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Strategical interactions on municipal public safety spending with correlated private information☆

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ABSTRACT

We investigate interactions of public safety spending among spatially related local jurisdictions in a framework of simultaneous move game both theoretically and empirically. Incorporating the mobility of residents and externality of public safety services, it is found that the public safety spending of a municipal government can be negatively related to those of its neighbors, which is empirically supported by a general interaction model with correlated private information using the data on municipalities in North Carolina. In this case, strategic interactions induce a reduction of municipal public safety spending by 7.2404% on average and a local government will reduce its own spending by 0.0927 million dollars when one of its neighbors is expected to increase public safety spending by 1 million dollars, showing strong "free-riding" effects.

1. Introduction

Interdependence of policies among spatially related local governments have been supported by recent empirical studies, such as Allers and Elhorst (2005), Case and Rosen (1993), Besley and Case (1995), Brueckner (1998), Bordigon et al. (2003), Ertur and Koch (2007), LeSage and Fischer (2007), Rincke (2007). This spatial dependence may come from either common shocks to neighboring municipalities or strategic interactions among local governments. One type of strategic interactions is the "yardstick" competition. The public policies of a jurisdiction can depend on some unobservables. By comparing local policies with those of a geographically close and similar jurisdiction can help the voters to judge the performances of their current officials. Allers and Elhorst (2005), Besley and Case (1995) and Bordigon et al. (2003) find empirical evidence of this kind of interactions in various regions. However, as Bordigon et al. (2003) have noted, this kind of interdependence only happens when the incumbent officials face a random re-election situation. It does not exist when the local officials cannot be re-elected or are confident to be re-elected. In addition, as Wilson and Wildasin (2004) have pointed out, these interactions are mainly informational, embodied by correlations between unobservables. Another type of strategic interaction originates in the interdependence of the welfare or payoff of public policies, which in turn comes from two sources, the mobility of consumer-voters between different communities (Tiebout (1956)) and the policy externality (Zodrow and Mieszkowski (1986) and Case and Rosen (1993)). As in this case, local governments' policies can be modeled as an equilibrium outcome of a simultaneous move game, this type of interactions is the "real" strategic interaction. In this paper, we investigate the interactions of local governments' expenses on public safety both theoretically and empirically. We build a theoretical model based on a simultaneous move game. With a function approximation of the equilibrium strategies, we derive econometric models for estimation, including the one under incomplete information with correlated privately known characteristics. Applying these econometric models to data on municipal governments' spendings on public safety in North Carolina, we found significant negative interaction effects.[1]

Our theoretical model hinges on two facts: criminals can move and commit crimes in adjacent cities and 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 of another city in its neighborhood in two ways. On one hand, as the neighbor spends more

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[1] We are also interested in other models as mentioned. However, our data would not have information on yardstick competition and might be irrelevant for its study. For common shocks, they would be captured by the use of panel data models.

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on public safety, it is relatively more likely for a criminal to be caught in the neighbor, driving criminal activities to this city, which 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. It is shown as an example that when the payment function is logarithmic and the probability of being caught has unit elasticity of substitution between crimes and public safety services, the substitution effect will dominate. Moreover, spendings by a neighboring city can affect the rate of a local jurisdiction's own policy effect. If an increase of spending on public safety in a city can reduce crime incidents in its own territory, when a neighboring city raises spending, the magnitude of reduction in crimes will be even bigger than the amount it would be without the spending increase by that neighbor. Owing to this type of spatial policy spillovers, the spending policy of one city will be affected by policies of its neighbors, showing "strategic interactions".

In general, there might not be an analytical form of the optimal policies in equilibrium. By taking a tractable approximation, we are able to derive econometric models for strategic interactions under different information structures including not only the Spatial autoregression (SAR) model under complete information but also social interaction models under incomplete information such as Manski (1993), Brock and Durlauf (2001), Lee et al. (2014), and Xu (2012). Moreover, with incomplete information, if there are asymmetric and private information on agents' traits, the econometric model with be the one analyzed recently by Yang and Lee (2016). According to Yang and Lee (2016), this model allows equilibrium expectations of outcomes of an agent to vary with not only her own characteristics but also private information used to make predictions, which is more general.

Interactions in a network can be modeled as either a complete information game or an incomplete information game. Although both scenarios are possible in theory, they can induce different implications. Under the rationale of Davidson and MacKinnon (1981), we propose a non-nested J type test which may help to select between those two information structures when there are private information on exogenous characteristics in an incomplete information model.

We analyze the public safety spending data for municipalities in North Carolina in 2012. We associate those spendings to demographics and financial status such as city governments' total annual revenues, populations, ages, education, and residents' income levels. As some demographics are not published when local officials make fiscal decisions, it is reasonable to assume that the values of some factors are private information. Therefore, we estimation the data by models of different information structures, the complete information model, the incomplete information model when all the covariates are publicly known to local jurisdictions, and the incomplete information one when some covariates are self-known. This possibly self-known variable is the median household income in a municipality. For municipalities in the same state, it is probable that income levels of their residents are correlated with each other. Three possible distributions of the median household income are considered. The first one is the benchmark case when median household incomes of different municipalities are independently and identically (i.i.d.) distributed. The second one is with random effects where the municipal median income is affected by the state level and some idiosyncratic shocks. In this case, the distribution of a municipality's household income conditional on that of another city is the same across any of the municipalities in the state. The third one is the SAR model, where a household income in a municipality will be spatially correlated with those of different neighboring cities. The estimates of all the models using different sets of covariates on financial status and demographics all show significant negative interaction intensities. Although the J type tests show that both complete and incomplete information structures are possible, the information criterion is in favor of the case that the municipal median household incomes are self-known and follow a SAR model. According to those estimates, if two cities with a distance no more than 50 kilometers are viewed as close to each other and spatially related, an increase of 1 million dollars in the expected public safety spending of a neighboring city can lead to a municipal government to lower its own spending by 0.0927 million dollars; and strategic interactions among local governments reduce the public safety spending by 7.2404% on average. Therefore, there is a strong evidence that municipal governments intend to be "free-riders" in terms of financing public safety services.

The paper proceeds as follows. Section 2 provides a theoretical investigation. The econometric specifications are discussed in Section 3, emphasizing numerical computation methods and properties of estimators for two different models from which the correlated private information may be generated, namely, the random effect model and the SAR model. There are also discussions on the J type tests to select between the complete and incomplete information models in that section. Data description and empirical findings are presented in Section 4. Section 5 concludes. All proofs are put in the Appendix A.

2. A theoretical model

Suppose that there are n municipalities. Two cities are spatially related if they share a common border or the distance between them is less than some cutoff value. Their spatial relations are described by an $n\times n$ matrix, W_n, the spatial weight matrix. For any two cities, $i \neq j$, $W_{n,ij} > 0$ if i is spatially related to j; and $W_{n,ij} = 0$ otherwise. $W_{n,ii} = 0$ for all i=1,...,n. Every municipal government spares some part of its annual revenue on policeman's salary, equipment, and facilities such as emergent alert. All those spendings on public safety for city i are summarized by the variable y_i. Public safety of neighboring cities are interdependent through two channels: criminals can mobilize between nearby cities and may be caught in any city.

Consider the decision of a representative criminal gang located mainly in city i. Suppose that it may commit crimes in i and each of i's neighboring cities. Collect the indices of those cities in set N_i. That is $N_i = \{j: j = i or W_{n,ij} \neq 0\}$. Denote its criminal activity scale in city j by $C_{i,j}$, for either j=i or $W_{n,ij} \neq 0$. The payment from the criminal activity $C_{i,j}$ is $U_i(C_{i,j})$. The payments from all the neighboring cities are additive so that the total payment is the sum, $\sum_{j\in N_i} U_i(C_{i,j})$. i may be caught in any of those cities when committing crimes. The probability of being caught in j varies with the public safety spending in city j, y_j, and the scale of crimes, $C_{i,j}$, and is described by the function $P(y_j, C_{i,j})$. This probability increases with both arguments, i.e. $P_y > 0$ and $P_C > 0$. Suppose the event that a criminal is caught in a city is independent of the event in another city. However, once caught in one city, a criminal cannot receive payments from any of those cities and has to pay a fine of $K_i > 0$ in addition. The allocation of criminal activities with public safety spendings as $(y_1, \ldots, y_n)'$ can be characterized by the following optimization problem:

$$\max_{C_{i,j}\geq 0, for j\in N_i}\left[\prod_{j\in N_i}(1-P(y_j, C_{i,j}))\right]\cdot\left(\sum_{j\in N_i}U_i(C_{i,j})\right)-\left[1-\prod_{j\in N_i}(1-P(y_j, C_{i,j}))\right]K_i. \tag{2.1}$$

Denote the optimal solution as $C^*_{i,j} \geq 0, for j \in N_i$. It satisfies the first order condition below:[2]

$$U'_i(C^*_{i,j}) = \frac{\sum_{k\in N_i} U_i(C^*_{i,k}) + K_i}{1 - P(y_j, C^*_{i,j})}\cdot\frac{\partial P(y_j, C^*_{i,j})}{\partial C_{i,j}}. \tag{2.2}$$

for any $j \in N_i$. Suppose that $U'_i(\cdot) > 0$ and $U''_i(\cdot) < 0$. It follows from Eq. (2.2) that

$$\frac{U'_i(C^*_{i,j})}{U'_i(C^*_{i,j'})} = \frac{-\frac{\partial \ln(1-P(y_j, C^*_{i,j}))}{\partial \ln C_{i,j}}}{-\frac{\partial \ln(1-P(y_{j'}, C^*_{i,j'}))}{\partial \ln C_{i,j'}}}\cdot\frac{C^*_{i,j'}}{C^*_{i,j}}, \tag{2.3}$$

[2] It is possible to have corner solutions, namely, $C^*_{i,j} = 0$ for some j's. In the qualitative comparative analysis, we focus on the case that there is a unique interior solution.