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# Endogenous peer effects: local aggregate or local average?☆

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ABSTRACT

We develop a unified model embedding different behavioral mechanisms of social interactions and design a statistical model selection test to differentiate between them in empirical applications. This framework is applied to study peer effects in education (effort in studying) and sport activities for adolescents in the United States. We find that, for education, students tend to *conform* to the social norm of their friends while, for sport activities, both the social multiplier and the social norm effect matter.



## 1. Introduction

In many circumstances, the decision of agents to exert effort in education, or some other activity, cannot adequately be explained by their characteristics and by the intrinsic utility derived from it. Rather, its rationale may be found in how peers and others value this activity. There is indeed strong evidence that the behavior of individual agents is affected by that of their peers. This is particularly true in education, crime, labor markets, fertility, participation in welfare programs, etc. (for surveys, see, Glaeser and Scheinkman, 2001; Moffitt, 2001; Durlauf, 2004; Ioannides and Loury, 2004; Ioannides, 2012). The way peer effects operate is, however, unclear. Are students working hard at school because some of their friends work hard or because they do not want to be different from the majority of their peers who work hard?

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The aim of this paper is to help our understanding of social interaction mechanisms of peer effects. For that, we begin by developing a *social network model* aiming at capturing how peer effects operate through social networks.[1] We characterize the Nash equilibrium and show under which condition an interior Nash equilibrium exists and is unique. Such a model encompasses the most popular peer effects models on networks: the *local-aggregate* and the *local-average* models. In the *local-aggregate model* (see, in particular, Ballester et al., 2006, 2010; Bramoullé and Kranton, 2007; Galeotti et al., 2009; Calvó-Armengol et al., 2009), endogenous peer effects are captured by the *sum of friends' efforts* in some activity so that the more active friends an individual has, the higher is her marginal utility of exerting effort. In the *local-average model* (e.g. Glaeser and Scheinkman, 2003; Patacchini and Zenou, 2012; Boucher et al., 2014), peers' choices are viewed as a *social norm* and individuals pay a cost for deviating from this norm. In this model, each individual wants to conform as much as possible to the social norm of her reference group, which is defined as the average effort of her friends.[2] Ghiglino and Goyal (2010) develop a theoretical model where they compare the local aggregate and local average models in the context of a pure exchange economy where individuals trade in markets and are influenced by their neighbors. They found that with *aggregate* comparisons, networks matter even if all people are equally wealthy. With *average* comparisons, networks are irrelevant when individuals are equally wealthy. The two models are, however, similar if there is heterogeneity in wealth.[3] We are not aware of a paper where both local-aggregate and local-average effects are incorporated in a unified network model.

Next, we study the econometric counterpart of the theoretical model. In the spatial econometric literature, the local-average and the local-aggregate model are well-known and their main difference (from an econometric viewpoint) is due to the fact that the adjacency matrix is row-normalized in the former but not in the latter. Our theoretical analysis provides a microfoundation for these two models. For the *local-average* model, Bramoullé et al. (2009) show that intransitivity in network connections can be used as an exclusion restriction to identify the endogenous peer effect from contextual and correlated effects. In this paper, we show that, for the *local-aggregate* model, different positions of the agents in a network captured by the Bonacich (1987) centrality can be used as additional instruments to improve identification and estimation efficiency. We also give identification conditions for a general econometric network model that incorporates both local-aggregate and local-average endogenous peer effects.

Finally, we extend Kelejian's (2008) *J* test for spatial econometric models to differentiate between the local-aggregate and the local-average endogenous peer effects in an econometric network model with network fixed-effects. We illustrate our methodology using data from the U.S. National Longitudinal Survey of Adolescent Health (AddHealth), which contains unique detailed information on friendship relationships among teenagers. In line with a number of recent studies based on the AddHealth data (e.g. Calvó-Armengol et al., 2009; Lin, 2010; Patacchini and Zenou, 2012; Liu et al., 2012), we exploit the structure of the network as well as network fixed effects to identify peer effects from contextual and correlated effects.[4] We find that, for study effort, students tend to *conform* to the social norm of their friends while, for sport activities, both the social multiplier and the social norm effect matter. Our results also show that the local-average peer effect is overstated if the local-aggregate effect is ignored and vice versa. In this respect, our analysis reveals that caution is warranted in the assessment of peer effects when social interactions can take different forms.

We believe that it is important to be able to disentangle empirically different behavioral mechanisms of endogenous peer effects because they imply different policy implications. In the *local-average* model, the only way to affect individuals' behavior and thus their outcomes is to change the *social norm* of the group. In other words, one needs to affect most people in the group for the policy to be effective. As a result, *group-based policies* should be implemented in the context of this model. On the other hand, for the *local-aggregate* model, one can target only one individual and still effectively influence the whole network. In other words, in the local-aggregate model there is a more salient social multiplier effect than in the local-average model, and hence, individual-based policies could be implemented.[5]

The rest of paper is organized as follows. Section 2 introduces the theoretical framework for the network models. Section 3 discusses the identification conditions of the corresponding econometric models. We extend the *J* test of Kelejian and Piras (2011) to network models with network fixed effects in Section 4 and empirically test the network models using the AddHealth data in Section 5. Section 5.4 discusses the policy implications of our results. Finally, Section 6 concludes. All proofs of propositions can be found in Appendix A.

[1] There is a growing literature on networks in economics. See the recent literature surveys by Goyal (2007), Jackson (2008) and Jackson and Zenou (2014).

[2] In economics, different aspects of conformism and social norms have been explored from a theoretical point of view. To name a few, (i) peer pressures and partnerships (Kandel and Lazear, 1992) where peer pressure arises when individuals deviate from a well-established group norm, e.g. individuals are penalized for working less than the group norm, (ii) religion (Iannaccone, 1998; Berman, 2000), since praying is much more satisfying the more average participants there are, (iii) social status and social distance (Akerlof, 1980, 1997; Bernheim, 1994; Battu et al., 2007, among others) where deviations from the social norm (average action) imply a loss of reputation and status.

[3] Another interesting paper is that of Clark and Oswald (1998) who propose a choice-theoretical justification for the local-average (i.e. conformist) model.

[4] The underlying assumption is that any troubling source of heterogeneity, which is left unexplained by the set of observed (individual and peers) characteristics can be captured at the network level, and thus taken into account by the inclusion of network fixed effects.

[5] See our discussion in Sections 2.5 and 6.