Gabrielle Demange

Karine Van der Straeten

1 Introduction and Background

This article is an edited version of a series of interviews conducted in July 2018.

Karine Van der Straeten (KVDS): *Thank you very much Gabrielle for agreeing to have these interviews. I am extremely honored to help in this process. Having known you first as a student, and then as a colleague at the Paris School of Economics and as a co-author, I am very impressed by the breadth and the depth of your scientific contributions and by your vision of economics in general. This makes the task of interviewing you all the more challenging!*

If you agree, I would suggest structuring the discussion as follows, according to the now established tradition of these interviews. At first, we could talk about your years of training, and the reasons or intellectual influences that led you to work in social choice. Then we could focus on two or three of your major contributions. Finally, I would like to take advantage of the broad scope of your themes of expertise and interests to discuss what you think are the most promising recent developments in social choice—or at least the ones that have interested you the most—and some of the new questions to explore.

Gabrielle Demange (GD): Thank you very much Karine for spending time on these interviews. It is a great pleasure and honor to participate in these series. It is also a great opportunity for me to go back to my previous works and think about my motivations!

KVDS: *So, could you please start by telling us about what drove you into the field of social choice?*

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GD: I was a master student in mathematics in Paris when I discovered game theory, strategic or cooperative, and social choice. I was very fortunate to follow a course on game theory given by Hervé Moulin, which was my very first introduction to these topics. I became so much interested that I started a PhD with him. I don't remember exactly the title of the thesis but it included 'imperfect competition' as game theory was becoming a main tool in industrial organization. Similarly, I did not see clear boundaries between social choice theory and game theory. Maybe because the main impossibility theorems bear both on aggregation of preferences and manipulability.

When I started in the early 80s, these impossibility theorems had been found and refined along various directions so part of the research expended to escape them and find positive results in more specific settings. It was the time where social choice theory somewhat created itself as a field. Maurice Salles organized a large conference in Caen with most people working in implementation, welfare, preference aggregation, fairness and so on. Maurice told me that the creation of the Society was decided there. While still working on my thesis, I attended the conference (but did not at the time realize how lucky I was). Many other young French scientists attended as well, such as, if I remember correctly, Marc Fleurbaey, Gilbert Laffond, Jean-François Laslier, Michel Le Breton, Alain Trannoy, who all later on pursued their own path in studying social choice.

The journal *Mathematical Social Choice* was also founded at that time and Bernard Monjardet proposed me to submit a work that became my first published paper (Demange 1983). This paper was a positive result, on the existence of a Condorcet winner in a domain of single-peaked preferences I called 'single-peaked preferences on a tree' (I remember Alan Kirman laughing, finding this name ridiculous!).

KVDS: *Where were you based at that time?*

GD: I was teaching mathematics in the French University (Paris VI) and doing research in the Laboratoire d'économétrie de l'Ecole Polytechnique (though no econometricians were there, but econometrics meant quantitative and formalized economics). This might seem strange outside France to be involved in two institutions but actually my environment was very good, thanks in particular to the director Claude Henry who played the role of a 'benevolent dictator', keeping us away from any administrative duties.

2 Articles

KVDS: *I would like now to come back to some of your main contributions to the field, and discuss them in some detail. Given the wide variety of topics you have worked on, it is very difficult to select a couple of representative or most significant contributions! During preliminary exchanges we had to prepare these interviews, you mentioned one paper on fair allocations, and one paper on stable coalitions, which we could discuss.*

Going in chronological order, maybe we can start with the article on fair allocations, co-*authored with Ahmet Alkan and David Gale and published in Econometrica*

in 1991 (Alkan et al. 1991). For those who are not familiar with this article, could you please synthesize what seems to you to be the main contribution of this work?

GD: We study the problem of distributing a set of 'objects' together with an amount of money, positive or negative, to a group of individuals. Each individual receives at most one object. For example, the objects are rooms to be assigned to students. The question here is to assign the rooms and the money in a manner that is fair, which means both (Pareto) efficient and envy-free, that is, everyone likes his/her own allocation (room together with the rent) at least as well as that of anyone else. When rooms are of different qualities (size, sunshine, room with a view…) and students' preferences differ, fairness requires to account for these differences both in the assignment and the rents' levels. The objects can be undesirable, for example, the members of an academic department must perform administrative tasks and the department has a fixed administrative budget to compensate them. When tasks and preferences differ, fairness can be achieved only by differentiating the compensations (and the budget is large enough!). We derive simple necessary and sufficient conditions for the existence of fair allocations. The notable feature here is that the existence proof is constructive, which allows us to derive qualitative properties of fair allocations. In particular, we show that if there are at least as many people as objects and a fair allocation exists, then if the amount of money is increased, there is a new fair allocation which makes everyone strictly better off.

KVDS: *How did you start working on these issues? What was your motivation?*

GD: I was fascinated by the 'divide and choose' method and the cake-cutting problem. It illustrates the many different aspects of fairness problems: Are there 'fair' shares? How to achieve them? You have two individuals, say you Karine and me, and a cake to split between us. The cake has strawberries, cream, almonds and so on. Fairness encompasses two properties: no-envy and Pareto efficiency. If we each get an identical share, with exactly the same composition, no one prefers the share of the other one: the split is envy-free. But there is little chance that it is Pareto efficient, say because you don't like strawberries and I don't like cream. Reaching simultaneously a Pareto efficient and envy-free split raises non-trivial questions: Is it possible? How will the divider cut the cake if she knows the other's preferences? And if she does not know them and is risk-averse?

The divide and choose method works for two individuals. My first work on this type of subject was inspired by a kind of extension of the method introduced by Crawford (1979). The procedure works with more than two people, starting with an auction in which agent bids for being a proposer. It implements allocations that are 'egalitarian-equivalent'. Egalitarian-equivalence is a notion of fairness that is less universal than envy-free as it depends on a reference bundle. Though, it is easier to handle and solves existence issues.

A simple and very elegant procedure to reach a fair allocation works in an exchange economy: Distribute the endowments equally between the agents and reach an equilibrium. But this procedure does not always work, for example because you cannot divide and distribute equally the goods. This is the case in the fancy cake-cutting problem if you must split the cake into slices. This is also the case in more serious problems if individuals differ in their abilities—their ability is like a non-transferable

endowment—or if the goods are indivisible, as in the paper. This is why fair allocations may not exist when goods are indivisible; in our paper we relied on a constructive method to find them.

KVDS: *Could you tell us more about your two co-authors on this paper?*

GD: David (Gale) was a well-known mathematician interested in game theory and economics. He spent a sabbatical year in Paris when I started my thesis. I was working on assignment games (Shapley and Shubik 1971) and after a while we started to collaborate together. It was a great opportunity for me and the fairness paper is our fourth joint paper. From a technical point of view, all our joint papers deal with the same type of problems, in which there are indivisible goods in the same category, say houses, tasks, and each individual is interested in having at most one of these goods. It includes situations without transfers (marriage or matching models) or with transfers (assignments of workers to tasks). Though the setting might seem restrictive, there are many applications and extensions currently developed under what is called market design.

Ahmet (Alkan) was a former student of David at Berkeley and came to Paris to visit David. This is how we met. He had also worked on assignment and matching games and this is how we end up working together the three of us.

KVDS: *In the paper, you insist on the "comparative statics" part (more money, more objects). What exactly is your conception of this comparative static exercise? You mention in Section 1C that in this literature, it is common to have results such as "more money or more things can make some individuals worse off". What was the vision/conception of these "paradoxical" results? And how did you interpret your "more positive" results, which you describe as "surprising", i.e. the results that under certain conditions, we can have good properties of monotonicity?*

First, to place these results in context, there were works on the 'transfer paradox': At a competitive equilibrium, an agent may end up worse off if some agent gives him part of her endowment. The interpretation of the transfer paradox in international economics has of course important consequences: a country may be worse off by accepting a gift from another country. This paradoxical result is due to price changes and their effects on the endowments' value. In the context we consider, such effects are not present as there is no ownership. We simply ask: if there is more money, can we make everybody better off at a fair allocation? Our positive result has to be contrasted with the impossibility result of Moulin and Thomson (1988) in the context of divisible goods. This is why we call the result 'surprising'.

KVDS: *What, in your opinion, have been the most important subsequent works that have taken up these results/this framework, in social choice or in other fields?*

GD: As I said previously, in many contexts, fair allocations may be impossible to reach simply because they do not exist. A question then is to find allocations that are approximately envy-free (or satisfies any other equity concept), or that 'minimize' envy. Another issue is to design procedures or algorithms that work well in dynamic contexts. Actually, I think that the closest works to mine are conducted by researchers in computer science. Interestingly, some tools that have been developed on Internet, such as the Spliddit Website (http://www.spliddit.org/apps/goods)

in which you enter some data and it computes fair division of goods, credits, or tasks. One of the algorithm implements the allocation introduced in our paper.

KVDS: *If you agree, let us now move on to the other paper, on group stability in hierarchies and networks. This very interesting paper was published in the Journal of Political Economy in 2004 (Demange 2004).*

It seems to me to be another example of an attempt at getting "positive results" (stability and efficiency), in a literature when the general problem usually gets more negative results. Would you agree with this statement? How would you summarize the main contribution of this paper?

GD: Yes indeed, it is again a result that one can qualify as positive. It has moreover some links with the possibility of preference aggregation, as I will explain in a little while.

The main contribution is to show that under a specific power structure linking individuals and subgroups/coalitions—a structure that I will interpret as associated with a 'hierarchy'—there always exists a stable outcome in the sense that no eligible (or effective) subgroup in this hierarchy has any interest in 'blocking' it. The notion of stability here is that of the core for a cooperative game. One difficulty with this notion is that there are some non-pathological situations where a stable outcome does not exist (as characterized by Shapley or Bondareva for transferable utility games). Very schematically, to ensure stability, intermediate coalitions should not have too large incentives to block.

I postulate that in a hierarchy, only some coalitions defined by the hierarchical structure can block. In particular, people at the same level cannot collaborate directly without a common superior. The simplest hierarchy is that of the 'principal-agent' model, in which the isolated agents have some power, but obviously minimal in that any other coalition with power must contain the principal. The power structure that I consider in a hierarchy can be seen as a generalization of this 'principal-agent' model with several levels. What is important is that two individuals can be in the same coalition only if their closest common supervisor also belongs to this coalition as well as all the intermediate between them (in formal terms, this means that the coalition is connected in the graph describing the hierarchy).

Provided there are no spill-over between coalitions, the stability result holds whatever the problem faced by the hierarchy (allocation of costs, provision of computing facilities, etc.), and whether it is super-additive or not. When the problem is super-additive, the whole society has an interest in coordinating itself on a single decision; whereas when the problem is not super-additive, the society may be more efficient by splitting into several independent subgroups, each taking decisions that apply to its members. One of the paper's interests is also to propose a very intuitive algorithm to calculate a stable allocation. Starting from the bottom of the hierarchy, one gives each individual his/her incremental contribution to all his/her successors.

KVDS: *You mentioned earlier the similarities with the problem of preference aggregation. Could you please make the link more explicit?*

In problems of preference aggregation, two broad lines can be followed to obtain 'positive' results. Let me describe them with the example of the majority voting game. A majority winner, often called a 'Condorcet winner', exists only if no coalition with

at least half of the voters 'blocks' it, i.e. unanimously prefers another candidate. The majority winner(s) thus coincide with the core of the majority voting game. As we know since Condorcet, often there is no majority winner. Two different approaches have addressed this majority instability. One approach is to restrict eligible preferences, as when one assumes single-peaked preferences or intermediate preferences. Another approach is to restrict the blocking power of some coalitions. A first paper along this line was Nakamura's paper and the fascinating 'Nakamura number' (Nakamura 1979). Nakamura considers super-majority rules where an effective coalition has more than a given fraction of the voters, say 60%. When the number of alternatives is smaller than the Nakamura number, the core is non-empty *whatever* the preferences. When the number of alternatives is larger, cycles may occur and the core may be empty. [To illustrate, for standard majority, the Nakamura number is 2, with the possibility of a Condorcet cycle as soon as we have three alternatives. (I am simplifying a little bit as the Nakamura number depends on the number of voters Nakamura (1979).)]

The result on hierarchies is of this type: the core is non-empty *whatever* the preferences.

KVDS: *How did this paper fit in your research agenda at that time?*

GD: I had always been interested in the stability of decisions in a collective context (and still am!), in particular the stability in relation to the blocking power of coalitions. I had already some works published in the *Journal of Economic Theory* (with Dominique Henriet, (Demange and Henriet 1991)) and the *Journal of Mathematical Economics (Demange 1994)*, which exhibited a context where a society can agree on a stable outcome—in general a partition of the society in independent sub-groups. I had in mind the modeling of two forces acting in opposite directions on the formation of coalitions and their size: the larger a coalition, the greater its power, but also the more numerous the causes of disagreement due to the dispersion of preferences. As an illustration, you can think of the (endogenous) splitting of the society into communities, each choosing a public good and a tax level to finance it (as first considered by Guesnerie and Oddou). I showed that under certain conditions on preferences—I called intermediate preferences on a tree—there was always a stable outcome. Under these preferences, an unstable outcome is surely blocked by a connected coalition in the tree, so one only needs to consider blocking by connected coalitions, and this ensures stability. The *Journal of Political Economy* article does not make such assumptions about preferences and directly considers which coalitions can or cannot be formed.

KVDS: *If I understood the paper correctly, in a hierarchy, some blocking coalitions are exogenously ruled out. Yet, individuals have agree about this hierarchy at some point. So it seems like it pushes the problem one step further. Is this a question you have been interested in?*

GD: Yes indeed, I take the hierarchical structures as given and I study their properties, regardless of the number of levels, the number of direct subordinates, etc. I do not say anything about the acceptability of the structure. My main argument is that it is a structure that facilitates decision-making for a multitude of problems, not for a particular problem, and this may explain its prevalence in many areas.

KVDS: *In the paper, you also compare stability in hierarchies and stability in networks, with the former being much more stable. In particular, you explain that the restricted conditions for stability in networks (Proposition 1 in the paper) might seem at odd with the large diversity of networks we actually observe in reality. It seems to me that in the article, you propose to explain this fact by the fact that most existing networks share information, rather than take actions. Could you please elaborate a bit more on the fundamental difference between information sharing and action taking? If sharing information or not can impact the kind of decision a group can make, there obviously seems to be some similarities.*

GD: There are so many different contexts where information plays a role that it is difficult to answer this question in any general way. In a financial market, for example, the sharing of privileged information does not make much sense and does not lead to an analysis in terms of coalitions. In other contexts where agents benefit from some coordination, it is true that the sharing of private information that allows for a better coordination may have similarities with my framework. But I don't know precise works exploiting such similarities.

KVDS: *Could you please tell us how the paper was perceived as fitting in the literature at the time of its publication? Who were the people the most interested in these results at the time? And now?*

GD: I think that the paper has been quite well received especially from researchers working in social choice and cooperative games, and economists who started working on networks. Some researchers have later on defined and provided axiomatizations for allocations built on hierarchical outcomes (such as the 'average-tree' allocations). There are also connections with the 'sharing the river problem', which analyzes how much water cities along a river consume and how much possibly they pay for it. Starting from the source, the river and its tributaries are represented by a graph similar to a hierarchical structure. Furthermore it is natural to assume that only connected coalitions can form. The problem may be more complex due to externalities across coalitions (I did not know it at that time, but this 'sharing the river problem' had already been considered before my paper, although not from a coalitional point of view.)

Though the principal-agent model is a particular hierarchy (as I discussed above), the paper did not have any echoes with the principal-agent literature in industrial organization. This literature is mainly concerned with problems of information and moral hazard. Some works have extended the principal-agent model by incorporating an additional intermediate level, with a focus on the delegation-centralization trade-off induced by better local information but different objectives. I do not address information problems. Now the paper is much more cited by works in computer science.

KVDS: *This is very interesting! Could you please elaborate a bit more on these interactions with computer science?*

GD: Computer scientists are very active in the domain, and actually have now close connections with social scientists and game theorists, through joint conferences and participation in editorial boards. The types of questions some computer scientists study closely relate to social choice.

For example, the following questions are very close to their core competence: How 'hard' is it to find a stable solution (in different contexts, cooperative or not)? How complex is it to find a winner in an election? How often is it possible to manipulate a voting rule? These questions make sense when the data (agents, actions) is large, say when there are many voters. Some works are directly related to the papers cited above: some study the complexity of finding a fair allocation; some propose algorithms to determine whether a set of coalitions is associated to a hierarchical-tree structure and algorithms to determine whether a set of preferences satisfy the 'single-peakedness on a tree' condition or the 'intermediateness' condition; some others compute how many profiles satisfy these conditions….

Computer scientists also use their access to data and investigate new problems raised by new technologies, such as the so-called 'ride-sharing problem', where a set of commuters arrange one-time rides at short notice. A group of researchers take a cooperative approach by considering the social network of the commuters, assuming they can form coalitions between connected agents. The issue then is to define stability, to determine the rides and the payments. Interestingly, the theory can be confronted to data.

3 Recent Development and Future Avenues for Research

KVDS: *When discussing the two papers on fairness and hierarchies, you mentioned the very interesting developments in computer science that followed. Do you think, more generally, that computer science has some important contributions to make to social choice?*

GD: Yes, I think that one of the most active communities today in social choice comes from computer science. Actually, computer scientists are active in the broader field of economic design, including social choice and mechanism design (See for example Brandt et al. (2016)). In a forthcoming volume entitled '*The Future of Economic Design*', researchers share their views on the future of the field (Laslier et al. forthcoming). I don't have the exact numbers, but a large number of the contributions are from computer scientists.

I see at least two main reasons why this should be the case, and why more fruitful interactions should be expected.

First, recent progress in computing facilities allows some new mechanisms and collective choice procedures to be designed and implemented.

Second, at a time when the increased reliance on complex 'algorithms' in many public and social areas raises some defiance in (some parts of) the public opinion, standard reasoning in social choice may provide ways to address these concerns. In particular, the "axiomatization approach" could help compare various algorithms in a clear and understandable way.

KVDS: *You say that recent progress in computing facilities allow new mechanisms and aggregation procedures to be implemented in practice. Could you give us some specific examples?*

GD: In a paper in the volume just cited, I discuss in some detail how, thanks to new computing facilities, new voting procedures can be designed. More specifically, I describe two recent promising set of experiments allowing for a fairer expression of voters' preferences.

The first set of experiments you know quite well Karine, since you were involved in some of them. In the past fifteen years, several experiments have been conducted in France and elsewhere to test new voting procedures. Taking advantage of Internet, it has become very easy to test on very large sample of voters various voting procedures, such as Approval Voting, Borda rule, Plurality, Single transferable vote, Majority judgment, and to compare their results. These tests are encouraging, as they show an interest from the general public and the media. I hope that more are to come.

The second set of experiments, conducted in Switzerland, led to an actual electoral reform. This experimentation started from some severe dissatisfaction with the electoral system used in Switzerland until 2004 for cantonal elections, which was deemed 'unfair'. During a trial period starting in 2004, a new method—called the New Apportionment Procedure (NAP)—was used in the Zurich canton to allocate seats to parties and districts. This new method is based on bi-divisor methods, which I introduced with Michel Balinski in the late 80 s. At the time I wrote these theoretical articles, I doubted that the methods could be used for real political elections, mainly because they are very difficult to compute by hand. The mathematician Friedrich Pukelsheim made a tremendous job to get this procedure implemented. This new method is now definitely adopted in the Zurich canton as well as in some other cantons in Switzerland.

The unfairness of the previous system in the Swiss cantons appears in many other elections when representatives are elected in areas of very different sizes, such as the countries in EU. I am not advocating for a bi-divisor method in the EU, but social choice theorists could be more involved in the design of electoral systems.

KVDS: *Coming back to the second reason you mentioned when highlighting cross-fertilization between social choice theory and computer science, could you please now explain why you think that the "axiomatization approach", very standard in social choice theory, can help shed some light on the desirable properties of algorithms?*

GD: On a theoretical level, there are close connections between the tools developed to rank Webpages (such as *PageRank* of Google) and aggregation methods. Computer scientists have recognized that and some works use the axiomatization method to characterize ranking or recommendation systems.

On a more practical level, algorithms often solve a social choice problem. They use data that are voluntarily provided by the citizens or extracted by the machines, say the search engines. When the designer is a governmental agency, there is a legitimate demand for explanation of the mechanism/algorithm and the axiomatization approach might be helpful in that.

In a forthcoming paper (to be published in an edited volume in the honor of Leonid Hurwicz, Demange forthcoming), I illustrate this point with a recent example in France. The French high education system is mostly public so an admission system has to deal with a high number of candidates. A procedure called APB ('Admission

Post Bac') was put in place in 2009 for assigning students at their entrance to the French universities. It was based on the centralized deferred-acceptance algorithm introduced by Gale and Shapley (1962), which, as you know, has many good properties. Though, APB turned out to be a failure, resulting in its replacement in 2018. I don't want to enter into details but one of the reasons is that APB modified the deferred-acceptance algorithm in an important way. To cope with the required 'no selection' principle, according to which any student with the 'Baccalauréat' is entitled to a seat in any field, no priority was set for the universities. When the number of applicants to some slots largely exceeded the number of seats, students were allocated at random to satisfy the no selection principle. The result was that some students lacking the background for succeeding in a field and almost certain to fail got a seat while some others, much better qualified, did not. The absurdity of the system led to its rejection in 2017.

The public blamed the 'non-human' aspect of the procedure, because it was implemented by an algorithm and used random draws. The result of APB's failure is a clear defiance towards 'algorithms' from the French population. In my view, the failure was due to the absence of consistency and transparency in the policy, not in the way it is computed. Taking the viewpoint of social choice theory would have been beneficial: explain the desirable properties the government wants to achieve and make explicit the constraints. It would have made clear that the joint effect of the no selection principle and the space constraints implied random draws. But this was not politically admissible.

KVDS: *Thank you these very interesting thoughts.*

To conclude these interviews, are there any other promising research directions you would like to mention?

GD: Well, it depends what defines the field. The description of the topics for the journal Social Choice and Welfare is now very broad, including many aspects of economic design and even accepting empirical works. There are many promising researches in these directions, such as the design of voting procedures I mentioned previously. One might think that the very distinctive features that characterized Social Choice Theory at its beginning are lost: the aim of addressing 'deep' almost philosophical issues related to democracy, fairness, through very elegant and parsimonious models, rigorous and robust methods with a minimum of assumptions (no Bayesian priors, no specific games), the definition of general principles and properties …. But, the future and new technologies such as artificial intelligence might raise such type of issues worth studying by social choice researchers.

KVDS: *You say that the distinctive features that characterized Social Choice Theory at its beginning are lost. How would you explain this transformation in the field?*

For example, in your opinion, is it because the main theoretical results have already been discovered? Or do you think that such general abstract questions could/should still be explored, but that the general trend we see today in Economics—with theory becoming less and less 'fashionable' and taught at the undergrad and master levels—is the main explanation?

How do you personally feel about this transformation?

GD: No, no, it was not general remark about the current place of empirics in economics. Though, true, I think that empirical works are overly represented at the moment. But it might have been true for theoretical studies thirty years ago! As you said there are fashions in research. What bothers me more is that basics in social choice and welfare (or general equilibrium) are almost absent in many master programs.

What I had in mind is that a large part of current research in social choice aims at obtaining possibility results, and we know that they can be obtained by restricting the framework or by weakening the requirements. The scope is necessarily more limited and more applied. There is no negative judgment in that (my own works were of this type!). These works integrate tools and approaches from different fields such as social choice, game theory, computer science. It might lead to the creation of a new field (economic design?) with its own 'community'.

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