Reform of finance education in US business schools: An historian's view

Robert R. Locke [University of Hawaii, USA]

Abstract:
This paper revisits the theme broached in the book *Confronting Managerialism: How The Business Elite and Their Schools Threw Our Lives Out of Balance* (Zedbooks, 2011). There the authors (Robert R Locke and J-C Spender) blamed mathematical models of markets devised by finance professors in business schools for market collapse, that is unbounded rationalism was held responsible for the unhappy outcomes. Here the argument is refined, with the conclusion that not scientific knowledge alone or in itself but insufficient scientific knowledge combined with ruinous intent induced the financial rout. The nature of the argument is extended, thereby, from "science" to ideology and bad education. The refined argument also clarifies recommendations for finance educational reform

Since the subject is historically specific (US finance education at end of the 20th century), the analysis that supports the conclusions is based on historical specificities, namely a comparison of the development of mathematical neo-classical economics in French engineering schools and in US business school departments of finance, with the claim that historical methodology clarifies the issue of reform in finance education much better than the "abstract analytical categories" of social science.

Keywords: engineer-economist, Ecole polytechnique, French university economists, Maurice Allais, Ford Foundation, reforms of US business schools, operations research, financial analysts, business ethics, mathematical cultures, and historical method

Principally because of the Enron debacle, the subprime mortgage crisis, and the collapse of financial markets in 2008-09, the US business school model has attracted special scrutiny with respect to its usefulness in teaching MBA students ethics, a sense of corporate social responsibility, and a regard for the sustainability of businesses, as opposed to measuring success in terms of a firm's short-term profits and its stock's current price on equity markets. (Cf. Wright and Bennett, 2011). In the work co-authored with J-C Spender, *Confronting Managerialism,* we line up with business school critics. In this paper, the argument is developed, using the same historical approach, with a focus on finance in US business schools after their adoption post World War 2 of the ideology of neo-liberalism and an econometric- mathematical toolkit.

In order to illuminate deficiencies in knowledge and ethics in US finance education and practice and clarify the way to reform, comparisons are made between finance education in US business schools and a different educational traditions, that of the engineer-economists in France. The historical argumentation is important because the shortcoming of the use of mathematics seems to reside in historical specificities (when, why, and where it is applied) rather than in anything inherent in the formal science of mathematics. Historical comparisons underscore the point.

French grandes écoles of engineering and the engineer-economists

It does not hurt to remind people in business schools, especially in US business schools where they know so little of it, about the alternative institutional tradition in the French grandes écoles of engineering that made major contributions to the development of operation research methodologies in economics and finance. The French engineering school especially of interest here is the Ecole polytechnique, which already in the 19th century was renowned. After graduating from it, the best former students attended the schools of application (in the 19th century the Ecole des Mines and the Ecole des Ponts et Chaussées) from whence most entered the state technical bureaucracies (Les grands corps d'état) charged with supervising the mining industry and civil engineering projects.

In all the technical grands corps d'état the engineers dominated (Mines, Bridges and Roads, and later Telecommunications, Aeronautics, etc). The only students from a grande école that rivaled them in state ministries after WW 2 were the Enarques, graduates from the Ecole nationale d'administration founded in 1946, prominent in the Ministry of Finance and the Bank of France.

The peculiarity of the French educational system is that the best students in these grandes écoles of engineering entered state service, on fast track appointments, working for ministers in their "cabinets" and in the grands corps d'état (like Mines) or in a prefecture. They also move from high places in the state administration to top jobs in private industry and back to state positions again (*Pantouflage*). They form a club of 10,000 who ran (and run) what the French call *la grande industrie*.

French *Polytechniciens*, because of the dreaded concours, a competition for school admission, which emphasized it, were well-schooled in mathematics. By the mid-nineteenth century already some of them began to think mathematically in economics about practical problem solving. Jules Dupuit (1804-1865) one of the pioneers and the most famous early example of an engineer-economist, published studies on market segmentation in the *Annales des Ponts et Chaussees i*n the 1840s. The publication venue hid his, and similar articles on economics by other French engineers appearing in their periodicals, from mainline mathematical economists outside France, who did not read French engineering journals and who, in any event, were unaccustomed to engineers getting involved in economics. The "foreign" economists' "discovery" of Dupuit occurred in the 1930s when five of his articles were published in a book (1933) edited by an Italian economists, and when Harold Hotelling's article about him appeared in *Econometrics i*n 1938. (Nelson, VI) Hotelling's piece finally provoked international debate among economists about marginal pricing, a debate ironically from which French engineer economists, despite their previous work, were cut off by the isolation of their country after the defeat of 1940.

Before 1940 the French engineers who did think about economics did not amount to a "school." As François Etner explains in his doctoral thesis they worked in the earlier period mostly alone. In his words: "The view that an *engineer-economist tradition* fought against another tradition (literary-economics) in order to impose a 'scientific' approach to economics…is false up to 1930." (Etner, 146). After France's defeat and in postwar rebuilding, however, a group quickly emerged. The specificity of historical method allows the investigator to discover the importance of French engineer economists in postwar applied economics policy making.

Undoubtedly the chief instigator for the gathering of these engineer-economists was Professor Maurice Allais. His book, *A la recherche d'une discipline économique* (1943), especially, gave impetus to marginal utility analysis; it presented a modern and complete explanation of Pareto's theory of the optimum (under the nomenclature theory of social return), which relied particularly on marginal cost analysis.

Shortly after the war, recently nationalized industries demanded sophisticated management expertise. At Electricité de France an OR group under Jacques Massé, a *Polytechnicien*, applied economic theory to management problems. None of the EDF group had degrees in economics but they knew their mathematics or could rapidly assimilate what they needed to know. As Allais noted: "The statistical and mathematical techniques which the engineer-economists need are not techniques specific to economics; their application is general and these techniques apply to all natural sciences." (Allais, 1952, 267) Massé's group embarked on the most far-reaching analyses. Studies were done on tariff construction and price policy, on consumption, on operating policy, and on investment policy, which applied marginal utility economics to problems, whose solution required quite sophisticated mathematical statistics. (Locke, 1989, 125-26) In December 1953, a two volume study published by the Director of Equipment in the Electricité de France revealed that Massé's group was a first-rate team whose work bore practical fruit in the form of EDF's Green Tariff of 1956. (Massé) Clearly the Tariff was based on marginal cost theory and amounted to decision making according to economic scientific rationale in a major industry. The engineer economists, to use Professor Allais's phraseology again, "applied a general knowledge of economic science to the study of the particular problems posed to management in firms and did that by calling upon the most elaborate techniques currently at our disposal." (Allais, In Lesourne, 1972) Allais was Lesourne's mentor).

The EDF group sparked emulation in other nationalized industries. The Coal Board (Charbonnage de France) commissioned Professor Allais to do a study on the economics of coal mining. (Allais, 1953) The study concluded strongly in favor of marginal cost pricing. The same board also commissioned J. Audibert and A. Terra to analyze short-and long-term investment policies in the same industry. At the Gas Board (Gaz de France) the definition and the calculation of marginal costs were done by F. Gardent and his colleagues; at the national railroad (SNCF), Roger Hutter evaluated marketing problems and rates schedules on marginal principles. (Hutter) When in 1959 Jacques Massé became Chief French Planner (commissaire général de plan d'équipment et de la productivité) for the Third Plan, the influence of the engineer-economists spread; Jean Mothes moved from Gaz de France to SNCF, to SEMA (Société de mathématiques et d'économie appliquée), a consultancy; Jacques Lesourne from the Coal Board to SEMA, Pierre Maillet from being project manager (*chef des travaux*) in the Ecole Polytechnique (1950-53) to a study group preparing the Third and Fourth Plans for the modernization and equipment of France.

With few exception, and the exceptions were mostly mathematicians and statisticians, these men were graduates of *the Ecole polytechnique. Many of them had also studied with Professor Allais at the Ecole des mines or at the Institut de statistiques in the University of Paris,* where he was also a professor. Allais pointed out that many of the biggest names among the engineer-economists had been his students. He had much to do with steering these engineering students into applied economics, since his tenure of the chair in applied economics at the Ecoles des mines began in 1944.

Beneficiaries of this educational heritage, the engineer-economists also became its benefactors. A cycle of studies, created by M. Guillbard, R. Henon, E. Morice, and J. Mothes at the Institut de statistiques, University of Paris, repaired deficiencies in the subject. All the problems current in industry, which this educational elite often knew by direct experience, were discussed in Allais's seminar at the Ecole des mines, in R. Roys' seminar on econometrics, and in the first seminar on operations research, founded by the director of the

Institut de statistiques, M. Guilbaud. A new periodical (Revue de statistique appliquée NUMDAM), organized by this close-knit group, proselytized the new methods.

Since it was an engineering tradition, especially for *Polytechniciens* in the grands corps d'état, to liaison with the grandes écoles of engineering, many of Allais's disciples interrupted their working careers to become researchers and teachers. Among them, Jacques Lesourne, who, after his studies at the Coal Board, taught economics and statistics at the Ecole des mines St-Etienne before moving to the Institut de statistiques and then on to the Conservatoire national des arts et métiers; Jean Mothes worked at the Institut de statistiques with Marcel Boiteux, who lectured at the Ecoles des Ponts et Chaussées; Edmond Malinvaud directed the Institut de statistiques; Pierre Maillet became a professor of economics at Lille.

The engineer-economists were not just mathematically and scientifically prepared to understand and apply neoclassical economic theory and exploit the toolkit of operations research but, in the French management scheme of things, at the top of the French industrial management ladder and in a position, therefore, to use theory and the toolkit to solve practical management problems

French engineer-economists thought highly of themselves in this regard and of their work, for, in Professor Allais' opinion (1958), "the work done by French engineer-economists in the last fifteen years…lifts France into the first rank, very far ahead, in my view, of Great Britain and the United States in the domain of the economy of the firm." (Allais Introduction to Lesourne, p. Xxxix, Also see Drèze)

The achievements of French engineer-economists were recognized more by American postwar economists than French economists, which is somewhat of a paradox since Allais' work was never appreciated enough in the US for it ever to be translated into English. (Genrot) The contradiction is easily explained, however; the French engineer-economists were a somewhat isolated club in France that was not co-extensive with the group people call "economists." Most French economists in mid twentieth century had in fact nontechnical educations; they had studied political economy in the faculties of law or at the School of Political Science ("Science Po") almost exclusively in the literary, juristic, or sociological tradition. If it is remembered that most of the people in the nontechnical *grands corps* (Conseil d'état, Cour des comptes, etc.) were educated at "Science Po," this signified that the French nontechnical *hauts fonctionnaires* (civil servants), even if they had studied economics had learned precious little about marginal utility or general equilibrium theory, or mathematical economics. The same was true of students who heard lectures from these nontechnical economists in the business schools (grandes écoles de commerce and the Ecole des Hautes Etudes Commerciale). (Locke, 1989, pp. 151-55) Economics Professor G. H. Bosquet recalled: "I did all my studies at the Paris Law faculty and at 'Science Po' without anybody ever citing the name Walras to me." (Bosquet, 691)

There were exceptions. Albert Aupetit, a disciple of Léon Walras, taught economics at "Science Po" during the interwar years. The people who worked at the Institut de statistiques were doing very valuable work. Many of them were engineer-economists but there were university professors among them as well. Attempts were made immediately after the war, moreover, to enlighten law faculty professors about modern economics. The *Revue d'économie politique*, spokesman for the university economists, put Professor Maurice Allais on its editorial board and when he won a medal from the American Management Science

Association for his work on marginal pricing, the award was proudly reported to the review's subscribers. (Fonction et avenir, 167) But few of them could have understood Allais's work.

The truth is that the university economists and those in the nontechnical state service were isolated from the engineer-economists in their schools of engineering and their management positions in *la grande industries*, even though so many of them were housed just up the street in Paris from each other. When the nonmathematical French economists set out to repair their "scientific" deficiencies in the 1960s they looked not to their own engineer-economists but across the Atlantic to neoclassical economists, who were avidly proselytizing their own mathematical toolkit. Ironically, the education of French university economists was drawn into the vortex of the postwar Americanization of economic science worldwide. But before US economists could do that, they had had in the first two decades after the war to set their own house in order.

Incorporating scientism into US economic studies and business school education

US engineers principally in schools of industrial administration (MIT, Carnegie Institute of Technology, Georgia Institute of Technology, etc.) propagated the scientific toolkit of operations research. But their interaction with corporate management differed considerably from what took place in France. In 1900 when Frederick Winslow Taylor began the scientific management movement, engineers on the shop floor were deeply involved. But by the second quarter of the 20th century a revolution in corporate governance was well underway. Its historian, Alfred D. Chandler, Jr., most famously in *The Visible Hand* (1977), describes this rise of new managerial hierarchies in giant corporations whose managerial needs were quite different from those Taylorism induced. Because top corporate management concentrated on money more than product management, it required staff that could deal with financial reporting and marketing, that could oversee money flows through the various corporate divisions -- information that was much more vital to decision making in a multifaceted strategic setting than product knowledge. It required accountants and controllers to design and run the management system; they replaced the engineers previously at the top. At General Motors Alfred P. Sloan installed systems of financial reporting to headquarters "based heavily on analysis of managerial accounting data," (Rother, 63). Sloan noted that GM was in the business of making money not automobiles. Other multiple division corporations followed suit. In 1929 The Controllers' institute was founded in the United States because of their increasing managerial importance.

French engineers at the head of industry, preoccupied with renewing a rundown industrial park in order to save their country from backwardness, succeeded in their task during what the French call "The Thirty Glorious Years" of postwar modernization (1945-75). American managers succeeded, too, in making lots of money. But there was little in the educational background of most top managers in US industrial corporations that permitted them to work closely with operational research scientists and economists like in the system of French engineering education and industrial leadership. US corporate moneymen lacked the scientific and mathematical knowledge needed to grasp quickly what operations research people and neo-classical economists were talking about.

In fact, in the US, private industry projects did not drive the development of OR and its methodological toolkit. The principle catalyst was the government and the Pentagon, with its affiliate agencies. The team of British scientists and engineers that worked on the 'operational use of radar information' at Air Ministry (Bawdsey Manor) could hardly have guessed their efforts to solve operational problems would have such consequences. Their success spawned operation research groups throughout the military on both sides of the Atlantic. C-H. Waddington, who was involved in anti-submarine operations along with two Nobel Prize winners and four other fellows of the Royal Society, wrote: "Never before has science been used by responsible executive authorities for such a thorough and such an unrestricted analysis of practical affairs as it was by the Royal Air Force from 1941 onward (Cited in Locke, 1989, 25)."

OR projects adopted statistical and mathematically informed techniques, such as queue and transportation theories that were particularly suited to maximizing efficiency in large-scale military operations (Fortun and Schweben, 1993). After a brief respite the use of science in military connected agencies expanded during the Cold War (Waring, 1995). In 1946 the Army Air Corps funded a new think tank, The Rand Corporation, to help solve operations problems. In 1947 George B. Dantzig and his Rand associates developed the simplex linear programming algorithms for decision-making. The procedure utilized modern mathematics (vector algebra, matrix theory, symbolic logic) and statistical technique in their effort to take the guesswork out of decision-making.

French engineer-economists readily assimilated and propagated the methods that scientists, mathematicians, and engineers developed in the US. But US neo classical economists could not immediately do so because of their educational deficiencies. Nonetheless, the postwar economists appreciated their importance when they encountered the methods utilized in government work and set about introducing them into their discipline. At Rand in 1948, the economist Kenneth Arrow used Dantzig's simplex linear programming techniques in his work on Rational Choice Theory. His book, *Social Choice and Individual Value* (1951), was the "first real classic" on what "is now taken as a given in economics and has spread out into many neighboring disciplines." (Bellah, 2000, 7) The neoclassical economists Joseph Dorfman, Paul Samuelson, and Robert Solow applied linear programming to their subject as well (in *Linear Programming and Economic Analysis*). In 1954, Kenneth Arrow and Gerard Debreu, a Frenchman who had studied with Allais, announced that they had achieved a mathematical solution of general equilibrium, "the theoretical core of neo-classical economics," which Edward Fullbrook states "has become the central showpiece of academic economics ever since." (Fullbrook, 2003, 5)

These were glory days for neo-classical economists. The Rand Corporation introduced scholarships and post-doctoral funding to help raise mathematical competence and added to the prestige of the discipline within the social sciences. That prestige grew even more when the Bank of Sweden created a "Nobel Prize" in economics in 1969. Most of the resulting Nobel's were handed out to them (Arrow, Samuelson, Solow, etc.). They, their students, and disciples, took over teaching and research in most American university economics departments from which their influence spread overseas through the Department of Defense into NATO, through government programs like the Marshall Plan, and through private agencies like the Ford Foundation.

In 2003 Fullbrook wrote of these neo-classical economists:

> They control the three most prestigious economics journals in which papers by their staff and PhDs predominate. Of the over 800 economists employed by the World Bank, a majority have been trained at one of the Big Eight (California-Berkeley, Harvard, Stanford, Yale, Chicago, Columbia, Princeton, and MIT). The International

> Monetary Fund is similarly provided, as are the other highly ranked economics departments in the US and in some cases in other countries. The 2003 edition of Penguin's *Dictionary of Economics* … has entries for 29 living economists. Of these, 26 … are from the US or have had all of the most important part of their careers there. Of the 26, 100 percent have either taught at or received their PhD from one of the Big Eight." (Fullbrook 2003, 6)

In contrast to French business schools that left scientific operations research to the grandes écoles of engineering, the engineer-economists, and their co-frères in industrial management, US neo-classical economists not only embraced the new scientific techniques but played a major role, along with business schools deans, and philanthropic foundation bureaucrats, in pushing the adoption of these methodologies in US elite business schools. (Khruana, "The Institutionalization of Business School – 1941-1970")

Most commentators trace the radical content change in business school curricula to the impact of two reports on business education that appeared in 1959, and the efforts of the Ford Foundation to promote management education reform, (Gordon and Howell; Pierson and Finberg; Khurana). An explosive growth of graduate business schools and MBAs began. In 1960 4,814 were granted, 23,400 in 1970, 49,000 in 1980, and 70,000 in 1990, with more than 200,000 plus per annum at the century's end. The Ford Foundation programs provided funds for upgrading graduate business school faculties, in order to get rid of "unimaginative, non-theoretical teaching from descriptive practice-oriented texts to classes of second-rate vocationally-minded students." (Locke, 1989, 161)

The limited impact on US business practice of MBA programs in mathematical economics

Professor Khurana ran into the work of the proselytizers at the Ford Foundation , which he described skillfully in his book on the history of US business schools. There are several aspects of their efforts, however, that histories mostly ignore. Although departments of operations research in schools of industrial administration were heavily involved in OR projects, the business schools proper did not have close contacts with industry, of the sort that French engineering schools and French engineer economist did. Consequently, business schools did not participate very much in the industrial transformation of America. They did not, for example, play a role in the Total Quality Management movement. Robert S. Kaplan, former dean of Carnegie-Mellon Business School and a Harvard Business School professor underlined their failure in manufacturing. After reviewing articles published in leading operations management journals and examining research and teaching in business schools, he concluded that "American business school research and teaching contributed almost nothing to the most significant development in the business world over the past half century – the quality revolution." (Kaplan, 1991, 1) Considering the magnitude of the threat from Japan, the failure of the business schools to throw themselves into the fight to save manufacturing is astonishing and a leadership failure of major importance. (Locke, 1996, pp. 169-70)

US business school MBAs also did not especially promote the digital revolution, which was America's most significant industrial achievement postwar. To some extent this was unavoidable during the pre1975 phase of IT development, because business schools deal primarily with the private sector. And pre1975 IT development was almost exclusively a government project. The economist Werner Sombart claimed in 1925 that "the growth of large-scale nationalistic warfare" was the root cause of economic development, since the demand for more effective weapons, offensive and defensive, stimulates technology and invention (quoted in Castells and Hall, 1994, 17). One group of scholars observed: "From the explosion of the first Soviet atomic bomb in 1949 until the mid-1960s, the driving force for science policy remained the military-technological competition with the Soviet Union." (Alic et al*,* 1992, 97) The people involved were scientists and engineers working for the pentagon and on government projects, not MBAs. Accordingly, as Rheingold concluded,

> "If necessity is the mother of invention, it must be added that the Defense Department is the father of technology: from the Army's first electronic digital computer in the 1940s to the Air Force research on head-mounted displays in the 1980s, the U.S military has always been the prime contractor for the most significant innovations in computer technology." (Rheingold, 1991, 80)

Low intensity MBA involvement was also true during the commercial phase of IT exploitation after 1975. In the start-up enterprises mushrooming in the Silicon Valley habitat, scientists and engineers were the heroes. Those from Stanford's Computer Science Department illustrate their importance. Andy Bechtolsheim, a founder of Sun Microsystems, John Hennessy, a founder of MIPS Technologies, Inc., Jim Clark, a founder of Silicon Graphics and Netscape, Jerry Kaplan, a founder of Techknowledge, Go, and Onsale, Forrest Basket, technical officer at MIPs, Len Bosack, a founder at Cisco Systems, and David Cheriton, a founder of Graniote Market Value all came out of there. In 2004 the combined worth of their companies amounted to about $90 billion. The scientists and engineers possessed the indispensable mathematical and scientific knowhow for the great product ideas essential to start-up IT firms.

Nonetheless, one would have thought that MBAs might have been heavily involved in the nontechnical aspects of IT innovation. Scholars investigating the high tech habitats have concluded, however, that the mathematical neo-classical new look in economics absorbed in business schools education little suited the IT entrepreneurial environment. The economist Gunnar Eliasson for one observed that "the bulk of subjects on the teaching agenda of business schools, like investment calculation and financial economics, rest on the assumption of [a formal knowledge] model." (Eliasson, 1998, 6) AnnaLee Saxenian, after investigating the Silicon Valley habitat pointed out that the informal networks of moneyed angels brought technical skills, operating experience, and a myriad of industry contacts – as well as cash – to the ventures they funded, abilities that MBAs from the elite business schools did not have. (Saxenian, 1994, 184) Closeness to local technology networks was the key to success. Quoting a former Wall Street executive about entrepreneurship, Saxenian wrote: "In New York, the money is generally managed by professional or financial promoter types. Out here [Silicon Valley] the venture capitalists tend to be entrepreneurs who created and built a company and then sold out. When problems occur with any of their investments, they can step into the business and help." The angel investors that funded IT start-ups had to know the "territory" for their investments to do well. Accordingly tacit knowledge about Silicon Valley money networks constituted venture capital competence more than formal knowledge of financial and investment techniques learned in business school finance courses.

Much of the top-down management techniques learned in business schools was also useless in IT organizations after start-up. The specialist chipmakers, the big hitters in IT, discarded the control mechanism, taught to MBAs in business schools, for network organizations, "where people teams, and sometimes whole organizations," as AnnaLee

Saxenian affirmed, “act as independent nodes, form multiple links across boundaries, support one another, share common values, and report to a matrix of leaders who act as coaches and mentors more than line managers.” (Saxenian, 1994, 90)

The entrepreneurs who developed Silicon Valley in the post-1975 commercial phase were in fact a diverse crowd drawn from all over the world. Most were educated in technical subjects and mathematics. Few of them were MBAs (Locke, 2004) Many were immigrants from Asia, who had come to study mathematics, science, and/or technology in American universities and then stayed on to work in firms, start their own companies, or both. Saxenian told their story based on the 1990 census. (Saxenian, 2000) At the century's end Asian immigrant entrepreneurs had founded seventeen percent of Silicon Valley high-tech start-ups. Almost simultaneously, IT centers developed in their homelands – in Taiwan, in Singapore, in Bangalore – incited through the Silicon Valley connection.

If, after the Ford Foundation reforms, US business schools did not teach subjects compatible with an IT entrepreneurial environment, once the schools awoke to the IT habitat's entrepreneurial demands they belatedly began out of sheer opportunism to develop centers of entrepreneurship. Professors and students in these add-on business school entrepreneurship centers participated in the activities of habitat start-up networking and the like But the faculties in the top research business school finance departments resisted, in the name of science, efforts to make entrepreneurship an academic discipline Indeed, Stanford's business school faculty is notorious for having rejected the endowment of a chair in entrepreneurship from a rich benefactor because they considered the subject scientifically unworthy. There were no Nobel prizes in economics to be won in entrepreneurship.

Finance -- The big business school exception

Although the reformed business schools did not pull their weight in the Quality Revolution (which the engineers handled in manufacturing) or in the development of IT, their adoption of the Ford Foundation-driven research and teaching agenda in mathematical economics permitted them to play a major role in the massive expansion of the US financial world during post-communist globalization. The pre-eminent pioneer in finance mathematics was probably Harry Markowitz, a Chicago student and eventual winner of the Nobel Prize in economics, who used quantitative methods to show how investors can maximize returns and lower their risks by diversifying their portfolios. But the development of the derivatives market proceeded not from this so much as from three other significant academic events. The first occurred in 1969 when Robert Merton introduced stochastic calculus into the study of finance; the second in 1973 with the publication of the Black-Scholes Formula for Pricing European Calls and Puts; the third in 1981 when Harrison-Plasma used the general theory of continuous-time stochastic processes to put the Black-Scholes option pricing formula on a theoretical footing, and consequently, demonstrated how to price numerous other derivatives. (Korn, 2010) This permitted mathematics to be used in all four branches of finance mathematics: modeling, optimal investment calculations, option pricing, and risk management. With these tools trading in derivatives could be modeled and market behavior reasonably predicted.

Although these were considerable individual achievements (for which Merton and Scholes won Nobel Prizes in economics in 1997 – Black was by then deceased) their invention really resulted from the transformation in the 1960s and 1970s of business schools during the Ford Foundation-sponsored reforms. The road of transformation began in operations research in World War II, invaded schools of industrial administration immediately thereafter, from whence it traveled into the social sciences. The academic careers of three professors involved in the significant events just mentioned tracked this development pattern. Robert Merton, who earned a bachelor of science in engineering mathematics at Columbia and a master of science at the California Institute of Technology, migrated into economics from engineering when he wrote a doctoral dissertation at the Massachusetts Institute of Technology under Paul Samuelson, who had himself drawn on OR methods developed at the Rand Corporation when he applied linear programming equations to neo-classical marginal analysis.

Stanley R Pliska's and J Michael Harrison's careers followed the path from operations research into social science even more directly. Both did PhDs in operations research at Stanford University, Harrison in 1970, and Pliska in 1972, before moving into mathematical finance, Harrison at Stanford's Graduate School of Business, and Pliska in the business school at the University of Illinois, Chicago Circle. Accordingly, their first job experiences and academic papers handled typical OR problems in firms before their interest shifted to quantitative analysis of derivative markets in a landmark collaboration.

Myron Scholes and Fischer Black did not start in operations research, but they worked with people who did. At MIT, where they entered into their famous collaboration, scientists had been preoccupied with operations research during and after the war.

In finance the relationships between business schools professors and practicing managers resembled those between the French engineer-economists and people in industrial management. Finance professors in top schools were not shy about establishing contacts with people in praxis. Milton Friedman, for example, lobbied for the establishment of an options exchange in Chicago. On 26 April 1975, a month before the Black-Scholes paper appeared, the Chicago Board of Options Exchange opened. Texas Instruments made a hand calculator that allowed financial dealers to price options using the Black-Scholes formula. Black, whose preoccupation with derivatives started while working for Arthur D. Little, which at the time had developed a great interest in OR, later took a job with Goldman Sachs (in 1984) designing derivative architecture (Magee, 2002). Professor Emanuel Derman, head of mathematical finance at Columbia University, worked at Goldman Sachs with Black. These examples illustrate the symbiotic relationship that developed between business school professors and people in praxis. (Chan, 2010)

Finance departments in business schools also solidified their contacts with praxis on the instructional level. The need for quantitative analysts prompted the schools in a very short time to develop specialized master's and PhD courses in financial engineering, mathematical finance, and in computational finance – and to create new degrees. Cass Business School near London's financial district, introduced quantitative finance programs. It established an MSci in quantitative finance, an MSci in financial mathematics and a MSci in mathematical trading and finance. In the UK Paul Wilmott taught the first mathematical finance course at Oxford University. Afterwards he developed the largest European training program in London, a one-year course that led to a widely accepted Certificate in Quantification Finance.

Not surprisingly, because it had been a leader under Dean Bach in developing the Ford Foundation's program, Carnegie Institute of Technology's Graduate School of Industrial

Administration (to become the Tepper School of Business in 2003) set up a Financial Analyst Security Trading Center (FAST) in 1989, one of the first US educational institutions to replicate successfully the live international data feeds and sophisticated software of Wall Street trading firms. (Bach, 1958) The business school at Carnegie Mellon introduced an MBA in computational finance, an MS in quantitative economics and an MS in computation finance in which the students studied equities, bond portfolio management, and the stochastic models upon which derivative trading, i.e., the Black-Scholes formula, is based. Although early off the mark, there was nothing exceptional in the last decade of the 20th century about the program in mathematical finance at Carnegie-Mellon; all the top business schools developed them.

MBAs increasingly found jobs in the banks, hedge funds, and investment houses of the expanding sector. Khurana's study of Harvard Business School MBAs cites a survey of first jobs for graduating Harvard Business School students: Between 1965 and 1985 students' entry into financial services and consulting "rose from 23 percent to 52 percent" of graduates (Khurana, 2007, 328-29). The same shift happened in "other elite schools, such as Wharton and the business schools at Stanford and the University of Chicago." By 2005 "among the 180 principals and managing directors in the 20 largest investment firms, 73…[held] an MBA from one of the six elite schools (Harvard 51, Chicago 7, Columbia 6, Stanford 5, Dartmouth's Tuck 3, and Northwestern 1." (349)

Difference between the institutionalization of French engineer-economics in grandes écoles and finance analysis in US business schools.

It is at this point that the specificities of history become important. Although networking between the finance-analyst and the finance community resembled networking between French engineer-economist and industrial management, two points must be made about how these communities actually differed.

The first concerns the culture of mathematics. French engineer-economists had no deep-seated problems with the mathematical knowledge extant in the grandes écoles of engineering and in *la grande industrie*. French Polytechniciens were among the finest mathematician in France. But even they, perhaps because of their mathematical awareness, realized the limitations of mathematics in economics. Maurice Allais observed in 1954 that "It is absolutely necessary to avoid the development of a complex mathematical apparatus when it is strictly speaking not indispensable." (Maurice Allais, 68) And he added that if it is acknowledged that "mathmatization is a necessary condition for the development of economic science, one cannot know how to be an economist if one is only an econometrician. The error of certain mathematicians sometimes is to make something a goal, which is perhaps only a means." (p. 59)

In America the Ford Foundation program and the Rand Corporation scholarships were necessary because of the abysmal mathematical knowledge circa 1950 of business school professors and students. After the reforms finance professors and their MBA students might have been able to use mathematics but their knowledge of the subject could never match that of the French Polytechniciens. Moreover, there is ample evidence that business school professors, students, and finance investors did not comprehend mathematics enough to see its limitation as a tool in the modeling of financial markets. Nicholas Bouleau, from the Ecole des Ponts et Chaussées, explains how the finance analysts' insufficient grasp of the epistemology of mathematical-science led them astray.(Bouleau) When the financial crisis came, surprised finance analysts, immediately after the fact, more or less admitted as much. In January 2009 Paul Wilmott and Emanuel Derman issued The Financial Modelers Manifesto, which opened with words reminiscent of Karl Marx: "A specter is haunting markets – the specter of illiquidity, frozen credit, and the failure of financial models." Then followed the admission:

> "Physics, because of its astonishing success at predicting the future behavior of material objects from their present state, has inspired most financial modeling. Physicists study the world by repeating the same experiments over and over again to discover forces and their almost magical mathematical laws. … It's a different story with finance and economics, which are concerned with the mental world of monetary value. Financial theory has tried hard to emulate the style and elegance of physics in order to discover its own laws. … The truth is that there are no fundamental laws in finance." (Quoted in Patterson, 2010, 294, see also, Dobbin and Jung)

That Bouleau and other doubters about the modeler's mathematical applications (Mandelbrot and Taleb) were educated in France suggests that the country had a more highly developed mathematical culture than that of the US neoclassical finance-economists.

Benoist Mandelbrot detected the flaw in Chicago Business School Professor Eugene Fama's Efficiency Market Hypothesis and the Black-Scholes pricing formula before they were even published (Cootner, 1964). His studies of cotton prices and income distribution revealed wild disparate leaps in prices that did not follow mathematical theories of predictable market behavior. He published the findings ("The Variation of Certain Speculative Prices") in an internal research memo at IBM. Then he worked out an alternative method to measure the erratic behavior of prices, based on the mathematics he learned in Paris under Paul Lévy. Mandelbrot's essay struck at the heart of the quantification revolution in finance because he challenged the core idea the revolution advanced -- that the market moved in tiny incremental predictable ticks. Ignoring Mandelbrot, Wall Street quantifiers decided to adopt strategies based on the Black-Scholes formula in order to shelter their highly leveraged ventures in derivative trading.

Nassim Taleb, another determined French educated critic of mathematical finance market models. stated that investors who believed markets moved according to a random walk and are, consequently, statistically predictable, are "fooled by randomness." (Taleb, 2001, Patterson, 2010, 59) There are wild, unexpected swings in markets, which he called "Black Swans." If mathematics-schooled traders used models based on historical trends and expectations of a random walk (models of predictable pricing), it would lead them to disaster. And there are "more Black Swans out there than people think." A little mathematical knowledge in US financial economics seems to have been a dangerous thing.

Financial mathematicians had naively sent misleading signals to non-mathematicians in the investment community, which promoted the belief that everything can be modeled. They had glorified simplistic modeling as state-of-the art; they had thought about risk measures and forgot about risk management. (Korn, 2010) They have taken high risk derivatives (Triple B rated securities) and stacked them into financial packages (Collateralized Debt Obligations, CDOs) that, under their coaxing, rating firms designated Triple A risks, that is no risk, and then sold them as such to pension plans, insurance companies, and other institutional investors globally. They created their own derivative world, without much reference in fact to business and industry, and sold it to the investor public.

Yaris Varoufakis, economists from the University of Athens, educated in mathematical economics in the United Kingdom, described their shenanigans:

> In more technical language, the formula used to assemble the CDOs assumed that the correlation coefficient between the probability of default across a CDO's different tranches or slices was constant, small and knowable. ... Doubt about the constancy of the correlation coefficient would have cost them their jobs, particularly as their supervisors did not really understand the formula but were receiving huge bonuses while it was being used. (Varoufakis, 233)

This combination of recklessness, bred from mathematical artlessness and greed, precipitated the subprime mortgage crisis in 2007 and the general financial systems meltdown that followed. Business school professors and finance mathematicians who designed these packages should have known, if their supervisors (unlike the Polytechniciens running French industry) did not, that what they were doing was fraudulent or at least a questionable application of mathematics. They did it on a grand scale. (Adams and Smith, 2010)

The second institutional difference that the historical comparison reveals between finance education in US business schools and that of postwar French engineer economists involves questions of morality. Recent cases of gross immorality in the financial world prompted business schools to respond with courses on business ethics. But a survey of 100 top business schools, after all the fuss, showed only half of MBA programs have managed to make ethics a required course, and only 6% of them dealt with issues of sustainability in their core curricula. (Wright and Bennett, 641-645) William C. Frederick lists seven reasons for the reluctance of business schools to adopt ethics courses. (Frederick, 1-2) They are

1. The failure of business schools accreditation agencies (AACSB) to require ethics courses as a condition of accreditation
2. The ineffectiveness of conventional principle-based instruction.
3. Fixation on behavioral models derived from neoclassical economic orthodoxy – emphasis on rational self interest….
4. Protection of faculty vested interest in conventional topics in the business curriculum (topics without ethical content)
5. An agency based conception of professional responsibility that omits consideration of complex social-cultural factors influencing business decisions.
6. Dean and faculty indifference, skepticism, or opposition, to the feasibility of influencing the values or ethical orientations of adult business students.
7. Perpetuation of an amoral sense of self through a failure to realize bio-neurological normative impulses.

The ineffectiveness of conventional principle-based instruction is a good reason **not** to take ethics courses seriously because principle-based instruction is the approach that is invariably followed. Besides, there is no reason to think that ethics courses in themselves are actually needed. Ethics has never been included in French engineering education inasmuch as nobody perceived the necessity. This suggests that formal courses in ethics for students are not essential to ethical education in professional schools. They are not because morality if personal and universal is nonetheless always situated in a particular social and institutional order, knowledge about which is the key to understanding the status of ethics in professional education. Once again, this time in the sphere of morality, the specificity of comparative institutional experience is instructive.

Frederick's six other reasons for business school resistance to the introduction of ethics courses shed light on historical institutional contexts, for they reveal the views of the power brokers in the business school establishment. The power brokers consist of the greater academic environment in which business schools are situated (the accrediting agencies) and the business school deans and faculties that devise and give life to curricula and define institutional purpose, that is to say the ideology through which the manner (or content) of thinking characteristic of the institution is expressed.

Reason 3, for example: "Fixation on behavioral models derived from neoclassical economic orthodoxy – emphasis on rational self-interest." US management emerged from World War 2 in an uneasy compromise with big labor, celebrated in numerous studies of American industrial democracy published in the Inter-University Labor Relations Program (Locke and Spender, 80-81). This tentative academic postwar recognition of industrial democracy gave way in business schools after the mid1970s to a neo-liberal ideological outlook, preached at the Chicago Business School, that managers had no responsibility other than to maximize profits for company stockholders. (Khurana, 363-383)

Reason 3 combined with reason 5 – "An agency based concept of professional responsibility that omits consideration of complex social-cultural factors influencing business decisions" – eliminates the institutionalization of ethics in business school education. French engineer-economists, it could be argued, subscribed to reason 3 but not to reason 5. These engineer-economists had embarked with their colleagues in industry on a noble mission after the war – to modernize French industry and the economy. They had, to use words in the title of Khurana's book, "higher aims." that were professional and patriotic: "Science and knowledge for the nation," is the credo of the Ecole polytechnique and they took it seriously. In a deeper sense perhaps, an engineer-economist also differed from a financial analyst because the former deals with artifacts and the latter with money. Ninety percent of French engineering students, responding to a recent survey, stressed the importance of the impact of technology on society and of sustainable development. (Pourrat and Dufour , 285)

That business school deans and faculty believe business knowledge serves the private interest of their clients, without considering the public good, automatically marginalizes ethics. Business maximizes return on investment, and business finance courses teach how to do it. Students learn this in the finance class, after attending a lectures on ethics, unless the lecture is an elective in their school, The resulting cynicism does not stem from the amorality of science but from making a public institution servile to a particular interest, that of the managerial caste (Locke and Spender, XI), which serves no interest other than personal enrichment and aggrandizement. No public institution worthy of the name would let the general interest be captured by a special interest driven by greed, which is what reason 5 indicates happened to US business schools, aided and abetted by an environment lacking a sense of the individual as a moral being (reason 7: "Perpetuation of an amoral sense of self through a failure to realize bio-neurological normative impulses). When professional schools lost any pretense of serving a public purpose, which is what Khurana claims happened to US business schools at the end of the 20th century, they succumbed to the limiting purpose of producing MBAs as "hired hands" working to fill the coffers of a business community driven by the ideology of neo-liberalism.

Reforming business school education

This comparative exercise turns out well for the French engineer-economists. But the paper does not advocate that the Americans follow the French pattern and let the engineers do heavily mathematized finance economics. If we, however, are to retain business schools as places that educate people in finance, this comparative historical analysis indicates that two reforms are in order.

- Since French Polytechniciens are among the best mathematicians in France, they hardly need to be watched over in order to detect deficiencies in the subject. But US business schools should be more strongly supervised especially in finance because of its close connections with the financial world and stock markets and their importance in economic life. To that end business school finance departments need to beef up their faculties with more mathematicians and/or establish cross-discipline committees that could hinder the use of simplistic mathematic model building.

- The second reform focuses on ethics. Since the problem involves curricula, the ideology of the faculty, and its narrow conception of professional responsibility that omits consideration of complex socio-cultural factor in decision-making, something needs to be done about all three. There is no reason why business schools could not serve the public good. Neo-liberalism is a pernicious ideology that should be publically flogged. Many religious affiliated business schools (Catholic and Protestant) do spurn neo-liberalism in their emphasis on educating the whole person. Only anti-neo-liberalism has to be pushed vigorously in non-denominational business schools, which includes the more prestigious business schools in the US. The target is not student ignorance but the faculty's moral failure, expressed in the way their amorality is institutionalized in teaching and research regimes. Deans and faculty should be the focus of reform rather than the students.

Figuring out how to induce faculty to understand that business school education is a social-cultural commitment as much as a commitment to the research and teaching of scientific specialties is a difficult problem. Perhaps faculty should broaden their contacts with people who are managed as well as to their managers, in order to understand that the managed have interests that cannot be trumped by science in any sustainable management order.

It might in fact be preferable to create much more inclusive systems of business education, like the system in the German speaking world, where business economists teach and research but do not, in their faculties, claim to educate a professional management elite. German faculties of business economics are not professional schools. This permits business economists, under the German regime of co-determination management, to service the educational needs of a broad range of partners involved in co-management, members of works councils, employee representative on supervisory boards, as well as regular management cadres. Such a broad ranging reform of US business education, of course, would be resisted strenuously in US business schools and management circles.

US business schools have to give up the idea that what they do is scientifically neutral and in the hands of scientifically trained managers, "objective." German trade unionists, even in ostensibly scientific matters, prefer that each interested party in a discussion bring its own scientists to the discussion table. (Leminsky, 370) And they prefer to tap into the German educational system in order to acquire the knowledge necessary for them to discuss management problems with management intelligently. (Locke, 1996, Ch 2, “German Obstinacy”) This American labor unions cannot do because US business schools are places that educate a management elite exclusively. To make US business schools give up professional management school pretentions for a broader spectrum of education, they would have to change their educational methods radically.

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