A multi-agent system to simulate school choice in French Speaking Belgium

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Abstract. After a brief description of the educational system context in French-speaking Belgium, showing that school socioeconomic segregation is fostered by the school quasi-market, this paper presents our methodology to develop an agent-based system and to use various models of school choice. The general purpose of our research is to assess the impact of school choice on school segregation. In order to do so, we develop multi-agent models of school choice, run simulations and determine the best-fit model by comparing results and actual data. The purpose of our presentation is to share our application of agent-based modeling for the simulation of the educational system.

Keywords: School choice, prospective research, multi-agent systems

1 Introduction

The particularities of the educational system in French-speaking Belgium, organised as a quasi-market (Le Grand, 1991; Maroy, 2006), foster socioeconomic segregation between schools. Several examples of segregation have been observed in numerous studies (Crahay, 2000; Demeuse & Baye, 2007) and synthesized by one of the authors of this paper (Demeuse & Friant, 2010). This high level of segregation has undesired consequences, among others, significant inequalities in school results (Dupriez & Dumay, 2006; Monseur & Crahay, 2008). Acknowledging this, the Government of the French Community of Belgium set out to encourage social mixing within schools by regulating enrolment in the secondary education. However, there is, at this time, little scientific evidence of the impact of school choice on social segregation between schools in French-speaking Belgium. Our main objective is to build a model of school choice in French-speaking Belgium using multi-agent models to assess its impact on school segregation.

School segregation is often studied from the point of view of post-structuralist theories (Allen, 2008) inspired by Bourdieu & Passeron (1970). This approach can be useful but finds its limits in a system where individuals are free to choose (Allen, 2008). An economical approach that considers the individuals as rational actors (Boudon, 1979) is more suitable in this case but in the same time assumes that individuals have more information than they actually do (Allen, 2008; Felouzis & Perroton, 2007). Moreover, we know that individual choices are interdependent (Manzo,

2011)Our approach allows us to overcome these difficulties by seeing the educational system as a complex system where a great number of agents interact and create emergent properties that, in turn, influence the agents (Gilbert & Troitzsch, 2005; Hourez, Friant, Soetewey & Demeuse, 2011).

2 Research and analysis method

Our method follows four main steps.

2.1 Describing the system

We use anonymous census data at the pupil level (pupils entering primary and secondary education in September 2007). These data were given to the research team for a research project commissioned by the network of state-run schools : 8% of all the pupils at the primary level; 23% of all the pupils at the secondary level according to Etnic, 2010. The variables of interest are:

- The pupil's socioeconomic index (SEI).
- The pupil's area of residence.
- The school attended by the pupil.
- The school's average socioeconomic index.
- The school's location.
- The distance between the pupil's area of residence and the attended school.
- The population density of the pupil's area of residence as a proxy for the density of educational provision in the area.

Statistical analyses are run on these data to describe the system. Our objective is to determine the scope of action of each pupil according to his/her SEI and to the population density of his/her area of residence. Multiple regression is used on continuous data and crosstabs are used on discretized data.

2.2 Developing a multi-agent system and building models

A generic model is built representing the real educational system in French-speaking Belgium: pupils, represented by agents, have the choice of any school and schools may reject pupils' request if the demand exceeds the number of available places in the school. If their requests are rejected, pupils have to choose another school.

A multi-agent system (Gilbert & Troitzsch, 2005) inspired by NetLogo (Wilensky, 1999) is developed (Hourez et al., 2011). It allows configuring the model by changing the value of various parameters for each group of pupils (maximum scope of action, schools's average socioeconomic index attended …) and schools (number of available places, student's placement choice …), to provide several graphical representations of the running models and to produce output data files.

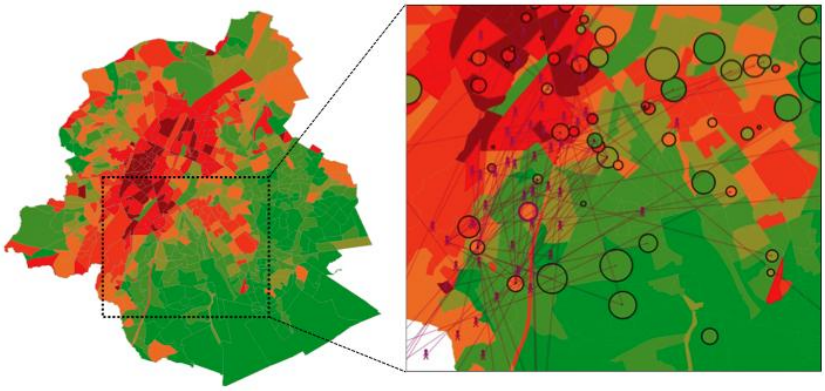

Fig. 1. Representation of the multi-agent system (Hourez, Friant, Soetewey & Demeuse, 2011)

2.3 Running simulations

Several models of school choice are tested using the multi-agent and the knowledge produced at step 1. In particular, the two following models are used: "choice of the nearest school" and "choice of a school in a scope of action depending of the individual preferences". In the second models, the individual preferences may be a random choice, a choice depending of the school's mean SEI (the most similar or the higher), … Moreover, schools preferences can be added to choose between several pupils.

Each part may be configured in the multi-agent system to test several models by applying differentiated values to several parameters (scope of action, pupils' preferences, schools' method of sorting …).

2.4 Comparing actual and simulated data

Outputs of the simulations are compared with actual data to determine the best-fit model. To do so, we compare the school allocated to each pupil by the simulation to the school where he/she is actually registered, producing a level of explaining power for each model.

To assess the impact of school choice on socioeconomic segregation between schools, we compare the level of segregation observed on actual data with the level of segregation observed on simulated data. To do so, we compute a segregation index. The segregation index used (S from Gorard & Taylor, 2002) is defined as:

$$S = 0.5 * \sum(|Ai/A - Ti/T|)$$

where Ai is the number of disadvantaged pupils in school i, Ti is the total number of pupils in schools i, A is the total number of disadvantaged pupils and T is the total number of pupils. For us, a disadvantaged pupil is a pupil with a low socioeconomic index.

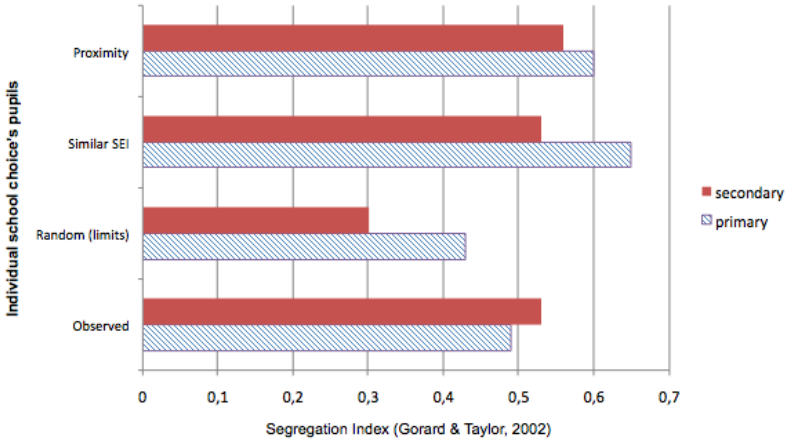

Fig. 2. Influence of several models on the segregation index.

3 Findings

We first tried to find the best model of school choice and our results show that:

- The pupils' scope of action differs according to their SEI and the population density of their area of residence.
- The best-fit model is the "choice of the nearest school" model. This model explains 69% of school choice at the entry in primary education and 59% at the entry in secondary education. Models taking into account schools' socio-economic composition produce lower levels of correct allocation.
- Levels of correct allocation differ according to the pupils' SEI, with lower levels of correct allocation for pupils with a lower SEI.

We then tried to assess the impact of school choice on school segregation. Our results show that the segregation index is higher with the "choice of the nearest school" model (S=0.60 in primary education and S=0.56 in secondary education) than observed on the actual data (respectively S=0.49 and S=0.53). This result could suggest a positive effect of school choice on school mix, but it is to be interpreted cautiously given some methodological limitations that we discuss below.

4 Discussion and conclusion

The high levels of correct allocation obtained by the "choice of the nearest school" model show the major influence of geographical variables (Taylor & Gorard, 2001) to explain school choice in French-speaking Belgium. Moreover, lower levels of correct allocation for low SEI pupils show that some of them adopt a strategy of avoidance of the nearest "ghetto" school in order to attend a more distant, less disadvantaged school. These strategies are also reflected in the lower level of socioeconomic segre-

gation between schools observed on the actual data than on the "choice of the nearest school" model output data. We must however remain cautious in the interpreting of these results given the several sources of potential biases. First, we work on data that can be regarded as census data but only covers pupils enrolled in state-run schools. Our simulations remain thus blind to schools that are direct competitors of state-run schools but are in another school network. It would be necessary to include these schools in the simulation and see if the "choice of the nearest school" model is still the best. Besides, our socioeconomic index is area-based and this could have some consequences in the interpretation of the computed segregation indexes. They can be higher than what would be found on an individual socioeconomic index. Moreover, the more disadvantaged pupils who tend not to choose the nearest school could have different socioeconomic, academic, or ethnic characteristics than other pupils coming from the same area.

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