8 Economic instruments and theory in the construction of Henri Lefèvre's 'science of the stock market'

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> It is in speculative trade that political economy will discover the theory of the circulation of wealth, which is one of the principal objects of its investigations.
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> (Henri Lefèvre, 1879a, 19).

The history of financial theory remains a rarely studied, and ultimately little-known, area. The first theoretical financial model is generally considered to have been formulated in Louis Bachelier's[1] doctoral thesis of 1900. But if we accept this genesis too readily, we risk overlooking a number of other attempts to construct a financial theory, especially in nineteenth-century France. These attempts – which played their part in the development of Bachelier's model – were particularly fruitful, and provided financial theory with some of its main instruments of analysis: in 1863 Jules Regnault[2] was the first to put forward the idea of using a random walk model to represent stock price fluctuations; in 1870, the French actuary Henri Lefèvre constructed the first graphical representations – now in common use – for analysing the outcome of complex combinations of stock market operations, most notably combined options.[3]

Henri Lefèvre was born in Châteaudun in 1827 and died in or around 1885.[4] He took a degree in natural sciences in 1848, but from the 1850s onwards steered his career towards economics, working his way into the selective circle of economic journalists. His interest in the 'dismal science' initially led him to work as economic correspondent for a number of different newspapers, eventually becoming chief editor of a Spanish-language economic journal, *El Eco Hispano-Américo*. After 1865, he turned to activities more directly related to finance, offering financial packages in the name of a company called the Comptoir Central de Souscription (Lefèvre 1865).[5] At various times he held positions as a banker, as the private secretary of Baron de Rothschild,[6] and also worked for the Union, one of the largest insurance firms in Paris. In 1869, he founded the Agence centrale de l'union financière with a group of partners, managing and acting as chief editor of its press organ, the *Journal des Placements Financiers*.[7] He also took an interest in accounting. In 1882 he published a brochure of which Mr Harang, president of the education section of the Seine Accountancy Committee, writing in the 1 August 1882 issue of the *Revue de la Comptabilité*, proclaimed that 'the teaching of accounting will soon be divided into two schools: one consisting of the partisans of practical education and the other, the partisans of theoretical education. *Without any doubt, the theoretical school will have been founded by Mr H. Lefèvre*' (italics added). This initial brochure was supplemented by a later work published in 1885. He also examined the 'theory of currency and exchange' in an article published in 1879 in the *Journal des actuaires français*. He probed the subject at greater depth in his treatise of 1881, *La Change et la Banque*, in which he sets out an original set of technical rules of exchange. This work, presented to the Académie des Sciences Morales et Politiques by Léon Say as 'containing, with regard to exchange operations, a discovery to some extent comparable with Monge's discovery of descriptive geometry' (1885a), was awarded a gold medal by the Société d'Encouragement pour l'Industrie Nationale. Finally, it is interesting to

note that Lefèvre made several attempts to alert public opinion to the need for specialist financial and commercial education in France, along the lines of the German business schools. At the Institut Polytechnique – not to be confused with the École Polytechnique – he created a course in 'higher financial education' and published a number of pedagogical works, such as his *Principes de la science du commerce* of 1874 or his two works of 1885. One characteristic already stands out clearly: there is strong practical streak in Lefèvre's work, which also runs through his contributions to financial theory.

The historical background to Lefèvre's financial analysis is marked by the development of the Parisian stock market. During the nineteenth century, France's financial markets began to assert their economic status. Their activities spread out beyond financing the public debt and into the sphere of private sector finance, a new dimension which led to the development of the Paris Bourse[8] in the second half of the century: in 1800, there were three listed stocks; by 1850, there were 197; this rose to 689 by 1876, and more than 1000 in 1900.[9] This 'prodigious growth in securities in the portfolios of French capitalists … mainly between 1850 and 1870' (Neymarck 1888, 8) indubitably left its mark on French society. In the 1860s and 1870s, a specialist press flourished: as Pierre-Cyrille Hautcœur (1994, 238) reminds us, Paris had 16 stock market journals in 1857 and 228 in 1881, not counting the financial sections of the 94 general newspapers. Neymarck (1903, 17) observes that, contrary to the prevailing view of the time, 'the vast majority of stock market investors are small shareholders, and the great majority is made up of those who have but one share and those who have between two and ten shares'.[10] The National Assembly and Senate were regularly called upon to legislate on legal and moral issues related to financial markets.[11] From the 1850s, French economists tried to raise public awareness of the economic role played by the financial markets, especially in the industrial development of the private sector.[12]

Paradoxically, however, the theoretical content of their economic analyses was relatively weak: more often than not its focus was limited to the history of the financial markets, or of the assets traded therein. With their literary bias, the 'traditional' economists remained highly descriptive, and had difficulty accounting for the workings of the stock market or apprehending its general mechanisms.[13] Consequently, they contributed very few original elements, whether practical or theoretical.[14] Shaken by the crisis in the field of political economy,[15] some economists tried to broaden its scope to encompass new problems and areas, including financial theory.

Decrying the lack of theoretical studies, a number of practitioners and more pragmatically minded economists tried to apply the new instruments at their disposal – graphical methods, statistics, probabilities, etc. – to the analysis of financial markets. Thus it was that, in 1863, the first theories and first financial models came to be constructed. These theoretical reflections on the stock market and finance – which ultimately led to the first Congrès international des values mobilières of 1900, among other things – developed independently from the traditional economists, for the reasons set out above. The work of the French actuaries, most notably Lefèvre, is worthy of particular attention here.[16] Lefèvre himself paints a sorry picture of the state of financial theory prior to his *Traité … des valeurs mobilières et des opérations de bourse* (*Treatise on Securities and Stock Market Operations*) of 1870:

> Works about the stock market and banking that promise more than they provide, and do nothing to help the reader understand the inner workings of the operations they purport to explain … . There is Courtois' *Treatise on Stock Market Operations*, which teaches no-one how to operate; Proudhon's

> *Speculator's Manual in the Stock Exchange*, which teaches no one how to speculate, and a plethora of minor works which serve as advertisements for the proponents of spurious financial schemes. (1885a, III)

From this starting point, Lefèvre set out on an ambitious quest to build a 'science of the stock market' that would determine the laws governing stock market activity. The new discipline was to focus on the circulation of goods. His analysis had a profound impact on other thinkers of the day: Léon Walras (1880a, 1880b) adopted his organic representation of society and his recommendations on access to the financial markets;[17] his work also inspired a number of eminent late-nineteenth-century economists and statisticians with an interest in financial theory, such as Paul Leroy-Beaulieu, Arthur Raffalovich[18] and Alfred Neymarck; finally, his graphical representations were widely circulated – by 1874, they were already known and much appreciated in stockbroking circles[19] – and re-used in theoretical works by other actuaries, notably Léon Pochet (1873),[20] as well as economists and mathematicians, including Louis Bachelier.

Such was the historical context that led Lefèvre to venture one of the first attempts at creating a new field of economic economics: financial theory. It was, of course, a very different concept to the one we know today. Analysis of Lefèvre's works should, however, shed some light on the way in which financial economics has come to be constructed, and the role played by technical instruments in its evolution. The aim of this chapter is to show that – by contrast with their current, highly restrictive, application – Lefèvre's graphs were originally part of a theoretical reflection on the stock market's economic role and the modalities of its contribution to economic development. Specifically, we look at how Lefèvre placed stock markets at the heart of economic theory by focusing on the circulation of goods and by developing theoretical instruments that would enable them to circulate with optimal efficiency.

This chapter is in two sections. The first discusses Lefèvre's thinking – highly original for its day – on how economic theory interfaces with financial theory. It emerges that his analysis of the economic organization of the circulation of goods and of exchange mechanisms is akin to the construction of a theoretical norm – i.e. an incipient ideal – designed to provide guidance for economic policy and for structural reforms of the financial markets. Lefèvre's goal was to determine which technical instruments and which economic policies could be employed to smooth the way towards this ideal situation. This is the object of the second section, which presents Lefèvre's practical recommendations for attaining greater economic efficiency by optimizing the stock markets as far as possible. This concern would notably lead him to formulate the graphical method that we know today, designed to facilitate stock market transactions.

1. The elaboration of a theoretical norm

Unlike almost every other nineteenth-century author who wrote on the subject, Lefèvre's aim was not to describe the stock market as it existed, but to conduct a general theoretical inquiry into the economic organization of society. He specifically analysed an ideal form of social and economic organization in which the stock market played a central role, sitting at the heart of economic activity and indirectly directing it. The integration of stock markets into economic theory – and the resulting outline of financial economics – can be seen as a product of Lefèvre's ideal representation of the economic organization of society. By projecting the form of organization to which society is heading, his approach amounts to the construction of a theoretical norm. This approach is presented in two stages, looking first at the origin of the norm, then at its nature.

1.1 The origin of the norm

Lefèvre's representation of the economic organization of society is a synthesis of elements drawn from two models of knowledge: on the one hand, that of Auguste Comte ; on the other, that of animal physiology. From the first, he takes the historical determinism inherent in the progress of civilization, according to Comte's law of the three stages: every society tends towards the stage of greatest perfection, i.e. positivism. The second, by analogy with the human organism, provides a representation of how such a perfect society should be organized. The synthesis of these two elements enables him to prefigure the ideal economic organization for society, from which perspective he analyses the economic transformations which were then taking place – in particular the emergence of stock markets.

In the field of research that he opened up in the 1820s, Auguste Comte focused on the evolution of civilizations and of the sciences. He was especially interested in the social organization that would be dictated by 'scientific policy', given the stage of civilization that had been reached. To understand this stage of development, one must first determine the process by which societies evolve, which can be discovered, according to Comte, by observing the past and analysing the data thus collected. From this one can determine the evolutionary direction of any civilization, and foresee its future development. Thus, 'scientific policy' seeks first to determine the system that history tends, of its own devices, to generate, and subsequently to optimize that system.

On the basis of his own historical observations, Comte considered that all civilizations passed through three stages of development: the theological stage, the metaphysical stage and the positive stage. This succession of stages always leads in the direction of the third and final stage of social development, that of the greatest perfection, culminating in the triumph of science and industry. The sole and constant goal of social activity becomes production; inevitably, in such a society, the economy has pride of place.

The historical determinism of Comte's model encouraged Lefèvre to construe the evolution of the economic organization of society as a historical process tending towards the state of greatest perfection:

> [Human societies] are, in a real sense, living organisms. Their degree of perfection varies, depending on whether they have developed slowly or quickly, and one finds, in different places and at different times, societies at different levels of organization … . Society initially organizes itself into slaves who feed it, warriors who defend it, and priests who govern it. But this is not the moment to recount the history of the various stages of humanity, of which the laws have been mapped out by our illustrious master, Auguste Comte. (1870a, 242)

Lefèvre saw, in the rise of the nineteenth-century stock market, a sign of society's economic progress. At that time, moreover, the large centralized stock exchanges, such as the Paris Bourse and the London Stock Exchange, were starting to list physical goods such as corn and sugar.[21] For Lefèvre, the stock market was not limited to capital transactions alone: it was that great organized marketplace in which raw materials, as well as capital, could be exchanged (1879a, 15).[22] Goods were no longer destined for local markets alone, as was the case, according to Lefèvre, in less developed societies; they could circulate freely over a wide network to meet the needs of any individual. Society was therefore moving towards the creation of a vast economic marketplace in which every agent, thanks to the great stock exchanges, had direct access to the whole range of goods produced. This vast marketplace could only operate perfectly – indeed, could only exist – in the final stage of development of human society. Lefèvre's

assimilation of human societies to living organisms, explicit in the quotation above, reveals another characteristic of his 'perfect society', and here we touch on the second model of knowledge from which he drew inspiration, that of animal physiology.

While Comte's historical determinism offered an explanation for social evolution, it provided no clear picture of how society was organized at the final stage. The physiological model of knowledge, however, gave Lefèvre a template for the final-stage society, by positing that human societies had living characteristics. After all, as society was evolving towards the stage of greatest perfection and could be assimilated to a living organism, the organization of final-stage society would ultimately be identical to that of the most perfect of living organisms. To find out what that was, one need look no further than the science which studies the organic functions of living creatures, i.e. physiology. And physiology told Lefèvre that the most perfect living organism was … man. The organization of the most perfect society should, therefore, be analogous to the organization of the human body: in other words, it should be characterized by a perfect fit between the organization and functions of society and those of the human form:

> We must obstinately proclaim, as a truth which can no longer be disputed, that societies are living organisms in constant development, successively perfecting their various functions, and their organs – which are the agents of those functions – in reaction to their ever more complete knowledge of Man himself. (1870a, 242)

The analogy between economic systems and the human body was not a new one: it crops up in many economists, even in the twentieth century, such as Théret (1995) or Ménard (1978, 111 ff.). In order to assert its scientific status, economics has frequently borrowed models or instruments from disciplines already recognized as scientific, such as biology or mechanics. Indeed, as Ménard (1981, 138) reminds us, one of the first mathematical economists, Canard (1801), represented the social body with the image of a living organism in which 'traders occupy "the centre of circulation", of which the two ventricles are the store and the cash-register and where work and its products represent the arterial system, while the movement of money is analogous to the venous system' (Ménard 1981, 138). Canguilhem (1968, 73) also makes the point that the nineteenth century was a heyday for determinist theories about biological phenomena.

The belief that society is evolving towards a final stage, characterized by an increasingly developed and highly perfected social organization, inevitably leads to a modification in the nature of that final stage. In Lefèvre's analysis, the nature and role of the final stage are made clear by the synthesis of the two models of knowledge. It is no longer just the culmination of a process of development; it becomes an ideal: 'Clearly, we are still a long way from a perfect conformity of this type; it is, in my view, an ideal' (1870a, 243). This touches directly on the nature of this final stage: by definition, an ideal can never be attained; it is something towards which one strives. In this particular case, moreover, society has an inherent tendency, because of the way it develops, to move towards a form of organization analogous to that of a living organism. The course of its evolution cannot be diverted; on the contrary, our constantly enriched knowledge about the organism guides political action by showing us 'that which must be'. The role of the final stage is clear: it is an ideal to which society inherently aspires. In the political sphere, it fulfils the role of a theoretical norm.

By identifying a deterministic process of historical evolution and defining the ideal towards which we are moving, Lefèvre constructed a theoretical norm that enabled him to represent society as it should be. But his synthesis also allowed him to go further. Since society is 'in

constant development', it evolves towards the final stage by perfecting its various functions and organs. Consequently, the study of the human body should offer us a preview of the way in which this ideal society will be organized, allowing us to identify the functions of the various social and economic agents: it enables us to examine in detail the nature of the norm.

1.2 The nature of the norm

Having discovered the ideal organization of society, Lefèvre sought to determine, in the economic sphere, the role of each element involved in the circulation of goods in the final stage of social evolution. One of the characteristics of any living organism, necessary for its general viability, is the separation of functions: each organ has a specific role. With Comte's law of the three stages, one can foresee that the evolution of economic organization will lead to local stock exchanges being integrated into a single stock exchange, in which all commodities are traded; but the physiological model of knowledge allows one to go further still, identifying point by point the analogies (or identities, to use Cohen's (1993) term) between the economy and the human body. Thus,

> In superior creatures and societies, these scattered centres all disappear, giving way to a single organ, namely the heart – or the stock exchange – and the social circulatory system tends increasingly, albeit empirically, to model itself on that of the individual. The individual is the standard which the collective organism seeks ever more closely to approach. (Lefèvre 1873, 213)

This involves proceeding by analogy to identify, empirically, the factors that must be modified in order to attain the ideal model.

The human analogy offered Lefèvre an opportunity for a further insight into the final stage of social development: he used it to sketch the outlines of the ideal economic organization. Just as living creatures are organized around their vital organ, the heart, so economic organization centres on the stock market, that 'organ of circulation' whose 'function is to circulate' the goods produced (Lefèvre 1874a, 12) – in other words, it is only through the stock market that commodities come to be exchanged. The stock exchange becomes the only point of encounter between supply and demand. More exactly, the stock market centralizes the commodities produced by the various industries dotted around the country and redistributes them according to intermediate and end consumer needs (Lefèvre 1873, 213). It would be wrong to conclude, however, that the stock market operates autonomously, independently from the rest of society. It is open to two influences: on one side, government; on the other, speculation. The first element, government, can regulate – or at least orient – stock market activity up to a certain point. But this dependency operates indirectly: 'the stock market is absolutely free in society, and governments cannot act directly on its fluctuations' (ibid., 214). For this reason, Lefèvre identifies the government with the brain: it is the cerebral organ 'which thinks and calculates, but which also hesitates, tires and falls asleep' (1873, 215). The government's scope for action is constrained by the economic context and economic activity. The second element, by contrast – speculation – is the real driving force behind the economy; it keeps the stock market moving, even if only slowly at times, and exercises 'deliberate direct action': 'Speculation is the – as yet incompletely formed – organic nervous system of society: it presides over the circulation, and thus over nutrition, and it gives the stock market, i.e. the heart of society, its constant impetus' (ibid.). Lefèvre uses the analogy with the human body to isolate two of the key elements that drive the circulation of goods: stock markets[23] and speculation. These two elements help him to resolve a fundamental economic problem raised by the circulation of goods: time.

The issue of temporality in the circulation of goods is not limited to the financial sphere; it is very much a real-world question. There is a time gap, in the 'real' sphere, between the moment when a good is produced and the moment when it is effectively sold. A comparable gap exists in the financial sphere between the moment when the capital is advanced to produce a commodity, and the moment when the consumer buys it. This double gap entails two types of risk. In the real sphere, there is a risk that consumer tastes will change between the two instants in time, burdening the producer with unwanted stock. In the financial sphere, the risk is that commodity prices will vary, forcing the producer to sell at a loss.[24] So, although the production quantities and costs of commodities are known elements, the same is not true for their consumption, i.e. the quantities bought and the selling prices. But given that society's system of organization – modelled on that of the human body – is ideal, these risks can be avoided by simply identifying the factors that promote good blood flow, and developing their counterparts in the economic sphere. Lefèvre therefore sought, through the analogy with the human body, to determine how the stock market and its constituent elements could ward off these two dangers.

The first temporal problem concerns the real sphere. Lefèvre starts out from the observation that it takes a certain amount of time to produce a commodity. Between the moment when an enterprise buys in raw materials and the moment when the output is produced, there is inevitably a lapse of time. Likewise, goods cannot suddenly be produced as and when the demand for them arises. More specifically, it takes less time to produce goods than it does to distribute and consume them. By raising the question of temporality, Lefèvre automatically brings in the issue of the circulation of goods between the different economic moments, and the problem of unforeseen events and changes in consumer behaviour or taste during the intervening period.

This built-in uncertainty of economic activity carries over onto the stock markets where the goods are – or, in their finished state, will be – exchanged. This was an important element for Lefèvre, one that had often, he felt, been under-estimated or ignored by economic theory:

> For the last hundred years, economists have been striving to found a science encompassing the production, distribution and consumption of wealth; but have they thought to examine the remarkable mechanism of the uncertain market, designed precisely to correspond to the uncertain conditions to which human existence, both individually and collectively, is constantly subjected? (1879a, 16)

What mechanism, therefore, will cover producers against the risk of variation in consumer tastes? In other words, what mechanism will keep the whole economy in supply despite changes in consumer behaviour?

The aim of Lefèvre's approach was to identify, by analogy with human physiology, the 'social organs' that fulfil the same role as those which, in the human body, enable the blood to supply any organ with what it requires, no matter what changes occur. In other words, one must identify the factors that will give society advanced warning of its supply needs, allowing it to modify supply flows at any moment without adversely affecting the producers. For Lefèvre, this is precisely the role that the stock market should play:

> Neither the public, nor the traders, nor even the economists are yet fully cognizant of the need for these large markets by means of which, ultimately, the existence of a whole society is ensured several months in advance. How many of them, at the present time, truly understand the process by which the entire floating volume of a commodity or stock can remain in suspension on the market, ready to meet all probable and even possible needs, and in a state of unstable equilibrium that only some great political catastrophe could disrupt? (1879a, 16)

Specifically, it is the futures markets that are able to redirect production in response to unforeseen variations in demand. These markets make it possible to terminate a contract at any moment if the economic conditions so require. In this case, speculation will perform the task of redirecting the goods towards other needs: 'It is the forward markets – the options markets, in a word – which force capital to preserve the current surplus of production over consumption, or to deliver it in accordance with the needs of that consumption' (Lefèvre 1873, 362). Stock markets keep goods permanently available. Speculation enables the economy to respond to unforeseen variations in tastes and requirements.

By resolving the problem of the time gap between production and consumption, the stock exchange should enable markets to attain equilibrium in time as well as in space. And while the stock exchange is the forum where supply and demand rub shoulders, it is the speculator who really makes them connect. 'The law of supply and demand truly comes into play between the speculators, and not at all between the real buyers and sellers, who represent the consumers and producers' (Lefèvre 1874a, 49). Stock markets therefore unburden the producers of the risk of not selling their output. The problem of selling off the goods produced is then borne by the entire collectivity (as represented by the stock markets) which takes care of finding the necessary outlets. Moreover – as a result of arbitrage operations – improvements in means of communication and in market organization have, Lefèvre explains, levelled prices on different markets by smoothing out the price differentials found on alternative markets at any given moment. This uniqueness of pricing from one stock exchange to another has led speculation to focus instead on price differentials between points in time, which may be nearer or further apart. Thus, by operating on futures markets, speculation establishes equilibrium in the temporal dimension.

However, the stock markets still need to address a second temporal problem, specific to the financial sphere. There is a time gap between the moment when capital is advanced and the moment when payment is received. This time gap exposes the producer to the risk of prices changing and may, at the end of the day, result in negative earnings. Once again by analogy with the human body, Lefèvre tries to identify a system in the economic sphere that will prevent the repercussions of retail price variations at the level of the consumer reflecting back on the producer; in other words, a system of insurance against the risk of variation in retail prices. And indeed, a defining role of any futures market is to ensure that a given quantity of a commodity will be delivered at a given date and at a price agreed in advance. For Lefèvre, this insurance function of the stock market[25] is analogous with the cardiovascular valve in the human organism, which prevents blood from flowing backwards. Options markets thus avoid the problem of price variations being passed back from one player to another. The potential this offers for insuring against price variation has benefits for the consumer, as well as the producer:

> The baker cannot escape the conditions of existence to which the whole of industry is subject, and above all the requirement that he should have the necessary capital or credit to ensure his supplies well in advance, rather than going to market in the morning to buy the few sacks of flour he needs for that evening's batch, thereby enduring and making the public – so easily panicked in such matters – endure all the fluctuations that grand speculation is wont to impose upon it.
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> We need a certain number of bakers, but not too many. Those who know their trade, who have a degree of business acumen …, will drive out some of their competitors by learning to buy their supplies on the options markets … and by selling … their bread more cheaply than those who have to buy their supplies for spot cash. (Lefèvre 1873, 357–8)

Ultimately, the consumer gains as much as the producer from being insured against price variation. Options trading thus protects the interests of the various players – producers, consumers, retailers – and prevents society's supplies from being threatened by an excessive drop in prices. The ability to insure against uncertainty acts as a stimulus to economic activity by enabling the players to cover themselves against the various risks. This system offers security for producers and consumers alike, an especially important consideration when it comes to supplying large conurbations, and thus in the overall organization of the economy.[26] This second function of speculation ultimately helps to smooth out prices and avoid instability in the price of finished goods due to unforeseen fluctuations in the price of raw materials.

The focus on the economic roles played by speculation underlines the closeness of the interaction between financial theory and economic theory. Both functions illustrate how speculation acts as an engine, indispensable to the smooth running of the economy and to its equilibrium. This leads Lefèvre (1873, 219) to account for financial or commercial disasters as the direct result of ignorance or non-compliance with the fundamental laws governing the circulation of goods. One can see how important it was for him to be able to identify the processes that lead to the ideal state of society. The norm thus derived must enable real problems to be assessed, by comparing the ideal with the reality, and political action must steer reality closer towards the norm. In this respect, society is 'a natural *organism* whose spontaneous workings we must first study in order subsequently to improve its development' (Lefèvre 1874a, 13). We must therefore turn our attention to the means for improving the organization and efficiency of the stock markets which will in turn accelerate society's convergence towards the ideal.

2. Practical recommendations for improving the circulation of goods

As we have just seen, the stock market acquires a central economic position because all goods must come to it to be exchanged. Given the central function of the stock exchange and of speculation in the economy, Lefèvre poses the question of how the stock market can be made as efficient as possible. The previously defined norm enables us to measure reality against the norm and thus to recommend ways of narrowing the gap that separates us from the 'final stage'. Although this process is already under way with a momentum of its own, it can be speeded up. In other words, Lefèvre seeks to identify the political actions that might hasten the advent of stock markets operating at optimal efficiency. The methods he envisages are of two types; we will look at each in turn. First, he applies the principle of organ specialization to the organization of stock markets, separating out the various agents involved in the circulation of goods in a way that isolates the role played by each one. He goes on to suggest rationalizing access to markets and to financial operations in line with each player's need, with the aim of avoiding such abuses as stockjobbing. Second, he outlines a method of analysis, specific to his field of research, designed to improve the way the various agents intervene on the markets. The method is a graphical one, and it enables the stock exchange to exercise its function (the circulation of goods) more effectively, and thus move closer towards the ideal situation analysed in the first section.

2.1 Rationalizing access to financial markets

One of the characteristics of the ideal social organization, as described above, is the division of functions. Each part of the human body fulfils a precise function for which it is uniquely adapted. The division of labour is, consequently, a sign of social progress: 'it is as necessary

in society as it is in industry; the confusion of the different functions is encountered only in the savage condition, and among inferior creatures' (Lefèvre 1874a, 55, note 2). Lefèvre therefore set out to determine how the division of labour operated in the financial markets. To this end, he drew on observations of the most efficient and highly developed enterprises of his time – the major trading companies – to deduce the division of functions that best served the circulation of goods in the ideal society to which we are all heading.

The circulation of goods via the big trading companies of the late nineteenth century depended on the actions of three key agents: the wholesaler, the broker and the retailer. Each agent constituted an intermediate step between producer and consumer, one that was necessary for the smooth circulation of goods:

> As we know, the division of labour in business calls for three sorts of agent: one, the wholesaler, deals with the product; another, the retailer, deals with the consumer; and then there is the intermediary between these two, the broker, a retail-wholesaler or commission merchant, who has nothing directly to do either with the public, nor even with the product. (1874a, 114)

This division of functions governs the relationships between the different players. At either end of the equation we have the wholesaler and the retailer. The first stores the finished goods while the second sells them as products to the consumer. Liaison between the two agents, who are not in direct contact, is made possible by 'an intermediary, who has no store, nor outlet, nor commodity, who has no need to handle a bail of cotton or a sack of flour or coffee … , but who runs between the wholesaler and the retailer: the broker [*courtier*] or runner [*couratier*], as he used to be called, is the man who runs and who sets the price [*qui court et qui fait le cours*]' (Lefèvre 1873, 216). Each agent is therefore characterized by a precise function which should logically correspond to a particular type of stock market operation.

This view of how financial markets are organized offers an interesting window on Lefèvre's thinking about social organization. But it also opens up a quite different set of questions: who are the agents whose role it is to participate in the various markets? This was one of the burning issues of the day: which operations could be considered permissible, and which illicit (Jovanovic 2001)? Lefèvre's answer is to shift the debate away from the nature of the operation (e.g. selling short or selling long) to its end: any operation that does not serve the circulation of goods must be prohibited. In this system, each agent has a precise function and practises a particular type of stock market operation, which leads him to operate only within certain markets. Accordingly, any operation not justified by the agent's economic function is illicit.[27] The consumer, for instance, who buys the good from the retailer, wants to consume it immediately and pays for it on the spot. He is not subjected to temporal constraints – even if he doesn't consume the item immediately, he has no stock management to worry about: the thing is his to use when he pleases. Consequently, since he pays for commodities on the spot, he has access only to the spot market. Futures markets should be closed to him: he does not require access to the futures markets to perform his operations. However, when the retailer takes the customer's money, it is not in fact a spot transaction but part of a forward transaction. The retailer, after all, had the goods well before the consumer approached him. He is therefore bound by a temporal constraint that leads him to purchase forward, buying goods from the broker that he then sells on to the consumer for cash. He must therefore have access to both spot and futures markets. As for the broker, he needs to hedge against unforeseen changes in consumption. It is thanks to him that the market readjusts to variations in demand. He needs to be able to exercise great flexibility of supply in order to insure against such uncertainties.

To this end, he must have access to the options markets to establish his contract with the wholesaler:

> The holder of large quantities of commodities or stocks puts some of them into circulation, where they float between probable consumption and possible consumption, and are sold to a buyer for more than they would have made by firm sale, by means of a written or verbal contract under which the vendor promises to take them back at a certain date if the buyer considers it in his interest not to demand delivery. (Lefèvre 1873, 218)

It only remains for the wholesaler to source the goods from the producer, who sells them firm, whether forward or spot.[28] From the basis of this division of functions in the circulation of goods, Lefèvre argues for restricted access to the different stock markets – spot and futures – in accordance with each player's social role. This form of access to the financial markets can thus be considered rationally grounded.[29]

The purpose of this rationalization is to ensure the efficient circulation of goods. As each agent operates in accordance with requirements specific to his own particular profession or line of business, he cannot operate on a market for personal reasons outside his professional capacity, for example, in order to gamble. Failure to comply with the rules of stock market access would transform speculation into mere gambling, a socially unproductive activity that can only be condemned:[30]

> [Respect for the natural hierarchy of the different social functions] is the only viewpoint which one should need to adopt in order to resolve the question of stock market gambling, a subject which has aroused such controversy, and on which there have been so many empty pronouncements, all without arriving at any criterion of judgment. Gambling, whatever form it may take, is not a social act, as it produces nothing of utility; society has no need to acknowledge its existence … . Between the retailer and the non-trading individual, who is a pure consumer, there can only be cash purchase and sale operations … . However, speculative or trading agreements between two non-trading individuals, or between one non-trading individual and a retailer, a wholesaler or a broker, should be considered a form of gambling, since one of the parties, if not both, is unqualified for such a trade … . Between different orders of trader, by contrast, it is not gambling, but legitimate speculation, since certain formalities have been completed in order for the effects of their mutual relations to be recognized. (Lefèvre 1874a, 116–17)[31]

Unlike gambling, which does not respect the natural order, legitimate speculation increases the welfare of the collectivity. On the basis of this analysis, Lefèvre feels able to judge the realities and economic policies of his day. He exposes what he sees as absurdities in market organization which, by violating this specialization, diminish the collective welfare.[32] Having established the case for rationalized (i.e. restricted) access to the stock markets, Lefèvre puts forward another method for optimizing the circulation of goods by improving the effectiveness of stock market operatives.

2.2 An original graphic method

The rationalization of access to the different stock markets is connected to the efficiency of trading. Financial markets need to organize themselves with a limited number of players and a growing number of commodities presented for exchange on the market. The growing number of commodities will be accompanied by an increase in the complexity of stock market operations, as the market must maintain a continuous temporal equilibrium. And if the circulation of goods is to be made efficient, everything must be done to allow players to act promptly.

Lefèvre therefore needed to find a way to facilitate stock market operations, i.e. by increasing the rapidity with which they could be performed by traders.

One of the goals of any market player is to have instant visibility of the outcome of any set of stock market operations, however complex, and for any listed stock. If the price subsequently varies, each player can react immediately on the basis of his position; and the faster a player can establish the accounting situation of his operations, the sooner he can intervene on the market – in other words, the more efficient he will be. The ability to establish one's accounting situation at any moment thus becomes a factor of economic efficiency, and a criterion that can easily be acted upon:

> When several operations have been performed by a wholesaler or by a speculator, it is important that one should know the resulting situation at any moment. To this end, one must learn directly to conjugate any number of markets, be they firm or options markets, by means of simple rules that anyone can apply. (Lefèvre 1873, 363)

As Lefèvre points out, there should be no need to be a specialist, since stock market operations are accessible to certain agents whose main line of business is not speculation. The earlier example of the baker who makes use of the stock market to avoid passing on price fluctuations to his customers is a case in point. One must therefore find an easily used instrument capable of analysing potential combinations of operations in terms of a player's trading outcome for any listed stock.

This quest takes us back to the models of knowledge from which Lefèvre drew his inspiration. As we saw in the first section, he draws partly on Comte's model. For Comte, the most advanced scientific disciplines – the positive sciences – eschew theoretical abstraction and advocate empirical observation. Positivism allows no other scientific method than induction, rejecting the use of abstract mathematics in favour of the concrete mathematics that structures the visible world, as used in mechanics and geometry (Callens 1997, 270–72). Thus, for Lefèvre:

> Although arbitrage trading represents a very interesting application of common algebra, speculative trading must borrow from analytical geometry to find a way of explaining its combinations; it is impossible to gain a clear picture of the subject by using arithmetic, algebra or ordinary language. (Lefèvre 1879a, 19)

Lefèvre's aim is to develop a geometry-based analytical tool to study combinations of operations and compare their outcomes. Arithmetical calculations have the advantage of being accurate, but they tend to be long and intricate, and thus impractical for many people. Geometry, by contrast, offers a simple, graphic mode of representation that anyone can understand. For example, the gain y from a security transaction can be expressed by the equation:[33]

$$y = n(l - a) - f,$$

where n is the number of shares, l the settlement price, a the purchase price and f the brokerage fees. By assuming a single share and leaving aside the question of brokerage fees – as we will continue to do from here on – we get:

$$y = l - a.$$

The profit from such an operation, as expressed by the gain function, can easily be depicted on a graph by plotting settlement prices on the x axis and outcomes on the y axis. The above equation yields a line (AA in Figure 8.1) in Lefèvre's example.

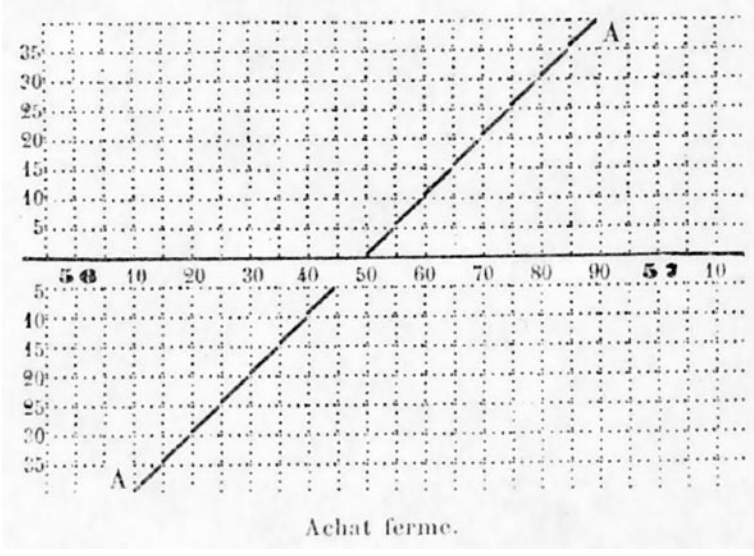

Figure 8.1 Firm purchase (Lefèvre 1873, 224)

The profit or loss arising from the firm purchase of a stock – or a commodity – for 56.50 francs can simply be read off the graph. If, for example, at the end of the period, i.e. when the operation is performed, the price of the stock (x axis) is Fr 56.80, 30 centimes above the price fixed by the firm contract, the profit (y axis) is 30 centimes. Likewise, the gain y of an option transaction will depend on whether the option is taken up. In the simplest case, the profit will be expressed by:

$$y = l - a.$$

The loss, however, will be equal to the amount of the option premium, p. In all, three cases need to be considered: if $l > a - p$, the option is exercised; if $l < a - p$, the option is surrendered; finally, if $l = a - p$, it makes no difference whether it is exercised or not. Lefèvre offers a graph (Figure 8.2) for the gain function of a call option with a 25c premium – an option to buy with a premium value (or option price) of 25 centimes – where the exercise price of the underlying asset is Fr 56.45.

The x axis represents the price of the stock, the y axis the outcome of the operation. According to this graph, if, on expiration, the underlying asset is priced at Fr 57.00, a profit of 30 centimes can be made;[34] if the price on expiration is Fr 56.20, then there will be a loss of 25 centimes.

These two illustrations are rather rudimentary. Their interest lies in the many permutations that can be generated by combining them, and in the ability to derive the total gain function

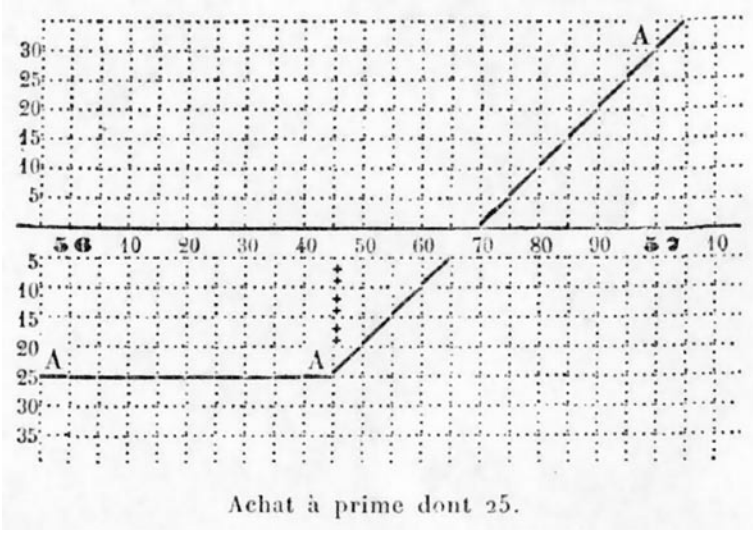

Figure 8.2 Call option with a 25c premium (Lefèvre 1873, 228)

using this system, dispensing with complex calculations. Lefèvre envisaged two types of application.

First, it could be used for complex hedging operations. For example, in Figure 8.3, by combining the sale of one option (curve VV) with the purchase of another (curve AA), Lefèvre suggests a hedge against strong volatility in prices (curve RR).

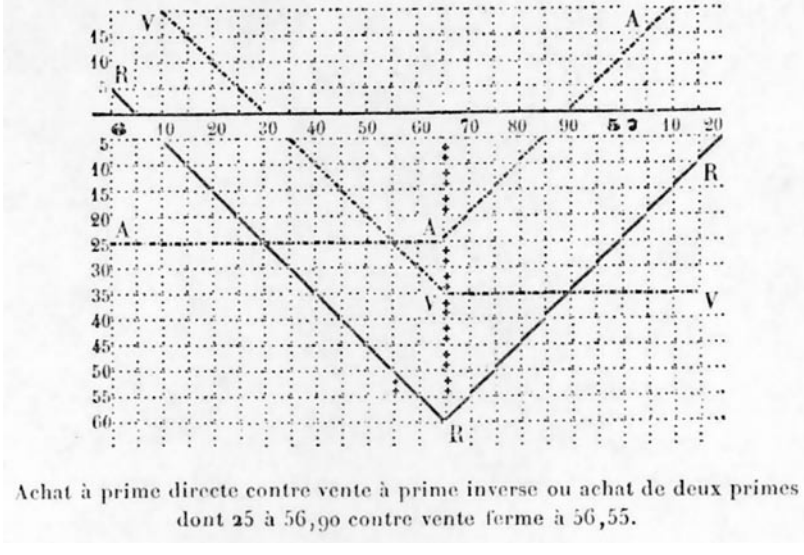

Figure 8.3 Direct call with converse put, or purchase of two options with a premium of 25c for Fr 56.90 versus firm sale at Fr 56.55 (Lefèvre 1873, 242)

In this instance, the option holder covers himself against the underlying asset being priced at less than Fr 56.05 or more than Fr 57.25 on expiration, in other words, against excessive volatility in the price of the underlying asset: his maximum loss is limited to the premiums paid on the two options, i.e. 60 centimes.

Second, on any given settlement date, a player will often have a number of stocks where he is sometimes in a position to sell and sometimes in a position to buy. The basic graphs described above can be combined to represent the player's final situation and thus assess the gain function of such operations, however complex they may be.[35] In this case, Lefèvre's graphic method fulfils its role perfectly, since 'however expert the calculations of those with long experience in this kind of operation, they cannot, through ordinary means, attain the accuracy and speed of execution' (Lefèvre 1873, 245) obtained by this method. In Figure 8.4, for example, Lefèvre derives the final situation for a series of operations on French 5 per cent bonds.[36]

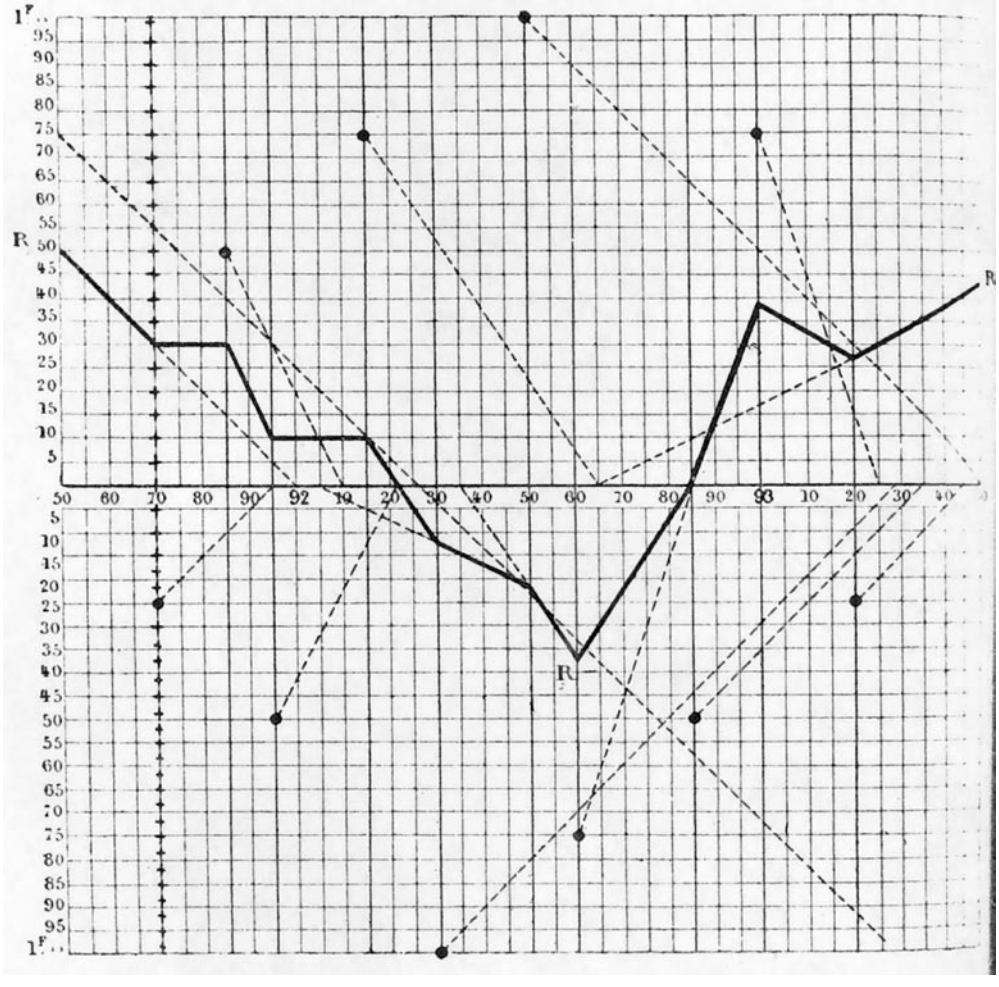

Figure 8.4 Complex strategy (Lefèvre 1873, 248)

The profit or loss at any given price point of the asset can be read directly off the graph, and the position adjusted if necessary. Thus, for any price between Fr 92.20 and Fr 92.85, the overall outcome from this set of operations is negative. What Lefèvre is finally suggesting, in an original way, is that a player's final situation should be evaluated relative to the total gain function, which can be represented in graphic form.

To enable every player easily to express any combination of stock market operations, Lefèvre goes back to the principle of the nomogram[37] and proposes nothing less than a 'typological alphabet of the stock market'[38] designed to represent the gain function for any combination of stock market operations, thereby providing a powerful instrument of analysis:

> Thanks to [the speculator's nomogram] … it is simplicity itself for anyone to perform stock market operations, no matter how complex, to take perfectly precise account of each operation, and to reflect quickly and accurately on the figures thus derived, something that no one has previously been able to do. (Lefèvre 1870b, 1870c, 3)

This instrument has a dual advantage. For one thing, the benefit of such an 'alphabet' resides in the ease with which – by virtue of its simple construction – it can be distributed, particularly in the newspaper medium. Lefèvre circulated his graphs widely, through his teaching, in the press and even on posters.[39] But they also enabled any player to work out his position at any moment, without the need for painstaking calculations. With this simple accounting control tool, everyone was equipped to operate efficiently:

> I have attempted to shed light on the workings of the Stock Exchange [*Treatise on Securities and Stock Market Operations*, 1871] and for this purpose have created an auditing instrument [the speculator's nomogram] with which everyone can be aware of what he is doing and thus avoid the traps which are set for him. (Lefèvre 1871, 7)

The advantage of the graphical instrument is that it relieves players of the need to perform tricky accounting calculations. Its ease of use considerably reduces response times to market fluctuations and speeds up the flow of transactions, thus improving the circulation of goods and, beyond that, the functioning of the economy as a whole. Lefèvre's graphs therefore fulfil a necessary social function by regulating and stimulating economic activity in a way that takes us closer to his 'norm' – the ideal standard described at the outset.

Conclusion

Lefèvre's work, drawing on two models of knowledge – animal physiology and Comte's historical model – can be read as an interesting attempt to apply economic theory to the financial markets of the late nineteenth century. By retaining only his graphical instruments, however, history casts a broader light on the direction taken by financial theory throughout its development. Lefèvre's graphs were adopted by theoreticians in two different ways. One group – whose standpoint is exemplified by Alexandre Masseboeuf (1923) – held onto their primary vocation as a pedagogical tool, offering an easily used mechanism for the uninitiated. The graphs obviate the need for complex and abstract formalization. For the other, they served as a starting point for a line of abstract reasoning that incorporated mathematical developments in order to formalize financial theory. The graphical tool was no longer an end in itself, but a support for mathematical analysis. For Bachelier (1900) and Alfred Barriol (1908), for example, graph-based approximations were no longer sufficient: they set out to formalize these graphic

representations in order to calculate an exact value. In his thesis, Bachelier made use of this graphical reasoning to determine mathematically the price of an option, but the graphs were isolated out from Lefèvre's wider work.

These authors used the same method as Lefèvre, but in a very different perspective. Bachelier and Barriol completely lost sight of the norm, keeping only the graphical tool, which thus breaks free from the philosophy and the particular model of society which brought it into being. These diverging paths signal an evolution in the methods used in financial economics. But beyond the methodological considerations, this 'emancipation' of the graphical tool reflects above all a radical shift in the nature of the theoreticians' goals, and even in the way that financial economics is conceived. With Lefèvre, we have a reflection on the utilization and social utility of stock markets. They must promote society's economic development and avoid non-professional exploitation. In becoming independent, his graphical method also became considerably poorer: an economic tool primarily for practitioners, with all ideas of wider social evolution abandoned and forgotten. It became no more than a technical expedient, with a new – and limited – purpose: playing the stock market.

Notes

1. The French mathematician Louis Bachelier (1870–1946) defended his doctoral thesis 'Théorie de la speculation' on 29 March 1900. He taught mathematics in Paris, Dijon, Rennes and Besançon – most of the elements of his biography are presented in Courtault et al. (2000) and in Mandelbrot (1995). His thesis, and his article of 1901, 'Théorie mathématique du jeu', are pioneering works in mathematical finance, and in the theory of random processes in continuous time. Long overlooked, as they were so far ahead of their time, they influenced both random process theory (especially the work of Itô) and probability theory (notably Kolmogorov's breakthroughs). His thesis was rediscovered by economists in the 1950s and 1960s and for a long time was mistakenly hailed as the first work of modern financial economics. On the mathematical repercussions of Bachelier's work, see Taqqu (2001); on his economic work, see Jovanovic and Le Gall (2002); on his contribution to financial economics, see Jovanovic (2000).
2. Little is currently known about this author. He was born in Bethencourt in 1833 and worked as a stockbroker at the Paris Bourse. His model provided a starting point for Bachelier's study (1900), enabling the latter to discover Brownian motion before Einstein. On this model, see Jovanovic and Le Gall (2001); on the link between Regnault and Bachelier, see Jovanovic (2000).
3. An option contract confers the right, but not the obligation, to sell or buy a financial or tangible asset for a predetermined price – the 'exercise price' or 'strike price' – at a set date, the 'expiration date'. In Paris, in Lefèvre's day, this type of financial asset was known as a '*prime*' and only European-style options were exchanged – for which the right could only be exercised just before the actual expiration date.

   One of the advantages of options is precisely that they can be combined ad infinitum to obtain any particular end result as a function of stock price movements. For example, one can, if so desired, determine a strategy that yields a profit if prices fluctuate beyond a certain interval, and a loss if they remain within that interval – a so-called 'straddle'. The outcomes of such strategies can be plotted on graphs, presented in greater detail in the final section.
4. Certain biographical elements are taken from Taqqu (2001, 14, note 14).
5. This was in all probability a small company set up by Lefèvre to manage stock investments for people who could not come to Paris in person or who had no direct access to the Bourse. Such firms were common at the time.
6. This particular position, which he casually mentions on the cover of most of his publications, may have had more to do with name recognition (and its effect on sales) than with any real employment.
7. At the time, financial journals offered to manage their readers' financial investments. This type of service, of obvious interest to those in the provinces who could not visit Paris regularly, gave rise to numerous financial scandals. Note surprisingly, some journals would sing the praises of certain especially effective investments with the sole aim of fleecing their readers. Likewise, small investment banks – like the one for which Lefèvre worked – were legion.
8. This evolution in the Parisian financial landscape was accompanied by a change in the attitude of the public – and of successive governments – towards the stock market (Reznikow 1990). A similar development marked the history of the British and American stock markets (Banner 1998); in France it was notable for the birth of financial economics (Jovanovic 2001).
9. These data, for stocks listed on the official market, are taken from Courtois (1877) and from the records of the

Congrès International des Valeurs Mobilières of 1900. Neymarck (1888, 8) tells us that in March 1888, '767 different stocks were traded at the Paris Bourse; 208 were traded on the spot and futures markets; 559 were traded on the spot market alone', to which must be added some 200 stocks traded on the free market. The nominal year-end stock market capitalization – in millions of current francs – was 9407 in 1851, 23 247 in 1861, 84 012 in 1880 and 130 304 in 1902 (Moreau-Nérêt in Hautcœur 1997, 245). However, these statistics are merely indicative of the development of the Paris stock market; since the sources are neither homogeneous nor easily verified, the data differ from one study to another.

10. For the six major railway companies, the average number of shares per French shareholder varied, depending on the company, from 22 to 47.24 in 1860, falling to the lower range of 10 to 13.6 by 1900. For bonds, the average was 42.10 in 1860, falling to within the range 24.69–32.00 by1900. Sixty-seven per cent of nominative bonds belonged to holders who had no more than 24 bonds.
11. For an overview of these issues, see Boboeuf (1864) and Jovanovic (2001).
12. The liberal economists' mouthpiece, the *Journal des Economistes*, regularly published articles about financial markets and the Société d'Economie Politique organized debates on the subject. The specialists on financial questions were Alphonse Courtois and his son Alphonse. The liberal economists were not the only ones, however, to stress the economic role of the stock market. In 1857, for example, Proudhon published his *Speculator's Manual*, in which he emphasized this function of the financial markets.
13. The field of political economy in nineteenth-century France was marked by a series of methodological disputes, notably regarding, on the one hand, the relationship between economics and mathematics, and, on the other, the relationship between economics and statistics (Ménard 1987; Breton 1991). Courtois was opposed to the use of probability in economics: 'with all due respect for the genius of those who created this science and for the higher intelligence of those – distinguished in so many ways – who have followed them down this path, I cannot but protest against stretching the laws of mathematics and nature in this way' (1879, 14–15).
14. For example, a large part of Proudhon's *Speculator's Manual* is taken up with descriptions of the status of stocks traded on the Paris market.
15. This troubled period was marked by a flurry of methodological debates, and the development of economic sociology, which 'criticized certain limitations of political economy in order to enrich economic theory by incorporating previously neglected or poorly studied phenomena' (Gislain and Steiner 1995, 14, our transl.).
16. In 1872, Hyppolyte Charlon founded the Cercle des Actuaires Français. The circle's periodical, the *Journal des Actuaires Français*, regularly published economics articles, especially with a mathematical bent. For example, Septime Avigdor (1874) proposed – almost simultaneously with, and independently from, Walras – that one should 'seek out the harmony that must surely exist, and consequently the relations that must come into play, between the prices of different objects of consumption' (1874, 300) using a model of general equilibrium very similar to Walras's own. The contributions of the French actuaries, highly innovative in terms of theory, are a perfect illustration of how economic and financial theory in France developed outside the traditional schools. We should also remember that Hermann Laurent, vice-president of the Institut des Actuaires Français (set up in 1890 as the successor to the Cercle), was strongly committed to introducing mathematical economics, especially the works of Walras, into France. For more details on the economic works of the French actuaries and their role in propagating mathematical economics in France, see Zylberberg (1988, 1990), Le Gall (1997) or Breton (1998).
17. See also Rebeyrol's analysis (1999, 194–5) of certain roles played by financial markets in Walras, who also cites Lefèvre in his 'bibliography of works on the application of mathematics to political economy' and recommends them to readers seeking a deeper understanding of stock market mechanisms (Walras 1880a, 370).
18. This Russian economist – an official correspondent of the Institut, and one of the greatest economists of the end of the nineteenth century (Gislain and Steiner 1995, 14) – takes up some of Lefèvre's ideas in his writings.
19. Lefèvre published a letter dated 27 February 1874, sent to him by the Paris stock exchange committee: 'Sir, The Committee has listened with interest to the report given by one of its Members, charged with studying your method for stock market operations. The Committee has decided that as your tables may be useful to the Company of Stockbrokers, a subscription should be placed for 60 copies, which I trust you will kindly have delivered to our treasury …' (Lefèvre 1874a, opening citation). In 1874, he also published a poster (100 × 60 cm) presenting his graphs and his theory of stock market operations. The poster was available from the Correspondence Bureau of the Paris Bourse.
20. This publication, which failed to acknowledge the works of Lefèvre, stirred up a controversy in this review (see Zylberberg 1988).
21. At the time, prices for raw materials were listed and some of them were already traded on a regular basis at stock exchanges, in both spot and futures markets. The Chicago Board of Trade, the great raw materials exchange founded in 1848, allowed American cereals producers to defer delivery of the harvest relative to the date on which the price was determined. In 1874, this market was extended by the new Chicago Mercantile Exchange.
22. In the nineteenth century, the term '*Bourse*' referred primarily to a forum of exchange, which was accordingly not limited to financial markets alone. For example, in the France of the 1840s, the idea emerged of organizing *Bourses de travail* or labour exchanges. Subsequently, a number of local initiatives were set up in France, and

the first long-term labour exchange was established in Paris in 1881. The concept was later expressed in theoretical form by Gustave de Molinari (1893). On the social aspect of labour exchanges in France, see Soriot (1999).

23. For Lefèvre, as mentioned earlier, the stock market must be understood as a forum for the exchange of commodities as well as financial assets.
24. The time at which Lefèvre was writing was marked by an ongoing debate about the risks generated by industrialization and assembly-line production, and particularly about how best to manage the risks incurred by industrialization. This debate eventually led, among other things, to the development of the welfare state in European countries; an acknowledgement is due here to the conference held in Paris on 12 January 2000 by the Association pour la Défense de l'Histoire Economique on the theme 'The Welfare State, from Construction to Crisis'.
25. In his analysis, Lefèvre (1873, 220) makes a clear distinction between commercial or financial insurance, on the one hand, and life or fire insurance on the other. By dissociating the different types of insurance, Lefèvre was generalizing out from the type of insurance that actuaries normally dealt with. His only point of interest in the matter lay in the uncertainty phenomena surrounding economic and financial risk. He left to his actuarial colleagues – Lefèvre joined the Cercle des Actuaires Français in 1873 and remained a member up until his death in 1890 – the task of analysing other types of risk and insurance.
26. This function of speculation was clearly set out later by Leroy-Beaulieu: 'speculation is a regulating force …, it is the marvellous worker-bee that regulates markets, apportions supply to demand and demand to supply and which, through its various oscillations, restores equilibrium everywhere … . The question has often been asked as to how, without government intervention, without directives from administrative departments, countries with populations of 40 or 50 million, towns of 2, 3 or 4 million souls, can be regularly supplied every morning with all their needs, and without any shortages. The credit for this feat is due to speculation, and price variations are its means of action. Abolish rises and falls in price, attempt to establish constant prices, contrary to the nature of things, and our markets will no longer be supplied' (Leroy-Beaulieu in Raffalovich 1893, foreword).
27. Walras (1880a, 1880b) later echoed this proposal for restricted access to the financial markets.
28. Lefèvre toyed with the idea of a fourth intermediary, the *agent de change* (stockbroker), acting as an intermediary between merchant brokers and thus barred from operating on his own account. The need for such a role, in Lefèvre's eyes, explained 'the natural origin of the sworn broker who, at the Stock Exchange, is the *agent de change*, at a higher level of the business and financial hierarchy' (1874a, 114). Consequently, he must be 'as far removed as possible from the public, with whom he should have no direct contact' (ibid.).
29. This idea pops up again in Walras (Rebeyrol 1999, 195).
30. There was much debate at the time about the utility of stock markets, and especially about whether useful speculation could be distinguished from gambling. For an overview, see Jovanovic and Le Gall (2001).
31. Walras in turn picked up on Lefèvre's argument when setting out his own vision of how stock markets should be organised: 'my proposal, in line with the opinion of Mr Lefèvre, differs from current practice in law and jurisprudence … . I would like … all stock market operations between merchants to be legal, and all forward transactions, for future settlement, to be illegal between non-merchants or between merchants and non-merchants. Thus, the market for capital would be reserved for professional speculators' (1880a, 393).
32. For example, Lefèvre notes that the division of labour specific to stock markets is not always observed. This lack of observance leads to dysfunctions in social organization: 'the broker, who should act only as an intermediary between merchants, is in direct contact with the public: he 'does retail' as well as 'wholesale and retail-wholesale' … . This is absurd; it makes it impossible for the retailer to exercise his own trade. … The general consumer has no business dealing directly with the Stock Exchange, which is the great market for all stock, or with the brokers who are – or at least should be – intermediaries between merchants, and whose interest logically lies in respecting the natural hierarchy of the different social functions, the absence of which leads only to disorder and fraud' (Lefèvre 1874a, 115–16).
33. These equations are used here only to illustrate Lefèvre's thinking and approach. He does not of course present them himself, since he rejects abstract mathematics. A number of theoreticians who later made use of Lefèvre's graphs, notably mathematicians such as Barriol (1908), formulated these equations explicitly.
34. To assess this profit, one simply assumes that the holder takes up the option, i.e. buys a share of the underlying asset for Fr 56.45 and sells it immediately at the market price of Fr 57. His net profit, after deducting the cost of the option premium (Fr 0.25 francs), is therefore 57 – 56.45 – 0.25 = 0.30 francs.
35. On the complexity of possible graphic representations, see Lefèvre (1873, 377 or 382).
36. Fr 91.95 call option with a premium of 25c; Fr 92.20 call, premium 25c; Fr 92.85 call, premium 25c; Fr 93.30 call, premium 100c; Fr 93.35 call, premium 50c; Fr 93.45 call, premium 25c; Fr 92.10 put option with a premium of 25c; firm sale at Fr 92.25; Fr 92.65 put, premium 50c; Fr 93.25 put, premium 25c; Fr 93.50 put, premium 100c.
37. Nomograms date back to the Cartesian coordinate system. They began to be commonly used from 1843 onwards by French engineers who saw the graphic method not only as a pragmatic mode of expression but also as an instrument of research in its own right (Marey 1885, introduction). Nomogram usage subsequently became

widespread and led the French mathematician Maurice d'Ocagne to advocate a whole new field of science called 'nomography' (Ocagne 1908). Nomograms have several applications in finance, notably for calculating the value of securities.

38. This alphabet is based on four fundamental characters: a mute character, a character representing a profit or loss on the purchase, another representing a profit or loss on the sale, and finally one representing stagnation of profit and loss (Lefèvre 1870a, 3).
39. They were taken up by French stockbrokers from 1874 onwards (Lefèvre 1874a, opening citation).

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