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## Economy as Matching

Philippe Steiner

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## **Economy as Matching**

Philippe Steiner

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The first part of the paper is devoted to explaining what is meant by matching in current economics, with a special emphasis on the works of Alvin Roth's work on matching markets. The second part concerns the sociological underpinnings of the matching approach to the economy, showing how different it is from the market approach. Focusing on the changes brought about by the vast amount of data and the technology necessary to implement a new form of governmentality, the third part connects economy as matching to Michel Foucault's views on the pastorate, showing how the old religious precept requiring the leader to govern the population as a whole and each individual in particular ("omnes et singulatim" in Foucault's terms) becomes effective.

**Working Papers Series**

# Economy as Matching

Philippe Steiner

Mars 2017

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## Abstract

The first part of the paper is devoted to explaining what is meant by matching in current economics, with a special emphasis on the works of Alvin Roth's work on matching markets. The second part concerns the sociological underpinnings of the matching approach to the economy, showing how different it is from the market approach. Focusing on the changes brought about by the vast amount of data and the technology necessary to implement a new form of governmentality, the third part connects economy as matching to Michel Foucault's views on the pastorate, showing how the old religious precept requiring the leader to govern the population as a whole and each individual in particular ("omnes et singulatim" in Foucault's terms) becomes effective.

## Keywords

Algorithm, Foucault, Matching, Roth

## L'économie d'appariement

### Résumé

L'article vise à expliciter l'importance de la notion d'appariement dans la théorie économique contemporaine en s'appuyant sur les travaux d'Alvin Roth sur les marchés d'appariement. L'article examine ensuite les bases sociologiques de l'appariement, en soulignant les différences existant avec les bases sociales du marché. Finalement, la troisième partie tire les conséquences de l'importante quantité de données personnelles requises pour le fonctionnement des appariements pour interpréter cette nouvelle forme économique en termes de ce que M. Foucault a appelé le pastorat avec son objectif (« omnes et singulatim ») de gouverner à la fois le collectif et chaque individu en particulier.

### Mots-clefs

Algorithme, Appariement, Foucault, Roth

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Since the second half of the 18<sup>th</sup> century leading economists have proposed many definitions of the subject matter of political economy, and then economics. These definitions range from the material to the formal. In the former case the science is said to be about wealth, understood as the set of resources that are both useful and difficult to produce (from Anne-Robert-Jacques Turgot to Jean-Baptiste Say, David Ricardo and John Stuart Mill). Or it is said to be about the rational use of scarce goods that may have alternative uses (from Lionel Robbins to Paul Samuelson).

Beyond that diversity there are some common features, stemming from the fact that economists are mostly endeavoring to define laws regulating the production, distribution and exchange — sometimes the consumption — of wealth, or of those scarce goods susceptible of alternative uses. This common thread applies both to the micro approach to political economy, from Adam Smith's famous chapter 7 on the functioning of a market in the *Wealth of the Nations*, to Gary Becker's and Jean Tirole's extended economic approach to human behavior; and to the macro level, from François Quesnay's *Economic Table* to Thomas Piketty's *Le capital au 21<sup>e</sup> siècle*, where it establishes general laws for aggregate magnitudes.

Recently, a new definition of the economy has appeared in which the matching process is central. Matching places the emphasis on the effective association of a given resource with a given person. Matching may thus appear to be an extension of the traditional concern with the distribution of wealth; but in contrast to this view, I will here suggest that matching is actually effecting a significant modification of the economic dimension of life.

The first part of this article is devoted to explaining what is meant by matching in current economics, with a special emphasis on the works of Alvin Roth, an economist who in 2012 received the Prize of the Bank of Sweden in honor of Alfred Nobel for his work on matching markets. The second part concerns the sociological underpinnings of the matching approach to the economy, showing how different it is from the market approach. Focusing on the changes brought about by the vast amount of data and the technology necessary to implement a new form of governmentality, the third part connects economy as matching to Michel Foucault's views on the

pastorate, showing how the old religious precept requiring the leader to govern the population as a whole and each individual in particular (*"omnes et singulatim"* in Foucault's terms) is becoming effective.

## Matching economy

On the face of it, matching seems a further development of political economy because, fundamentally, it deals with the markets, the central institution of the modern economy as Smith's chapter on the market makes clear. Matching then appears to be strongly connected to competitive relations in the market: "A competition will immediately begin among them [buyers confronted to a shortage of goods], and the market price will rise more or less above the natural price, according as either the greatness of the deficiency, or the wealth and wanton luxury of the competitors, happen to animate more or less the eagerness of the competition" (Smith 1776, I, p. 73-74). Beyond this general connection, matching involves something more than the formation of a price (or a shadow price) that clears the market, and more than the formation of pairs maximizing output (Becker 1973).

### Matching: market and arena<sup>1</sup>

The competitive allocation process driven by the setting of an equilibrium price is a satisfying proxy for the matching issue as long as some structural conditions in the functioning of the market are omitted<sup>2</sup>. Structural elements involve issues about preferences, quality, and information (Stovel and Fountain 2009; Coleman 1984).

Matching is about the *precise allocation* of a resource — be it a person, a service or a material

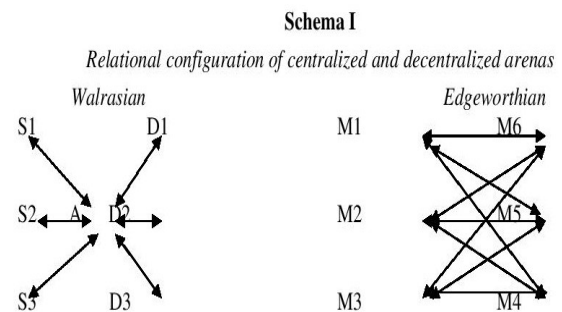
1. Throughout this article I use arena in the sense suggested by Harrison White (1992, p. 30-32). In an arena, "actors are there to make matching" (White 1992, p. 52) in a one-shot process designed to "select" and "purify".

2. See for example, Alfred Marshall's chapter "On Markets", where he explained that general markets require a universal demand and things that can be easily and exactly described: "Thus for instance cotton, wheat, and iron satisfy wants that are urgent and nearly universal. They can be easily described, so that they can be bought and sold by persons at a distance from one another and at a distance also from the commodities. If necessary, samples can be taken of them which are truly representative; and they can even be 'graded', as is the actual practice with regard to grain in America, by an independent authority" (Marshall 1920, I, p. 326). Léon Walras' general equilibrium of "well organized markets" is grounded on the same assumption: goods (wheat and barley) are nothing but an abstract "essence in the philosophical meaning of the term" (Walras 1900, p. 44).

good — *to a specific person under the constraint of symmetrical preferences* according to which a match occurs if and only if *a* prefers *b* to any other possible match, and *b* prefers *a* to any other possible match. In a matching arena it is not enough to have preferences over resources, since “resources” also have preferences that must be satisfied. In markets the good is standardized, as economists implicitly assume. However, once the resource is not homogeneous, the issue of allocation becomes more complicated: it is not enough to get a part of the resource you need (a student room on campus, a kidney for transplantation, a position in a hospital or in a school, etc.), because people also have preferences on some other dimension of the resource (a room close to one’s friends, a kidney more compatible with one’s body, a hospital in a given city, a school that stands higher in a reputation ranking). In all these cases, resources are not homogeneous from the point of view of the “demand” side. This applies in many cases to the “supply” side: for those in charge of managing the accommodation of students, the transplant system, the functioning of a hospital or of a school, all applicants are not exactly the same. Matching is a general and demanding process, since it requires the solution of a dual problem of quality assessment for a pairing that has important and long-lasting consequences. Finally, matching requires that actors on both side of the arena have information on the actors they face, in order to perform the three tasks of screening, selecting and matching. Obtaining relevant information is costly, and so the matching process can be plagued by search costs; conversely, information can be overabundant and thus difficult to manage. For this reason, there are matchmakers whose job is to reduce transaction costs for the actors; but this is also why matching arenas adopt a centralized structure (similar to a Walrasian market) instead of a decentralized one (similar to an Edgeworthian market), as showed in schema I.

Empirically, sociologists have long studied matching processes in order to see whether a specific type of match is characterized by homophily or heterophily (respectively, the tendency to match with similar or different people). This is notably the case when one is interested in the sociology of family and marriage; this is also the case with network analysis (Stovel and Fountain 2009); sociologists also consider this issue in more surprising and limited settings, such as pair formation in aikido tournaments (Duprez and Barbut

2007). Matching is also a well-known approach to studying the labor market, for example in order to understand how people get their job (Granovetter 1974), or why job contracts are broken (Mortensen 1988). All these cases are about non-centralized Edgeworthian arenas. More recently, due to the immense transformation brought about by information technology, matching has become a key issue for economists, with the growth of platforms or so-called multisided markets. Here an entrepreneur sets up a meeting place on the Internet where the two sides of a market will gather and then interact, producing matches and thereby creating a value that the entrepreneur endeavors to capture. The economic theory of such markets — notably the interrelation between the two “demands”, and the unusual pricing model according to which one demand side may be paid to appear in the market — has been elaborated by Jean Tirole (see for example Tirole 2016, chap. 14); whereas the management of Internet platforms which reduce transaction costs thanks to which such markets operate is now a thriving field of publication for those who have expertise in this new domain (Evans and Schmalensee 2016; Parker, Van Alstyne and Choudary 2016).



In a Walrasian arena participants are connected only to an auctioneer who is the central actor for the information graph, with a maximal degree of centrality. In this market organization the central entity does not collect resources that have been produced or demanded, but limits itself to centralizing information so that equilibrium prices can be achieved; then an exchange of resources takes place in the economy according to the distribution of preferences among market actors. In an Edgeworthian arena, each entity is directly connected with all the others in order to negotiate and re-negotiate the conditions of exchange so that, in the end, the arena converges toward an equilibrium price, theoretically equal to the Walrasian equilibrium



price if the number of entities involved is high enough. In the Walrasian approach the issue is to find the *true* price for reaching the equilibrium that is also an optimum; in the Edgeworthian process, the issue is to find the *path* leading to this equilibrium.

Both economic and business theorists agree in stressing the key role played by the management of information. In Tirole's case, this is straightforward since his theoretical expertise lies in the economy of information, an approach that appeared in the 1970s and 1980s when the Walrasian General Equilibrium research program was abandoned. For him, this platform economy is about management of the information required to perform a search (a job, a partner, a seller, etc.) leading to an exchange when there is too much information, and thus a high search cost: platforms provide what in 1969 Herbert Simon already called an "economy of attention". There are also specific information issues related to this platform economy, related in particular to the ownership of data and information, and to trust: the customer must *trust the information* sent by the other side of the platform, and she must also *trust the algorithm* that selects possible matches that may correspond to her demand and her behavior. The management of information is important for business theorists. Platforms require actors to send information or even fill out a questionnaire; an algorithm then selects from a database the resource corresponding to what the actors are looking for; other platforms use data collected on the web to find commonalities between actors who are then connected to each other, expecting them to match, that is to say to exchange and thus create a value that platforms capture in part. This software, or "filters" (Parker, Van Alstyne and Choudary 2016, p. 40) produce possible matches — no one is obliged to buy the books that Amazon's algorithm suggests when one buys a book on this website. They reduce the search cost, they are also forms of advertisement aiming at persuading the recipient to buy something, but they are not directly making matches.

There is therefore a large amount of software at work on platforms designed to transform the working of the economy through the multiplication of Internet market places. However, most of them are not about matching: "These platforms are selling connections" as David Evans and Richard Schmalensee aptly put it (2016, p.

35). These platforms simplify the problem of finding relevant information and channel customers to possible matches, and they create "algorithmic cultures" through the devices and performances related to new technologies (Seyfert and Roberge 2016); but they are not matching platforms properly speaking. In order to be more specific, I would like to focus on Walrasian platforms in which *matching is the goal and outcome*, and not simply a possible result of connections bought and sold. These two restrictions are significant, of course, because there are matching arenas — notably the job market — where such *centralization* does not exist, and because there are centralized arenas that do not provide matches, but interaction; however, Walrasian matching platforms are numerous enough to include market and non-market transactions, the latter having been generally omitted from the economic literature so far.

### Algorithmic Walrasian matching arenas

The modern study of algorithmic matching began with a seminal article by David Gale and Lloyd Shapley's published in a mathematical journal (Gale and Shapley 1962). They proposed a technique — deferred acceptance — and an evaluation of its results in terms of optimality. They demonstrated that a two-sided arena in which individuals have preferences (a ranking) over the individuals on the other side has *stable* solutions in the sense that no blocking pair exists; that is to say, two individuals, *a* and *b*, respectively belonging to each of the two sides, matched with other people whereas both *a* and *b* would prefer to be matched together. Furthermore, a stable solution is *optimal* in the sense that no individual can achieve a better position in any other stable solution. They also demonstrated that there were different stable solutions according to the side given priority.

The functional principle of deferred acceptance is the following. Assume a set of men and a set of women, in equal numbers, in which every individual ranks all the individuals of the opposite set; suppose that priority is given to women (they propose first): in the first move all the men who receive one or several proposals reject all of them but the highest in their ranking. Nevertheless, this is not their final choice, since if all the women have sent a proposal to the man who is



top of their ranking, and if the men have selected the women who are the highest on their ranking, that does not mean that the women selected at this first stage are the highest in the men's ranking (they are only the highest among the proposals received so far). Acceptance is thus only conditional. At the second stage, women whose proposals have been rejected send a proposal to the men who are second in their ranking; then those men who receive one or several proposals select the highest among these proposals plus the one they may have accepted at the previous stage. After a finite number of steps, each man has received a proposal, and has selected the highest proposal received all along the series of steps. This matching is stable: if Laura prefers Peter to her match Paul, she has sent a proposal to Peter, who rejected it because he prefers his match to Laura. There is no blocking pair and thus no "justified envy".

Then other techniques and algorithms were elaborated, notably the "Top Trading Cycle" by Lloyd Shapley and Herbert Scarf, the algorithm being provided by David Gale. This algorithm is often related to housing allocation between students. Suppose that each student at a university has got a room; nevertheless, some students would prefer a different room than the one resulting from the initial allocation. The algorithmic solution to this allocation issue requires that students rank the rooms, indicating which room is preferred by each of them (the "Top"). Then, the algorithm looks for cycles in order to match students with the room which is preferred: if  $a$  prefers room 1 to his room 2, whereas  $b$  prefers room 2 to his room 1, there is a cycle of length 2. Both students exchange their rooms and are both in a better situation. Then these two students and their rooms are removed and the algorithm looks for a new cycle — note that a cycle could be of length 1, when a student prefers the room initially allocated. When there are no more cycles there are no more mutually beneficial exchanges, and the matching process is ended. This matching technique has some interesting properties, notably the solution is unique and the process is strategy-proof in the sense that it is never advantageous for an agent to cheat regarding her preference. It is important to note that these path-breaking results are about centralized Walrasian arenas; the study of decentralized Edgeworthian arenas is much less developed, even if it has been shown that the random path at work in these

arenas is similar to Gale and Shapley's deferred acceptance (Roth and Vande Vate 1990).

This approach to allocation through matching algorithms was taken up by Alvin Roth, who explored the mathematics of matching on the one hand, and on the other developed a new approach to economics as "economic engineering" (Roth 2002, Roth and Peranson, 1999). This has two interesting consequences for the present inquiry.

First, this approach to economic theory is still in line with the "classical" definition of political economy, in the sense that the distribution (or allocation) of resources has been a key dimension of political economy since the middle of the 18th century. However, as mentioned above, the matching process significantly modifies the institutional underpinnings of economics. Economics is usually strongly associated with the market, an institution characterized by the fact that there are two sets of people exchanging resources after they have agreed on a price for the good, and a mechanism to allocate scarce goods, notably competition. In this case, it is either the first to ask for the good at the posted price, or the one who offers the highest price for the good, who gets it; in any case, the buyer must have the financial resources necessary to play the market game. It has already been explained that matching structures are quite different from the assumptions governing economists' views of markets<sup>3</sup>. This remark must be pushed further: matching is a general social phenomenon that has no reason to be limited to markets, since matching processes can occur in arenas of exchange for allocating goods that are not scarce — in the simple mathematical models mentioned above, there are as many men and women, or rooms and students, and thus there is no scarcity. Furthermore, in the world of matching, institutional underpinnings are significantly modified even when the matching process resembles

3. "Another example of markets in which social structure is important is the matching process that occurs in monogamous marriage or in job markets. Sociologists and demographers call this assortative mating. It is clearly a social process with some complexity. It can, however, be seen as an economic exchange market in which each actor has exactly one good to trade, and can get exactly one in return. Yet it is very different from a neo-classical perfect market. For example, the role of 'price' as allocation mechanism is greatly altered; and the entities exchanged are not fungible — there is not a market in trading wives" (Coleman 1984, p. 86). In his *Foundations of Social Theory*, Coleman comes back to this topic in order to link the micro and the macro dimensions of the marriage issue thanks to the deferred acceptance algorithm (Coleman 1990, p. 22-23).

the labor market, as is the case with the medical resident matching program (Roth and Peranson 1999). This comes from the fact that there is no price in these “matching markets”. Students are not primarily motivated by the money they would get from the hospital they rank first, since more is involved in the choice of a hospital: geographical location, career prospect, research opportunities, etc. Conversely, hospitals are not competing in terms of the wage offered to medical residents. This economy is not based on price and financial resources, but on “fit”, or more precisely on “being selected”, that is on choices driven by preferences. One may say that this does not entail any significant change to the market economy since choices and preferences are the foundation stone of the latter, and the rationale for market actors’ behavior. This would however be misleading, since if it is true that preferences and choices are key elements of market activity and theory, they are not limited to the institution of the market: choices and preferences are the basic fuel of many social arenas other than the market, as is the case with the social arena of organ transplantation subject to both national and international bans on market exchange of human kidneys<sup>4</sup>. So, *if it is true that markets imply choices and preferences, the reverse is not true: choices and preferences do not imply the market. This non sequitur* statement involves some significant consequences. First, as mentioned above, there are matching arenas (school choice, organ transplantation, etc.) in which price and money have no function; second, in these arenas the central issue is distributive justice — i.e. equal opportunity of access — and not the commutative justice that economists place at the core of the market<sup>5</sup>. Matching economy is about allocation of resources, but these resource allocations are processed in social arenas for which markets are only a sub-set. It is necessary to bear in mind the generality of the matching process when it comes to analyzing the social basis of the matching economy.

Second, the algorithmic approach to the distribution of goods has given birth to what Roth

4. The only exception is the regulated market for kidneys in the Islamic republic of Iran, dating from a law passed in 1987.

5. Walras was clear on this issue: appropriation is a “humanitarian fact” involving distributive justice, whereas market exchanges are “natural facts” involving commutative justice (Walras 1900, 4<sup>th</sup> lesson, p. 57-66). See also Friedrich Hayek on cattalectic justice in a spontaneous order (Hayek 1976, chap. 9 and 10).

has called “economic engineering”. Engineering becomes the key point because the economist must deliver an algorithm and not a theorem: a workable algorithm able to perform the matching in a finite number of steps, within a defined length of time and which is not a general theorem *sub specie aeternitatis*. This means that economists are no longer using the same kind of mathematical tools; they abandon the search for general results and theorems in favor of focusing on the pragmatic working of a given arrangement or device. The use of simulation becomes very important, as simulations open the door to testing various possibilities when designing the matching software (Roth 2002, Roth and Peranson 1999). This means also that these economists are no longer limited to describing or analyzing an economic world “out there”, but are constructing arenas in which algorithmic allocations can be implemented (Steiner 2010, and 2016, chap. 6-7). We are thus at the precise point where we can bring together the different theoretical underpinnings of present research. As an economic engineer, Roth has built arenas mimicking the basic principles of the (labor) market with the resident-hospital program (Roth 2003, Roth and Peranson 1999), and also a second arena differing significantly from these principles, as is the case with organ transplant for non-compatibles pairs of donor and recipient (Roth, Sönmez, and Ünver, 2004, 2005, Roth and Saidman, 2006). The basic requirement for entering this latter arena is not money and capacity to pay in a competitive environment, but to persuade a friend or a sibling to donate a kidney for free. Accordingly, the nature of the resource on the one hand, and the nature of the social underpinnings (particularly the sets of people and the way they enter into the matching system) on the other, will be considered in some detail so that we may move beyond the mathematics of matching.

## The social basis of matching economy

As mentioned above, sociologists have emphasized how matching structures differ from market structures when it comes to actor’s preferences, the quality of goods, and information flows; nevertheless, other structural elements must be taken into account. As a structured social process matching requires three key elements: a specific *institution* located at the center of the process, an

entity that Roth has suggested be called a “Clearinghouse”; *specific groups* connected to this central institution and which I propose to call “Blocks”; and finally, a *relational process* for sending specific information to the software located at the core of the institution. Once these three components are put together, the effective matching can occur<sup>6</sup>. After a general description of this social structure, I will examine how the French Agence de la biomédecine matches patients on a waiting list for kidney grafts with kidneys coming from *post mortem* procurement.

### Blocks, Clearinghouse and matching software

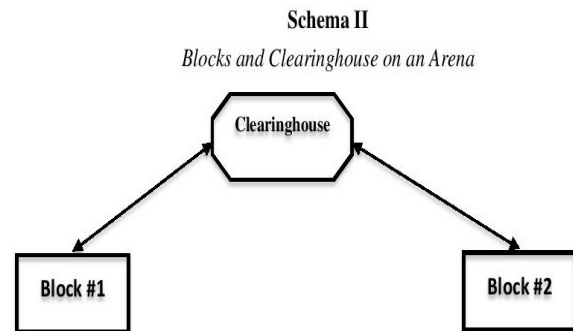
As mentioned above, the elegant results demonstrated by Gale and Shapley are based on the existence of two populations, each of which has preferences over the members of the opposite population. Hitherto economists have treated the key issue as the design of a matching device that would require *true preferences* to be sent to the Clearinghouse; such that, to maximize the chance of achieving one’s best choice, it would be pointless to send false preferences.

But what about the populations present in the matching arena? How do these populations deal with the matching devices? And finally, what can we say about these populations? These are the central question to be answered from a socio-economic point of view.

These populations are examples of a new form of social entity that I propose to call a “Block”, because their existence can be studied by what is known as “Blockmodelling” in social network analysis (Faust and Wasserman 1995, chap. 10). Blockmodelling comes from the definition of structural equivalence, according to which two individuals are equivalent if they send and receive links from and to the same actors in the network (Lorrain and White 1971, p. 63). Accordingly, individuals acting on both sides of an arena are in a situation of structural equivalence since they send links to and receive links from the Clearinghouse, and thus to opposing blocks, composed of individuals with whom they will be matched

6. This process has strong similarities with the three dimensions of “algorithmic governmentality”: production of a large quantity of data located in data warehouses, data management and production of knowledge, and, finally, action upon behavior (Rouvroy and Berns 2013, p. 168-171). The main difference is about the last dimension since matching economy goes beyond behaviors for producing effective matching.

(schema II). These two sides, or “Blocks”, are thus made up of individuals who share a common identity in the arena, either as a “patient” or as a “donor”, even if this does not mean that individuals composing the Blocks are directly connected to each other — usually they are not.



Several questions arise once this basic and simple structure is revealed. First, a distinction must be made between the way in which people are selected when entering into one of these Blocks. In some instances the selection process is quite limited, in the sense that block membership is compulsory: French children must go to school and thus are required to fill out the documents necessary to find a school place using AFFELNET or APB, two Internet platforms that match them with high schools and universities. In many other cases membership is optional, and generally associated with a selection process that may either straightforwardly exclude some people if they do not meet the required quality for entering the matching arena, or sort them into different categories according to their relevant performances or status. This is generally the case for transplant activity, since local hospitals and surgeons decide whether or not they will put a patient on the waiting list, and under which category (“urgency”, “super urgency”, “hyper immunized”, “rare HLA group”, etc.). In other instances, such as that of a school, the selection process is less dramatic and more open to public scrutiny, since almost all the children will go to high school, and many of them will go to a college or a university. Membership occurs just once in a life because actors become older and pass examinations. This is also the case for American medical students when it comes to getting a residency. In all these cases, an individual is not supposed to come back into the block: the matching process is just a one-shot process. In some other cases, block membership has no reason to happen just once in a life; unfortunately, being unemployed may happen more than once,



and thus a person may appear on the demand side of the matching arena for matching workers and jobs. In other instances, the possibility of an actor coming back to find a new match is an important issue: this happens with kidney transplantation for young people, because it may be necessary to offer them a second graft if the first kidney fails a few years later. In that case, the first match is somewhat more complicated to perform, since it is necessary to avoid the consequence of hyper-immunization resulting from the first graft, preventing the potential second one.

Second, there is a deep asymmetry between blocks, depending on the nature of their populations. In many instances there are individuals (pupils, physicians) on the demand side, whereas organizations (high schools, hospitals) are on the supply side; but it may happen that the supply side is made of material items, as is the case with transplantation where patients in the first block are waiting for kidney appearing in the second block. Accordingly, the preferences sent to the Clearinghouse differ: individual preference formation raise different issues than organizational preference formation. In the first case, the issue is to understand how to induce individuals to send their true preference and to avoid attributing too much importance to the social capital at their disposal, or any other relevant characteristic (age, gender, geographical location, etc.); on the other, it is important to know who will be in charge of setting the organization's preferences, and on what basis.

Third, cohesion among individuals belonging to a given block may differ. They have no reason to know and meet each other; they belong to the same block because they are connected to the opposite block through the matching device at work in their arena. Obviously, in some instances individuals entering a block may have strong social connections (medical residents may have studied at the same university), but there is no reason to suppose the existence of any such links between people going on to the waiting list for a kidney graft. Nevertheless, an initial absence of links does not prevent a process of link formation once individuals become members of the same block: working in the same hospital as a medical resident, studying in the same high school or university or going through regular biopsy exams may create strong and long lasting links between actors. Thus, even if blocks do not suppose

previous links between members, they may create them.

Fourth, the time dimension in membership in a given block may be significantly different according to the nature of the matching arena. Block membership is not supposed to be a permanent situation: pupils and students are supposed to be assigned to a high school or a university for the next academic year; medical residents are in the same situation for getting a position in a hospital just after they pass their final exams. In other cases, block membership can be rather durable, perhaps too durable! This is particularly the case with organ transplantation, where the efficiency of the medical system is often evaluated according to the number of people who are on the waiting list (i.e. Block #1 of schema II) and the time they have to wait while on the list (Steiner 2010b, chap. 1)<sup>7</sup>. This is also the case for people who are trapped in unemployment: long-lasting block membership is then felt as a disgrace. The other side of the matching arena can be very different in respect of the time dimension: contrary to individual actors who are not supposed to stay for long in block #1, where block #2 is made up of institutions (high schools, universities, hospitals, etc.), these are supposed to perform their task over a long period of time — for centuries in the case of Universities. They are committed to offer positions to the people facing them in the matching arena. However, and conversely, the time dimension could be shorter and much more stringent on block #2, as is the case with kidney transplantation. In that specific instance, block #2 is composed of kidneys harvested from a stream of brain-dead patients for whom agreement exists, given either by the dead person herself or from her family. Being a brain-dead patient is a transitory situation — medically complex and difficult to maintain — so the procurement process has to be completed swiftly. This is all the more true for the kidneys once they are extracted from the body, since the shorter the cold ischemia (the length of time during which the kidney does not receive oxygen from blood circulation) the higher the odds of success for the graft. As

7. This is all the more critical since there is a significant number of people each year who die while on the waiting list, even when there is a medical alternative (dialysis) which works well. For example, available data indicates that the attrition rate for people waiting for a kidney graft is 1.6%; however, this rate increases with the length of time on the waiting list, reaching 2% after 12 months and peaking at 7% after 36 months (Agence de la biomédecine 2014, p. 9).

a consequence, kidney membership in block #2 does not expand over a few hours: this is a fast-moving flow, not a stock.

The clearinghouse also raises some interesting issues. They must be thickly populated, in the sense that many actors should be attracted to make transactions using the clearinghouse's matching device; then the software should be able to manage the huge amount of data sent by actors in the two blocks in a restricted amount of time, so that actors can deal with the various steps of the algorithm. The quality of the matching is obviously an important dimension of the functioning of the clearinghouse: Roth has studied different matching arenas over the last decades, showing that the clearinghouses that did not provide stable matches were usually unable to last long (Roth 1991; Mongell and Roth 1991). The clearinghouse also has to offer a safe and efficient exchange system, in the sense that opportunistic and strategic behaviors are not attractive (Roth 2013, p. 29-30). This set of constraints pushes matching institutions toward the Walrasian centralized structure<sup>8</sup>. Finally, it is important to bear in mind that matching institutions have some high-stakes requirements to fulfill: *matching is a business in equality*. Matching students with hospitals, pupils with high schools or ESRD patients with kidneys has longstanding implications for the individuals on the demand side of those arenas and, accordingly, individuals and their relatives have strong emotional feelings in terms of equal access to the matching device and then to the matching outcomes. This makes sense for the individuals forming block #1, because the stakes are high for those expecting a good high school or a good university, since many opportunities will follow or disappear according to the match; this is all the more true for the patients, since the quality and length of life is significantly superior for those who benefit from a kidney graft compared to those constrained to perform a dialysis twice a week. But this makes sense as well for the clearinghouses, whose official duty is to offer equality of access to patients; failing on this ground could trigger social protest among the population and/

8. Edgeworthian matching structures are less common and more difficult to implement. See Julien Brailly's and Guillaume Fabre's PhD dissertations on the failure to build a matching system in trade fairs for television programs, failure mainly due to the opportunistic behavior of major players (Brailly 2014, Favre 2014). Furthermore, these Edgeworthian structures are less likely to offer clear results in terms of equity in the access to medical treatment (Besle 2015).

or a strong institutional reaction from the government<sup>9</sup>. Equality issues also explain why Roth was personally involved in redesigning the software used to match students' and hospitals' positions — even if, according to his testimony, previous software was in this instance functioning correctly (Roth and Peranson 1999, p. 748-9 and 758). Since students believed that the software was functioning to the advantage of the hospitals, and that it was possible to “game the system”, the legitimacy and trust necessary to the smooth functioning of the device was lacking. This equality issue seems to have been settled; however, it should be noted that the last press release of the National Resident Matching Program ends with two paragraphs stressing that the software was associated with a Nobel Prize in economics, and that it uses applicants' preferences as a basis for the matching<sup>10</sup>. Legitimacy and equity are always at the heart of the functioning of the Clearinghouse<sup>11</sup>.

## Matching kidneys and patients: the French Agence de la biomédecine

Organ transplantation is a form of commerce between human beings — commerce is here understood as a form of social relation, while

9. This happened in Spain when in 1986 the execution of kidney transplantation was considered unsatisfactory by patients and their families: consequently, a new institution (the Organización nacional de trasplantes) was created a few years later (1989). France-Transplant, the French institution created by transplant surgeons also went through significant problems when it became clear that one Parisian hospital was offering a large number of kidneys to patients coming from abroad, and all from the same country. After an official inquiry made at the demand of the transplant community, a new organization (Etablissement français des greffes) was created in 1994 (Steiner 2010b, p. 136-138).

10. “The NRMP uses a computerized mathematical algorithm to match applicants with programs using the preferences expressed on their ranked lists. Research on the NRMP algorithm was a basis for awarding Roth the Sveriges Riksbank Prize in Economic Science in Memory of Alfred Nobel in 2012. The National Resident Matching Program® (NRMP®) is a private, non-profit organization established in 1952 at the request of medical students to provide an orderly and fair mechanism for matching the preferences of applicants for U.S. residency positions with the preferences of residency program directors”, <http://www.prweb.com/releases/2016/03/prweb13277506.htm> (accessed August 11, 2016).

11. These issues are also at the root of a controversy in France on the functioning of the software in the APB matching device for places in French universities. The Ministry of Education released information that was deemed insufficient, notably because the structure and thus the choices delivered by the software were not clear enough (see Piketty, “Le scandale APB”, *Le Monde*, July 12, 2016).

market commerce is no more than a specific form of social relation. This form of commerce is relevant here because market relations have been in the USA since the National Organ Transplant Act was passed in 1984. The banning of the market and the promotion of gift-giving as the only legal form of commerce do not mean that there are no economic issues in organ transplantation. Gift-giving brings about its own form of economy, because there are issues over costs — transplant medicine is very costly — and how they might be financed, both at the national level and at the micro level of individuals and hospitals (Steiner 2010b, chap. 5). Furthermore, transplantation involves the production of the required resource — human organs — and then its allocation to patient duly selected as compatible with the rare organs available for the numerous patients queuing on waiting lists. This allocation requires an elaborate matching system. While there are economists who equate economy and markets and argue that the creation of markets for human organs would be very beneficial, Roth has shown that economists can contribute to limiting shortage in a context dominated instead by the proscription of the market, studying transplantation as a matching arena (Roth 2007). More precisely, Roth and his colleagues have applied their economic engineering expertise in demonstrating that the Top Trading Cycle approach was able to create new opportunities for transplantation between non-compatible pairs of donor and recipient (Roth, Sönmez and Ünver, 2004, 2005; Roth and Saidman 2006; Sönmez and Ünver, 2013). Without entering too much into the details, Roth's idea is the following: the first step is to create a database, ideally at the national level, to register all the non-compatible pairs. Then, a "Kidney Exchange Clearinghouse" will organize exchanges between these pairs of non-compatible patient and donors. Patients choose the most suitable kidney among those available on the database; or they opt to be given priority on a waiting list for a good match with kidneys coming from the *post mortem* procurement process; or, finally, they can choose to wait for the next matching process if they believe there to be currently no good match. It is further supposed that donors and patients have the same preference. On this basis, the mathematics of pure economics has engendered software that searches for cycles (a closed set of patients-donors exchanging their donors) or w-chains (an open set of

patients-donors, since the head of the set will receive a kidney from the waiting list and the tail of the chain will give a kidney to the waiting list). When such cycles and w-chains are revealed, transplants occur and the matching process goes on until there are no more cycles or w-chains. Simulations built on the data provided by the United Network for Organ Sharing show that this matching process significantly increases the number of transplantations, diminishes pressure on the waiting list (because patients who previously could not swap donors were among the many people queuing on the waiting list), and improves the position of patients with type O blood who suffer from a specific asymmetry: type O donors are universal donors and always compatible with a patient whatever the latter's blood type, but O patients must receive an organ from an O donor.

This economic achievement is impressive. Blocks (incompatible pairs), matching technology and Clearinghouse are thus shown at work in the "world out there". However, this is only one aspect of the history since, as mentioned above, the social underpinnings of this matching arena must be taken into account. While it is all the more necessary that the matching of non-compatible pairs of donors and recipients is effective for a very limited number of transplants, the very large numbers (even in the US) are related to post mortem procurement. The question is thus: do matching technology, Clearinghouse and blocks work as well when it comes to transplants with *post mortem* organs?

To be more explicit, we can consider in greater detail the matching arena of organ transplantation as it works in contemporary France. This offers the possibility of examining how concerns about justice and information flows structure the matching process.

First we can flesh out the abstract structure represented in schema II. The Agence de la biomédecine is the Clearinghouse, Block #1 is composed of all the people entered on the waiting list (about 15,470 persons at the end of 2014), and Block #2 represents the flow of *post mortem*-procured kidneys (about 2 720 in 2014). This three dimensional system is operated so as to secure equality of access and efficiency in the allocation of the rare resource that human kidneys are. To achieve this goal the Agence de la biomédecine is organized with a view to "optimizing" (a very common motto



within this medical world) matches between donors and kidney as soon as the latter are “produced” in various French hospitals.

The first concern of the Agence de la Biomédecine is to know what is happening in Block #1. The management of the list is monitored under the two main constraints: an efficiency constraint related to the odds of success of a graft for a given patient, and the equity constraint that requires equal access to transplant procedure for the patients. It is important to bear in mind that entering this block does not come automatically once a patient is diagnosed with end-stage renal failure: between this medical status and block membership, the patient must be entered on the national waiting list by local kidney surgeons. This first step acts as a filter, sorting out patients and selecting those suited to possible transplant surgery. According to the last report on the management of renal patients, the inscription procedure is highly restrictive, notably for the old patients: “For the cohort [for the period 2009-14] of 57,565 new patients under dialysis, the probability of being initially entered on the waiting list is 19% in 12 months, 27% in 36 months and 29% in 60 months. Among the 15,636 new patients less than 60 years old, these probabilities are respectively: 50, 68 and 71%. Among the new patients between 70 to 74 years old, the same probabilities are: 7, 11 and 12%” (Agence de la biomédecine 2014b, p. 252). Furthermore, it is not uncommon that individuals disappear from the list, either because of death or because the development of the disease makes the graft impossible, temporarily or definitively. The waiting time on the list is a major indicator for the Agence, together with the attrition rate of patients.

Confronting this block stands Block #2, which has some highly specific characteristics. Kidneys enter Block #2 as a consequence of a socially-constructed altruism (Healy 2006; Steiner 2010) resulting from the work done by the Agence’s policy of exhortation in order to raise the number of people donating their organs after brain death. Kidneys are a scarce resource of high value; however, the placement in Block #2 of a human kidney comes only after a filtering process, making sure that kidneys are medically “clean” (they are not tainted with cancer cells, or viruses). Membership is very much time-limited, between a few hours to no more than 48 hours, the usual maximal cold ischemic time before a graft. This placement, or

more precisely, this flow is managed very closely by people in the Agence so as not to lose a single kidney.

The final step, the actual matching, requires that an accurate connection is built between these two blocks. This is done thanks to a platform — CRISTAL — running software able to sort out all the patients on the waiting list (Block #1) that can be matched to a kidney as soon as the latter appears in the database (Block #2). CRISTAL is thus the meeting place for these two populations; and the existence of the two opposite blocks is really located in the software. However, this is not enough to produce matches. According to what is known from matching techniques, each side of the matching arena has to give its preferences regarding the other side. In the present case, there is no such decision: neither from the patients, nor the kidneys. The patients’ decision is assumed to be in favor of any fitted kidney, but patients are unable to go beyond this general view; and, kidneys do not decide anything, but have specific characteristics that transplant medicine is able to decipher. The match is entirely supervised by a paternalistic medical system that operates under the twin constraints of efficiency and equality. In order to meet these two constraints, the French Agence has rationalized its set of criteria through a score attached to the medical status of all the patients on the waiting list — this matching system is thus an algorithmic one in a Walrasian arena.

A score is a magnitude that is attached to a patient on the waiting list; the score changes with the situation of that patient. Patients are ranked on the list according to the value of their score. The score is built upon compromises between conflicting constraints, and the compromise takes the form of a specific valuation (a parameter of a given value) of relevant items (length of time on the waiting list, quality of the HLA match, etc.). Christian Jacquelinet, the person in charge of designing and managing the matching software, stresses the key role played by the quantification at the heart of the score: “The decision rule becomes parametrized, it is possible to run simulations and to evaluate the outcome. Modifying parameters permits refinement to the functioning of the matching process when it is working” (Agence de la biomédecine 2015, p. 7). In that case, as in Roth’s work, simulations play a key role in the engineering of the score and on

the matching arrangement at the core of the work done by the Agence de la biomédecine.

The design of the score is such that it gives priority to patients who are facing death and those who are hyper-immunized; beyond these specific cases, the score is based on the length of time on the waiting list and on dialysis, the quality of HLA<sup>12</sup> match between the body of the recipient and the kidney, the difficulty of access to a graft, so that those who have a rare HLA type are not excluded from the possibility of obtaining a graft, the time necessary to move the kidney from the “production” hospital to the patient’s hospital, and the match between the age of the donor and of the recipient. To this complex series of constraints is also added the decision to allocate one of the two kidneys regionally, whereas the other is offered nationally.

Jacquelinet explains that the score is grounded on many biological and evidence-based medicine results; however, he also makes clear that some decisions are not medically based, such as the preference given to young patients, or the regional allocation which is needed to give an incentive to local surgeons in retrieving kidneys. The use of a score is a recent development in response both to the efficiency and the equality constraints. Efficiency is improved thanks to connection with a national database of patients, allowing the selection of a recipient among a larger set of patients, increasing the odds of finding a perfect HLA match, and ensuring a better fit between the age of the donor and of the recipient. But efficiency also requires some considerations about the activity of the medical staff in the different hospitals that are homologated for transplant surgery, each of them needing a sufficient amount of transplants per year in order to stay fully efficient. Answering the equality of access issue is a bit more difficult, since there are many criteria for measuring this equality: gender, age, geographical localization, blood type, HLA type, etc. So the Agence de la biomédecine carefully presents a series of tables showing how the implementation of the score that sorts out patients on the waiting list improves the outcome of the matching process in several ways (Jacquelinet and Hourmant 2015, p. 10-22).

12. Human Leucocyte Antigens, discovered by the French immunologist Jean Dausset in the 1960, are used to identify the immunity system of the recipients and the fit with the immunity system of the kidney.

## Big data and the “omnes et singulatim” forms of governmentality

Beyond the politics of the biomedical dimension (Rose 2007), economy as matching has a political dimension of its own that must be considered carefully, particularly when Walrasian algorithmic matching is at stake. Beyond the formation of blocks, the process thanks to which an individual is accepted or rejected in a block, and the key issue of equality of treatment once admitted into a block, the political dimension of algorithmic matching is about the *form of government* of individuals that is emerging in contemporary societies.

### Quantification and governmentality

As it is now well known, Michel Foucault examined political economy as a form of government, or “conduct of conducts”. The institution of a self-regulating grain market in 18<sup>th</sup> century France was thus understood as a solution to a political issue, namely, the production of security to a population on a given territory (Foucault 1977-8) — this what he called governmentality. This form of government is driven by “optimization”, in the sense that the issue is not about forbidden behaviors that must be tracked, made illegal and then eradicated from the social body (government by law); nor is it about controlling undesirable behaviors through a process of continual monitoring of the population, as with prisons (government by control). Optimization means that some unpleasant, dangerous or even forbidden behaviors will occur, but they are considered to be inescapable components of the best possible social order<sup>13</sup>. Banning by law or controlling these behaviors would end up in a worse (or “less best”) social order.

The strong connection between markets, utility optimization-led behaviors and political issues was not examined further by Foucault, who just points it out when dealing with Gary Becker’s approach to law enforcement (Foucault 1978-9, p. 274-80). Historically, we may find some

13. In this sense, Foucault is close to Leibniz’ view of theodicy, where the present social order is considered as the best possible order, the order that God has established in the same way that a mathematician would find a relative extremum of a function thanks to calculus — a mathematical technique that Leibniz discovered together with Newton at the end of the 17<sup>th</sup> century.

interesting evidence from economists of the 19<sup>th</sup> century who put these three elements together, notably the German mathematician-economist Hermann Gossen; considering this could have helped Foucault in refining his approach before he entirely discarded it from his research agenda (Steiner 2011, 2017). However, the time was not ripe in the mid 19<sup>th</sup> century for the full development of these ideas: technical devices necessary to monitor the huge amount of data required to implement governmentality were not available. Societies were still located in what could be called the *Quetelet regime of quantification*, organized around the average and its human materialization, the so-called “average man” (*l’homme moyen*), then associated with the study of the distribution of individuals around that central value and, later on, with inferential statistics.

This regime of quantification is still at work, obviously, but it is not relevant for the form of governmentality that stands at the core of the matching economy because, as mentioned above, relevant data are highly personal data monitored by powerful software able to find out the optimal use of resources, both at the social level and at the individual one. This is what I suggest can be called the *Pentland regime of quantification*<sup>14</sup>. Quantification is then about the individual herself, thanks to the technologies that make it possible to manage efficiently a vast amount of data — ideally all the relevant data<sup>15</sup> — within a large population in order to get a fine-tuned match between individuals and resources: “Big data give us a chance to view society in all its complexity, through the millions of networks of person-to-person exchanges” (Pentland 2014, p. 11). In that case, governmentality bypasses Quetelet’s favorite tools (mean, standard deviation, etc.) to reach and manage directly individuals and their interactions. Technologies are obviously of prime importance; but social and political technologies are also very important. Pentland stresses that building the appropriate social and political

technologies is neither straightforward nor easy: “The biggest barrier to building better societal systems using such massive data, however, is not their size or speed, nor even privacy and accountability in sharing. Instead, the biggest challenge is learning how to build social institutions based on the analysis of billions of individual connections. We need social physics, so that we can move from systems based on averages and stereotypes to ones based on the analysis of individual interactions” (Pentland 2014, p. 185).

The matching arrangements studied so far belong to the institutions that Pentland is thinking about here. They deal with a large amount of information related to significant number of individuals — about 20,000 in the case of the resident match program set up by Roth, and about 15,000 people on the waiting list for kidney grafts in the Agence de la biomédecine. These databases are made up of individual data: about the body, about intimate wishes thanks to which matching devices are producing the best possible social outcome (a good job match for an efficient health system, good body match for achieving the cost-reducing benefit of transplant versus dialysis).

### From obedience to optimality

The Pentland regime of quantification is a great step toward what Foucault called the *pastorate*, the form of government that preceded political economy, whose characteristic is aptly summarized by the “*omnes et singulatim*” motto. I think it useful here to link the matching economy to the *pastorate* as a form of government in order to understand the political dimension to this approach to the economy.

According to Foucault the *pastorate* comes from the Christian religion, in the sense that it is a specific view of the relation between God and human beings. The *Pastorate* is organized around three principles (Foucault 1977-8, p. 129-32): it is about the government of a population and its movements; it is benevolent in the sense that the pastor provides subsistence or care to each member of the population; and finally, it deals with each individual and, at the same time, with the whole population — hence the “*omnes et singulatim*” formula. The *Pastorate* is neither political, nor rhetorical nor pedagogical; it is a form of governmentality, that is to say a political technology deliberately built for producing subjection through obedience (Foucault 1977-8, p. 177 and

14. Alex Pentland is a scientist working in the MIT Media-lab. He is the author of *Social Physics* (Pentland 2013), by which he — probably unknowingly — replicates the subtitle of the book in which Adolphe Quetelet (1835) made the case for the average as the quantitative knowledge suited to the government of modern society (Dérosières 1993).

15. In this sense, data accumulation in Walrasian algorithmic matching is close to the “*N = all*” claim made by some big data scholars (Mayer-Schönberger and Cukier 2013, chap. 2). However, the arenas studied here do not fit two other claims: messiness versus accuracy in the data, and correlation versus causality.



187). The subject must reveal the truth that lies within himself, as a way to reaching the state of obedience and thus gain salvation.

In his lectures Foucault explained that the pastorate went into crisis in the 16<sup>th</sup> century and faded away in the 17<sup>th</sup> century to be replaced first by police, and then by political economy. This last form of governmentality is significantly different from pastorate, since it relies on the interested behavior of human beings — there is a strong element of utilitarianism in the Physiocratic doctrine that Foucault took as a point of departure — and because it is grounded on a new form of truth, with the idea that there exist mechanisms which regulate the social, understood as a new form of naturalness that statistics can quantify (Foucault 1977-8, p. 353 and 357).

What we have said so far about the engineering of matching suggests that this modern form of the economy has strong commonalities with the basic characteristics of pastorate, albeit with some significant differences.

In the case of the matching system at the core of transplant medicine, the issue is the government of two symmetrical populations linked by the Clearinghouse, and these populations are constantly moving: they are (in the case of the dead donors) flows, or they should be (the patients) transformed into fast-running flows, instead of people stuck on the waiting list. This matching system is benevolent, since it is about providing care to one block with the help of the resources offered by the opposite one. The institution at the center of the matching device has to manage whole populations (patients suffering from end-stage renal failure and brain-dead patients in ICU) through a highly personalized system, precisely through the set of highly personal data that the Clearinghouse requires for optimizing the match between organs and patients. The quality of the Clearinghouse is thus determined by the fate of whole populations (patients on the one hands, kidneys on the other), having also to care about individuals and the fate of each individual (the life of each “functional grafted kidney” and the life of each grafted patient). Finally, the matching software needs to obtain accurate and intimate data from both populations. Obviously, the nature of the data differs according to the specificity of the matching issue (labor market, education, transplantation); the way of producing them differs as well their different procedures. These are

the major commonalities between matching arenas and the pastorate.

There are nevertheless two important differences. The first one comes from the fact that the Clearinghouse is also busy with the production of one population: obtaining kidneys from dead bodies is not an easy task; it demands constant work to be achieved. The second difference is probably more substantial, with the key importance given to the flows of information. Contrary to the pastorate, matching devices are not designed to produce obedience; they are built upon the idea that people are self-interested, opportunistic and strategic players trying to beat the system. *Accordingly, in line with the basic tenets of the economy of information, incentives are built up in such a way that it is better for the individuals to send their true preferences and data if they wish to get their best match.* Economy as matching stretches the series of social arrangements that, according to Foucault, are associated with telling the truth: Greek and Roman pedagogy was an arrangement in which the revelation of truth was mainly the concern of the one in charge governing the subject; Christian “psychagogy” aimed at bringing the subject to tell the truth (Foucault 1981, p. 389-91) and thus gave birth to the confession; with centralized matching arrangements, the subject is still induced to tell the truth in order to optimize her chance for gaining access to the valuable resource (a life-saving organ, a position in a good hospital, a good high-school, a good job, etc.) that is likely to substantially modify her life. This new social relation to truth could be called “optimagogy”<sup>16</sup>: the issue is to encourage self-interested and optimizing people to give information that induces an optimal use of resources, both for each of them individually and for the whole population. After several decades of research on the paradoxes of rationality, notably with robust demonstrations of the difference between individual and social rationality, nobody can believe that this is an easy task to achieve. Such governmentality is based on expertise (in the process of filtering/

16. This emphasis on optimality has as well put by Antoinette Rouvroy and Thomas Berns (2013). Instead of producing a subject with her own subjectivity, algorithmic governmentality places the subject into a selected possible world so that she has just to react to information, behaving in the optimal way without thinking deeply about it. Nevertheless, algorithms at the core of matching economy are more demanding than the big data world these two authors are studying, since consent and data are much more structured in order to produce blocks and effective matching.

selecting populations, on the design of the matching device) and on the nudging of individuals through a series of fine-tuned incentives so that the information sent to the matching device is one of the best and most appropriate quality. However, as in the “libertarian paternalism” at the core of the theory of nudges (Thaler and Sunstein 2007), matching arrangements designed by social engineers, specialists in optimizing theories, leave open the possibility to act otherwise, namely to make mistakes or to stick to one’s personal views; in other words, these arrangements do not produce obedience or confession, but the optimal situation for the subject and the society as a whole. Finding one’s way towards optimality is thus the characteristic of this form of information-led governmentality, both for the Clearinghouse at the center of the matching device, and for the subjects.

## Conclusion

This inquiry is a first attempt at delineating the changes associated with centralized algorithmic matching in our present society when it involves the usual issues related to the distribution of useful, scarce resources. In this sense, matching processes are becoming an important part of our present economic life, whether the exchanges occur in markets or in non-market arenas. In any case, equilibrium and optimality are defined in a specific way, generally without any price-tag or use of money, but directly through the preferences of the two sets of actors who are in the arena. The first conclusion is thus that matching processes blur the distinction between market and non-market arenas, between compulsory and optional matching, and between self-interested behavior and altruism or gift-giving: the same economic apparatus can be implemented in any of these various social settings.

Beyond a brief presentation of the properties of the algorithms, I wanted to stress that the social components of matching arenas are dominated by concerns about freedom and justice: freedom to access the matching arena; social justice when it comes to decide who will be admitted to the matching arena; then again, social justice related to the outcome of the matching software. This means that access to matching arenas is becoming an issue for the proper functioning of our present society, as access to markets was and still is an important issue. Furthermore, freedom and

justice are difficult to implement since actors in the blocks are usually different (individuals and organization) and the way they confront the choices offered in these matching arenas for singular and key resources is also significantly different. The choice is most engaging for the individuals, but it is generally a once in a lifetime choice; whereas it is a continuous process for the people in charge of the organizations, who also have the possibility of benefiting from learning by doing. The fact that the asymmetry in these arenas cannot be controlled solely by the incentive to send good information to the Clearinghouse highlights the need for social justice.

Finally I come to the political dimension of matching arenas. Following Foucault’s approach to the pastorate understood as a form of governmentality, my final conclusion is to stress that matching arenas are new devices for governing individual conduct. The crucial point is not so much the quantitative nature of this governmentality, because this was the case at least from the end of the 19th century; the new phenomenon is the close association of matching arenas and a highly personalized government, involving both each individual and the whole population. In this sense, the matching economy and its social underpinnings in our present society reintroduce the old “Omnes et singulatim” religious motto, according to which the government has to take care of each individual in particular as well as the whole population, even if this involves libertarian paternalism.

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