Spatial dependence, contextual factors and pricing behaviour of gas stations: evidence from the city of Rome.

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Introduction & Motivation

- This work aims at empirically exploring the nature of price variation in the retail gasoline market
  - ✓ suitable for the investigation of the spatial price competition (product homogeneity)
  - ✓ ***contextual factors shape the price fixing behaviour of gasoline stations***?

- The empirical analysis is focused on the city of Rome, showing a great deal of heterogeneity across sub-municipal areas.
  - ✓ ***We employ variables at sub-municipal level accounting for micro-territorial differences.***

Outline

- Literature review
- Italian gasoline sector
- Empirical setting: Rome municipalities
- Data collection and variables
- Empirical strategy
- Results
- Concluding remarks

Literature Review

The discussion about the factors expected to play a significant role are grouped by the following categories:

1. ***market competition***
2. ***spatial dependence in price***
3. ***contextual factors***

Literature Review: market competition (1)

Different measures of market competition have adopted in the literature

- Clemenz and Gugler (2006) find a **negative association between *station density* and the average price** charged by all gasoline stations within a district in the Austrian retail gasoline market.
- Van Meerbeek (2003), focusing on Belgian gasoline stations, shows that, as long as the ***number of competitors*** in a given municipality **increases**, the **gasoline prices** of competitors in that municipality **decrease**.
- Pennerstorfer (2009) and Pennerstorfer and Weiss (2013), find a **positive relationship between density (*number of stations per inhabitants at district-level*) and prices of gasoline stations** in Austria, because a lower demand per station increases the price.

Literature Review: market competition (2)

- Some contributions also consider **local concentration** indexes, i.e. the Concentration Ratio (CR_n) and Herfindahl-Hirschman Index (HHI)
  - Sen (2003) and Eckert and West (2004) shows that, in the Canadian market, the **local market concentration is significantly associated with higher retail price**.
  - Kihm et al. (2016), exploring the German retail gasoline market, find that **a higher HHI increases the ability of that station to set higher prices**.
  - However, Clemenz and Gugler (2006) find that **market concentration**, measured by the CR_1, CR_4 and HHI, **does not significantly affect average price.**

Literature Review: spatial competition

- Ning and Haining (2003) show a **positive relationship between the observed station's price and the average price of stations in the same local cluster**.
- Pennerstorfer (2009) and Pennerstorfer and Weiss (2013) find that gasoline stations' prices are spatially correlated: **the price of the closest neighbour influences a given station's pricing behaviour**.
- Hogg et al. (2012), focusing on the South-Eastern Queensland market, prove that **neighbouring stations experience unobserved shocks in a very similar way** (i.e. spatial propagation of prices).
- Firgo et al. (2015) in the Austrian market, prove that both **spatial proximity and centrality of stations explain the spatial correlation of prices**.
- Alderighi et al. (2015), on an Italian market (Cuneo), find **a weak but significant spatial dependence** (diesel price is more reactive than gasoline price).

Literature Review: contextual factors

- The novelty of this study is to understand whether the **sub-municipal context** affects gasoline prices
  - to date, this issue has been less regarded.
- Most of the studies account for the ***population***
  - Kihm et al. (2016) Clemenz and Gugler (2006) and Pennerstorfer (2009) show a positive relation with the price dependent variable.
- Pennerstorfer and Weiss (2013) show a negative relationship between **density population** and the **share of tourists** with gasoline prices
- Alderighi and Baudino (2015), include the **number of workers near gas stations**. They find a positive effect of labour on prices (shift in demand induces a rise of the prices).

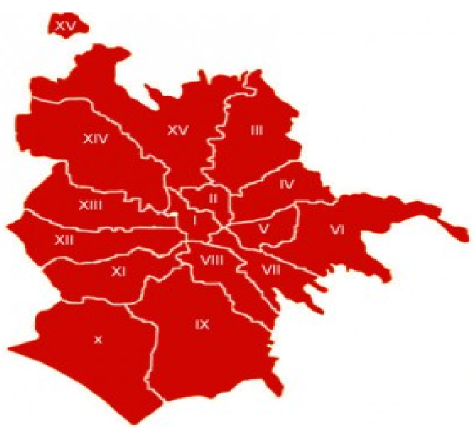
Italian gasoline sector

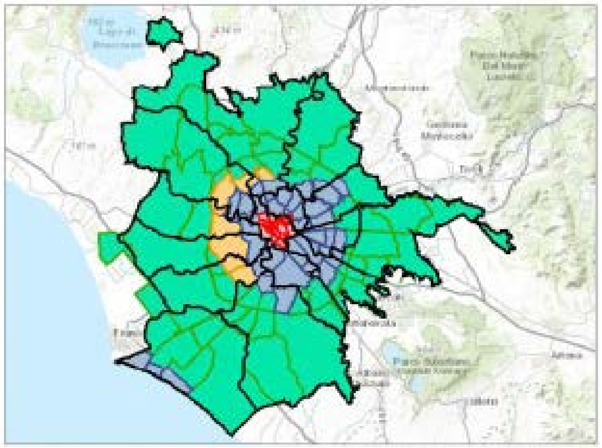
- A few and big vertically integrated companies
  - ✓ 8 big companies holding about 95% of the Italian retail fuel market
- Most of the branded stations are company-owned while few are operated by independent retailer
  - ✓ a few presence of «white pumps»
- Abundance of gas stations

- The price is designed as follows (Andreoli-Versbach, 2011)
  1. the **companies suggest a price to the stations' manager** which is not binding and not necessarily corresponding to the final price for consumers
  2. the **owner** of the station receives a discount on the suggested price and may decide to increase the suggested price by a certain percentage
  3. the service station **manager can set a price** ranging from a minimum equal to its purchase price to a maximum established by the company.

Empirical setting: Rome municipalities

- Municipalities of Rome represent the administrative subdivision of the territory of Rome. In total, there are fifteen municipalities including:
  - 22 wards (*rioni*) that make up the historic centre, all included within the Aurelian Walls
  - 35 districts surrounding the historic centre outside the Aurelian Walls
  - 6 suburbs, territories beyond the district
  - 53 sparsely populated areas called the Agro Romano.





Data and variables

- Station-level data of Rome city in 2016 are collected from the «Osservatorio Prezzi Carburanti» provided by the Italian Ministry of the Economic Development.

Dependent variable

- ***Price***: average yearly price, computed using the daily prices charged by each gas station over the observed year
  - gasoline and diesel prices of self-market

Explanatory variables

- **HHI**, i.e. $\sum_{k=1}^{K} s_{i,k}^{2}$, where *s* is the market share of station *i* in district *k*, calculated as the number of same-brand stations within a district over the total number of stations
- ***Motorway***, equal to 1 if the gasoline station is located on a motorway, 0 otherwise (omitted category)
- ***Trunk road***, equal to 1 if the gasoline station is located on a trunk road, 0 otherwise
- ***Other road***, equal to 1 if the gasoline station is located on other roads, 0 otherwise

Data and variables

Context variables

- **Population 20-69:** number of inhabitants residing in the municipality divided into the various toponymic areas.
  - *Source*: official statistical section of Municipality of Rome

- **Number of commercial businesses** active in 2012 for the municipality
  - *Source*: ISTAT

- **Real estate value** of the buildings in the toponymic areas of the municipality of Rome
  - *Source*: "Agenzia delle Entrate", the minimum and maximum value of the property per semester is made available.

Empirical Strategy (1)

- The form that consider the violation of OLS properties is given by the following equations:

$$y = \lambda Wy + X\beta_{(1)} + WX\beta_{(2)} + u \qquad |\lambda| < 1$$

$$u = \rho Wu + \varepsilon \qquad |\rho| < 1$$

  - **y** is the N × 1 vector of observations on the dependent variable
  - **X** is the N × k matrix of observations on the independent variables
  - **W** and **M** are N × N spatial-weighting matrices that parameterize the distance between neighborhoods
  - **u** are spatially correlated residuals and ǫ are independent and identically distributed disturbances
  - **λ** and **ρ** are scalars that measure, respectively, the dependence of yi on nearby y and the spatial correlation in the errors.
  - Maximum Likelihood estimator used in all estimates

Empirical Strategy (2)

1. To define the spatial effects, we need to define the **spatial weights matrix**
   - We use the maximum distance between the various service stations to see how much their prices spread in the city of Rome.
   - We also standardized our matrix to sum unity in each row.

2. To test the spatial correlation, among the variables considered, we use the **Moran's test** under the null hypothesis a non-correlation between regression residuals.

Moran's I test under randomisation		
Moran I statistic standard deviate = 5.1743,		p-value = 1.144e-07
alternative hypothesis: greater		
	sample estimates:	
Moran I statistic	Expectation	Variance
3,66E+04	-1,62E+03	5,45E+01

Results (1)

Spatial Lag Model Gasoline (self-mode)					
	1	**2**	**3**	**4**	**5**
HHI	4.7218e-06*** (1.4329e-06)	4.8991e-06 *** (1.4457e-06)	3.7827e-06*** (1.4324e-06)	3.9017e-06*** (1.4167e-06)	3.8331e-06*** (1.4514e-06)
Latitude	4.7218e-06*** (1.4329e-06)	-8.6296e+00 (5.3582e+00)	-1.1489e+01*** (5.3901e+00)	-1.2356e+01** (5.4063e+00)	-1.3550e+01** (0.0130495)
Longitude	-8.3286e+00 (5.3321e+00)	-2.9103e+01 (1.8033e+01)	-3.8777e+01** (1.8143e+01)	-4.1577e+01** (1.8200e+01)	-4.5660e+01** (1.8378e+01)
Latitude*Longitude	6.7096e-01 (4.2853e-01)	6.9548e-01 (4.3069e-01)	9.2607e-01*** (4.3329e-01)	9.9402e-01** (4.3467e-01)	1.0912e+00** (4.3894e-01)
Station types (omitted category: highway)					
Trunk road	-4.4183e-02** (1.9143e-02)	-4.3367e-02** (1.9156e-02)	-4.7546e-02 (1.8913e-02)	-4.5516e-02** (1.8773e-02)	-4.7672e-02** (1.8784e-02)
Other road	-4.2974e-02*** (1.3631e-02)	-4.3645e-02*** (1.3626e-02)	-4.9856e-02*** (1.3597e-02)	-5.1157e-02*** (1.3551e-02)	-5.4628e-02*** (1.3591e-02)
Lagged price (Lambda)	**0.47742 ****	**0.50154****	**0.41678****	**0.24527**	**0.25151**
Brand dummies	YES	YES	YES	YES	YES
Contextual variables					
Population 20 to 69		5.4391e-03 (6.4452e-03)			9.4490e-04 (6.7987e-03)
Commercial activities			2.3649e-02*** (5.8273e-03)		1.6529e-02** (6.5484e-03)
Real Estate Value				1.5819e-05*** (3.1821e-06)	4.0491e-02*** (1.1691e-02)
LR test value	5.5412	6.0591	4.0683	1.2211	1.2422
Wald statistic	9.6254	11.168	6.4406	1.8189	1.8738

Results (2)

Spatial Lag Model Diesel (self-mode)					
	1	**2**	**3**	**4**	**5**
HHI	4.5620e-06*** (1.5435e-06)	4.6447e-06 ** (1.5584e-06)	3.7827e-06** (1.5487e-06)	3.6689e-06** (1.5294e-06)	3.5977e-06** (1.5684e-06)
Latitude	-8.8844e+00 (5.6362e+00)	-9.0314e+00 (5.6779e+00)	-1.1887e+01** (5.6995e+00)	-1.2818e+01** (5.6986e+00)	-1.3830e+01** (5.7680e+00)
Longitude	-2.9968e+01 (1.8968e+01)	-3.0466e+01 (1.9110e+01)	-4.0122e+01** (1.9185e+01)	-4.3149e+01** (1.9185e+01)	-4.6608e+01** (1.9421e+01)
Latitude*Longitude	7.1607e-01 (4.5299e-01)	7.2804e-01 (4.5641e-01)	9.5830e-01*** (4.5817e-01)	1.0316e+00** (4.5819e-01)	1.1139e+00** (4.6385e-01)
Station types (omitted category: highway)					
Trunk road	-3.9977e-02** (2.0241e-02)	-3.9594e-02** (2.0272e-02)	-4.3091e-02** (2.0064e-02)	-4.1467e-02** (1.9875e-02)	-4.3766e-02*** (1.9927e-02)
Other road	-3.6992e-02** (1.4422e-02)	-3.7285e-02 ** (1.4426e-02)	-4.3498e-02 ** (1.4434e-02)	-4.5834e-02*** (1.4355e-02)	-4.8749e-02*** (1.4426e-02)
Lagged price (Lambda)	**0.53308****	**0.54238****	**0.48744****	**0.33388**	**0.33041**
Brand dummies	YES	YES	YES	YES	YES
Contextual variables					
Population 20 to 69		2.5178e-03 (6.8231e-03)			-1.2953e-03 (7.2140e-03)
Commercial activities			2.1842e-02 *** (6.2071e-03)		1.5036e-02** (6.9673e-03)
Real Estate Value				1.6296e-05*** (3.3837e-06)	4.2824e-02*** (1.2438e-02)
LR test value	7.7817	7.9066	6.3049	2.5857	2,4434
Wald statistic	13.58	14.349	10.201	3.8956	3.6741

Results (3)

Spatial Error Model Gasoline (self-mode)					
	1	2	3	4	5
HHI	4.6865e-06*** (1.4302e-06)	4.8376e-06*** (1.4359e-06)	3.6471e-06** (1.4396e-06)	3.5977e-06** (1.4171e-06)	3.6681e-06** (1.4433e-06)
Latitude	-1.2213e+01 (8.0962e+00)	-1.2540e+01 (8.4376e+00)	-1.6059e+01** (7.0175e+00)	-1.3941e+01** (6.8078e+00)	-1.5487e+01** (6.7937e+00)
Longitude	-4.1244e+01 (2.7202e+01)	-4.2360e+01 (2.8347e+01)	-5.4234e+01** (2.3588e+01)	-4.6972e+01** (2.2882e+01)	-5.2234e+01** (2.2839e+01)
Latitude*Longitude	9.8544e-01 (6.4958e-01)	1.0123e+00 (6.7695e-01)	1.2954e+00** (5.6328e-01)	1.1230e+00** (5.4645e-01)	1.2485e+00** (5.4541e-01)
Station types (omitted category: highway)					
Trunk road	-4.2017e-02** (1.9122e-02)	-4.1519e-02** (1.9106e-02)	-4.5519e-02** (1.8952e-02)	-4.5297e-02** (1.8762e-02)	-4.7268e-02** (1.8760e-02)
Other road	-4.5195e-02*** (1.3579e-02)	-4.5933e-02*** (1.3560e-02)	-4.9447e-02** (1.3546e-02)	-5.2323e-02*** (1.3449e-02)	-5.5483e-02*** (1.3484e-02)
Rho	**0.5144****	**0.54632*****	**0.39051****	**0.37419***	**0.36604**
Brand dummies	YES	YES	YES	YES	YES
Contextual variables					
Population 20 to 69		6.7414e-03 (6.9044e-03)			3.2681e-03 (7.0590e-03)
Commercial activities			2.2941e-02*** (5.9221e-03)		1.4373e-02** (6.5592e-03)
Real Estate Value				1.7788e-05*** (3.4236e-06)	4.9627e-02*** (4.6314e-06)
LR test value	6. 2731	7. 0169	3.0424	3.0491	2.505
Wald statistic	11. 477	14.089	5. 0124	4.4594	4.202

Conclusions

- We found evidence of spatial competition among different companies in the city of Rome.
- The most important aspect concerns the use of **context variables** as regressors to explain price behaviour of service stations.
- *Rho* and *Lambda* coefficients are significant and explain how spatial price propagation works in this area.
- Interestingly, the variable for the real estate value plays a very important role because when included in the model,

  the *rho* coefficient is no longer significant:

  - **prices seem to be correlated with each other in space, but this correlation is weakly due to spatial propagation of prices**
  - **rather, it is determined by the fact that stations operating in neighbourhoods with higher property values tend to set higher prices.**

Thank you for your attention!