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Strategic behaviour in Schelling dynamics: Theory and experimental evidence ☆

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ABSTRACT

In this paper we experimentally test Schelling's (1971) segregation model and confirm the striking result of segregation. In addition, we extend Schelling's model theoretically by adding strategic behaviour and moving costs. We obtain a unique subgame perfect equilibrium in which rational agents facing moving costs may find it optimal not to move (anticipating other participants' movements). This equilibrium is far from full segregation. We run experiments for this extended Schelling model, and find that the percentage of full segregated societies notably decreases with the cost of moving and that the degree of segregation depends on the distribution of strategic subjects.

1. Introduction

Segregation is a relevant economic, political and social problem all around the world, as it enhances marginalization, poverty, illiteracy, etc. Examples such as *favelas* in Brasil or *red districts* at Pattaya and Chonburi (Thailand) do not need further explanations.[1]

Individuals with similar ideas, habits, preferences, political affiliations or from the same ethnic group tend to join together and create cliques and clusters in communities, which result in segregation at the society scale. Schelling (1971) provided the first model of spatial segregation. He showed that even individuals with very low mixing aversion may cause a segregated society in dynamic environments.[2]

Segregation can be the result of *individual preferences* but also the *maximizing social welfare* configuration. In other words, an equilibrium configuration can exhibit high levels of segregation, although there are not individuals' preferences for segregation per se. This phenomenon illustrates unintended consequences resulting from the interaction between individuals.

The basic prediction of Schelling's model is that under some general conditions it is nearly impossible to fight against a high level of segregation.[3] With individuals acting in their own self interest we have a socially suboptimal configuration.

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[1] Programs such as "*Moving to the Opportunity*" indicate how strong is the social concern about segregation in the U.S. (for more references see Kling et al., 2007).

[2] Schelling defined a model in which agents, divided into two types, move on a checkerboard according to a given utility function. Within this set up, Schelling shows that segregation occurs even when individuals have very mild preferences for neighbours of their type, as long as they are allowed to move in order to satisfy their preferences.

[3] The Schelling segregation benchmark consists of a spatial model in which agents of two well-differentiated types distribute along a line with preferences that depend on the composition of their surrounding neighbourhoods. In this model there are no objective neighbourhood boundaries; individuals define their neighbourhood with respect to their location. An individual moves if she is not content with the type mixture of her neighbourhood, moving to a place where the mixture of individuals meets her tolerance level, which is defined as the proportion of individuals of different types in her neighbourhood. Schelling's seminal model strikingly predicts a high segregation outcome from the initial situation when agents are myopic and can move costlessly.

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This *paper provides a new and more optimistic result*. When subjects are completely rational and moving is costly then the full segregated configuration is not an equilibrium.

How can we get this result? Individuals in the Schelling model are myopic. We consider as myopic agents those individuals who move according to the Schelling specific rule: individuals move whenever they are not content. So, they do not compute too much and they just respond *instinctively* (see Rubinstein, 2007). However, in our model we check whether the dynamics of the model change when we do not assume such non-elaborated reasoning. Surprisingly, when we model the Schelling dynamics using strategic – instead of myopic players – we obtain an unexpected result: we do find that less segregated outcomes, than the ones predicted by Schelling, are also equilibria. Hence, under rationality, the full segregated society *is not the unique equilibrium*.

Theoretically it would be highly desirable to find an environment in which society members' incentives are aligned around a unique equilibrium. This problem is already solved when we introduce *costly moving*.[4] We find that the introduction of any positive cost in the strategic model solves the multiple equilibria problem. This equilibrium with moving costs constitutes our first result.

The introduction of moving costs makes the model closer to reality, where the costs of moving play a crucial role on individuals' decisions,[5] and solves the theoretical problem aforementioned.

The second contribution of this paper is experimental. We design an experiment to unravel how individuals play when moving is costly. We use a one-shot game where eight subjects are randomly placed (face-to-face) around a real circle describing an *unhappy* society configuration: black, white, black, white, etc. We call a configuration in which at least one individual may improve her happiness by changing her location an unhappy society. In our setting subjects are given the chance to move or stay in order to reach the maximum level of happiness in the form of a fixed monetary payoff.

With the spirit of capturing the real decision of moving we introduce low and high moving costs. We compare this with the baseline model of no costs.

Our experimental data show that the Schelling outcome does not always emerge, especially if there are moving costs. The existence of moving costs fosters the appearance of individuals behaving strategically. Therefore, we also show that strategic behaviour is not rare but, on the contrary, quite abundant in treatments with moving costs. And most importantly, the fully segregated outcome vanishes in the presence of strategic players.

The rest of the paper is organized as follows. The related literature is presented in Section 2. Section 3 is divided into three subsections. In the first subsection we recall the classic Schelling linear model, in the second subsection we present our extensive Schelling dynamic game and, finally, we introduce two definitions of individual behaviour in the third subsection. The experimental design is explained in Section 4, results are presented in Section 5, and Appendix A concludes.

2. Related literature

Using one and two-dimensional landscapes, Schelling (1969, 1971) showed the emergence of high segregation even if individuals in the society had mild preferences for living with neighbours of their own type. Schelling's result is, in general, of interest to economists, policy makers and social scientists because it illustrates the emergence of an aggregated phenomenon that cannot be directly foreseen from individual behaviour and concerns an important problem: segregation. This striking result has generated a vast amount of literature from a wide range of scientific trends. Miltaich and Winter (2002), assuming that individual's characteristics are unidimensional, find a stable partition that not only is stable but also segregating. Likewise, Karni and Schmeidler (1990) examine the conditions for segregation and group formation in an overlapping generations model. On the other hand, the seminal concept of stochastic stability introduced by Foster and Young (1990), and developed within the evolutionary game theory literature, provides generations insight into Schelling's spatial proximity model. Young (1998) and Young et al. (2001) present a simple variation of the one-dimensional Schelling model, showing that segregation tends to emerge in the long run, even though a segregated neighbourhood is not preferred by any agent. Zhang (2004) extends Young's set-up (1998) into a two-dimensional framework. Both studies argue that complete segregation is the only viable long-run outcome for best-response dynamics if the agents' preferences are biased in favour of their own type. Pancs and Vriend Nicolaas (2007) also find that complete segregation is the only possible long-run outcome in a ring where agents have balanced preferences about the racial composition of their neighbourhood. Although the analytical result in Pancs and Vriend Nicolaas (2007) cannot be extended to a two-dimensional society setting, they show, through simulations, that best-response dynamics also tend to produce segregation even in a two-dimensional space.

In summary, this branch of the literature shows that even if all individual agents have a strict preference for perfect integration, myopic best-response dynamics may lead to segregation.[6] This finding casts some doubts on the design (ability) of public policies to improve integration by promoting openness and tolerance with respect to diversity.

On the empirical side, many studies on racial segregation analyse discrimination in housing prices. Specifically, studies from the 1960s, such as King and Mieszkowski (1973), tend to find evidence that African-Americans pay more for equivalent housing. However, studies from the 1970s, such as Follain and Malpezzi (1981), do not confirm this evidence. Cutler et al. (1999) confirm that the African-American rent premium fell dramatically between 1940 and 1970 and had reversed entirely by 1990.

Another branch of the empirical literature explains segregation through social interaction models. In this literature, the concept of tipping[7] is crucial for understanding the dynamics of segregation. In particular, segregation emerges and persists precisely because such residential patterns resist tipping. Clark and Fossett (2007) provide simulation experimental results crafted to explore the implications of ethnic preferences in multi-group situations. They establish that ignoring the role of choice behaviour based on own-race preferences is akin to omitting the potentially important influence of racial and ethnic dynamics in residential composition. Using regression discontinuity methods and Census tract data from 1970 through 2000, Card et al. (2008) find strong evidence that white population flows exhibit tipping-like behaviour in most cities of the U.S. This result is consistent with that of Cutler et al. (1999) and Card et al. (2008), who find that tipping points are significantly higher in cities with higher minority shares.

In sum, the empirical evidence also points to the existence of high segregation even when agent preferences depend on

[4] The assumption of free moving in the original model is restricted to minimal movement (the nearest place). Therefore, Schelling is assuming that, in certain sense, moving is not completely costless.

[5] Individuals are utility maximizers, and they may be indifferent to several actions if they get the same payoff. However, the existence of costs that may reduce their benefits may make them to behave more strategically. Therefore, strategic agents facing moving costs may anticipate subsequent movements by other participants, finding it optimal not to move.

[6] In the above literature, the main assumption about individual behaviour is that individuals do not behave rationally.

[7] Tipping is said to occur when some recognizable minority group in a neighbourhood reaches a size that motivates other residents to leave.