The Value of Nothing: A Review of *The Quants*

Reviewed by David Steinsaltz

The Quants
Scott Patterson
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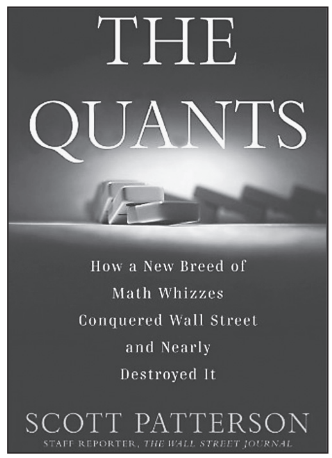
Scott Patterson, former financial journalist for *The Wall Street Journal*, has written a book-length love letter to quantitative finance and its practitioners. To judge by some comments posted on amazon.com and elsewhere, though—"naïve", "mathematically illiterate", "sensationalism", "bumbling idiot"—the love is not requited. Of course, the book is not really about the sort of people who write comments on the websites of online retailers. The "quants" of Patterson's title are a handful of capitalist potentates, supremely successful and influential practitioners of mathematically inspired finance. Putting to one side a certain oversensitivity to criticism and the unquestionably sensationalist subtitle—"How a New Breed of Math Whizzes Conquered Wall Street and Nearly Destroyed It"—many who identify with the job title "quant" are very far removed from the world of Patterson's conquering heroes and from Patterson's enthusiasm for them. While the book makes little pretence of reflecting their careers or their experience, it probably offends by implying—with little evidence—that the managers and the menials share a unified mathematical culture and mindset.

But the managers, and their real and perceived relationship to mathematics, do make an important story. Economic historians teach us that one indispensable ingredient in a financial crisis is an excuse for ignoring the lessons of the past, for overriding the traditional safeguards, for believing that "this time is different" [15]. The most recent round of excuses was provided, if not directly by mathematicians, then under the banner of mathematics, and the crisis that ensued was of terrifying proportions. For this reason alone *The Quants* would deserve the attention of the mathematical community. Few readers will be bored, and most will learn some things that are worth knowing about the world and about the place of mathematics in the world.



This book joins a long list of recent popular or semipopular titles on quantitative finance and its practitioners. It is not the best in all respects, certainly not as a technical primer. Its approach can seem infuriatingly nonanalytical and apolitical, even willfully obtuse at times. But it is intelligent and serious, by and large, and its relentless focus on the look and feel of the rarefied quant world, although a limited perspective, is a valuable one, and one that requires the skills of a talented journalist, which Patterson obviously is.

The quants, as Patterson describes them, "couldn't care less about a company's 'fundamentals', amorphous qualities such as the morale of its employees or the cut of its chief executive's jib. That was for the dinosaurs of Wall Street […] who focused on factors such as what a company actually made and whether it made it well. Quants were agnostic on such matters, devoting themselves instead to predicting whether a company's stock would move up or down based on a dizzying array

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of numeric variables." It's an old story, actually. A similar conflict embroiled the earliest attempts, three centuries ago, to expand the nascent probability theory beyond its disreputable origins in games of chance. Historian Lorraine Daston writes, "The mathematicians created a new approach to the subject that challenged the previous *practice* of risk, legal and otherwise. […] It was as if the jurists and the commercial class they wrote for lived in a world of fine-grained detail where regularities were partial at best […] The mathematicians, in contrast, apparently lived in a world strictly governed by invariable laws that could be expressed as the function of a small number of variables" [4, Chapter 3.1].

In that twilight struggle, B. Gnedenko has argued [11], the probabilists were routed. From the early gambling studies there followed a profusion of "papers devoted to applications in various branches of the natural sciences and public life. Many of these had so little validity that they were considered 'mathematically scandalous affairs'. Disenchantment followed and among Western European mathematicians probability theory began to be thought of as some kind of mathematical entertainment hardly deserving serious attention."

Probability's association with gambling endangers more than just respectability. Human beings have natural intuitions about risk that are systematically violated by cards, dice, and roulette wheels. As evolutionary psychologists have remarked, "If humans had evolved in casinos where their winnings translated into reproductive success, selection probably would have eliminated the gambler's fallacy" [13]. In the real world, probability theory is a specialized adjunct to more natural human intuitions, not a substitute for them.

In Patterson's account, modern quantitative finance originated with Ed Thorp, a mathematician who applied the Kelly criterion to blackjack in his 1962 book *Beat the Dealer* before turning the same principles to finance in *Beat the Market* (1967). Patterson makes clear (as do other sources) that Thorp himself has always been the farthest thing from a gambler by temperament, but some of his intellectual heirs revel in high-stakes poker parties and junkets to Las Vegas casinos. Describing the credit derivatives group at Deutsche Bank around 2000, Patterson writes "In their downtime, Weinstein's traders would randomly bet on just about anything in sight: a hundred on the flip of a coin, whether it would rain in the next hour, whether the Dow would close up or down." The financial markets are "the world's biggest casino". While "investors" put up the money, the quants "place bets": Bets on trade patterns, bets on currency exchange rates, bets on company growth and defaults, and bets on the bets that other traders would make.

There is nothing new about the accusation that financial transactions involving risk—insurance, stock purchases, futures contracts—differ only in name from gambling. Indeed (see [4, Chapter 3.2]) life insurance in the sixteenth and seventeenth centuries was often a short-term bet on the life of some famous person. Usually the accusation is lobbed from the left, to be dismissed by the financiers as propaganda, ignorant of the vital work performed by capital markets. It is a surprise to see how many of today's leading financiers—not all of them mathematical types—have come to embody this accusation. "Every day they went head-to-head on Wall Street, facing off in a computerized game of high-stakes poker in financial markets around the globe, measuring one another's wins and losses from afar, but here [in their quant poker games] was a chance to measure their mettle face-to-face." It is not the least of the paradoxes that Patterson's protagonists eagerly seek risk in gambling, while their core mathematical models presume that investors pay a premium to dispose of risk. The contradiction does not seem to register on Patterson, who throughout seems entranced by these sharp operators using financial markets as a gambling den.

After probability and compound interest, the key financial principle underlying the quant models is arbitrage, the financial perpetual motion machine generated by price discrepancies. In principle, if you find the same asset being sold at different prices in different markets—Patterson uses the example of gold trading for $1,000 in New York and $1,050 in London—you can buy in one market and sell in the other to generate riskless profit. Back in the day, you would need to float your gold bricks over the Atlantic, but today the only limit on your profits would be the amount of money you could borrow and the amount of gold you could buy before the New York market raises the price. *Statistical arbitrage* expands the possibilities, by allowing for randomness. It attempts to extract profits from discrepancies in the future expectations of combinations of assets. Patterson is at his best when describing these strategies, both the mechanisms and the psychology that gives birth to them. These depend, in different ways, on inefficiencies in pricing mechanisms, creating short-term disequilibria that can generate profits as they reset.

Unless they don't. The book is punctuated by crises, large and small, in which the expectation fails. A casino owner needs only to pump enough money through the system and let the law of large numbers take care of the rest. In the financial markets all the "bets" are correlated, in hard-to-estimate ways, and the probabilities are only vaguely defined, estimated by analogy with the past. Not to mention that the quant strategies themselves alter the patterns of the markets. Pumping large quantities of borrowed money through these strategies can lead to a meltdown.

Arbitrage is a bit like dumpster diving. Lars Eighner formulated [5] three rules for safely consuming discarded comestibles. The third rule: answer the question "Why was this discarded?" The principle of "efficient markets" says that market prices already incorporate all publicly available information, so there should not be any opportunities for statistical arbitrage. This principle need not be true—indeed, there are good reasons, well discussed in this book, to believe it is not—but mathematical market models generally depend on it. Thus the computations of quantitative finance are largely based on the principle that these computations are a waste of time. Patterson repeatedly circles back to this paradox, which clearly troubles many of the quants. How can they consistently beat the market average? Some explanations on offer:

- **They're smarter than other people.** This seems to be, unsurprisingly, their favored explanation. Traders who translate new information into prices can profit, a process that Patterson compares to throwing meat into a pool full of piranhas. The meat (new information) disappears quickly, but the piranhas (the traders) do get fed. Now, Patterson describes the quants —with some notable exceptions—as unconcerned with anything so coarse as commerce, but their pattern-seeking is another way to integrate information, including past information and unrecognized persistent biases. This could earn them a steady profit.
- **Weaker regulatory constraints.** If you find a pristine can of soup in the dumpster on its sell-by date, you know why the supermarket couldn't use it; unconstrained by rigid health directives, an ordinary person could be fairly confident that the contents are worth having. Retail banks, pension funds, municipal governments, and many other institutional investors are tightly regulated, forced to make decisions based on crude categories. Laws constrain the sorts of risks they are allowed to take with the funds entrusted to them. By loaning the capital to hedge funds or investment banks the regulations vanish, a benefit sometimes called *regulatory arbitrage*. Considerable theoretical ingenuity has gone into producing financial instruments, such as the now infamous auction-rate securities that duplicate traditional banking functions within an unregulated securities framework, sometimes called "shadow banking".
- **Special privileges.** A significant portion of quant profits come from their access to information and trades closed to ordinary investors. They have top-of-the-line computer systems for bringing in market information, processing it, and executing trades instantaneously. They work for major international investment banks, or they win preferred-customer treatment from the banks. They may also profit from inside knowledge of how their own vastly leveraged trades are moving the markets. Many of the most lucrative trades are simply closed to outsiders. Michael Lewis's *The Big Short* [10] narrates the years-long struggle of investors, who predicted the collapse of mortgage-backed securities (MBS), to make the necessary contacts to sell the MBS short. The big quant shops would have made the short sale in microseconds.
- **They act crazy.** Patterson's quants cultivate an aura of strangeness. Some gamble manically. Many defy Wall Street dress conventions. They organize company paintball tournaments. One rages at bad news and destroys computer monitors. One makes a show of busking in a Wall Street subway station. They rave about the Truth of "Alpha".[1]

  Patterson describes all this with amusement, as some blend of residual math-nerd culture and plutocrat eccentricity. He never considers its strategic value. If Trader A makes a large sale of stock Z, he signals that he doesn't think Z is worth holding at the current price, causing the price to drop. George Akerlof analyzed this problem in his famous study of the used car market and came to the conclusion that this information imbalance—A knows why he sold, but B doesn't—depresses prices and can lead to a market-destroying downward spiral. If A appears crazy, or at least inscrutable, his trades will have less influence on the market. Eccentricity functions like the poker player's dark glasses.
- **They're not.** If I were to sell budget earthquake insurance in California, I could make a fortune—until the earthquake. Economist Joseph Stiglitz

[1] *α is just the intercept term in a linear regression of an individual asset price against an overall market index, but the quants, or Patterson, or both, seem to confuse it with the cabalistic aleph.*

writes: "In today's dynamic world, this market discipline broke down. The financial wizards invented highly risky products that gave about normal returns for a while—with the downside not apparent for years. Thousands of money managers boasted that they could 'beat the market', and there was a ready population of shortsighted investors who believed them" [17].

As long as high profits over a few years are enough to be labeled a success, there is an incentive to define the earthquakes out of the model. Until the earthquake strikes he's a genius, and after the quake he still gets to keep his genius bonus. At the height of the last crisis one of Patterson's heroes, Citadel Investment chief Ken Griffin, estimated that his company had a 55 percent chance of surviving [12]. How high do the annual returns need to be, to be worth risking everything on a coin flip?

This is not, primarily, a book about mathematical models. It includes some nice profiles of mathematicians and some slightly dodgy accounts of random walks and Lévy processes. For all that it has to say about mathematical thinking or the application of mathematical models, though, it could be *Harry Potter and the Volatility Smile*, with BlackBerries instead of wands. It's all gesture and evocation, as in: "The quants pulled out their calculators, cracked open their calculus books, and came up with solutions." Indeed, nearly every figure of any significance in the book is referred to as a "wizard" or a "whiz". There is "quant alchemy" and the "dark art of securitization".

What we get instead is a psychohistory of unresolved adolescent conflict, shading into a pervasive sexual menace. "The money was huge, the women were beautiful, and everyone was brilliant and inside the secret. […] At Deutsche Bank, risk wasn't [expurgated] *managed*. Risk was [expurgated]-slapped, risk was tamed and told what to do." The quants identify the dinosaur traders of Wall Street with all the privileged bullies who humiliated them on the playground and mocked their mathematical interests in high school. They are burning for revenge, and Patterson channels their fantasies into his narration: "A friend sent Muller congratulatory flowers for his new job. The bouquet was delivered to his desk on the trading floor. It was raw meat to the grizzled traders around him: *Look at the California quant boy and his pretty flowers*."[2] In the 1980s we read, "quants were seen as second-class citizens at most trading firms, computer nerds who didn't have the balls to take the kinds of risks that yielded the real money." Thus begins one of the more fascinating vignettes of the book, told from the perspective of one Aaron Brown, who was "sick of seeing the same rich kids he'd suckered at Harvard lord it over the quants in trading-floor games such as Liar's Poker." Brown killed the game off by spreading a winning strategy among his fellow quants. "No longer would they stand at the end of the line and be victimized by the [BSDs]."[3]

In such an environment women can only be peripheral objects: wives and girlfriends distracting the quants with the blandishments of forty-bedroom home and hearth; or a secretary, whose firing gives a clue to the mental state of her (male) boss. The one female quant in the book, Kim Elsesser—also, though herself quite senior, the book's token representative of nonkingpin quant-dom—disappears after a few amusing anecdotes "to study gender issues in the workplace at UCLA". It hardly surprised me after this to read of the recent lawsuit charging persistent gender discrimination at Goldman Sachs [3] or that the number of women working in U.S. finance has been dropping steadily [18].

The tone shifts in the aftermath of the crash. Skeptical academics take the stage (along with the irrepressible and omnipresent Nassim Taleb). Paul Wilmott, who wrote back in 2000 about the dangerous misuse of mathematics in finance [20], produced with Emanuel Derman a "modelers' Hippocratic Oath": five vows of humility, concluding with "I understand that my work may have enormous effects on society and the economy, many of them beyond my comprehension." Estimable sentiments, but absent a suitable educational program, what is it worth to swear an oath to "understand" something? It seems about as effective as combating the modelers' anglophone parochialism by requiring the vow: "I understand Chinese."

Has the corner of mathematics called "mathematical finance" actually influenced financial practice? Haug and Taleb [8] have debunked the mystique of the Black-Scholes-Merton formula, arguing (persuasively, if somewhat self-contradictorily) that the formula has never been applied in the real world, that equivalent calculations have been known and applied since the dawn of time, and that it is fundamentally misleading. Li's copula formula (which Patterson describes as a phenomenon without really explaining) has been blamed for the collateralized debt obligation (CDO) fiasco [19], but it is so banal in itself that it seems more like a decoration than a real impetus to the CDO market.

[2]*In this case, though, it is possible to compare Patterson's dialogue directly to his source. There is evidence of considerable embellishment.*

[3][*BSD*] *is here a crass expression for the bankers' anatomical endowment that seems to be a term of art in the finance world.*

It takes more than Hardyan "uselessness" [7] to buy a mathematician a clear conscience these days, though. University mathematicians have served the finance industry with a steady stream of students trained to look past the reality of the world to an abstract realm of interchangeable entities and to accept models axiomatically, without skepticism. At least as important, we have participated in what G. Bowker [2] has termed "legitimacy exchange" (though with a view to the huge blow suffered by the reputations of both groups, perhaps it might be called a "credibility default swap"). The bank's team of MIT Ph.D.s is a token of seriousness, like the Picasso in the lobby, the marble columns, and the expensive wristwatch. In return for lending the reputation of their subject, academic mathematicians are compensated by sharing the financiers' reputation as important people doing important work, and the enviable status as a conduit to high-paying careers, whether or not they also pocketed consulting fees.

Faced with dwindling public esteem, defenders of quantitative finance have sought to mortgage their intellectual stature for a legitimacy loan from the engineering profession. Patterson picks up on this, writing "few—aside from zealots such as Taleb—were calling for them to be cast out of Wall Street. That would be tantamount to banishing civil engineers from the bridge-making profession after a bridge collapse." (It is not clear exactly who Patterson is quoting here, but he or his source is channeling the very similar comments published in 2008 by mathematician S. Shreve [16].) M. Hellwig, in the course of an otherwise careful analysis of sources of the crisis [9], averred that "One might as well blame the architect of the World Trade Center for not having taken the risk into account that kerosene-filled airplanes might be flown into the building." As it happens, the lead structural engineer for the World Trade Center told reporters in 1993 [14] that the towers *had* been designed to withstand a jet collision. The collapse has since been extensively studied as an engineering failure, but thousands survived because of the safety margin that was built into the building. Cranking the 9/11 metaphor up another notch, David Hand has compared bank executives to people who break into a 747 cockpit and crash the plane [6].

Mathematicians are not engineers, and not only because one can hardly imagine top civil engineering academics reacting with nonchalance if their best graduates were not building bridges but finding bridges prone to collapse so they can cash in buying insurance on them. Or boasting of how their elite training and inherent brilliance enabled them to hoodwink the inspectors into approving shoddy plans. The engineering analogy was eloquently demolished by Nicolas Bouleau, financial mathematician and professor at the École Nationale des Ponts et Chausées. "Engineering culture and financial culture" is a chapter in his book [1]. (An earlier version of this chapter was published in the late 1990s.) The traditions and professional ethic of engineering "charges them with examining painstakingly what will happen in case of an accident, a fracture or conflagration, and to effect a repair." Engineers, he wrote, plan for the inevitability of failure and for its consequences.

Financial engineers don't install emergency exits, and on the evidence of this book they cannot imagine the need. Is this ostentatious math-nerd naïveté genuine or merely a camouflage? Surely, one thinks, as the disasters and near-disasters pile up, as the difference between brilliance and bankruptcy is the whim of a single deep-pocketed investor, or a flight to liquidity, or the faith of creditors, or a government decision to bail out a counterparty or temporarily ban short-selling, surely they cannot still believe that there is an ineffable truth to the markets, to be captured in probabilistic models and calculated to the fifth decimal place. It is disappointing that Patterson never poses the question of premeditation. The people who end up with the billions are portrayed as innocent bystanders, just little boys on the seashore collecting pretty pebbles. We are even invited to pity their stressful days and sleepless nights during the crash: "A quant nightmare. Markets were at the mercy of unruly forces such as panicked investors and government regulators."

The mighty quant barons of this story are not, it must be emphasized, the entire world of quantitative finance, and one longs for a latter-day quant Max Weber to map the lines of power and the percolation of ideology through the institutions. Until he or she arrives, Patterson has produced at least one plausible journalistic portrait of the past few decades of quantitative finance, one that is at least consistent with what we see in other recent books. It is a picture from outside the mathematical community, and it shows us how, whatever we may believe personally, the successes of financial mathematics will be largely privatized, while the failures will be hung around all of our necks. "Quant alchemy" indeed. By the end, I couldn't help thinking of H. G. Wells's famous takedown of Winston Churchill after the First World War: "He believes quite naïvely that he belongs to a peculiarly gifted and privileged class of beings to whom the lives and affairs of common men are given over, the raw material of brilliant careers." The quant aristocrats have had their Gallipoli. How will they adapt? How will the mathematical community respond? After the last quant has done his turn on the economic stage, it now seems hard to imagine that anyone will want to erect a statue to his memory.

References

[1] Nicolas Bouleau, *Mathématiques et risques financiers,* Odile Jacob, Paris, 2009.

[2] Geof Bowker, How to be universal: Some cybernetic strategies, 1943–70, *Social Studies of Science* **23**(1), February 1993, 107–127.
[3] Andrew Clark, Goldman Sachs hit by lurid allegations of sex discrimination, *The Guardian*, September 16, 2010, p. 27.
[4] Lorraine Daston, *Classical Probability in the Enlightenment*, Princeton University Press, Princeton, 1995.
[5] Lars Eighner, My daily dives in the dumpster, *Harper's*, December 1991, 19–22.
[6] David J. Hand, Mathematics or mismanagement?: The crash of 2008, *Newsletter of the London Mathematical Society* **382**, June 2009.
[7] G. H. Hardy, *A Mathematician's Apology*, Cambridge University Press, 1940.
[8] Espen Gaarder Haug and Nassim Nicholas Taleb, Why we have never used the Black-Scholes-Merton option pricing formula. Available at `http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1012075`.
[9] Martin F. Hellwig, Systemic risk in the financial sector: An analysis of the subprime-mortgage financial crisis, *De Economist* **157**(2) (2009), 129–207.
[10] Michael Lewis, *The Big Short: Inside the Doomsday Machine*, W. W. Norton & Company, New York, 2010.
[11] L. E. Maistrov, *Probability Theory: A Historical Sketch*, Academic Press, New York, 1974.
[12] Sebastian Mallaby, *More Money than God,* Bloomsbury, London, 2010.
[13] Rose McDermott, James H. Fowler and Oleg Smirnov, On the evolutionary origin of prospect theory preferences, *Journal of Politics* **70**(2), April 2008, 335–50.
[14] Eric Nalder, Twin Towers engineered to withstand jet collision, *Seattle Times*, February 27, 1993.
[15] Carmen M. Reinhart and Kenneth S. Rogoff, *This Time is Different: Eight Centuries of Financial Folly*, Princeton University Press, Princeton and Oxford, 2009.
[16] Steven Shreve, Don't blame the quants, *Forbes*, October 7, 2008.
[17] Joseph Stiglitz, *Freefall: Free Markets and the Sinking of the Global Economy*, Penguin Books, 2010.
[18] Kyle Stock, Ranks of women on Wall Street thin, *Wall Street Journal*, September 20, 2010.
[19] George Szpiro, Eine falsch angewendete Formel und ihre Folgen, *Mitteilungen der Deutschen Mathematischen Vereinigung* **17**(1) (2009), 44–45.
[20] Paul Wilmott, The use, misuse and abuse of mathematics in finance, *Royal Society Philosophical Transactions: Mathematical, Physical and Engineering Sciences* **358**(1765), January 2000, 63–73.

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Revitalizing the 1960 Mathematics Major

Alan Tucker

I entered college around 1960 in a golden era for the mathematics major. At that time, 5 percent of freshmen expressed an interest in becoming math majors (although only half as many earned math degrees). Math grads were in demand for new careers in aerospace and other technological industries, along with traditional careers in insurance and teaching. Many of my math major friends planned to go to medical or law school, as well as graduate school in mathematics or other quantitative disciplines. For many smart freshmen with unsure career plans, mathematics was a default major. This piece sketches my reading of why the math major changed, along with an argument for why it needs to be revitalized.

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Most United States universities in the 1950s had many tenured non-Ph.D. faculty in mathematics, and many offered a dated mathematics curriculum, e.g., a typical junior math course was tensor calculus. A dramatic increase in the number of math Ph.D.s was needed both to upgrade the quality of faculty and to match the rapid growth of college enrollments. The mathematics major curriculum required a massive revision to reverse the high failure rate in first-year graduate courses in Lebesgue integration and such. The proposed solution appeared in *Pregraduate Preparation for Research Mathematicians* (1963), the first report of the MAA's new Committee on the Undergraduate

Program in Mathematics (CUPM). The widely adopted 1965 CUPM report, *A General Curriculum for Mathematics in Colleges*, presented a gentler version of the 1963 recommendations with the goal that mathematics majors at all institutions should have some preparation for graduate study in mathematics (it was assumed that one-third of math majors would earn an M.S. in the mathematical sciences).

From 1960 to 1965, the number of math bachelor's degrees grew from 11,000 to 20,000, and math Ph.D.s from 300 to 700, according to AMS and CBMS survey data. The 1968 NRC COSRIMS report predicted 60,000 B.S.s and 2,200 Ph.D.s in math by 1975. The bachelors' number actually decreased, dropping to 12,000 by 1980 and staying around there to this day. Ph.D. numbers did grow but more slowly. Many math majors struggled with the more abstract curriculum, and employers complained that math graduates often seemed ill prepared to work on industry's problems. Further, new programs in computer science lured away many potential math majors. Although math majors were now better prepared for success in graduate school, the catholic 1960 image of the math major had faded. From 1975 on, only 1 percent of college freshmen expressed an interest in a math major.

Now let me turn to the situation from the faculty viewpoint, based on conversations with my father A. W. Tucker, who was chairman of the Princeton Mathematics Department around 1960. His view of academic life was that he was paid to teach but given the free time to do research, which he loved. That was a time when universities had modest graduate programs and the focus was on undergraduates; federal support of research was just starting. All Princeton faculty, including department chairs and even the dean of the college, taught two courses per semester. One semester each year my father was the lead professor in the big calculus course that most freshmen took. When I asked him years later when I was a department chair why he assumed this extra duty, he looked at me like I was crazy and said, "The most important thing the Princeton Mathematics Department did was to teach freshman calculus, and so as department chairman it was obvious that I should lead that effort." As chair, he felt it was also his job to get to know most of the math majors personally. [For more vignettes about those days, see my personal website: www.ams.sunysb.edu/~tucker.]

My father believed that one person could be blamed (or credited) with reorienting university faculty toward graduate students and research—Clark Kerr. In seeking to recruit star faculty from the Ivy League schools to Berkeley, Kerr hit upon the winning strategy of offering reduced teaching loads and little undergraduate teaching. I remember seeing one after another of our faculty neighbors get lured away, while my father and the rest of the Princeton administration watched helplessly as they stuck to their two-courses-per-semester, undergraduate-focused tradition. Other public universities followed the Berkeley example, and finally the Ivies gave in. Soon all faculty at universities wanted to be treated like stars with reduced teaching loads. A huge increase in precalculus and other low-level mathematics enrollments at public universities, along with the pressure to get research grants, has further diminished the attention given to math majors over the past forty years.

I believe that research mathematics departments will have trouble flourishing, especially at public universities, without flourishing math majors. This was a key message in the 1999 AMS *Towards Excellence* report, which cited examples of several universities with flourishing math majors. As one model, in the programs cited at UCLA and Chicago, research faculty collaborate with nonresearch faculty or mathematically trained advisors to give math majors personal attention.

Mathematics departments cannot compete with the natural sciences for resources in research dollars. Because regular faculty do limited teaching in calculus-and-below courses, which represent over 80 percent of math enrollments, mathematics departments cannot count on the huge enrollments in these courses to justify their size. Indeed, administrators are increasingly using four-course-per-semester lecturers, adjuncts, and technology to provide cheaper instruction than graduate students and instructors—and they often do a better job; in the process, math teaching assistantships and faculty lines are eliminated.

Without meaning to diminish the importance of research mathematics, I believe that a broad-based, thriving major in a core discipline such as mathematics is valued and respected by administrators as an important university service to society and its economic well-being. The value of studying mathematics is perhaps more in its mental training than its content. The wide-ranging accomplishments of math majors speak for themselves: from economist John Maynard Keynes to biologist Eric Lander, who led the Human Genome Initiative, to Jim Simons, professor turned hedge fund guru turned philanthropist, and even to basketball star Michael Jordan.

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