Covid-19 and urban exodus: did urban dwellers contaminate rural dwellers?

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Motivation

- Following the announcements of lockdown measures by governments to prevent the spread of the Covid-19 epidemic:
  - millions of urban dwellers anticipated these lockdowns
  - they escaped from the major cities for the duration of the lockdown: **urban exodus**
- Since the major cities were the first and most affected by the epidemics, these "Covid-19 immigrants" could have spread it to rural areas
- Economically and politically interesting

What is the causal impact of the urban exodus on Covid-19 deaths and hospitalizations?

Contextual background

- I distinguish between:
  1. those returning to their main residences: the residents
  2. **those leaving their main residences: the non-residents**

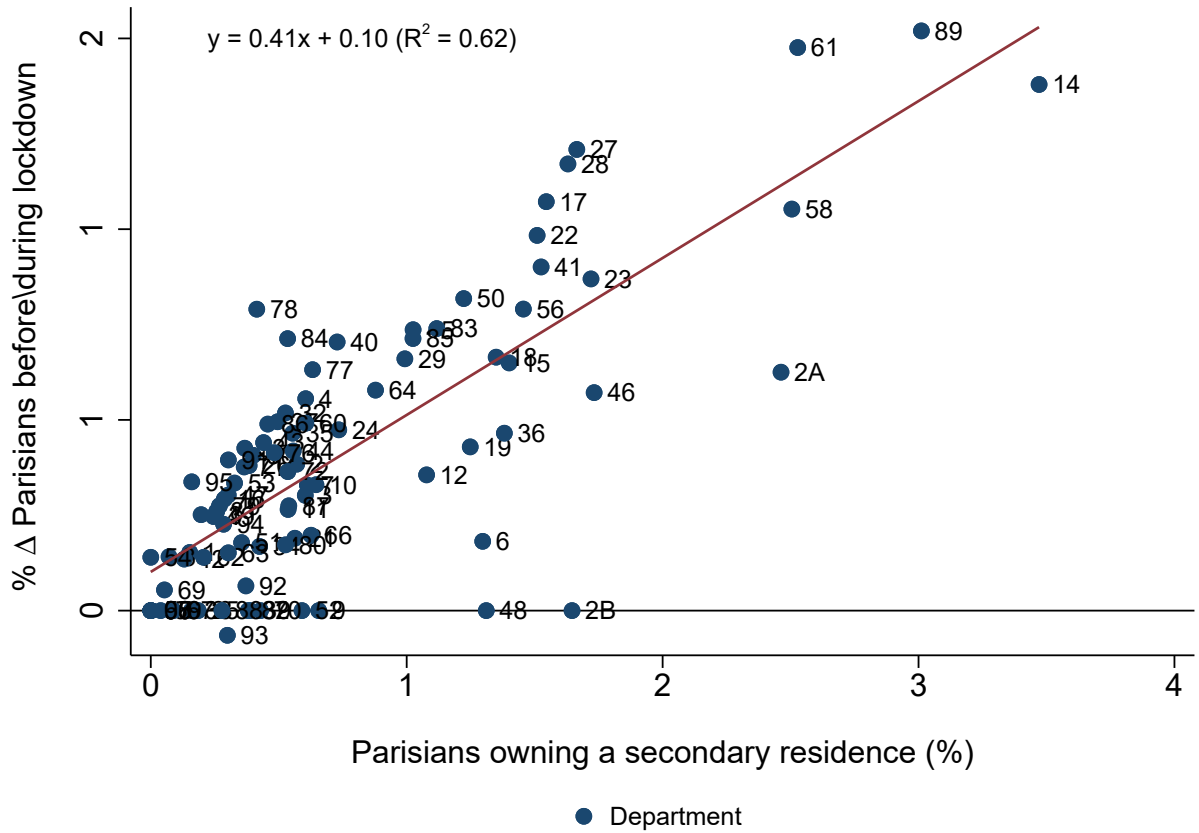
- Among the non-residents leaving their main residences there are:
  1. **persons owning a secondary residence**
  2. students/young workers living in a densely populated municipality who moved back to their family residences

This study

- I use a difference-in-differences strategy and new data on users' mobile phone location from the French mobile operators
- On March 14, 2020, Edouard Philippe – the French Prime Minister – announced that all non-essential public spaces will be closed from March 17
- According to the French national statistical institute (INSEE):
  - 1.5 million inhabitants went back to their department of residence
  - at least 218,000 Parisians left (i.e. 10% of Paris' population and 71% of Parisians owning a secondary residences in another department)

Stylized fact: Parisians' urban exodus and secondary residence

Figure 1: Urban exodus of the Parisians according to the share of Parisians owning a secondary residence by departments



The French case: a quasi-natural experiment

- Most of these "Covid-19 immigrants" went to the department where they have a secondary residence
- As-if random distribution of these immigrants among the departments during the lockdown
  - some departments have a very large share of secondary residences among the total of housing, while others have almost no secondary residences
  - the treatment intensity is very different across departments
- Starting point for a quasi-natural experiment
- Allows to estimate the possible spread of Covid-19 from urban to rural population (causal impact of the urban exodus)

Main result

Urban exodus led to an increase in the number of hospitalizations

Related literature

- Many papers have already examined the relationship between population density and mobility restrictions on Covid-19 incidence, but none have specifically examined the impact of a large population shift from cities to rural areas

- Before the Covid-19 epidemic, there were economic and health studies on the 1918 influenza pandemic, aiming to estimate the causes of the spread
  - Garrett (2007); Mills et al. (2004); Chowell et al. (2008); Chapelle (2022)
- Significant and positive correlation between population density and/or poverty on Covid-19 incidence
  - Wheaton and Kinsella Thompson (2020); Almagro and Orane-Hutchinson (2020); Carozzi et al. (2020); Brandily et al. (2020)

Related literature

- Previous economic literature on Covid-19 has focused also on the effect of social distancing measures or to the compliance to such measures
  - A 10% decrease in mobility is associated with a 14.6% decrease in the average daily cases growth rate
    Soucy et al. (2020); Yilmazkuday (2020)
  - The degree of work mobility reduction is driven by the intensity of poverty
    Bargain and Aminjonov (2020a)
  - Compliance is significantly higher in high-trust in government regions
    Bargain and Aminjonov (2020b); Brodeur et al. (2021)
- Negative (positive) effect of mobility (restrictions) on the spread of the epidemics
  - Glaeser et al. (2022); Couture et al. (2022); Coven et al. (2022); d'Halbis et al. (2023);

Data

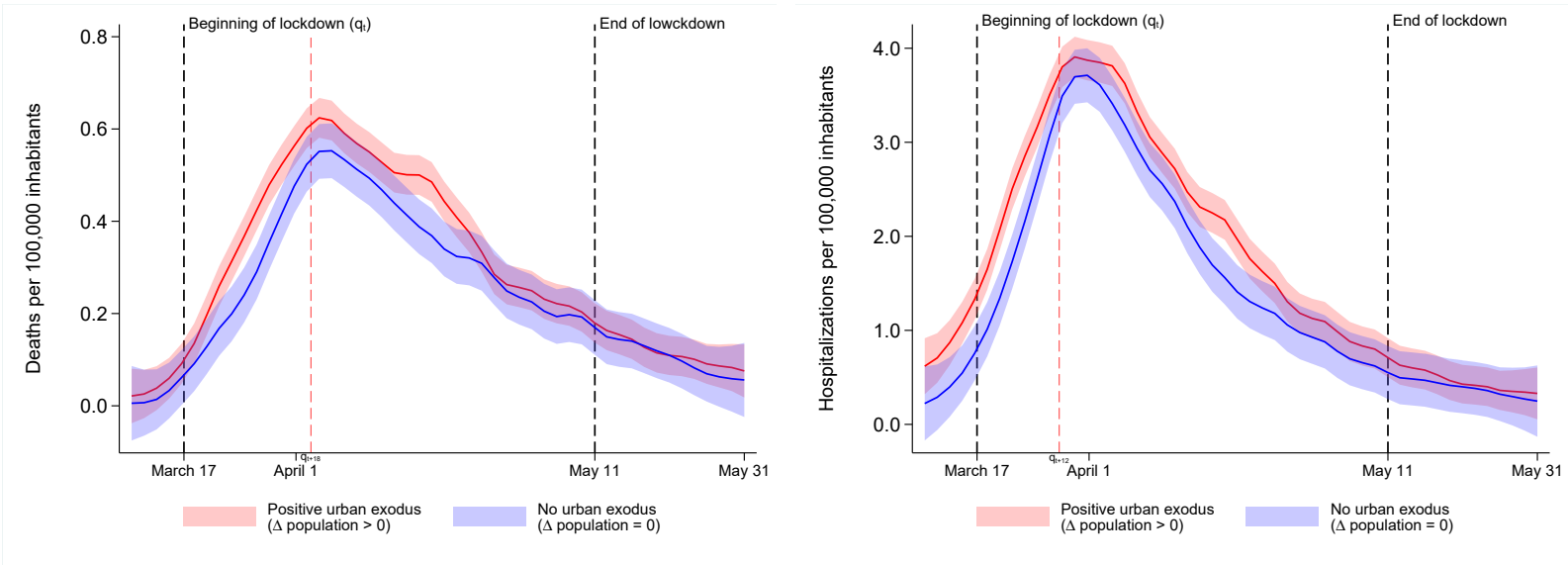
1. Deaths and hospitalizations
   - Official data from Public Health France (*Santé Publique France*)

2. Variation of population before and after the beginning of the lockdown
   - Based on user's mobile phone location aggregated by French mobile operators and compiled by the INSEE for each department
   - Split in residents of the department, non-residents of the department, foreigners, and Parisians

3. Population mobility
   - Google Covid-19 mobility reports
   - Aggregated data from users' mobile phone location (Google maps)

Differences-in-differences

Figure 2: Common trend between departments with positive and zero urban exodus



(a) Deaths

(b) Hospitalizations

Empirical strategy: DiD

- Difference-in-differences
- Identification strategy:
  1. uses the Covid-19 incubation period as a pivot for a pre- and post-period
  2. takes advantage of the differences in treatment intensity of the urban exodus (positive, negative or zero)
  3. captures heterogeneous effects of urban exodus in the departments with advanced epidemic stages before lockdown
- Disentangling the effect for different type of "migrants"
  - Total urban exodus (residents + non-residents + Parisians + foreigners)
  - Non-residents urban exodus (excluding the Parisians)
  - Parisians urban exodus

Period of treatment

- Two different periods of treatment (Post period)
  1. **12 days** after the first day of lockdown (i.e. March 28)
     For the hospitalizations per 100,000 inhabitants
  2. **18 days** after the first day of lockdown (i.e. April 3)
     For the deaths per 100,000 inhabitants

- Come from the mean days estimated by clinical studies literature between infection and hospitalization then death
  - Mean duration of incubation of 5 days, followed by a 7 days elapsed between the onset of the first symptoms and hospitalization
    Wang et al. (2020); Guan et al. (2020); Zhou et al. (2020); Nie et al. (2020)
  - Median and mean time to death of 18.5 and 18.8 days respectively
    Zhou et al. (2020); Verity et al. (2020)

Causal impact of urban exodus: DiD model

$$\begin{aligned}\text{Covid-19 cases}_{dt} = \beta_0 + (\delta + \gamma \times \text{Advanced epidemics}_d) \\ \times \text{Post}_t \times \text{Urban exodus}_d + \alpha_d + \alpha_t + \epsilon_{dt}\end{aligned} \tag{1}$$

- $Covid-19\ cases_{dt}$ is either the daily number of Covid-19 deaths or hospitalizations per 100,000 inhabitants
- $Urban\ exodus_d$ is a continuous treatment variable which corresponds to the variation of population before and after the beginning of the lockdown in department d.
- $Post_t$ is a dummy variable defining the treatment period
- $Advanced\ epidemics_d$ is a dummy variable defining whether a department had advanced Covid-19 epidemics cases before lockdown
- α_d department fixed effects and α_t day fixed effects

Threat to identification

- Endogeneity issue: did urban dwellers left for rural areas not or less affected by Covid-19?
- Such behavior would lead to a simultaneity bias
- But urban dwellers who left their main residence for another department are two types of people:
  1. People owning a secondary residence
  2. Students/young workers living in a densely populated municipality
- Those "Covid-19 immigrants" did not take into account the previous Covid-19's cases when choosing their place of departure
  - They left depending on the location of their secondary or family residence
- Nonetheless, one could still argue that people who moved were people with secondary or family residence not in departments with advanced epidemics stage
  - No evidence of such a correlation between the level of variation of population and the level of Covid-19 cases before lockdown

▸ Graphs

Main results

- The urban exodus led to a significant increase in the number of hospitalizations
  - between 1,850 and 13,500 excess hospitalizations in France
    ▸ Computation
  - corresponds to 1.65% and 12% of the cumulated hospitalizations for the period respectively
- Additional evidence that most if this excess Covid-19 cases come from the Parisians "immigrants"
  - They represent an important share of the people who left their main residence to join another department (around 218,000)
  - Paris region was one of the most impacted place by the epidemic before the lockdown

Additional results

1. Examine the local determinants of the spread of Covid-19
   ▸ Econometric model
2. Estimate the effect of mobility on reducing the spread of the epidemic in France, i.e. the effectiveness of the lockdown
   ▸ Econometric model

- Local determinants of Covid-19 spread are:
  - population density (inhabitants/km^2): + effect
  - the share of social housing: + effect
- People living in poor and densely populated areas are more likely to be contaminated

Additional results

- Elasticity estimates of Covid-19 cases growth rate with respect to different mobility indices shows:
  - a 10% reduction in retail and recreation mobility leads to a relative decrease in the average daily deaths growth rate of 17%
  - 35.4% of decrease for workplaces mobility
  - 12.2% of decrease for parks mobility
- Lockdown and stay-at-home measures implemented by the French government were truly effective in reducing the spread of the epidemic

Robustness checks: spatial correlation

- I test for a possible bias from the spatial correlation of the Covid-19 cases using two methods

1. Performing an ordinary least squares (OLS) with a standard errors adjustment for spatial (across nearby units) autocorrelation (spatial HAC)
   - Method pioneered by Conley (1999, 2008), and further developed by Hsiang (2010), to deal with the potential spatial correlation in the error term

2. Using a spatial error model (SEM) ▸ Econometric model

- Estimates show similar significance levels and magnitudes

Discussion

- Effect was less significant in the departments with advanced epidemics stage prior the lockdown
  - Social distancing measures were taken before the lockdown
  - People who immigrated to these departments were probably more vigilant
- Evidence in favor of a higher or single causal impact of urban exodus on hospitalizations
  - Before the lockdown, the Prime Minister announced that all non-essential public spaces will be closed and that person-at-risk will have to stay-at-home
  - Non-residents met mostly non-at-risk person
  - Those contaminated and hospitalized were less likely to die from Covid-19 (e.g. young and healthy)

Conclusion

- "Covid-19 immigrants" or non-residents of the departments increased the number of Covid-19 cases
- At this stage, it is impossible to disentangle whether this excess number of hospitalizations is the result of contamination by these "Covid-19 immigrants", or whether it comes from these non-residents solely
  - Non-residents arriving in the department were young and healthy
- Difficult to assert that the urban exodus effect was negative, even if it increased the number of Covid-19 cases
  - e.g. by auto-allocating the patients between departments, it released patients congestion from the most crowded hospitals
  - if such, the urban exodus led to decrease the total (aggregated) number of Covid-19 deaths in France

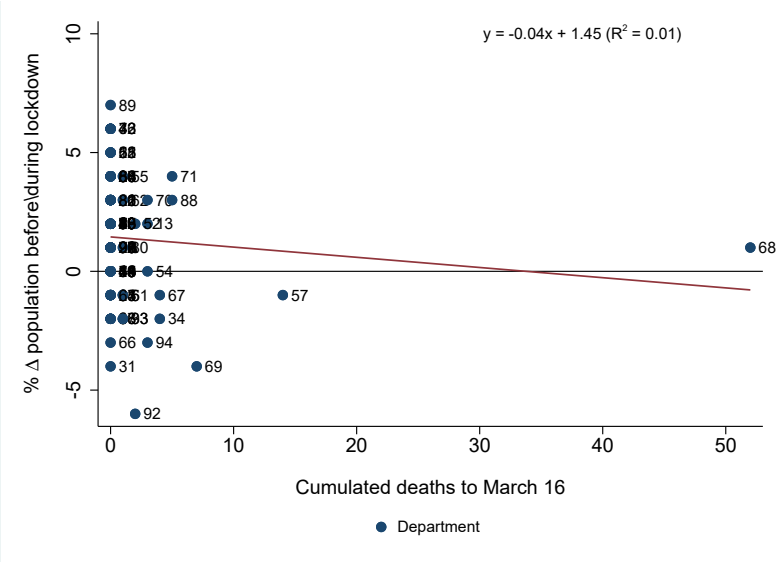
Appendix

Related literature

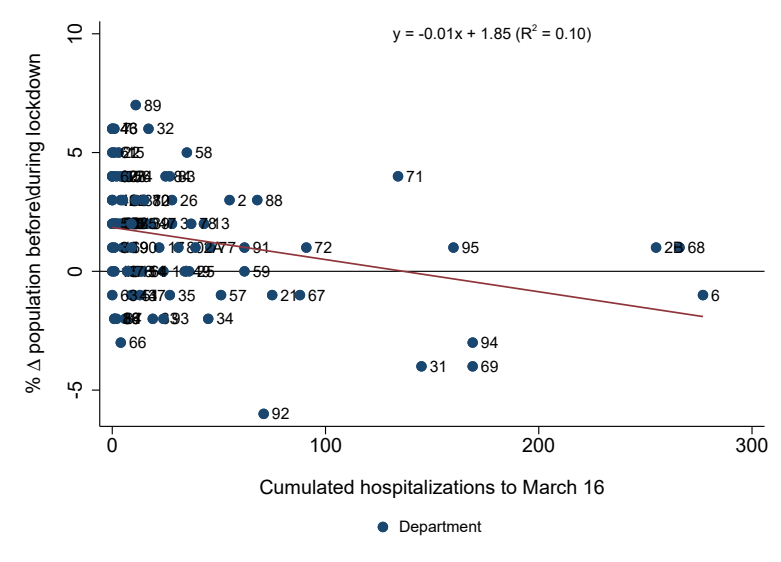
- Some quasi-natural experiments studies estimate the effect of the 2020 French municipal election, due to possible contamination in the polling places
  - Contradictory results
  - No impact of the municipal elections on the spread of the epidemic
    Zeitoun et al. (2020); Bach et al. (2020)
  - Excess hospitalizations and deaths due to the elections
    Cassan and Sangnier (2020); Bertoli et al. (2020)

Threat to identification

Figure 3: Urban exodus in function of the Covid-19's cases before lockdown



(a) △ population before\during lockdown (%) in function of the cumulated deaths before lockdown



(b) △ population before\during lockdown (%) in function of the cumulated hospitalizations before lockdown

◂ Return

Additional hospitalizations due to the urban exodus

- Computation is performed only for the departments with a positive variation of population (i.e. urban exodus > 0)

$$\text{Additional hosp.}_d = (\widehat{\delta} + \widehat{\gamma} \times \text{Advanced epidemics}_d) \times \text{Post}_t \times \text{Urban exodus}_d \quad (2)$$

- Then multiply the results by the department d's population and the number of days in Post period
- Added up the additional hospitalizations of each department to obtain the total number of additional hospitalizations in France

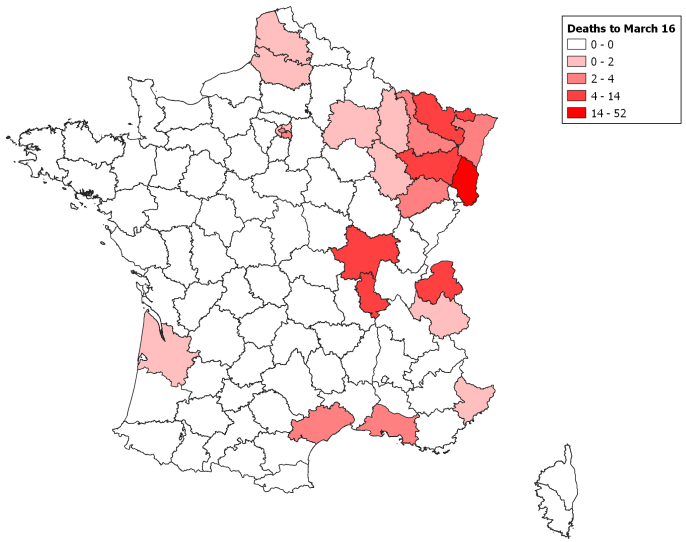
◂ Return

Spatial model

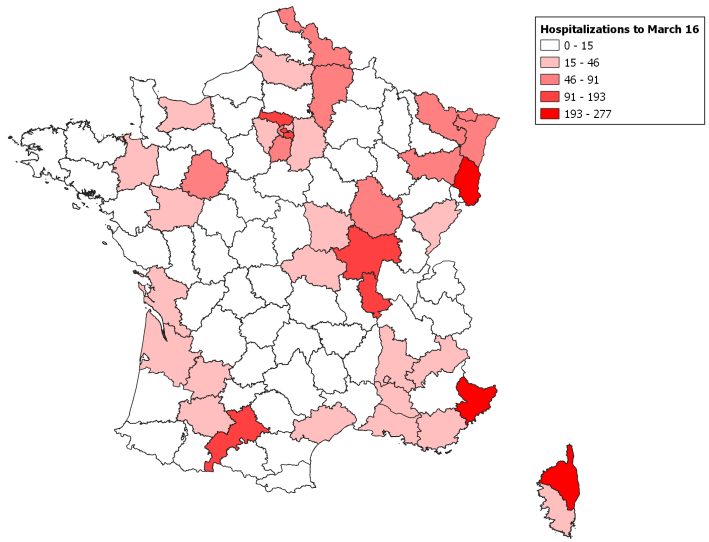
- Transmission of the virus spreads spatially around clusters
- Spread of the disease depends a lot on social contacts
  - Varies according to the duration of contact, age, region, and date for instance, and can be modeled using a matrix of contacts
    Mossong et al. (2008); Prem et al. (2017)
  - Covid-19 spread is correlated a lot with local culture:
    Platteau and Verardi (2020)
- Very difficult (and beyond the scope of this study) to compute a matrix of social contacts
- Such heterogeneous correlation would be part of the error term
  - Error terms would be spatially dependent and heteroskedastic

Spatial correlation

Figure 4: Covid-19's cases: cumulated at the beginning of the lockdown



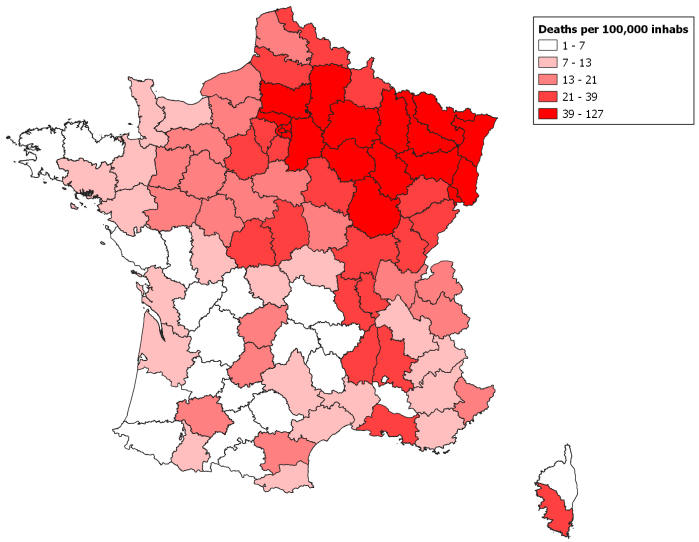
(a) Deaths



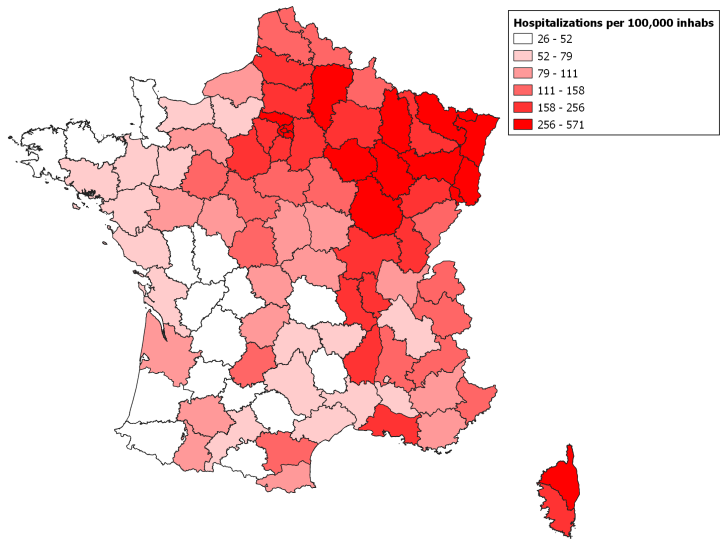
(b) Hospitalizations

Spatial correlation

Figure 5: Covid-19's cases: cumulated at the end of the regressed period



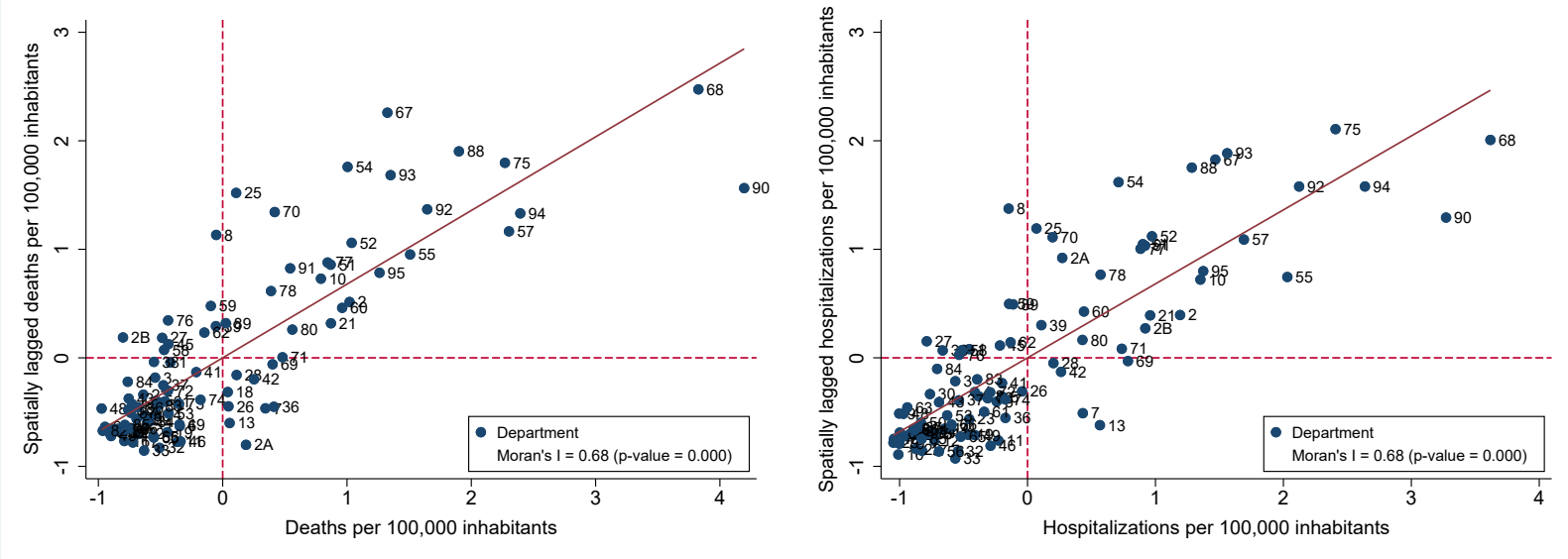
(a) Deaths



(b) Hospitalizations

Spatial correlation

Figure 6: Moran's I plots



(a) Deaths

(b) Hospitalizations

The determinants of the spread of Covid-19

$$\text{Covid-19 cases}_d = \beta_0 + X'\beta_1 + \epsilon_d \tag{3}$$

- X is a vector of variables suspected to be correlated with the Covid-19 propagation
- I instrument the urban exodus variable with the share of secondary residences by department
- Is it a valid instrument?
  - The share of secondary residences is correlated with the urban exodus variable
  - The share of secondary residences is not directly correlated with Covid-19 cases, except through the non-residents of the department who went to their secondary residences (exclusion restriction)

◂ Return

Population's mobility

The log-log estimation model is:

$$\log(\text{Growth rate}_{rt}) = \beta_0 + \varepsilon \cdot \log(\text{Mobility}^{j}_{rt}) + \alpha_r + \alpha_t + \epsilon_{rt} \quad (4)$$

- *Growth rate*$_{rt}$ corresponds to the daily upcoming growth rate of deaths or hospitalizations per 100,000 inhabitants in region r at day t
- *Mobility*$^{j}_{rt}$ corresponds to the daily percentage of variation in mobility index j (either retail and recreation, grocery and pharmacy, parks, transit stations or workplaces)
- α_r region fixed effects and α_t day fixed effects

◂ Return

DiD with spatial model

The spatial error model (SEM) is:

$$\begin{aligned}\text{Covid-19 cases}_{dt} = \beta_0 + (\delta + \gamma \times \text{Advanced epidemics}_d) \\ \times \text{Post}_t \times \text{Urban exodus}_d + \alpha_d + \alpha_t \\ + u_{dt}, \quad u_{dt} = \lambda W u_{dt} + \epsilon_{dt}\end{aligned} \tag{5}$$

- u_{dt}, the spatially lagged error term is composed of:
  - Wu_d which accounts for the spatial autocorrelation among the errors
  - ϵ_d the error term
- W is a row-standardized contiguity spatial weighting matrix which gives a weight of 1 if two departments are neighbors, 0 otherwise

◂ Return