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ORIGINAL PAPER

Bertrand Schmitt · Mark S. Henry · Virginie Piguet · Mohamed Hilal

Urban growth effects on rural population, export and service employment: evidence from eastern France

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Abstract This paper examines how the spatial pattern of urban growth in functional economic regions influences the interplay of rural export employment, rural services employment, and population change in rural areas. Using an extension of the Boarnet's model (Papers in Regional Science 73:135–153, 1994), we find that urban spread effects to rural areas in France are more likely than urban backwash effects, and that spatial urban (both dynamic and static) externalities affect rural population and employment growth. In the functional economic regions where the urban core is declining and the urban fringe is expanding, urban population growth involves an increase in rural export employment, and larger change in service employment favors rural population growth. However, urban export job growth reduces the growth in rural service jobs and expanding urban service jobs reduce rural export jobs, suggesting that expanding urban employment opportunities draws employees away from proximate rural communities. Conversely, where both urban core and fringe are growing, we observe an urban spread effect from the urban export sector to rural services—an export base multiplier effect with a spatial dimension—and from urban population growth to rural service employment.

JEL Classification C39 · R11 · R12

B. Schmitt (✉) · V. Piguet · M. Hilal
CESÆR (Centre d'Economie et de Sociologie appliquées à l'Agriculture et aux Espaces Ruraux), UMR INRA-ENESAD, 26 bd Dr Petitjean, BP 87999, 21079 Dijon, France
E-mail: schmitt@enesad.inra.fr

M. S. Henry
Department of Applied Economics and Statistics, Clemson University, Clemson, SC 29634 0313, USA

1 Introduction

A critical issue facing regions with rapidly growing urban centers is how to anticipate the impacts of growth of the urban complex on proximate rural areas. Recent empirical evidence suggests that urban to rural spread effects are present in regions of France, the US, and Denmark (Henry et al. 1997, 1999; Schmitt and Henry 2000). Urban population and employment growth affects rural places in different ways depending on the size of the urban core and fringe and their patterns of change. But these approaches have considered employment as homogeneous and have not examined how urban growth might affect export and service employment in proximate rural areas. The purpose of this paper is to examine how patterns of urban spatial expansion influences rural export and services employment, and population change in rural areas of functional economic regions.

Works by Henderson et al. (1995) and others, e.g., Glaeser et al. (1992) or Combes (2000) to estimate the impacts of spatial externalities on urban growth, provide a useful taxonomy of spatial externalities and is suggestive of how they might influence growth within functional economic regions, both the urban complex and rural hinterland. Static externalities are of two types. First, information spillovers and labor pooling between establishments in the same industry comprise *localization* economies. Second, *urbanization* economies are associated with urban size where benefits of specialization and division of labor increase with urban size. In addition, dynamic externalities provide cost-saving benefits to a firm from *learning by doing* either between establishments in the same industry (MAR type) or from a *building up of knowledge* across industries in a more diverse (larger) urban place (Jacobs type) (Henderson et al. 1995). We describe next how urban spatial externalities might affect rural areas in the context of traditional models of regional development.

The direction of causality in the "jobs follow people or people follow jobs?" literature (Steinnes and Fisher 1974) was addressed by Carlino and Mills (1987) by constructing location equations as a two-equation simultaneous system. Underlying wage and land price structural equations are not specified since variation in amenities across space is assumed to be capitalized into local wages and rents (see Roback 1982). Amenity variables in the two-equation system reflect these wage and rent effects across space.

As suggested by Henry et al. (1997), to incorporate the interplay of employment and population changes into the spatial development process within a region, urban growth and size influences on development in proximate rural areas are assumed to follow the monocentric tradition, with some contemporary twists. First, consider a set of functional economic regions (FERs), each with an urban core, urban fringe (suburbs and edge cities), and a rural hinterland. The spatial extent of the region is limited by commuting costs from the urban core and fringe to proximate rural villages.

Second, population and two kinds of economic activities, export and services, may locate in each of the three subareas of the region. Households require trade and service goods within a shopping trip distance that is shorter than the distance they are willing to commute to employment opportunities. Accordingly, the demand for service goods comes primarily from households within the subarea where the service establishment is located. Service employment depends on the size of the local population.

Third, demand for the export commodity comes from outside the functional economic region so its level is exogenous. However, the marginal cost of producing the export commodity is influenced by spatial externalities within the functional economic region. Establishments located in functional economic regions with higher densities of employment in the export industries and of population may have lower costs. Examples of agglomeration economies that reduce production costs in urban areas compared to rural areas are: *deeper labor markets* or labor pooling that provides lower transactions and labor costs in urban areas, lower input costs from supplying industries as these industries achieve scale economies, and spillovers of knowledge that are more likely in urban areas (p. 265 in Kilkenny 1998).

However, rising urban land rent within FERs with high population and export employment density plays a dispersive force. As urban land rents increase with proximity to the urban center and increased competition for fixed urban land resources, these added costs may offset other reductions in production costs from spatial agglomeration economies. Rising housing costs push households away from their job location until increasing commuting cost offsets the land rent rise (Fujita 1989; Goffette-Nagot 1999), causing population dispersion within functional economic region as well as between functional economic regions (Tabucchi 1998). If land rents in the urban center are high enough (relative to rural areas) to offset cost savings from urban agglomeration economies, export sector firms and households (and associated service firms) seek new locations in the urban fringe or rural hinterland as export demand expands.

Negative spatial externalities, like congestion costs, can also induce urban *spillovers* or spread from the urban core to the fringe and rural hinterlands. Moreover, with improvements in transportation, rural villages become more attractive to residents who commute to jobs in the urban core or fringe. In all cases, the impact of spatial externalities on rural villages can be expected to decay with distance from the urban center. Variations in amenity levels across rural places also shape the attractiveness of rural places as residential sites and as sites for export and service employment.

The general theoretical framework that captures the strategic interactions of these agents—including the effects from spatial externalities—is summarized in Brueckner's (2003) resource flow model. Paraphrasing Anselin (2002, p. 250), this framework posits an agent's objective functions, $U(y_i, s_i, x_i)$ where y_i is the agent's decision variable (where to locate within the functional economic region in our case), s_i is a resource stock available to agent i (for example, the labor force pool of interest to a business firm or residential amenities that appeal to household agents), and x_i is a vector of agent characteristics (for example, type of firm). Spatial lag models arise because the resource, s_i, available to agent i depends on the decisions of other (proximate) agents. Here, $s_i{=}H(y_i, y_{-i}, x_i)$ where y_{-i} are the decisions by all agents other than i (in our case, summing over other agent decisions yields employment or population densities in proximate areas). Substituting for s_i in the agent's objective function yields a spatial lag model, for example, as shown in the spatial cross-regressive model developed below.

In sum, there are three agents (firms in export and in population services and households) seeking sites in one of three subareas in each functional economic region (urban core, fringe, and rural hinterland). Two hypotheses focused on employment and population change in rural villages are suggested by the potential behavior of the three agents. First, size and growth of employment opportunities in urban areas proximate to the rural village are hypothesized to affect the desirability of rural places as a residential site and, thus, positively affect rural population and rural service employment growth. Second, export employment in rural hinterland areas is positively related to spatial agglomeration economies that will increase with size and growth of the urban core and fringe in the functional economic region.

In the next Section, we offer a new version of the Boarnet (1994) and Henry et al. (1997) models, which captures the interplay of the three agents as they decide whether to expand in rural parts of the functional economic regions. In Section 3, data needed to estimate the model and econometric issues are presented. Empirical results for the selected French regions (eastern France) are examined and discussed in Section 4. A summary of findings and rural policy implications are provided in the conclusive section (Section 5).

2 Empirical model

Boarnet's model of local development is modified in two ways. First, to capture possible urban growth and size influences on nearby rural places, urban center and urban fringe growth rates are allowed to interact with rural labor and residential zones as suggested by Henry et al. (1997). Second, employment is disaggregated into a service sector and an export sector.

Consider I areas that belong to the rural hinterland of different functional economic regions. Each FER has an urban center and an urban fringe. Call P rural population, and E_1 and E_2 rural employment in two sectors, an export (or industrial) sector and a service (or population-serving) sector. As suggested above, rural population density acts on rural service employment density through demand for local goods and on rural export sector through labor-pooling effects. Rural and urban employment in each sector influences changes in rural population density by providing job opportunities and urban employment acts on rural population by increasing land use competition in the urban center. Urban and rural employment in each sector is allowed to influence changes in urban and rural employment density in the other sector through customer and/or supplier-driven linkages. Accordingly, both rural and urban components of economic activity are expected to influence rural changes.

In addition, proximity characteristics and community amenities might influence residential choices (better schools, shopping opportunities, proximity of hospitals, and so on), export firm locational choices (better access to transport nodes, skilled labor pools, and so on), and service sector firm location choices (better access to customers, distance to competing stores in urban centers, and so on). These proximity and amenity effects are captured in sets of local attributes, called A_i, B_i, and C_i for residents, export firms, and services, respectively. Proximity characteristics and amenities also are capitalized into local rental or housing prices. For example, rural villages closer to the urban center are expected to command higher rents than more distant villages. Accordingly, varying proximity characteristics and amenity levels serve as a proxy for variation in rents across rural places. If local rents fully reflect varying proximity characteristics and amenity levels, then countervailing effects from higher rents may conceal the attraction of more favorable locations and higher amenity levels.

Finally, because of commuting and shopping trips, we construct residential and labor market zones surrounding each rural place. The decision to reside or to locate a business in a particular rural village is influenced by the characteristics of both the rural village and the places within its commuting zone.

The expected population and employment interdependencies and amenity influences are introduced in the simultaneous equation model shown in Eq. 1:

$$\begin{aligned} P^*_{i,t} &= \Psi\left(A_i, EMP^*_{i,1,t}, EMP^*_{i,2,t}, f_1, f_2, g_1, g_2,\right) \\ E^*_{i,1,t} &= \Phi\left(B_i, POP^*_{i,t}, EMP^*_{i,2,t}, h_1, h_2, g_1, g_2\right) \\ E^*_{i,2,t} &= \Xi\left(C_i, POP^*_{i,t}, EMP^*_{i,1,t}, h_1, h_2, f_1, f_2\right) \end{aligned} \tag{1}$$

where $P^*_{i,t}$, $E^*_{i,1,t}$, and $E^*_{i,2,t}$ are equilibrium population and employment in export and service sectors in the ith rural area at time period t. $POP^*_{i,t}$, $EMP^*_{i,1,t}$, and $EMP^*_{i,2,t}$ are equilibrium population and employment in local residential and labor market zone (i.e., in the rural area and its nearby commuting areas). f_1 (f_2) is the urban center (urban fringe) employment growth rate in the export sector for the FER to which the ith rural area belongs. g_1 (g_2) is the urban center (fringe) growth rate in the service sector, and h_1 (h_2) is the urban center (fringe) population growth rate.

The cross-activity effects on local changes (i.e., local population effects on local employment, etc.) are captured by the $POP^*_{i,t}$, $EMP^*_{i,1,t}$, and $EMP^*_{i,2,t}$ variables that include values of the ith area $P^*_{i,t}$, $E^*_{i,1,t}$, $E^*_{i,2,t}$ and of its nearby areas. The $POP^*_{i,t}$, $EMP^*_{i,1,t}$, and $EMP^*_{i,2,t}$ variables are found as $(W+I)P^*_{i,t}$, $(W+I)E^*_{i,1,t}$, and $(W+I)E^*_{i,2,t}$, where $\mathbf{I}$ is the identity matrix and $\mathbf{W}$ is a spatial weight matrix. $\mathbf{W}_{ij}$ is nonzero for places that are proximate to each other, except $\mathbf{W}_{ii}$ is set to zero. This proximity measure may simply be one, as assumed here, for places within a 30-km commute, or it may be based on a gravity model index as in Boarnet (1994). $\mathbf{I}$ is the identity matrix so that $(\mathbf{I}+\mathbf{W})$ represents a cluster of places within a 30-km commute of each other.[1]

Adopting linear forms of Eq. 1 and assuming interactions between rural population (or employment in each sector) and urban employment in each sector (or population) growth yields Eq. 2.

$$\begin{aligned} P^*_{i,t} &= \alpha_1 + \alpha_2 \cdot A_i + (\alpha_3 + \alpha_4 \cdot f_1 + \alpha_5 \cdot f_2)(I+W)E^*_{i,1,t} \\ &\qquad + (\alpha_6 + \alpha_7 \cdot g_1 + \alpha_8 \cdot g_2)(I+W)E^*_{i,2,t} + \nu_1 \\ E^*_{i,1,t} &= \beta_1 + \beta_2 \cdot B_i + (\beta_3 + \beta_4 \cdot h_1 + \beta_5 \cdot h_2)(I+W)P^*_{i,t} \\ &\qquad + (\beta_6 + \beta_7 \cdot g_1 + \beta_8 \cdot g_2)(I+W)E^*_{i,2,t} + \nu_2 \\ E^*_{i,2,t} &= \gamma_1 + \gamma_2 \cdot C_i + (\gamma_3 + \gamma_4 \cdot h_1 + \gamma_5 \cdot h_2)(I+W)P^*_{i,t} \\ &\qquad + (\gamma_6 + \gamma_7 \cdot f_1 + \gamma_8 \cdot f_2)(I+W)E^*_{i,1,t} + \nu_3 \end{aligned} \tag{2}$$

[1] **W** matrices using a 15- or 30-km commute between cantons and distance decay parameters were used in alternative model estimates. Empirical results were most robust for the row-standardized **W** matrix over the 30-km commute range. Furthermore, we estimate models with alternative **W** matrices (row-standardized and nonrow standardized) to test for spatial autocorrelation in the error term as discussed in the "Estimation results" section.

where ν_1, ν_2, and ν_3 are random disturbance terms that are assumed to be normally and independently distributed with zero mean and constant variance; α_2, β_2, and γ_2 are vectors of *local characteristics* parameters; etc.

As suggested by Carlino and Mills (1987), partial adjustment equations to the equilibrium levels for the *i*th area are:

$$\begin{aligned} dP_i &= \lambda_p\left(P^*_{i,t} - P_{i,t-1}\right) \\ dE_{i,1} &= \lambda_{e1}\left(E^*_{i,1,t} - E_{i,1,t-1}\right) \\ dE_{i,2} &= \lambda_{e2}\left(E^*_{i,2,t} - E_{i,2,t-1}\right) \end{aligned} \tag{3}$$

where dP_i, $dE_{i,1}$, and $dE_{i,2}$ are population change and employment changes in export and service sectors; λ_p, λ_{e1}, and λ_{e2} are the rates of adjustment to equilibrium levels for population and employment in sectors 1 and 2, respectively.

By substituting Eq. 2 into Eq. 3 then simplifying the resulting equation, the three simultaneous equations are:

$$\begin{aligned} dP =& \delta_0 + A\cdot\delta_1 - \lambda_p P_{t-1} + (\delta_2 + \delta_3 f_1 + \delta_4 f_2)(I+W)E_{1,t-1} \\ &+ (\delta_5 + \delta_6 f_1 + \delta_7 f_2)(I+W)dE_1 + (\delta_8 + \delta_9 g_1 + \delta_{10} g_2)(I+W)E_{2,t-1} \\ &+ (\delta_{11} + \delta_{12} g_1 + \delta_{13} g_2)(I+W)dE_2 + \varepsilon_1 \end{aligned} \tag{4a}$$

$$\begin{aligned} dE_1 =& \theta_0 + B\cdot\theta_1 - \lambda_{e1}E_{1,t-1} + (\theta_2 + \theta_3 h_1 + \theta_4 h_2)(I+W)P_{t-1} \\ &+ (\theta_5 + \theta_6 h_1 + \theta_7 h_2)(I+W)dP \\ &+ (\theta_8 + \theta_9 g_1 + \theta_{10} g_2)(I+W)E_{2,t-1} \\ &+ (\theta_{11} + \theta_{12} g_1 + \theta_{13} g_2)(I+W)dE_2 + \varepsilon_2 \end{aligned} \tag{4b}$$

$$\begin{aligned} dE_2 =& \tau_0 + C\cdot\tau_1 - \lambda_{e2}E_{2,t-1} + (\tau_2 + \tau_3 h_1 + \tau_4 h_2)(I+W)P_{t-1} \\ &+ (\tau_5 + \tau_6 h_1 + \tau_7 h_2)(I+W)dP \\ &+ (\tau_8 + \tau_9 f_1 + \tau_{10} f_2)(I+W)E_{1,t-1} \\ &+ (\tau_{11} + \tau_{12} f_1 + \tau_{13} f_2)(I+W)dE_1 + \varepsilon_3 \end{aligned} \tag{4c}$$

Note that the δs, θs, and τs are reduced form parameters that are products of the structural model parameters in Eq. 2 and the rates of adjustment coefficients are λ_p, λ_{e1}, and λ_{e2}.

In the empirical model presented in Eqs. 4a, 4b, and 4c, the transmission of urban spread or backwash effects is captured in two ways: through urban size and growth. Urban size affects the values of **(I+W)** P_{t-1}, the size of the labor pool centered on a rural canton, as well as **(I+W)** $E_{1,\,t-1}$ and **(I+W)** $E_{2,\,t-1}$, the size of the *job market* centered on a rural canton. Urban growth rates for the core, f_1, g_1, h_1, and fringe, f_2, g_2, and h_2, interact with both the beginning period sizes and changes in the labor pools and job markets. Urban growth also affects **(I+W)** dP, **(I+W)**

dE_1, and $(\mathbf{I}+\mathbf{W})\, dE_2$, change in the sizes of the labor pool and job market over the study period.

To relate the regression results to spatial externalities, we construct hypotheses of expected effects on rural areas with urban spatial externalities. First, if *dynamic spatial externalities* are present, regression coefficients on base period employment or population size will be significantly different from zero via building up of knowledge across industries in a more diverse (larger) urban place. Second, if *static spatial externalities* exist, regression coefficients on contemporaneous change in employment and population will be significantly different from zero.

3 Data used and estimation issues

3.1 Data geography

French data are organized across 429 functional economic regions from six eastern regions of France, and FERs are delineated using commuting flows between *communes*, i.e., French municipalities (Schmitt and Henry 2000). Each commune is assigned to a FER either as an employment center (the urban core), a *periurban* area (the urban fringe), or a peripheral rural area (the rural hinterland) in relation to the number of commuters from commune to the employment center. We first calculate the urban core and fringe population and employment growth rates (f_1, f_2, etc.) by aggregation of communal data.

Estimating Eqs. 4a, 4b, and 4c using commune level creates a problem because employment data come from a one-quarter sample of the French censuses. Data are not reliable at this level so use of *cantons* (an upper political level in France) is required. Each canton is allocated to a FER and to its rural hinterland if the population of its communes mainly belongs to the rural hinterland of this FER. Data are finally aggregated into 191 cantons belonging to rural hinterland of only 64 FERs as shown in Fig. 1. The Appendix gives more details on delineation of the FERs and choice of cantons.

Rural cantons are the units of observation for the dependent variables. We distinguished them into two subsets: one for rural cantons in FERs with declining urban cores (84 rural cantons), the other for rural cantons with growing urban cores (107 cantons). Estimates of Eqs. 4a, 4b, and 4c are made for each subset of rural cantons.

As shown in Table 1, all the FERs introduced into the analysis are decentralizing their population from their urban core to their urban fringe. Three out of the 64 FERs do not have any communes in their urban fringe and only one has its population change in urban fringe lower than its population change in urban core. In general, we observe a large increase in fringe population while population in the urban core and in the rural hinterland is declining. The same phenomenon is observed with the export employment but, in this case, the urban core decline is higher and the rural hinterland change fairly positive. Lastly, the change in service sector employment is positive in the three categories, but it is higher in the urban fringe and lower in the rural hinterland.

The differences between the rural hinterland belonging to FERs with declining core and those belonging to FERs with growing core are the following: the rural population and export employment are strongly declining in FERs with declining core while they are expanding in FERs with growing core. On the contrary, the change in service employment does not differ between both categories of rural hinterland: +8% during the period in both cases. But this change is much lower than the changes observed in the growing urban core and their fringe and close to the changes observed in the declining urban core and their fringe. Finally, the difference between both categories reflects a difference of demographic and economic dynamism between FERs.

3.2 Data sources

The data are assembled from French statistical sources including: *Census Files for Population and Job Data*, 1975, 1982, and 1990; *Communal Inventory*, 1980, 1988; and *Taxable Income File*, *General Director of Taxes*, 1984. Variables used to estimate each equation are defined in Table 2.

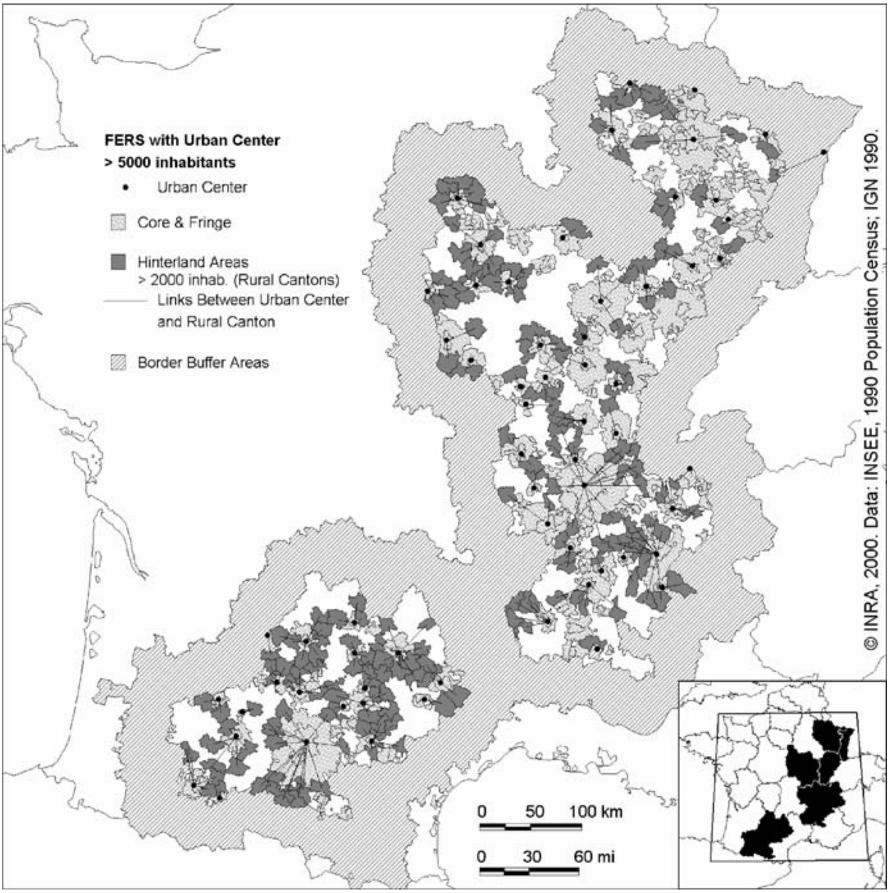

Fig. 1 Rural hinterland of FERs in six French regions

3.3 Dependent variables

The dependent variables are: *dP* (or *VDP8290*), change in rural canton population density from 1982 to 1990; dE_1 (or *VDE8290*), change in rural canton employment density export sector from 1982 to 1990; and dE_2 (or *VDS8290*), change in rural employment density in service sector from 1982 to 1990. We first defined the service sector as all the sectors belonging to retail shops and personal services sectors and other nonagricultural sectors are considered to be *export sectors*. Thus, this latter category includes manufacturing sectors and business services. Densities are used for the employment and population change variables to control for the geographical size of the cantons. For the same reason, we also used densities for beginning period (1982) employment and population variables, which appear in Eqs. 4a, 4b, and 4c: the $(-\lambda_p P_{1,t-1})$, $(-\lambda_{E_1} E_{1,t-1})$, and $(-\lambda_{E_1} E_{2,t-1})$ terms.

3.4 Explanatory variables

As suggested by the reduced form of the model (Eqs. 4a, 4b, and 4c), explanatory variables included several amenity and proximity characteristics of the rural canton, beginning period employment and population densities in commuting zones centered on each rural canton, and change in these densities (i.e., dependent variables), both later combined with growth rates of population and employment in

Table 1 Growth rates of population, export, and service sector employment (1982–1990) in the urban cores, urban fringes and rural hinterlands of the selected FERs

	FERs with declining population in urban core		FERs with growing population in urban core		All the FERs	
	Mean	SD	Mean	SD	Mean	SD
% Rate of population change in:						
Urban core (h_1)	−3.99	3.29	4.15	3.02	−0.43	5.15
Urban fringe (h_2)	6.93	6.23	13.87	7.58	9.95	7.63
Rural hinterland	−3.17	3.75	2.16	7.14	−0.84	6.06
% Rate of export sector employment change in:						
Urban core (f_1)	−5.34	13.17	4.67	8.16	−0.96	12.24
Urban fringe (f_2)	−0.55	22.80	30.86	42.35	13.13	36.06
Rural hinterland	−2.70	17.14	3.60	13.60	0.05	15.89
% Rate of service sector employment change in:						
Urban core (g_1)	8.78	9.83	16.38	6.21	12.11	9.20
Urban fringe (g_2)	9.31	25.67	28.01	27.94	17.45	28.06
Rural hinterland	8.36	24.57	8.38	9.49	8.37	19.34
Number of analyzed FERs:	36		28		64	
Without fringe	1		1		2	
Change in fringe pop.≤change in core pop.	0		1		1	
Change in fringe pop.>change in core pop.	35		26		61	

Table 2 List of variables

Name of variables	Definition
Dependent variables	
dP=VDP8290	Change in population density in the rural canton 1982 to 1990
dE₁=VDE8290	Change in export employment density in the rural canton 1982 to 1990
dE₂=VDS8290	Change in service employment density in the rural canton 1982 to 1990
Spread/backwash variables	
DWPOP82 (WVDPOP)	Residential zone population density (change in density), 1982
DWPOPH1 (WVDPH1)	Urban center growth interaction with *DWPOP82 (WVDPOP)*: $h_1 * (I + W)P82$ and $h_1 * (I + W)dP$ where h_1 is the population growth rate in the urban center 1982 to 1990
DWPOPH2 (WVDPH2)	Urban fringe growth interaction with *DWPOP82(WVDPOP)*:$h_2 * (I + W)P82$ and $h_2 *(I + W)dP$ where h_2 is the population growth rate in the urban fringe 1982 to 1990
DWOTH82 (WVDOTH)	Export sector labor market zone employment density (change in density), 1982
DWOTHF1 (WVDOF1)	Urban center growth interaction with *DWOTH82(WVDOTH)*:$f_1 * (I + W)E_182$ and $f_1 * (I + W)dE_1$ where f_1 is the export sector employment growth rate in the urban center 1982 to 1990
DWOTHF2 (WVDOF2)	Urban fringe growth interaction with *DWOTH82(WVDOTH)*: $f_2 * (I + W)E_182$ and $f_2 * (I + W)dE_1$ where f_2 is the export sector employment growth rate in the urban fringe 1982 to 1990
DWSHO82 (WVDSHO)	Service sector labor market zone employment density (change in density), 1982
DWSHOG1 (WVDSG1)	Urban center growth interaction with *DWSHO82 (WVDSHO)*: $g_1 * (I + W)E_282$ and $g_1 * (I + W)dE_2$ where g_1 is the service sector employment growth rate in the urban center 1982 to 1990
DWSHOG2 (WVDSG2)	Urban fringe growth interaction with *DWOTH82(WVDSHO)*: $g_2 * (I + W)E_282$ and $g_2 * (I + W)dE_2$ where g_2 is the service sector employment growth rate in the urban fringe 1982 to 1990

Table2 (continued)

Name of variables	Definition
Population and labor market variables:	
DPOP82	Population density in each rural canton, 1982
NATBAL_P	Rural canton natural population growth (births–deaths)1982 to 1990
VDP7582	Change in rural canton population density during previous period (1975–1982)
DOTHE82	Export employment density in each rural canton, 1982
VDO7582	Change in rural canton export employment density during previous period (1975–1982)
DSHOP82	Service employment density in each rural canton, 1982
VDS7582	Change in rural canton service employment density during previous period (1975–1982)
Proximity and amenity variables for French residents (the *A* vector):	
DPBAS90C	Distance from the rural canton to the urban employment center (centroid to centroid)
D2PBAS90C	Distance to the employment center squared
DEQU80S	Index of the density of public services available, 1980
SCHO80D	Distance to the nearest secondary school in 1980
HOSP80D	Distance to the nearest hospital in 1980
D1AUTOR	Distance to the nearest freeway entrance point in 1988
INCOM84	Household taxable income in 1984
Business proximity and amenity variables for the export and service sectors (the *B* and *C* vectors):	
DPBAS90C	Distance from the rural canton to the urban employment center
D2PBAS90C	Distance to the urban employment center squared
DAGGLO	Distance to the nearest urban agglomeration greater than 200,000 inhabitants
DIAUTOR	Distance to the nearest freeway entrance point
NOBLU82	Active population in executive and intermediate occupations by active population of manual and clerical workers in 1982
SKIWO82	Active population of skilled manual workers by unskilled manual workers in 1982
SELFJ82	Percentage of non-salaried jobs in non agricul tural sectors in 1982: nonsalaried jobs % total jobs

Table2 (continued)

Name of variables	Definition
RCHOM82	Unemployment rate in 1982: Unemployed % active population
Specific variable for the service sector:	
DCAPAC80	Density of tourist accommodations in the rural canton

the urban core (f_1, g_1,and h_1) and urban fringe (f_2, g_2, and h_2) of the functional economic region to which the rural canton belongs.

As noted earlier the direction of causality in the "jobs follow people or people follow jobs?" literature is addressed by constructing location equations as a simultaneous equation system. Underlying wage and land price structural equations are not specified since variation in amenities across space is assumed to be capitalized into local wages and rents. Amenity variables in the equation system reflect wage and rent effects across space. Amenity variables expected to affect household location decisions are made that reflect quality of public services and distance factors. Similarly, a second set of amenity variables is chosen that is likely to influence costs of doing business to firms across space.

For the population Eq. 4a, a vector of rural canton characteristics, *A*, is used to control for the following canton attributes: the density of shops and personal services available in the canton, distance to the nearest urban center, distance to the nearest autoroute entrance (*interstate highway*), distance to the nearest secondary school, distance to the nearest hospital, average household's income, natural population balance (births–deaths), and change in population density during the previous period, 1975–1982. Note that we introduced the natural population balance as a control variable. Population change can then be viewed as a result of in or out-migrations.

In both employment Eqs. 4b and 4c, the *B* and *C* vectors of variables reflect the following rural canton characteristics that might be expected to influence firm location and expansion decisions: distance to the nearest urban center, distance to the nearest urban area with at least 200,000 inhabitants, distance to the nearest autoroute entrance, the ratio of *white collar* to *blue collar* workers, ratio of skilled to unskilled manual workers, share of workers in self-employed occupations, beginning period labor zone unemployment rate, beginning period residential zone average household income as a proxy for local average wage levels, and prior period (1975–1982) growth in employment density in the rural canton. We finally included the beginning period density of tourism accommodations in the rural canton only in Eq. 4c (service sector employment equation).

Spatial variables (denoted *WVDPOP*, *WVDOTH*, *WVDSHO*, *DWPOP82*, *DWOTH82*, and *DWSHO82* in Table 2 and in the tables reported in Appendix 2) are formed by multiplying dP, dE_1, dE_2, P_{t-1} , $E_{1,t-1}$, and $E_{2,t-1}$ by a $\left(I_N + W_N^*\right)$ row-standardized (queen) spatial contiguity matrix. W_N^* is an *N* by (*N*+*J*) matrix to capture the influence of all cantons that surround each rural canton. *N* is equal to 191, corresponding to the sample rural cantons. (*N*+*J*) is equal to 388 and includes the sample rural cantons and other cantons in the six regions (see Anselin and Kelejian 1997 for a discussion of the importance of taking into account a $N+J$ matrix rather than a $N+N$ one in a spatial configuration like here). The w_{ij}^* element is $1/\sum_j w_{ij}$ if the ith and jth cantons are within 30 km of each other, otherwise $w_{ij}^* = 0$. Multiplying the W_N^* matrix times the 1 by 388 vector of values for the variable across all cantons forms the spatial lag of a variable. In this way, local labor market zones and residential zones centered on each of the 191 rural cantons are constructed.

3.5 Estimation issues

The econometric estimates are obtained in a two-stage process using an instrumental variable method since there is simultaneity implied between the changes in population density, dP, and changes in export or service sector employment density, dE_1 or dE_2, in the rural cantons. The instruments used for the estimation in the first stage are all the exogenous variables introduced in the three populations and employment equations and, when possible, their spatial lag values.

We modified the set of instruments according to the results of the tests for instrument validity. To do this, we used the Sargan test for instrument validity. In addition, we tested for exogeneity of dependant variables by performing an *added* regression. As shown in tables 1, 2, and 3 reported in Appendix 2, the Sargan statistics (Qs) are always low enough to lead to a probability of the χ^2 much higher than 0.10. The lowest probability is obtained with the export sector employment equation for the cantons belonging to the FERs with growing urban core (Table 2 in Appendix 2). In this case, the Qs value is 21.6 and corresponds to a probability of 0.12 for nonvalidity of the instruments. The selected set of the instruments could be therefore considered as valid. It includes all the exogenous variables and their spatial versions (except the spatial versions of *NATBAL_P*, *DPBAS90C* and *D2PBAS90C*, *DSHOP82*, *DOTHE82* and *DPOP82*). Finally, we used 38 instruments.

The tests for exogeneity of dependent variables included at the right side of the three equations are made with the added regression method. The values of the corresponding F are often low enough to accept the exogeneity of those variables. The only cases for which we have to reject the exogeneity hypothesis (H_0) are the export sector employment and the service sector employment equations estimating in the case of growing urban core. Despite this, we performed all the estimations with the instrumental variable method to use a homogenous methodology through the different equations.

As reported by Rey and Boarnet (2004), there are two ways to obtain the predicted values of endogenous variables needed for the second stage of estimation with spatial lags in the endogenous variables. The first, suggested by Anselin (1988), is to use predicted values of the dependent variables obtained by regression on the exogenous variables and then multiply the predicted values by the **W** matrix: $\mathbf{W}\,[X\,(X'X)^{-1}X'y]=\mathbf{W}\,[X\beta]$. The second technique is to use the predicted values of the dependent variables obtained by regression of the spatially lagged dependent variables on instruments: $X\,(X'X)^{-1}X'\,\mathbf{W}y=X\beta_w$. Kelejian and Oates (1989, p. 321) and Rey and Boarnet (2004) suggest that the first method involves an inconsistent estimator. In this paper, the second option is used. The $I + W_N^*$ endogenous variables are computed before the first stage estimation.

To test for the presence of spatial autocorrelation in the errors, the I-Moran test was used as suggested in Anselin and Kelejian (1997) in models with endogenous regressors. Tests for spatial error autocorrelation were made with three different spatial weight matrices: the row-standardized matrix of contiguity between cantons ($\mathbf{W}_0$); the row-standardized matrix of contiguity in a radius of 15 km around the canton ($\mathbf{W}_{15}$); and, the non-standardized matrix of distance inverse $1/d_{ij}$ between canton centroids ($\mathbf{W}_d$) where d_{ij} is the distance between canton i and j. Because the I-Moran tests did not detect spatial autocorrelation in our estimation, we did not need to correct for it.

4 Estimation results

Complete results from the second stage regressions for Eqs. 4a, 4b, and 4c are listed in the Appendix 2. For the most part, the control variables that were most significant include the prior period change (from 1975 to 1982) in the dependent variable and the beginning period value of the dependent variable. Only a few proximity or local amenity variables were statistically significant yet all were retained to provide control across proximity characteristics and amenities while estimating the interplay effects between employment and population size and change.

The impacts on rural canton economies from the interplay of employment and population change in the urban core, fringe, and rural hinterland in each FER are summarized in Table 3. These findings are derived from the regression results for Eqs. 4a, 4b, and 4c at mean growth rates (f_1, f_2, etc.) for the urban core and fringe across the FERs. For example, in Table 3, we obtain the parameter $(\theta_2 + \theta_3 h_1 + \theta_4 h_2)$=0.0510 for the variable $(\mathbf{I}+\mathbf{W})P_{t-1}$ with a t value of 1.80.[2] It means that an increase in the beginning period population of 1,000 is expected to increase rural export jobs by 51 if the urban core population is declining at the average rate (h_1) of −3.99% over the period, while the urban fringe population grew at the average (h_2) rate of 6.93%.

The results in Table 3 reflect the urban impacts on proximate rural cantons—a test for the presence of urban spatial externality effects on proximate rural areas. Recall that there is no direct link from urban population (employment) change to rural population (employment) change in the model. Rather, urban population growth rates are hypothesized to affect the growth of population (labor pool) within a commuting range of a rural canton. In turn, if the size of the labor pool within commuting range of a rural canton increases, the rural place may attract more employers, while the added jobs attract more residents to the rural place.

[2] The term $(\theta_2 + \theta_3 h_1 + \theta_4 h_2)$ corresponds to the following linear combination of parameters and mean values: $[0.058 + (0.000142 * -3.99) + (-0.00094 * 6.93)]$=0.051, with h_1=−3.99 and h_2=6.93 from Table 1 and θ_2=0.058, θ_3=1.42 E−04, and θ_4=−9.4 E−04 from table 2 reported in Appendix 2. Its joint t value is computed using variance computed as follows: var $(\theta_2 + \theta_3 h_1 + \theta_4 h_2) = s_{22} + 2g_1 s_{23} + g_1^2 s_{33} + 2g_2 s_{24} + g_2^2 s_{44} + 2g_1 g_2 s_{34}$, where s_{ij} are elements in the variance/covariance matrix because $(\theta_2 + \theta_3 h_1 + \theta_4 h_2)$ is a linear combination of parameter estimates (see Aiken and West 1991, pp. 24–26).

Moreover, urban growth rates in the model reflect the *pattern of change in spatial structure* in a given urban complex (core and fringe). For example, if the fringe is growing rapidly while the core is stagnant or declining, there is a pattern of decentralization. Rapid growth of the core with fringe decline yields a more center-oriented urban complex. In this case, the local labor market areas, $EMP_{i,1}$ and $EMP_{i,2}$ or residential zones, POP_i for a rural place, might be affected. Accordingly, urban spatial growth patterns may influence the desirability of a rural place as a location choice for a new firm because the local labor force pool, POP_i, may increase with rapid urban fringe growth or decrease with rapid urban core growth. In Eqs. 4b and 4c, the relative values of h_1 and h_2 affect POP_i. For example, a low h_1 and a high h_2 mean that urban population is spreading to the suburbs. This suggests that nearby rural places will have a larger labor pool available to potential new firms and favorably affect $E_{i,1}$ and $E_{i,2}$ employment in a rural place. Alternatively, the desirability of a rural place as a location choice for a new household, Eq. 4a, may increase or decrease as urban spatial employment growth patterns (f_1, f_2 and g_1, g_2) affect the size of the local job opportunity pool, $EMP_{i,1}$ and $EMP_{i,2}$.

Table 3 Effects of urban size and growth on rural cantons in eastern France

	In FERs with declining urban core		In FERs with growing urban core	
	Parameter	Joint *t*	Parameter	Joint *t*
Effects of size and growth in urban population on	Rural export jobs		Rural export jobs	
1.$(\theta_2 + \theta_3 h_1 + \theta 4 h_2)(I+W)P_{t-1}$	**0.051**	**1.80**	0.014	0.57
2.$(\theta_5 + \theta_6 h_1 + \theta_7 h_2)(I+W)dP$	**0.313**	**1.97**	0.152	0.81
Effects of size and growth in urban population on	Rural service jobs		Rural service jobs	
3. $(\tau_2 + \tau_3 h_1 + \tau_4 h_2)(I+W)P_{t-1}$	0.008	0.23	−0.014	−1.09
4. $(\tau_5 + \tau_6 h_1 + \tau_7 h_2)(I+W)dP$	0.098	0.53	**0.260**	**2.54**
Effects of size and growth in urban export jobs on	Rural population		Rural population	
5. $(\delta_2 + \delta_3 f_1 + \delta_4 f_2)(I+W)E_{1,t-1}$	0.016	0.09	−0.152	−0.48
6. $(\delta_5 + \delta_6 f_1 + \delta_7 f_2)(I+W)dE_1$	−0.601	−0.92	1.108	1.37
Effects of size and growth in urban export jobs on	Rural service jobs		Rural service jobs	
7. $(\tau_8 + \tau_9 f_1 + \tau_{10} f_2)(I+W)E_{1,t-1}$	−0.158	−0.87	**0.116**	**1.85**
8. $(\tau_{11} + \tau_{12} f_1 + \tau_{13} f_2)(I+W)dE_1$	**−0.733**	**−1.64**	0.004	0.02
Effects of size and growth in urban service jobs on	Rural population		Rural population	
9. $(\delta_8 + \delta_9 g_1 + \delta_{10} g_2)(I+W)E_{2,t-1}$	0.147	0.59	−0.187	−0.56
10. $(\delta_{11} + \delta_{12} g_1 + \delta_{13} g_2)(I+W)dE_2$	**1.743**	**1.99**	2.579	1.63
Effects of size and growth in urban service jobs on	Rural export jobs		Rural export jobs	
11. $(\theta_8 + \theta_9 g_1 + \theta_{10} g_2)(I+W)E_{2,t-1}$	−0.160	−0.89	0.083	0.45
12. $(\theta_{11} + \theta_{12} g_1 + \theta_{13} g_2)(I+W)dE_2$	−0.757	−1.31	−0.266	−0.34

Entries in boldface indicate significance at the .10 level

In each pair of rows in Table 3, the first row represents the impacts of *beginning period* (1982) local employment (population) interacting with urban growth rates on rural growth in employment (population). The second row in each pair in Table 3 represents the impacts of *change* (1982 to 1990) in local employment (population) interacting with urban growth rates on rural growth in employment (population).

Our hypothesized effects on rural areas from urban spatial externalities are tested in two ways. First, if dynamic spatial externalities are present, regression coefficients on base period employment or population size will be significantly different from zero via building up of knowledge across industries in a more diverse (larger) urban place.

Results show that *for regions with urban areas that have declining urban cores*, larger urban populations promote faster expansion in rural export jobs but not rural service jobs (rows 1 and 3 in Table 3). Moreover, larger beginning period levels of urban export and service sector employment do not affect rural population (see rows 5, 7, 9, and 11 in Table 3). For regions with urban cores that are in decline, we conclude that larger populations in urban areas promote increases in rural export employment. But for these FERs, the urban population size has no impact on rural service employment and the urban employment sizes do not influence rural population change and rural employment changes in each sector.

For regions with urban areas that have growing urban cores, we find that larger urban employment in export jobs induces higher levels of rural service jobs (row 7, Table 3)—the export base multiplier effect with a spatial dimension suggesting a learning by doing effect. However, there is a weak negative effect on rural service jobs from larger urban populations (row 3, Table 3). This suggests that large urban centers that are growing provide services to proximate rural residents that substitute for services in rural areas. Growing suburban shopping districts may be replacing jobs formerly provided by establishments in proximate rural cantons. Note that, for these FERs and contrary to the previous case, there is no effect of urban population size on rural export employment change.

Second, if static spatial externalities exist, regression coefficients on change in employment and population will be significantly different from zero. We find empirical support for static spatial externalities—both positive and negative—export employment via labor pooling and knowledge spillovers and services through added local population.

In urban areas that have a growing urban core, urban population growth increases rural service jobs in these FERs (row 4, Table 3). In FERs with declining urban cores, urban export job growth reduces the growth in rural service jobs (row 8, Table 3) and expanding urban service jobs reduce rural export jobs (row 12, Table 3). Together, these results suggest that expanding urban employment opportunities draws employees away from proximate rural communities. In parallel, larger change in urban population increases rural export employment (row 2, Table 3) via benefits of labor pooling that increase with urban size, and larger change in urban service employment increases rural population (row 10, Table 3) through added local supply of services.

5 Summary and conclusions

In selected regions of France, we find that urban patterns of spatial growth affect proximate rural growth through several channels. First, urban spatial effects are much more likely in FERs where urban cores are declining and the fringe is expanding. If the urban core is declining, we find that urban population growth increases rural export employment and, consequently, rural population increases. This suggests that urban core land rents are rising faster than cost savings from spatial externalities—labor pooling, knowledge spillovers, etc.—spreading growth to the urban fringe and to rural areas. Alternatively, urban backwash affects rural places when larger urban places with growing employment opportunities induce firms and people from nearby rural places to relocate to the urban core or fringe. In this case, urban core land supply does not appear to be an important constraint to core growth, and cost savings from urban spatial externalities offset higher urban rents. Overall, we find that spread effects are more likely than urban backwash.

If the urban core is growing (and the urban fringe is also expanding), we find that urban export growth leads to rural population growth and expanding rural service employment. Further, urban population growth increases rural service employment. We also find spatial linkages between changes in urban export employment and rural service employment—the export base multiplier effect with a spatial dimension. However, there is also evidence that growing urban services displace service jobs in rural places.

Finally, the results presented in Table 3 assume average growth rates for the urban core and fringe. As illustrated in Schmitt and Henry (2000), the model developed can also be used to assess the impacts on rural places from a wide range of urban spatial expansion scenarios—from rapid urban sprawl to increasing concentration in the urban core. Empirical results may vary significantly across regions within nations that have transportation networks and regional development policies that differ substantially from those in France. Nevertheless, the conceptual framework developed should be useful for understanding spatial development processes within functional economic regions.

Urban sprawl issues are at the forefront of the agenda of many planning agencies as they grapple with the costs of providing new infrastructure across expanding spatial reaches from the urban core. However, *smart growth* policies should be designed to benefit both rural and urban communities across a functional economic area. To avoid unintended negative impacts in a region, it will be necessary to understand the employment and population spatial consequences of policies to promote smart growth by increasing density in the urban core or fringe. The models developed here can aid in understanding how policy interventions for smart growth are likely to affect the spatial patterns of growth within a functional economic region.

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Appendix

1 FER delineation and canton selection

For defining the FERs, we used a hierarchical classification based on commuting flows between communes (1990 Census data). The link between each couple of communes (A, B) is calculated as:

$$Link(A,B) = Commuting\ flow(A \rightarrow B)\big/Pop(A) + Commuting\ flow(B \rightarrow A)\big/Pop(B)$$

It allows taking into account for double relationships between communes. After classification, the 4,084 communes making up the six selected regions are grouped into 414 FERs. Each FER has an urban core (the greatest urban unit of the FER), an urban fringe (all the communes that send more than 30% out of their active residents working in the urban core and fringe), a rural hinterland (all the other communes).

In contrast to previous studies (Schmitt and Henry, 2000), we cannot use the commune level in this paper because the employment division between export and services employment uses data from a one-fourth sample of the French census. The reliability of data is not sure under a threshold of 2,000 people and 4,007 communes among the 4,084 introduced in the analysis having less than 2,000 inhabitants. Thus, we used the canton level that is an intermediate administrative level. In our 414 FERs, there are 482 cantons where more than 2,000 inhabitants live and where at least one commune belongs to the rural hinterland. Among these, there are 225 cantons of which more than 50% of their population live in the rural hinterland. After eliminating cantons, which belong to FERs having a small urban core (less than 5,000 people), only 191 cantons can be introduced in the analysis.

These 191 cantons belong to 64 FERs, of which some main characteristics are given in Table 1 below. Our analysis takes into account a large part of the land area of the six selected regions (about 50%) and a large part of their rural hinterland population. Furthermore, we focus on the rural hinterland related to large and medium-sized cities: 37 FERs have a core size larger than 20,000 inhabitants, and 27 FERs have between 5,000 and 20,000 inhabitants. This corresponds to the largest and medium-sized FERs: their mean size is 140,000 inhabitants but with a large standard deviation (about 260,000). Our analysis tends to exclude many small FERs or/and FERs with small rural hinterland.

Table 1 Comparison between FERs included in the analysis and FERs excluded to the analysis.

		FERs with rural hinterland <5,000 inhabitants		FERs with rural hinterland ≥5,000 inhabitants		All the FERs	
		Mean	SD	Mean	SD	Mean	SD
FERs with urban core <5,000 inhabitants							
With cantons included in the analysis	Number of FERs	0		0		0	

		FERs with rural hinterland <5,000 inhabitants		FERs with rural hinterland ≥5,000 inhabitants		All the FERs	
		Mean	SD	Mean	SD	Mean	SD
Without cantons included in the analysis	Number of FERs	206		18		224	
	Population in FER	4,092	2,446	10,770	2,373	4,628	3,040
	FER land area (ha)	14,667	11,341	37,891	19,945	16,533	13,733
FERs with urban core between 5,000 and 20,000 inhabitants							
With cantons included in the analysis	Number of FERs	5		22		27	
	Population in FER	19,353	4,844	24,942	8,597	23,907	8,258
	FER land area (ha)	50,025	28,454	71,344	31,440	67,396	31,531
Without cantons included in the analysis	Number of FERs	63		27		90	
	Population in FER	13,802	5,780	24,804	12,746	17,103	9,820
	FER land area (ha)	23,150	14,313	49,259	29,612	30,983	23,316
FERs with urban core ≥20,000 inhabitants							
With cantons included in the analysis	Number of FERs	0		37		37	
	Population in FER	–	–	221,037	314,693	221,037	314,693
	FER Land Area (ha)	–	–	190,313	129,522	190,313	129,522
Without cantons included in the analysis	Number of FERs	13		23		36	
	Population in FER	46,161	17,049	118,503	72,689	92,380	68,284
	FER land area (ha)	36,662	20,352	86,461	46,640	68,478	45,802
Total FERs							
With cantons included in the analysis	Number of FERs	5		59		64	
	Population in FER	19,353	4,844	147,917	265,785	137,873	257,383
	FER land area (ha)	50,025	28,454	145,952	118,900	138,458	117,217
Without cantons included in the analysis	Number of FERs	282		68		350	
	Population in FER	8,201	10,499	52,781	63,811	16,862	34,387
	FER land area (ha)	17,576	13,665	58,833	39,652	25,592	26,822

2 Estimation results

The first two columns in Tables 1, 2, and 3 reported below are parameter estimates for observations on rural cantons in FERs with a declining urban core and the next two are for rural cantons in FERs with a growing urban core. First, consider the proximity and amenity effects and impacts of earlier growth (from 1975 to 1982). Since the impact of urban spatial externalities on rural communities can be expected to decay with distance from the urban core, more remote rural villages (greater distance and/or no autoroute access), can be expected to grow slower than villages proximate to urban cores. Alternatively, villages with lower quality amenities are expected to grow more slowly than their more appealing counterparts.

We find few strong proximity or amenity effects on rural population. In each regression in Table 1 reported below, larger increases in the rural canton population over the 1975 to 1982 period (*VDP7582*) are associated with more rural people from 1982 to 1990. Since the natural balance (births less deaths, *NATBAL_P*) is a control variable, these population changes can be viewed as a result of in- or out-migrants.

In Table 2, the determinants of rural export employment growth indicate that again only a handful of amenities and initial conditions matter. Rural cantons that had more prior period growth (*VDO7582*) tended to have less export employment growth. However, larger beginning period export employment (*DOTHE82*) increased export employment (the parameter estimate in Table 1 reported below is multiplied by −1, as indicated in Eq. 4b). Higher initial period unemployment rates (*RCHOM82*) also tended to boost export employment growth. Increasing distance to the nearest urban area with more than 200,000 residents (*DAGGLO*) increases export employment in rural cantons.

In Table 3, we find that larger beginning period service sector employment (*DSHOP82*) decreases rural canton service employment (again the parameter is multiplied by −1 as shown in Eq. 4c). Moreover, in FERs with growing urban cores, prior period service employment growth (*VDS7582*) slows rural service employment growth. Higher density tourist accommodations (*DCAPAC80*) also slow subsequent serves sector employment.

Table 1 Estimation results for rural population change equation

	Cantons belonging to FERs with declining urban core		Cantons belonging to FERs with growing urban core	
Variable	Parameter	*t*	Parameter	*t*
N	*84*		*107*	
INTERCEP	−2.177	−0.88	**−8.478**	**−1.75**
DPOP82	−0.017	−0.55	0.076	1.43
DPBAS90C	−0.092	−0.76	0.158	1.00
D2PBA90C	0.001	0.55	−0.001	−0.47
NATBAL_P	−0.090	−1.33	0.068	0.54
DEQU80S	−2.738	−0.67	−0.525	−0.08
DIAUTORO	−0.001	−0.22	0.014	0.90
SCHO80D	0.055	0.83	−0.068	−0.59
HOSP80D	−0.035	−0.82	−0.077	−0.99
INCOM84	0.047	1.20	**0.115**	**1.79**
VDP7582	**0.291**	**1.69**	0.318	1.29
DWOTH82 (δ_2)	0.027	0.15	−0.221	−0.61
DWOTHF1 (δ_3)	0.002	0.48	−0.015	−1.38
DWOTHF2 (δ_4)	0.001	0.24	0.004	1.15
WVDOTH (δ_5)	−0.787	−1.02	**3.584**	**2.13**
WVDOF1 (δ_6)	−0.035	−0.76	−0.003	−0.03
WVDOF2 (δ_7)	0.006	0.22	−0.080	−1.31
DWSHO82 (δ_8)	0.195	0.67	1.094	1.00
DWSHOG1 (δ_9)	−0.007	−0.74	−0.045	−1.13
DWSHOG2 (δ_{10})	0.002	0.38	−0.020	−0.82
WVDSHO (δ_{11})	1.302	1.04	−2.082	−0.43
WVDSG1 (δ_{12})	0.046	0.43	0.101	0.47
WVDSG2 (δ_{13})	0.004	0.11	0.107	0.77
Adj. R^2	0.57		0.75	
Sargan test (Qs)	$\chi^2(14)=18.27$		$\chi^2(15)=4.88$	
Exogeneity test	$F(10,50)=0.24$		$F(10,73)=0.64$	
I−Moran: $\mathbf{W}_c$	0.220	1.05	−0.274	1.17
$\mathbf{W}_{30}$	−0.075	0.54	−0.096	0.52
$\mathbf{W}_d$	−0.028	0.75	−0.019	0.60

Entries in boldface indicate significance at the .10 level

Table 2 Estimation results for rural export sector employment change equation

Variable	Cantons belonging to FERs with declining urban core		Cantons belonging to FERs with growing urban core	
	Parameter	*t*	Parameter	*t*
N	*84*		*107*	
INTERCEP	−1.055	−1.12	**−4.486**	**−1.90**
DOTHE82	**−0.267**	**−4.87**	−0.066	−1.08
DPBAS90C	0.048	0.70	0.056	0.71
D2PBA90C	−0.001	−0.70	−0.001	−1.04
DAGGLO	**0.012**	**2.03**	0.011	0.93
DIAUTORO	0.001	0.13	0.006	0.60
NOBLU82	0.008	0.69	0.002	0.09
SKIWO82	−0.004	−0.99	0.003	0.86
SELFJ82	−0.003	−0.33	0.000	0.01
RCHOM82	−0.070	−1.17	**0.253**	**2.16**
VDO7582	**−0.425**	**−1.86**	−0.170	−0.55
DWPOP82 (θ_2)	**0.058**	**1.69**	0.057	1.21
DWPOPH1 (θ_3)	0.000	0.08	0.000	0.07
DWPOPH2 (θ_4)	−0.001	−0.84	−0.003	−1.51
WVDPOP (θ_5)	0.298	0.69	0.236	0.36
WVDPH1 (θ_6)	0.010	0.17	−0.054	−1.11
WVDPH2 (θ_7)	0.008	0.31	0.010	0.34
DWSHO82 (θ_8)	−0.193	−1.10	−0.456	−0.75
DWSHOG1 (θ_9)	0.005	0.78	0.006	0.17
DWSHOG2 (θ_{10})	−0.001	−0.41	0.016	1.54
WVDSHO (θ_{11})	−0.438	−0.61	0.332	0.08
WVDSG1 (θ_{12})	−0.082	−1.26	0.131	0.58
WVDSG2 (θ_{13})	**0.043**	**1.87**	**−0.098**	**−1.76**
Adj. R^2	0.48		0.25	
Sargan test (Qs)	$\chi^2(14)=10.02$		$\chi^2(15)=21.59$	
Exogeneity test	F(10,50)=0.99		**F(10,73)=2.36**	
I−Moran: $\mathbf{W}_c$	−0.091	0.28	−0.134	0.93
$\mathbf{W}_{30}$	−0.164	0.88	−0.129	1.05
$\mathbf{W}_d$	−0.042	0.99	−0.036	1.28

Entries in boldface indicate significance at the .10 level

Table 3 Estimation results for rural service sector change equation

Variable	Cantons belonging to FERs with declining urban core		Cantons belonging to FERs with growing urban core	
	Parameter	*t*	Parameter	*t*
N	84		107	
INTERCEP	1.206	1.31	**−1.981**	**−1.99**
DSHOP82	**0.415**	**3.46**	**0.164**	**2.40**
DPBAS90C	−0.030	−0.47	0.046	1.16
D2PBA90C	0.000	0.19	−0.001	−0.85
DAGGLO	0.003	0.50	0.001	0.23
DIAUTORO	0.001	0.18	0.007	1.54
DCAPAC80	**−0.028**	**−1.90**	−0.008	−1.55
NOBLU82	0.002	0.14	0.001	0.06
SKIWO82	−0.003	−1.03	0.000	0.12
SELFJ82	−0.007	−0.53	0.007	1.24
RCHOM82	−0.032	−0.56	0.021	0.47
VDS7582	−0.005	−0.02	**−0.359**	**−2.12**

Variable	Cantons belonging to FERs with declining urban core		Cantons belonging to FERs with growing urban core	
	Parameter	t	Parameter	t
N	84		107	
DWPOP82 (τ_2)	0.006	0.17	−0.007	−0.42
DWPOPH1 (τ_3)	0.001	0.68	0.002	1.20
DWPOPH2 (τ_4)	0.001	0.96	−0.001	−1.53
WVDPOP (τ_5)	**0.470**	**1.74**	**0.474**	**1.76**
WVDPH1 (τ_6)	0.006	0.11	**−0.042**	**−2.00**
WVDPH2 (τ_7)	**−0.050**	**−1.94**	−0.003	−0.27
DWOTH82 (τ_8)	−0.176	−0.96	**0.086**	**1.69**
DWOTHF1 (τ_9)	−0.004	−1.14	0.002	0.76
DWOTHF2 (τ_{10})	0.002	1.02	0.001	0.71
WVDOTH (τ_{11})	**−0.976**	**−2.08**	0.210	0.61
WVDOF1 (τ_{12})	−0.049	−1.50	0.001	0.03
WVDOF2 (τ_{13})	**0.031**	**1.69**	−0.007	−0.52
Adj. R^2	0.61		0.51	
Sargan test (Qs)	$\chi^2(13)$=17.22		$\chi^2(14)$=17.28	
Exogeneity test	$F(10,49)$=0.86		$\mathbf{F(10,72)=2.21}$	
I−Moran: $\mathbf{W}_c$	−0.012	0.06	−0.128	0.82
$\mathbf{W}_{30}$	0.002	0.01	−0.037	0.33
$\mathbf{W}_d$	−0.010	0.25	−0.032	1.10

Entries in boldface indicate significance at the .10 level

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