (2018) extend the likelihood framework of Aquaro et al. (2015) to Bayesian framework and set forth a Markov Chain Monte Carlo estimation methodology. LeSage and Chih (2018) argue that their methodology is advantageous over the quasi-maximum likelihood framework both in terms of MCMC estimation and the ability to impose Bayesian priors on the model parameters. In addition to considering the HSAR specification, LeSage and Chih (2018) also study the heterogeneous spatial Durbin model (HSDM). Building on LeSage and Chih (2016), they further compute marginal effects in these heterogeneous models and the associated measures of dispersion. Finally, Monte Carlo results are presented for the finite sample performance of their methodology, and an empirical illustration is given by estimating a US state-level monthly wage-curve over January 2011 to July 2016 period, where a significant heterogeneity is found in state-specific spatial autoregressive parameter and unemployment rate elasticity.

The paper by Geniaux and Martinetti (2018) also concerns the parameters stability across individuals, but in a cross-section framework. They propose a new methodology to deal simultaneously with spatial autocorrelation and spatial heterogeneity embedded in spatially varying coefficients. It is well known in the literature that it is difficult to disentangle between these two characteristics of geo-coded data. In the cross-sectional framework, this has been the focal point in several contributions (see among others Fotheringham et al., 2002; McMillen, 2003, 2012; Pace and LeSage, 2004; Basile et al., 2014). However, up to now, the models developed in the literature do not allow for mixed cases, where only a subsets of coefficients would be heterogeneous. Further, the computational burden associated to the estimation of the developed approaches is high. Geniaux and Martinetti (2018) introduce a new class of data generating processes (DGP), called MGWR-SAR (mixed geographically weighted regression for spatial autoregressive) models in which the regression parameters and the spatial autocorrelation coefficient may vary over space. The estimation of these new models relies on the spatial two-stage least squares (S2SLS) technique (for further details, see Kelejian and Prucha, 1998, 1999). Geniaux and Martinetti (2018) perform an in-depth Monte Carlo analysis to assess the performance of classical models as well as their proposed heterogeneous coefficients models, devoting special attention to simulate data under the realistic assumption of possibly multicollinearity problems and/or misspecification of the covariates. Furthermore, they suggest a specification procedure to identify the correct spatial weight matrix for DGPs with spatial heterogeneity and spatial autocorrelation. They conclude with an empirical study on Lucas county house prices, confirming the good performance of the proposed estimators.

Yang and Lee (2018) investigate theoretically and empirically the interactions of public safety spending among spatially related local jurisdictions in a framework of simultaneous move game. Their theoretical arguments hinge on two characteristics: i) criminals can move and commit crimes in adjacent cities, ii) they will be punished no matter in which city they are caught. Consequently, the crime incidents in one city may be influenced by the public spending on safety in a neighboring city in two ways. On the one hand, as a neighboring city of A spends more on public safety, it is relatively more likely for a criminal to be caught in the neighboring city, driving criminal activities to A. This is the "substitution effect". On the other hand, a larger public safety spending in a neighboring city makes it less likely to receive payments (or utilities) from criminal activities and reduces the total number of crime incidents in any city, which is similar to the "income effect" in consumer theory. Using a function approximation of the equilibrium strategies, Yang and Lee (2018) derive several econometric models, including the one under incomplete information with correlated privately known characteristics. Confronting these specifications to data on municipal governments' spending on public safety in North Carolina, they found significant negative interaction effects. Specifically, strategic interactions induce a reduction of municipal public safety spending by 7.2404% on average, and for a one million-dollar increase in public safety spending of a neighboring city it is expected that a municipal government lowers its own spending by 0.0927 million dollars, showing strong "free-riding" effects.

Fischer and Pfaffermayr (2018) investigate the impact of migration on regional income growth and convergence across European regions in the aftermath of the enlargement in 2004. To uncover the causal effect of migration on regional economic growth, the authors consider a spatial systems of equations, which accounts for spatial interactions between regions (due to migration) as well as interdependency between income levels and migration.[3] The spatial system estimates obtained support neoclassical models, which predicts that, in the absence of brain drain, migration promotes convergence in income per worker. This is caused by an increase in capital-to-labor ratios in lagging regions due to emigration of workers to richer regions in Europe (see Barro et al., 1991; Barro and Sala-i Martin, 1992, 2004). In addition to identify β-convergence, the spatial system of equations developed by Fischer and Pfaffermayr (2018) also allows to study income per worker σ-convergence. The authors then confront their theoretical model by studying the convergence process of 270 NUTS-2 European regions between 2004 and 2010. They estimate the spatial systems of equations by the feasible generalized spatial three-stage least squares estimator developed by Kelejian and Prucha (2004). The empirical results indicate that migration has a more pronounced effect on σ- than on β-convergence.

Fiaschi et al. (2018) study the spatial agglomeration dynamics in European regions and the main sources of spatial externalities. The presence of spatial clubs in European regions may have crucial implications on several debated issues in the literature. While the evidence supports core-periphery models advanced by the New Economic Geography (see, e.g. Fujita et al., 1999), it challenges the commonly accepted growth model of (conditional) convergence (see, e.g. Barro and Sala-i Martin, 2004). Moreover, the existence of spatial dependence raises the question of which type of spatial dependence characterizes EU regional growth, i.e. if spatial externalities are mainly driven by geographical, technological, social or institutional proximities. Through the analysis of a sample data consisting of 224 regions over 22 periods (1991–2012) based on an extended Moran scatterplot referred to as the *local directional Moran scatterplot* (LDMS) with an innovative spatial weight matrix, the authors find evidence for the existence of three spatial clubs (instead of two in the literature): the first mainly populated by regions belonging to the former Eastern Bloc countries, the second by regions of the Southern Mediterranean countries (Portugal, Italy, and Spain) and the third by regions of other EU countries (notably Germany, France, UK and Northern European countries), resulting in a twin-peaked distribution of GDP per worker in 2012. The authors further conclude that the spatial externalities appears to be mainly driven by geographical, technological and social proximities, but only marginally by institutional proximities. They perform a forecast exercise for the 30-year ahead GDP per worker distribution and the results suggest a weak convergence among the three clubs and a persistent spatial agglomeration in the future.

Ciccarelli and Elhorst (2018) estimate a dynamic spatial Durbin panel data model with common factors based on a data set covering 69 Italian provinces over the period 1877–1913, to explain the non-stationary diffusion process of cigarettes consumption. The adopted econometric specification takes into account both weak and strong cross-sectional dependence, with the former being modeled by spatial weight matrix and the latter by common factors defined as the cross-sectional averages of the current and lagged dependent variables and the current independent variables (see Pesaran, 2006, for further

[3] The endogeneity of migration and economic growth has been established in early works, such as Greenwood (1978).

details in the non-spatial case). Their econometric model results from a series specification tests, using the specific to general approach: weak and strong cross-sectional dependence tests (Pesaran, 2015; Bailey et al., 2015), followed by the cross-sectionally augmented Dickey-Fuller (CADF) statistic (Pesaran et al., 2013) and the spatial stability test (Yu et al., 2012; Elhorst, 2014). The authors finally interpret their empirical findings by computing short and long term impacts based on the reduced form of their specification. They find that cigarette demand is a normal good with a long-term total income elasticity of 0.385 and a long-term total price elasticity of −0.392. These results can be further decomposed in long-term direct and indirect effects, which takes the respective values of 0.076 and 0.309 for income elasticities and values of −0.537 and 0.145 for price elasticities.

The paper by Alivon and Guillain (2018) studies the effect of the spatial organization of the urban area of Marseille – Aix-en-Provence on unemployment. A Bayesian spatial autoregressive probit model with Markov Chain Monte Carlo method of estimation is applied to two data sets extracted from the 2009 Census of Population and FiLoSoFi. The adopted model and method allow to account for two central determinants of individual employment: the peer effects and the neighborhood effects. Further, the authors deal with the endogeneity of location choices on employment by considering only young people still living with their parents, an approach advocated among others by O'Regan and Quigley (1996, 1998). Alivon and Guillain (2018) first corroborate standard results of labor economics that intrinsic individual characteristics affect the outcome on labor markets. The probability of being employed is higher for non-immigrant, highly-educated men. Moreover, the authors show the relevance of peer effects as geographically close neighbors have an influence on the employment outcomes at individual level. Finally, by considering different types of neighborhoods, characterized by their wealth's degree, Alivon and Guillain (2018) show that the spatial structure impacts the probability of finding a job. Residing in a deprived neighborhood indeed decreases the probability of being employed for young adults still living with their parents.

The paper by Franco and Macdonald (2018) concerns the measurement and valuation of urban greenness. While there is extensive empirical work on the valuation of open spaces and green amenities in the housing market, research in the context of the urban environmental literature is challenged by the necessity of highly detailed spatial data. If households value the overall greenness of their residential neighborhood, there should be a positive capitalization through housing values of these landscape attributes. Yet, a valuation of the green amenities requires the development of measures of neighborhood greenness that incorporate the various dimensions of green cover and also capture the extent of green coverage for residential properties in an urban neighborhood context. This paper examines the role of remote sensing techniques in creating tree canopy coverage measures for neighborhood green spaces in Lisbon (Portugal). These measures typically serve as explanatory variables in a hedonic valuation model. The authors also explore how these variables interact with the additional GIS (Geographic Information System) variables to obtain enhanced measures of urban environment. The remote sensing techniques provide an accurate tool to classify urban tree canopy coverage and vegetation and lead to a cheaper and faster way of data collection than the traditional methods of in-situ sampling or using municipal inventories. The authors find that the residential real estate market values the relative size of neighborhood tree canopy coverage. Further, their results indicate positive amenity value for vegetation in mitigating storm water runoff, complementary effects between historic zones and lush high quality vegetation, and yields some substitutable benefits to properties which are not located near the Tagus River (main River in Lisbon). Proximity to urban forests is positively valued at 0.03% per kilometer decrease in distance, with stronger effects coming from being located near larger urban forests due to the provision of larger amounts of recreational services. Alternatively, while residents may not value living near parks, there is a marginal premium for living closer to smaller parks compared to larger ones, potentially due to their heterogeneity and the congestion of visitors in the large parks.

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