Assemblage of a market mechanism

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Abstract

In this paper, we address the mechanistic character of markets through an empirical investigation on the automation of a stock exchange: the Paris Bourse. In this market, open outcry was fully replaced by an automated trade execution system in the late 1980s: since then, the confrontation of buy and sell orders was to be performed by an algorithm. We show how the officials and engineers in charge of the innovation process where constantly combining technical and social elements in order to make the new market mechanism hold together. They had to carefully inscribe into the new market device the interests at stake in order to prevent the breakdown of the equilibrium existing between bankers and stockbrokers. This process of translation shows the socially situated nature of this market mechanism.

Keywords

open outcry, exchange automation, financial markets, economic sociology, science & technology studies, mechanisms.

Introduction

Markets, as decades of research in economics have shown, can easily be described as mechanisms. Notions of equilibrium in the neoclassical tradition are explicitly mechanistic (Ingrao & Israel 1990) and algorithmic metaphors seem to be playing an increasing role in the analysis and understanding of markets (Mirowski & Somefun 1998; Mirowski 2002). But one thing is to be described as a mechanism and one other, quite different thing is to actually be constructed as such. Are markets mechanical entities for real? How can an empirical market be made to behave as a machine outside the laboratory of economics? One possible answer is to simply refuse the validity of economics (at least in its neoclassical versions), and oppose to such mechanistic views the lively social entanglement of real economic life. Sociological critique has often accused economics of ignoring real markets and of abstracting economic principles from their social context (e.g. Carrier & Miller 1998). But this kind of approaches leaves us with little resources to understand two important facts. First, economics - despite of its (often self-conscious) over-abstraction - is been increasingly, widely and (more or less) effectively used as an applied science for the construction of real markets (Callon 1998; Guala 2001; Izquierdo 2001; MacKenzie & Millo 2003). Second, real markets are meeting mechanisms in a quite literal sense: algorithms are been used not only to describe markets but to actually build them, like in the case of electronic auctions and financial exchanges (Domowitz 1993; Domowitz & Wang 1994; Lee 1998). These remarks, however, do not allow us to comfortably rely on the axiomatic views of economics. It rather leads us to a different sociological research program: an inquiry into the pragmatic efforts that have to be made in order to turn a market into a machine. It is always `by construction' that a market becomes a mechanism. The purpose of this research program is precisely to follow this construction activity.

In this paper, we follow this approach with a case study on the automation of a stock exchange. The *Bourse de Paris* (Paris Bourse) became a fully automated stock exchange in the late 1980s.`Automation' means, in this precise context, the automation of trade execution, i.e. the computerization of the process according to which buy and sell orders are matched together, market prices are determined and shares are allocated. In the case of the Paris Bourse, this process had a quite poignant material translation: the dismantlement, from 1986 to 1989, of the traditional open outcry (the *criee*) held in the trading floor of the *Palais Brongniart*, in Paris. The construction of liquidity (i.e. the provision of a consistent flow of quotes) was no longer handled through the face-to-face confrontation of stockbrokers (the *agents de change*) operating in the floor of the exchange, but was instead delegated to a machine. The Parisian machine, CAC (*Cotation Assistee en Continu*),[1] was in fact imported from Canada: it was a version of CATS (Computer Assisted Trading System), the trading device that was functioning in Toronto Stock Exchange since 1977 and that is considered as the very first fully automated trading system in the world. CATS provided what is usually known as an `electronic order book': standing orders for a given

stock are inscribed into a computer memory, queued, matched and then executed according to a double auction algorithm. Traders rely on the screen of their computer terminals to observe the state of the order book and transmit orders according to their trading strategy. No face-to-face confrontation does happen in the process and no flesh-and-blood intermediary needs to intervene in order to guarantee order matching. Liquidity relies on the pure mechanics of the electronic order book and the double-auction algorithm, i.e. on the `price discovery mechanism', as economists often term it.

We will not explore here all the complex circumstances of the automation of the Paris Bourse.[2] We will limit the scope of this paper to two simple questions. The first question is a rather straightforward sociological question: how was the transition from open outcry to automated exchange made possible? This question joins a second, more elaborated one: how did the market hold together? Or, in other words, how social was the instituted mechanism (knowing as we know that no institution can sustain itself without some sort of a social bond)? In order to outline an answer to the first question (and to bring some light into the second one), we will proceed as follows. In a first section, we briefly present the situation before automation. In the following section, we introduce the reform program. In a third section, we focus on the choice of CATS. The fourth section analyses some social elements of the innovation campaign. In the fifth section, we present the core of our analysis: we explore the technical elements that guaranteed the stabilization of the reform. We finally conclude on the material process of translation that allowed for the stabilization of market automation.

The Paris Bourse in the early 1980s

The French financial world of the early 1980s was a space articulated in several complementary fields, with heterogeneous and sometimes opposed interests. A main relevant distinction is to be drawn between banks and brokerage houses, a distinction that somehow embodied a divide between finance (as a capitalistic enterprise) and the market (as a trading activity). The organization of French financial industry diverged from Anglo-American models in which brokers constituted powerful financial firms. In Paris, the market belonged to stockbrokers but finance was on the side of bankers and the boundary between both was relatively rigid.

In the early 1980s, trading activities at the Paris Bourse were controlled by the *Compagnie des Agents de Change*, the corporate body of the official stockbrokers, the *agents de change*, that were appointed as ministry officials and transmitted their business to their sons in a hereditary fashion. This limited and exclusive professional community benefited from a monopoly of quotation (Lehmann 1997). All bankers and investors wanting to buy or sell stocks listed on the Paris Bourse had to go through the services of those *agents de change*, like one has to pass through a notary for a transaction in the real estate market. In the floor of the *Palais Brongniart,* they handled quotation in a quite personal manner. Practices of connivance and preferential treatment were quite widespread. But, in spite of these prerogatives, the use of own funds was strictly limited: French financial law did not allow these *agents de change* to use their own capital to stand as a counterpart for clients' orders.[3] On one hand, the agents de change were quotation professionals, but lacked the financial strength of brokerage houses such as the ones operating as dealers or market makers in London, Chicago or New York.. On the other hand, French banks did possess the necessary networks to construct a powerful financial industry but could not become market professionals, as Anglo-American investment banks were.

The organization of quotation in the Paris Bourse was a complex matter and followed rather traditional methods (Defosse & Flornoy 1986; Bacot, Dubroeucq & Juvin 1989).4 Many quotation methods did co-exist inside (and outside) the floor of the stock exchange. Among those, the daily open outcry (the *criee*) played a major role.

The *criee* functioned as follows. At 12am, after having collected and sorted out their clients' orders, the *agents de change* of the different brokerage houses and their employees (the *commis*) met at the *Palais Brongniart*. At 12:30am, a bell announced the beginning of the quotation of the first stocks. Listed equities were grouped in several trading groups. The *agents de change* themselves traded at the *Corbeille*, the trading pit for the forty most important stocks, and were represented by their *commis* in the five remaining groups. In each group, stocks were traded one by one, according to a predetermined order, in successive `calls'. Consequently, each stock was quoted only once a day (sometimes twice or, at most, three times) according to a call auction protocol known in France as `fixing'. Market time was discontinuous.5

The debates for each *fixing* were directed by a *coteur*. *Commis* and *agents de change* indicated through voice and gesture the quantity wanted or given at the price proposed by the *coteur*. The *coteur*, as a sort of an auctioneer, had to search for the price that allowed for the exchange of the biggest quantity of shares. He wrote indicative prices on a blackboard. On simple oral agreements, preliminary transactions were concluded. As soon as an equilibrium price was found (the coteur underlined it in the blackboard), the negotiations were definitive and another stock was called for quotation. At 14:30pm, the trading activity was closed, with a single daily price attributed to each traded equity.

The modernization program

Quotation was handled according to these rules in the floor of the Palais Brongniart until mid-1980s. " At that time", says an

official in charge of the reform, " the Paris Bourse was a prehistoric market; there were no more than 5 or 6 computer terminals on the floor, just to enter the quoted prices" (interview A).6 By the end of the 1970s, a number of market professionals had started to worry about this state of technology.

In spite of the words of warning emanating from some officials at the executive committee (Chambre Syndicale) of the Compagnie des Agents de Change, the population of the Palais Brongniart resisted any organizational, legal or technological innovation, fearing redefinition of skills and massive personnel redundancies (the hereditary character of the agents de change's businesses, the traditional aspect of their professional world and the financial and technical difficulties of a possible modernization played against the acceptance of any modernization initiative).

International competition, however, was starting to be a considerable menace. Big investors were threatening the Paris Bourse with the possibility of diverting trading flow to foreign stock exchanges (London, mainly). Along with listed companies, they increasingly asked for higher liquidity and started to criticize an exchange that provided only a quote each day and that was too exposed to the agents de change's own personal arrangements. Investors and listed companies benefited from an important ally: The State itself, that was giving them a central role in the financial reforms undertaken by Rene Monory, the Minister of Economy and Finance.

The Perouse Report, published in 1981, was the result of the surveys and deliberations of a commission appointed by Rene Monory to evaluate the technical circumstances that could lead to a reform of French financial structures (Commission Perouse 1981). The origins of this political commitment were to be found in the worried claims of an agent de change, Yves Flornoy, albeit agents de change were widely against any attempt to alter the status quo. Flornoy, who was head of the Chambre Syndicale (the executive committee of the Compagnie des Agents de Change), convinced Monory and Prime Minister Raymond Barre of the importance of conceiving a large scale plan for modernization (Bacot, Dubroeucq & Juvin 1989: pp. 30-41). The primary question was how to develop a financial structure capable of absorbing the new forms of economic adjustments devised by the French government. At the center of the answer lied a new character that was still a stranger to French financial market: the computer.

It is in the pages of the Perouse Report were one can observe the nascent form of the arguments in favor of a computer-based continuous market, and the subsequent outline of a radical transformation of the world of the agents de change. But, in spite of the insistence on the necessity of a continuous market, little is said about the concrete frame this innovation could be embedded in. A central question is carefully avoided in the report, or only mentioned in hesitant and cautious terms: would continuous trading mean the disappearance of open outcry? As several relevant examples show - including the New York Stock Exchange - an exchange can operate continuously on the exchange floor without becoming fully automated. The Perouse Report was full of rhetoric precautions and hesitations on the status of `the computer'. Will machines come to equip and enhance the open outcry or to eradicate it? The Perouse Report was far from having closed the controversy.

One of the main activities of the members of the Perouse Commission's working groups during the preparation of the report was to travel. Several visits to worldwide exchange institutions where scheduled: to New York, Washington, Toronto, London, Frankfurt, Zurich, Amsterdam, Tokyo and Osaka (Commission Perouse 1981). The Perouse Report maintained that no ready-made solution to the Parisian case was to be found in foreign markets. The trip to Toronto, however, seemed to bring more inspiration than the others. After a visit to the Toronto Stock Exchange in 1979, its CEO Pearce Bunting was invited to give a talk in Paris (the talk is reproduced as an appendix to the Perouse Report).

We know that Toronto's CATS (Computer Assisted Trading System) was the system chosen to conduct the Parisian reform. What were the elements that shaped this arrangement? How were controversies closed through this particular device? CATS was not only a technical solution for quotation. It embodied two fundamental choices. The first was the abandonment of any model based on the role of market makers. CATS was an auction-based system, an order-driven architecture: the confrontation of buy and sell orders was made though the automated auction protocol, without the active intervention of dealers or market makers.7 The second choice was the rejection of an open outcry solution and the inclination towards the highest level of automation. Although CATS was able to cohabit with open outcry, it allowed for a full computerization of the price determination and order matching processes.

This model's compatibility with the arguments deployed in the Perouse Report was far from straightforward. With a system such as CATS, the position of the agents de change was to be deeply challenged. But the Perouse Report seemed to consider their privileged status in a positive way (as an interesting regulatory way of preventing market fragmentation). Moreover, although some voices of criticism of open outcry were expressed in the Perouse Report - mainly through bankers' claims for a continuous and more transparent market - no clear assert favoring the abolition of the criee is found in the text. In the more explicit proposal found in the Perouse Report, computers, displayed inside the trading venue of the Palais Brongniart, would provide only indicative prices and the coteur would keep a major role in the determination of execution prices. Negotiators would still be physically present, the main novelty being that they could announce their positions on their terminals, which would increase the visibility of the reciprocal positions and the indicative execution price during the fixing:

The basic structure would thus remain that of the criee - the computer would be considered as a prosthesis of the criee, not as its replacement.

Importing Toronto's CATS

The political inflection caused by the victory of socialist candidate Francois Mitterrand in the presidential elections of May 1981 brought to a halt the modernizing impetus of the Perouse Report. From this date, the small team in charge of the project at the Chambre Syndicale (Francois Bacot and Paul-Francois Dubroeucq, under the supervision of Yves Flornoy, and then of his successor Xavier Dupont) had to undertake rather discreet work to carry on the reform. This is, ultimately, the moment when controversies where unlocked and the path started to find its way to CATS. One of the persons in charge of the reform recalls it as follows:

"There was a conflict, which became a political conflict. It was monopoly against monopoly. The banks would have liked to obtain their monopoly on the market. You see, there was a more or less clear struggle. And then, therefore, I went to re-examine a certain number of systems in various countries. And I was quite enthusiastic about CATS because I was convinced enough of one thing: that we had an enormous revolution pending. The majority of the Anglo-Saxon countries had already a continuous market for a long time. And thus they had only to computerize a system that was, somehow, already there. In France, we had first to go from the call market to the continuous market, which was a terrible job, because that called into question all the working methods. [...] We thus had to undertake a complete reform of our brokerage houses' culture. What I liked about the CATS system was that I found there, in a computerized and continuous frame, the essence of what I had devised as a way to make the criee evolve towards a computer tool. I found everything inside. Thus, we worked much on this system, and ended up buying it." (Interview B).

CATS contained "everything inside". It was the tool that could lock-in the reform at a point when there was neither the time nor the resources to carry out a whole reform of market practices.

A relatively growing liquidity crisis on the Parisian market made convenient the shift to automation at that precise period (mid-1980s). Competition with London was a concern for the Chambre Syndicale, as well as for the whole community of the agents de change. "There were everyday in the Anglo-Saxon press articles saying things like: `40%, 60% of the volume of Elf Aquitaine [an important French oil company] is traded in the London Stock Exchange'", recalls a former consultant for the Chambre Syndicale (interview A). This state of concern worsened in 1986. The London Stock Exchange was experiencing what the actors of the time called the `Big Bang', and which culminated in October 1986 with a process of massive deregulation. Moreover, London's marketplace was adopting the SEAQ system (Stock Exchange Automated Quotation), a trading system based on the NASDAQ model.8

The pressure of competition thus precipitated the decision to shift towards electronics, and the CATS solution seemed to be quite timely. The first case of real quotation on CATS took place on June 23rd, 1986. The Chambre Syndicale kept on working on the introduction of CATS in Paris until its culmination at the end of 1989. The French machine was re-named with a French acronym: CAC (Cotation Assistee en Continu), which means "continuous-time assited quotation". The 15th of July 1987, a notorious date, the Corbeille (the main trading pit at the Palais Brongniart) was dismantled.

How to enroll the floor in its own dismantlement

Although the Chambre Syndicale did not lack completely the authoritative means to enforce automation, the actors from the Parisian market had to be enrolled into the reform: they had to be interlocked in the new trading device. Toronto's experiment showed how crucial `social engineering' was for the transition to automation. In spite of its pioneer role, some could still say that the computerization of the Toronto Stock Exchange was a failure. Its former president exposes it as follows:

"In the fall of 1977 we started trading our first listed company. Unfortunately, because of continued opposition from the floor and some member firms, we were forced to start with lightly traded shares, which is exactly the opposite from what we should have been doing. This incidentally was a lesson that we were able to pass on to Paris. The opposition to the system was intense, including an effort to have me removed as President of the exchange. Slowly but steadily, the system was implemented and in 1989 all shares were traded on CATS. However the floor still existed, with traders giving their orders vocally to exchange clerks, who then entered them into the automated system. The floor was finally eliminated by my successor in 1997." (Personal communication C).

In 1987, after 10 years of struggle, the controversy remained on the Toronto Stock Exchange's agenda. Canadian press echoes incidents like the following:

"A dispute between floor traders and senior management at the Toronto Stock Exchange [TSE] is brewing again, as the exchange studies whether computers or people should be at the center of stock market action. After what one exchange official described as a `shooting match' between the two sides, the exchange has launched a new, $1.25 million study looking into computer-based trading compared with person-to-person stock market trades. `People's livelihoods are involved here, so tensions and anxieties are high,' the official said in an interview. [...] The controversy over computerized trading has been simmering for some time, but erupted a year ago after the exchange's board of governors approved a plan to switch two

large stock issues from the trading floor to the TSE-developed Computer Assisted Trading System, known as CATS. CATS was originally introduced to handle trades in less active stocks, while major share issues remained in the hands of floor traders. The computerized system now handles almost half of the total listings on the exchange. But the news that two large stock issues were going over to CATS hit like a bombshell. Traders banded together into a Professional Traders Association to voice their concerns." (Source: `Computers-or-people dispute flares at TSE' (by F. Lebolt), Toronto Star, December 19th 1987, p. B1).[9]

We find here a good example of the situations that needed to be avoided in Paris while installing the Canadian device: the `same' machine, one would say, only with a narrow vision of what is a technical device. The keystone of the Parisian success is to be found, precisely, in the particular sociology of the device.

We find first, at the center of the most obvious strategies for smothering criticism, the surprise effect. Actually, only a few exchange clerks and stockbrokers believed in the proposals of the Chambre Syndicale: "We thought, very honestly, that a computer would never be able to have the degree of smoothness which we had", notices a former commis, who had played a significant role in the trade-union movement in the Paris Bourse (interview D). Downsizing plans following the reform were drastic: "At our brokerage house we were 227; we ended up being only 42", recalls this same person. The first dismissals were thus faced with astonishment. The trade-union movement could not react in time.

But the shock effect could not guarantee the success of the operation by itself. Trading professionals, or at least a part of them, had to be enrolled. How did the populations of the criee take part in a reform whose aftermath was going to be so critical for their own activity? One of the `craftsmen' of the reform explains the importance of a whole work of enrolment that counted, among its paramount arguments, on the importance of adapting oneself to new tools to preserve a certain privileged position in the market:

"We used very traditional methods. Dialogue, above all. Especially with the potential leaders of a revolt. There were the old guys from the market, the hard men, and they were not very keen on the reform. Those guys were 50 or 55 years old. They saw well that they would not be able to continue to be the leaders of a system that they would not understand well. They could easily loose their means of influence. [...] We tried to detect which would be the leaders, which would be the big opponents. There were around ten of them, which I saw all the time, that I put in the loop, in order to make them feel that they were not loosing their power. Without devaluating them too much, to let them remain leaders." (Interview B).

One of the material means used for this enrolment policy was the organization of training programs in Toronto. A total of about 120 persons - minimum of two persons per brokerage house - flew to Canada to take part in these programs. Recalcitrant brokers found themselves thus trained to a new tool that promised to give them a comparative advantage back in Paris. Some CATS training seminars were also scheduled in Paris. Everything was done to form an avant-garde of promoters of the reform. This pedagogy of the system was coupled with an intense marketing activity: publication of brochures and leaflets, development of commercial arguments. It was not a simple persuasion campaign. The seminars and training courses were also a guarantee of continuity trough the acquisition of new competences. The criee professionals were starting to understand the scope of the reform and the threat to their working practices. For the first time, particular technical skills were imposed as part of their work qualification. Access to trading terminals was limited to the competent negotiators, i.e. to those of them having passed an exam.

As the first tests on CATS took place, a parallel institution was introduced with the aim of making market practices evolve towards continuous quotation: it was the `morning session' (seance du matin), inaugurated on March 1986. This was the more publicized innovation in this period of the reform, clearly put forward in institutional communications, whereas the tests on CATS' prototype still remained discreet. For the majority of the actors of the market, including for those who had been able to observe the CATS system in Toronto, the general impression was of a criee located on the exchange floor which was going to be extended in time instead of providing only one single quote per equity, possibly assisted by data-processing tools for order entry and for the quotation of the equities with weak liquidity (as it was the case in Toronto, and as it was more or less suggested in the Perouse Report).

As we can see, a whole program of social engineering was involved in the innovation process. But this program, in order to be effective, could not stop at the perimeter of the technical device: it had to penetrate it. Indeed, the transition was not solved on a pure plan of marketing, human resources and institutional communication. Nothing, in the elements that we have just provided, guarantees that the new device can absorb, in a relatively peaceful way, the activity of negotiation on all the equities traded on the Paris Bourse. A finer comprehension of the passage to automated quotation requires, therefore, a more detailed attention to the technical aspects of the operation.

Technical inscription of the interested parties

The location of trading terminals

One of the most obvious advantages on which the Paris Bourse counted on for the installation of CATS, compared to its Canadian partners, was the fact that the system, as such, already existed. In Toronto, the system had to be constructed `from scratch'. The conditions for the Toronto innovation were harder (`trial and error' developments, to carry out without the

support of preliminary experiences). The `large scale' experimentation of the new machine required proceeding by low doses (stocks with low liquidity), which prevented the deployment of a strategy of massive transformation. The Paris Bourse was in front of a turnkey device that had already proved reliable.

However, the installation of the device was far from being a technically obvious task. An exchange mechanism is not transposable just as it is. In other words, its transposition requires a fine adjustment of the fasteners that make it hold together. We thus face, in the Parisian case, technical adjustments that, far from being `purely' technical, are at the origin of the interlocking of the device in an idiosyncratic site. The device had to succeed in translating the entanglement of forces constitutive of the Parisian environment.

The first element that interests us in this level of technical detail is the purely spatial dimension of CATS. Where should the trading terminals be located? In the exchange floor or in the brokerage houses? The installation of trading terminals apart from the criee was already a lesson that Pearce Bunting, CEO of the Toronto Stock Exchange, had tried to communicate to the Parisian team: "My personal impression is the following: the further away the users are from the stock exchange, the more they seem to appreciate the advantages of the system", he declared in his 1980 speech in Paris (Commission Perouse 1981: vol. III, p. 186). The reflection of the persons in charge for the Parisian reform went in the same direction:

"At the beginning we were saying: `we shouldn't radically break the stock exchange down, it is necessary to have people actually going there, it is necessary for them to be there everyday.' We wanted to have something like criee groups with computers. But I ended up thinking: `this is completely insane; the guys will work a la criee above the computers.' I thought that, on the contrary, they had to be kept on their premises. You know, it was necessary to break very old traditions, without killing people's enthusiasm, and by promoting them. By promoting their new skills. [...] In Toronto, they had a continuous market, they put the computer terminals on the floor and people didn't take a step forward. Traders kept their vocal system and put some clerks in front the terminals. In our case, we located the terminals inside the houses and we put in front of them the leaders that we had formed." (Interview B).

On this point, the computerization plan diverges consistently from the suggestions for computer assistance to the criee outlined in the Perouse Report. It is not because quotation was computerized that trading activity could be displaced to the stockbrokers' premises. Quite the contrary, it is because this geographical aspect was considered from the very beginning that the computerization process could be carried out and stabilized in the long term.

The connection between order routing and quotation

Once the trading tool was confined within the brokerage houses, a controversial issue inevitably arose: the interaction of this tool with the system that was used to route orders from the banks to the brokerage houses. In Paris, an order routing system called RONA (Routage des Ordres et des Negociations Automatisees)10 had been developed before the introduction of CAC (Bacot, Dubroeucq & Juvin 1989). RONA connected the retail branches of the banks with the brokerage houses. The orders were entered on terminals by the employees of the banks and then forwarded to printers located in the stockbrokers' headquarters (before the trading session) or directly to the Palais Brongniart, to the `box' of the stockbroker (if the orders were transmitted during market hours). The existence of this system at the time of the installation of CAC was going to cause a critical situation for the rebalancing of the weights of the various actors at stake. The situation was expressed in very clear terms: once one had, on one side, a system for collecting orders (RONA) and, on the other side, an electronic trading system (CAC), it was potentially possible to connect both. This situation rendered almost absurd part of the activity within the brokerage houses and pointed directly to a crisis for many professional activities. The disappearance of the activity that consisted in taking the orders from the routing system and entering them into CAC in the near future was almost self-evident. The connection between order routing and negotiation challenged the status of stockbrokers in a very direct way.

On the model of RONA, the engineers in charge of the CAC project developed COCA (Connexion CAC),11 a routing system that recovered the order in a bank's files and sent it directly towards CAC's central computer. COCA brought, for the first time, a routing continuity from the banks' branches to the quotation computer. Continuity could even be expanded upstream to retail customers thanks to the Minitel (France Telecom's screen-based communication network), which could be connected easily to RONA and which had already been used to stimulate electronic order routing. This innovation was highly considerate towards banking industry, as it embodied a technical response to their bankers' claims against the opacity of the agents de change.

The flow of orders entered (through RONA) and left (through CAC) the brokerage houses in continuity. "In this business, what does the stockbroker do?" asks a former engineer at the Paris Bourse (interview E). This problem was critical for the acceptability of the reform to the other party at stake: the stockbrokers themselves. The essential function of stockbrokers, which was used to some extent as a justification for their particular status, was to assume the responsibility for an order towards the market. It is on this precise argument that a tool was designed, the `filter', which materialized this competence. As one of the engineers in charge puts it:

"If I establish a direct access - if I kill, technically speaking of course, the function of the stockbrokers - I kill the responsibility of stockbrokers towards their fellow exchange members. So, if we wanted direct access, we had to materialize, in some way, this responsibility, this function of assuming the defense of the client's order. And that's how we came up with the filter. The filter is a piece of software which I, a stockbroker, switch on in order to check that the order that you pass to me, via RONA, is compatible with the market, and compatible with your interest. The implication of this is that you are not going to have your trade executed in unbearable conditions and that this order is logical with regards to the liquidity of the stock, that you do not send it to us on to the market with an excessive volume. Thus the plausibility of the order is ensured by this software that I, the stockbroker, have to set up and all the orders that do not pass the filter, it is my duty to retain them, to give you a phone call to check if you really want to execute this order there, and so on. Thus we have exceptionally a manual treatment." (Interview E).

The principle of the filter was the materialization of the intermediation between the client and the market. We find the maintenance of this "responsibility of the stockbroker" in front of the market in current activity, even nowadays, in the brokerage services of the Parisian marketplace.

Broadcasting solution to information dissemination

The acceptance of the reform by the agents de change was to pass through a durable translation of their function within the quotation device. But the alternative scenario proposed by the bankers was the opening of the `black box' of trading activity to all actors involved, not only to the stockbrokers, but to the totality of the banks, the collectors of orders. One important condition became necessary, among others, to make the reform pass with respect to the bankers: real-time access to the information contained in the order book should be egalitarian (accessible inside the brokerage houses as much as inside the local branch of a bank).

One of the architectural elements that made the reform go through "on the sociological level" - this is the expression used by one of the architects of the reform (interview E) - was the broadcasting solution developed for the diffusion of information and the updating of the state of the order book across all the trading terminals. An order sent to the central quotation server modifies the state of the corresponding file automatically. The computer has to return a signal informing of the modification of the order book's state. It has to return this information not only to the sender terminal (the one that originated the update), but to all the terminals of the system. "With the computers of the time, you could explode the largest IBM configuration", says an engineer at the Paris Bourse (interview E).

The solution came from the use of broadcasting. TDF (Telediffusion de France, the national television operator) had, besides its regular television broadcasting frequencies, a spectrum space available for transmitting digital information. The solution was perfect. As soon as price limits moved following a signal from a terminal, the totality of terminals was `sprayed' with the new data over the airwaves (one way, with no return signal) overcoming the heavy resources constraint. "Thus, with Hertzian broadcasting, everyone, both in Paris and in regional branches, has an order book that has changed [simultaneously] to the new state", says this same informant (interview E). Subsequently, diffusion of data using broadcasting was then replaced by satellite diffusion, but the principle remained the same. This solution provided an answer to the two conditions put forward by the banking partners: egalitarian routing and the same information on the terminals of the stockbrokers and on those of their clients. These conditions had been expressed in rather aggressive terms by the banking sector: "You will never succeed in guaranteeing to us the same information in our local branches as that in the brokerage houses and as it will be a privilege, we will refuse the system" (interview E). Without the broadcasting solution, the reform could have been aborted.

Order book transparency

We start to better understand the intense socio-technical work that was necessary in order to inscribe and contain, in the same market device, both the interests of bankers and stockbrokers. Yet another technical point is necessary to understand the stabilization of the innovation process: that of the publication, in the trading screens, of the `agent code', which made it possible to recognize the identity of the stockbrokers positioned on the market. On the one hand, the principle of anonymity was to be clearly preserved with regard to the customers who sent the orders. One major function of the intermediaries was precisely to safeguard the anonymity of the customers. But the practices of the criee guaranteed, on the other hand, the publicity of the actions of stockbrokers among themselves. In spite of attempts to impose the principle of anonymity between negotiators themselves at the time of the installation of CAC (following the point of view of bankers), the final implementation kept this trace of the identification of the counterparts:

"In Paris, anonymity is still removed between traders. Why? Because in the negotiation of the transition to CAC we did not succeed in saying: `you, stockbrokers, who knew each other in the criee groups, who knew that this was [agent de change] Ferry and this other one was [agent de change] Bacot-Allain, you will not have that anymore'. Stockbrokers retorted: `no, this is an advantage I keep; I know that Ferry works for Arnault [an important French company], I know that he works for such or such investor, so leave me that'. [...] Anonymity or not

anonymity is a power struggle, an advantage granted or not to the broker in relation to the investors." (Interview E).

The crystallization of the new quotation device preserved this prerogative of stockbrokers. It is only recently, in April 2001, that strict anonymity has been introduced in the Paris Bourse. Until this date, exchange members could recognize the origin of limit orders placed on the electronic order book of each stock.

Concluding remarks

The technical solutions put forward to guarantee the political legitimacy of the automation of the Paris Bourse were to play a fundamental role in the crystallization of the final `script' of the system, i.e. the manner in which the system distributed their roles to the various connected actors. It is only through those technical adjustments that we may understand the way in which the new trading machine translated the forces at stake and enabled the achievement of the reorganization of the Parisian market. The market mechanism holds together because bankers and agents de change - their points of view, their practices, their presence - have been successfully translated into its algorithmic configuration. `To translate' does not mean exactly `to respect': a translation is, above all, a modification (Callon 1986). The material support of the interests at stake does change. The old support - the criee - is dismantled. The new automated support preserves traces of the life of the exchange floor, removes others, but also allows for new forms of market organization and, therefore, of the reconfiguration of interested parties themselves.12

This process of translation is, in the case explored here, a matter of material displacement. It is based in a twofold movement of dismemberment and assemblage.13 Dismemberment or disentanglement, initially, in the sense that many of the adjustments directly aimed at moving the negotiators (stockbrokers and clerks) apart from the confined space of the exchange floor. This movement characterizes the choices, explored above, relating to the location of trading terminals, to the importance attached to the order routing system and to the mode of quote information diffusion. In this movement, we primarily identified the interests of bankers. But assemblage or recombining also took place in the sense that the new device is required to translate into its center the presence of the stockbrokers, preserving them, to some extent. We refer, here, to the adjustments concerning the transparency of the order book (publication of the identity of counterparts) and the ways to enter it (the filter located at the brokerage houses). It is through this double movement that the device is able to make the market - which includes the stockbrokers and the bankers - `hold together'.

What does this empirical case study tell regarding our opening question, i.e. the validity of a mechanistic conception of markets? The Paris Bourse is a mechanism for real: exchange operations are handled though a computer algorithm. Before this mechanism was installed in the Parisian market, trades were concluded in an open outcry: this social institution was far from being a mechanism in a literal sense. Comparing the `before and after' states of this process could have led us to a rather common sociological conclusion: emptying the stock exchange from its trading crowd is a rather `unsocial' move - society might remain at the outskirts of the system (screen-based sociability in the trading rooms of investment banks and brokerage houses), but not at its core (the exchange mechanism).14 Conversely, if we follow the market mechanism `in the making', we end up with a quite different picture: a machine that is social in all of its aspects because it is an instantiation of a social space. The fact that the market mechanism is not directly transposable from one location to another and that the engineering for its implementation is intrinsically socio-technical confirms its socially situated condition.

Notes

[1] In English: Continuous-Time Assisted Quotation. See appendix for a complete list of translations for French expressions.

[2] A more elaborated version of this empirical analysis is presented in Muniesa (2003a, 2003b).

[3] These kinds of practices, although illegal, were indeed current in the Paris Bourse, but aimed at feeding personal arrangements more that the construction of a financial intermediation industry.

[4] Early 1980s' trading practices did not seem to have evolved much from mid-20th century. But the term "traditional" is, of course, relativistic. Historical accounts of 19th century stock exchange operations in Paris show a rather different organization that included, among other features, multiple and continuous quotation (Walker 2001).

[5] This call market institution strongly resonates with neoclassic (Walrasian) theory in the economic literature, as opposed to continuous markets (Kregel 1995).

[6] All interviews have been conducted between 1999 and 2002 as part of a fieldwork for a PhD thesis (Muniesa 2003a). The anonymity of interviewees has been preserved. Original transcripts in French have been translated for quotation by the author.

[7] In order to maintain market's liquidity, market makers compete between themselves and permanently propose buy and sell prices (their bid-ask spread) to market participants.

[8] SEAQ made possible the electronic diffusion of market makers' bid-ask spreads and allowed the market to function apart from the exchange floor.

[9] Cited in Hugh Miller, `Toronto Stock Exchange Automation?', The Risk Digest, vol. 5, n ° 79, message posted December 20th 1987 (http://catless.ncl.ac.uk/Risks/5.79.html).

[10] In English: Automated Order Routing and Trading.
[11] In English: Connection to CAC.
[12] We present a deeper analysis of the circumstances of this reconfiguration, of its consequences in regards to the construction of liquidity and of other aspects of Paris Bourse's algorithmic configuration in Muniesa (2000a, 2000b).
[13] We meet here some of the relevant features of what Bruno Latour calls a "center of calculation" (Latour 1987).
[14] Recent work in social studies of finance - a field rather used to highly technological fieldworks - often takes this assumption for granted and looks for the "social" at the extremities of the market system, i.e. at the surface of screens (Knorr Cetina & Bruegger 2002; Zaloom 2003).

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Appendix: translation of words and expressions in French

Agent(s) de change: stockbroker(s).
Bourse de Paris: Paris Bourse, or Paris Stock Exchange.
Chambre Syndicale: stock exchange committee (at the Compagnie des Agents de Change).
Commis: stock exchange clerk(s).
Compagnie des Agents de Change: professional corporation of stockbrokers.
Corbeille: main trading pit.
Cotation Assistee en Continu: Continuous-time assisted quotation.
Coteur: stock auctioneer.
Criee or a la criee: open outcry.
Fixing: call market.
Palais Brongniart: Brongniart Palace, the stock exchange building in Paris.