Agent-Based Simulation Case Study

Impact Evaluation with Small Cohorts: Methodological Guidance (70–73)

Case Study

Reardon, S., Kasman, M., Klasik, D. & Baker, R. (2016). Agent-based simulation models of the college sorting process. *Journal of Artificial Societies and Social Simulation, 19*(1), 8. DOI: 10.18564/jasss.2993. Available at: https://www.jasss.org/19/1/8.html (Open Access)

Due to the technical and context-specific nature of this approach, and the education-related nature of the case study, it was not considered useful to include a Fabricated WP example.

In the table below, the 'Case Study' column breaks the case-study evaluation down into a series of methodological steps as described by the Methodological Guidance. The nature of this 'Small *n*' approach means that there may be no single 'correct' way of applying this methodology. The example given should be considered illustrative rather than a definitive model.

Case Study
Reardon et al. (2016) Outline of paper: This paper explores how agent-based simulation approaches can be used to model student decisions about which colleges to apply for in relation to family resource factors (socio-economic inequality). The article describes a US context. Key research questions: Who attends college? Who attends higher-ranked colleges? How closely aligned is college ranking with available student resources?
Context for the model
The evaluators defined the assumptions underpinning their model: Students were assumed to apply to the highest quality/ranked college they could. The higher the ranking of a college, the more selective it is likely to be and the greater the competition for places.

To help establish the criteria for the model, evaluators conducted a research process, which indicated that students with higher socioeconomic status were more likely to apply for a college place and more likely to apply to selective and higher-quality colleges than their peers from lower socioeconomic contexts.

Colleges were understood to assess applications on the basis of:
i) student performance in standardised tests
ii) high school academic record
ii) teacher recommendations
iv) student-written essays
v) involvement in extracurricular activities.

The relative balance of these factors in colleges' decision-making is opaque. Furthermore, outcomes are determined by a two-way matching process. Students can apply for as many colleges as they wish; colleges then select from the pool of applicants at their discretion.

The simulation model focused on student resources (socio-economic), noting a strong relationship between economic resources and scores in standardised tests, but also took into account access to information, social and cultural capital and access to relevant social networks. Students with higher socioeconomic resources may also have more access to work experience and extra-curricular experiences that make them more attractive to colleges.

Factors in the model

The authors of the report focused on five key resource-based mechanisms, based on socio-economic differentiation:

- differential high-school academic performance
- ability to enhance academic preparation for college
- access to high-quality information and advice about colleges and the application process
- proportion of applications from higher-resourced student populations
- differences in valuing more or less selective colleges

The model is two-sided and agent-based with decisions made by students and by colleges (1.4).

The model was run iteratively, with each new 'generation' of applicants able to access information about application patterns and success in previous cohorts. Colleges were able to draw on data from previous iterations about how successful they had been in recruiting sufficient student numbers.

The model draws on and extends two previous cognate simulations of college application processes (1.12).

Model assumptions

1) Students are rational, utility-maximising actors with idiosyncratic preferences, imperfect information and limited resources (1.15).
2) If practices are seen as positively influencing the college application process, they spread through a network through social learning (1.18).
3) There is a strong correlation between family income and academic achievement (1.19).
4) Students may engage in application-enhancing activities, but these require access to sufficient resources (1.20).
5) Different students have access to different amounts and different qualities of information (1.21).
6) Different students may have different perceptions of the value of attending high-status colleges (1.22).
7) The better resourced an applicant, the more applications they are likely to make (1.23).

Model Agents

Student agents were given two key attributes – 'resources' and 'calibre' (2.3).
Resources = a value that aggregates different forms of economic, social and cultural capital.
Calibre = a value that aggregates observable markers of academic achievement and potential.

Students were understood to want to enrol in the highest quality college possible.

College agents were assigned a single attribute 'quality' (2.4), comprising the aggregate calibre value of enrolled students.

Colleges were assumed to want to maximise the calibre of students enrolled.

Random noise was added to decision-making to reflect imperfect access to information. Less noise was added to the decision-making process of higher-calibre students, who were assumed to have better knowledge than students with lower-calibre values (2.7).

Model operation

The model included three stages: application, admission and enrolment (2.8).

Application – student agents selected potential colleges by assessing the colleges' quality and their own calibre and from their knowledge of previous decision-making data (2.8).

Admissions – colleges ranked applicants by observable calibre and admitted the highest-ranked candidates to a level assumed to fill all places. This level was determined using information about the outcome of previous application cycles (2.9).

Enrolment – students selected the college offer seen to provide the highest utility of attending (2.10).

At the end of each model run, the evaluators reviewed student and college agent decision-making and behaviour.

As the iterations progressed, student and college behaviour co-evolved and tended to reach a point of stability within 10–20 iterations (2.14).
Model experiments
By manipulating the key variables, evaluators examined how changes in resources impact outcomes for different student groups in terms of the likelihood of applying to college and enrolling at a high-status college and the changing balance between student resources and college quality (2.17). To manage the complexities of these variations, each of the five variables was divided into 10 even cut-off points, to segment them. Eight Models were tested: Model 1 – Excluding resource influence This model produced an equal distribution of students of varying resources across colleges (3.2). Model 2 – Real-world baseline – All resource pathways The values for all the pathways were designed to reflect empirical data and this resulted in application patterns that matched the empirical data. This confirms the capacity of the simulation to model real-world data (3.3). Models 3–8 produced varied outcomes enabling evaluators to test the strength of influencing relationships between student resources and college destinations (3.6–3.11). Removing the hypothesised correlation between available resources and student calibre decreased enrolment differences for very high and very low resources from 50% to 20%. Removal of the application enhancement variables results in a significant shift towards equality. When students with high socioeconomic resources were unable to mobilise these to increase their attractiveness to colleges, the difference in enrolment rates between the highest and lowest resourced students was reduced. Removing the variable for access to quality information did not impact the likelihood of enrolment but did mean that students in the middle of the resource distribution were more likely to enrol in a highly selective college.
Conclusion

The evaluators conclude that, although the model they created was 'highly stylised' and limited its focus to the relationship between student resources and calibre, it did replicate real-world patterns of college application and enrolment. They note that the model is extensible and, therefore, additional variables (such as the provision of financial support) can be built in to increase its complexity.

The model exposed the substantial role played by the relationship between student resources and student calibre in facilitating the socio-economic sorting of students into colleges.

The model also served to demonstrate the complex interrelation of other factors in inhibiting the outcomes of students in the low socio-economic group. Outcomes from the simulation suggest that the ability of highly-resourced students to increase their attractiveness to colleges, to access more and higher-quality information and to make more applications increase their ability to access higher-status colleges. They conclude, therefore, that 'student- or institutional-level policies (such as application coaching and providing college information to students in low-income schools or encouraging affirmative action-like policies for socio-economic dimensions) could have notable impacts on how students sort into colleges' (4.3).