THE JOURNAL OF
INVESTMENT
CONSULTING

A reprinted article from Volume 22, Number 1, 2023

THE MASTERS SERIES

James H. Simons, PhD: Using Mathematics to Make Money

INVESTMENTS & WEALTH INSTITUTE®

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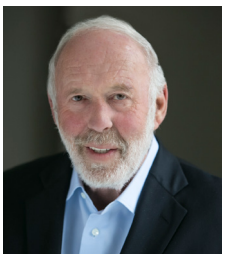
USING MATHEMATICS TO MAKE MONEY


James Simons, PhD

James H. Simons, PhD, is chairman of the Simons Foundation, an organization dedicated to advancing the frontiers of research in mathematics and the basic sciences. The foundation's philanthropic activities include a major research initiative on the causes of autism and establishment of an institute for research in mathematics and theoretical physics. Particularly focused on the growing interface between the physical and life sciences, the foundation has established and endowed several such research programs at universities and institutions both in the United States and abroad.

Simons founded Renaissance Technologies LLC, a highly quantitative investment firm, from which he retired in 2009, after serving as its chief executive officer for more than thirty years. Previously, he was chair of the Mathematics Department at the State University of New York at Stony Brook. Earlier in his career, he was a cryptanalyst at the Institute of Defense Analyses (then located in Princeton, New Jersey), and taught mathematics at the Massachusetts Institute of Technology and Harvard University.

Simons is the founder and chair of Math for America, a nonprofit organization whose mission is to improve math education in U.S. public schools. He serves as a trustee of Brookhaven National Laboratory, the Institute for Advanced Study, Rockefeller University, the New York Genome Center, Institut des Hautes Études Scientifiques, and the Mathematical Sciences Research Institute in Berkeley. In addition, he is a member of the board of the MIT Corporation and chair emeritus of the Stony Brook Foundation, as well as a member of the American Academy of Arts and Sciences, the American Philosophical Society, and the National Academy of Sciences.

Simons earned a BS in mathematics from the Massachusetts Institute of Technology and a PhD in mathematics from the University of California, Berkeley. His scientific research was in the area of geometry and topology. He received the American Mathematical Society's Oswald Veblen Prize in Geometry in 1976 for work that involved recasting the subject of area-minimizing multi-dimensional surfaces. Simons' most influential research involved the discovery and application of certain geometric measurements, now called the Chern-Simons invariants, which have wide use, particularly in theoretical physics.

In September 2022, James Simons spoke with members of the Journal of Investment Consulting *editorial board about how his experience as a mathematician prepared him for success in the financial world; the main ingredients of his quantitative investment firm's success—building and continuously improving investment models through regular testing; hiring excellent scientists who have decided they want to make money rather than people with previous experience in finance; and fostering collaboration among the company's workforce. Other topics covered in the discussion included current competition in the quantitative approach to investing, the difficulty of predicting how advances in fundamental research will eventually be applied in the real world, and the numerous philanthropic activities Simons supports. Taking part in the discussion were Inna Okounkova, Columbia University and editor-in-chief of the* Journal*; Edward Baker, Mesirow Financial; Ludwig Chincarini, University of San Francisco and United States Commodity Funds; Arun Muralidhar, Mcube Investment Technologies; and Margaret Towle, Yakima River Partners.*

Edward Baker: You were an extremely successful mathematician in the early part of your career with some path-breaking work in differential geometry. And your work with Shiing-Shen Chern in particular was important to the future of that field and many fields in mathematics.[1] Then you went into finance. Has your deep training in mathematics helped you? Or has that just been interesting but superfluous to your success in finance?

James Simons: Well, as you know, Renaissance is very quantitative, and the fact that I was a mathematician was somewhat helpful. It gave me the ability to tell who was good and who wasn't.

Edward Baker: In terms of your employees, you mean?

James Simons: Yes. The work with Chern was amazing, because what's called Chern–Simons theory is now embedded in physics.[2] Every day an average of four papers come out in the physics journals, or in the archive, referencing and using

Chern–Simons. It's particularly astounding because neither of us knew any physics. Well, maybe Chern knew a little, but I didn't know any physics.

Edward Baker: It's typical of mathematics, isn't it, that when new ideas come to light, they don't seem to have anything to do with the applied world. And then in many cases, they become hugely important.

James Simons: Well, I certainly like mathematics, and I was a pretty good mathematician. Then I started trying to make money.

Edward Baker: And has the mathematics been useful, or has it just helped you identify talent?

James Simons: I understood that people would come up with new ideas that I was able to understand because I am a mathematician. But mostly, hiring great people was beneficial.

Edward Baker: Has collaboration been as important in your research team as it is in mathematics?

James Simons: At Renaissance, collaboration has been extremely important.

Margaret Towle: Over the course of your career, Jim, you've given a number of interviews. In one of them in 2020, you talked about the secret sauce of what made you successful. You said the first ingredient was hiring great people, and the second one was providing great infrastructure. What you did early on was to create an infrastructure that was not just out of the box—it was a brand-new box. And you were fostering collaboration as Ed mentioned, and sharing profits with everyone.

In your family office and especially in your private foundation, there's a different model in terms of sharing the profits. How have you compensated for this missing element? How do you run the private foundation or your nonprofit activities to take advantage of what I consider an important tenet of successful organizations?

James Simons: Obviously we're a not-for-profit, so we don't have any profits to share. We hire scientists in various areas. Math and physical science constitute one area in which we offer grants. We also offer grants on the biological side. We also created the Flatiron Institute,[3] which now has five groups of about fifty people each: computational biology, computational astrophysics, computational quantum physics, computational mathematics, and computational neuroscience.

These groups don't have to apply for grants, like many scientists have to, because we pay them. I won't say these people are not interested in making money, but they get good salaries, and the best people get the highest salaries, more or less. The people are terrific, and they've accomplished an awful lot. The Flatiron Institute is called that because it's in the Flatiron District in New York City. I'm very proud of it.

Margaret Towle: It sounds like you've figured out a way to motivate group members relative to their interests. Applying for grants is time-consuming and often involves a lot of administrative hassle. So perhaps you've substituted salaries for a share of the profits.

James Simons: Well, if you think a share of the profits is not having to apply for a grant.

Inna Okounkova: On the topic of philanthropy, Jim, you and your wife Marilyn have provided substantial financial support to various causes in many fields. In the field of mathematics specifically, your funding is probably comparable to the support of the National Science Foundation, and it touches all levels of mathematical education from middle school to universities to scientific institutes. The next International Congress of Mathematics will be in Philadelphia, thanks to your generosity, and we're all grateful to you for that. But how satisfied are you with the impact you've made on mathematical research and education so far?

James Simons: Let's talk about education. We started a nonprofit called Math for America, which, in its early years, focused on recognizing outstanding teachers in New York City—identifying the best teachers and bringing them into the fold.[4] They had a four-year run, and they received $15,000 a year on top of their regular salaries. After four years, if they had done a really good job, they could apply for another four years. At a certain point, we decided to include science as well as mathematics. Currently, about half of the high school courses cover mathematics, and the other half deal with biology, chemistry, and physics. It's been a remarkable project. It's been going on for maybe twenty years, and it costs us $25 million a year to run. Now, it's going to be national.

In the science bills that just passed Congress, there's a provision that's going to take nationwide what we've been doing in New York City.[5] I tried to get that done for years. We approached Obama with the idea; he liked it, but his Department of Education head only wanted to fix bad teachers. We're doing the opposite. We're identifying and rewarding outstanding teachers. So now this program will be nationwide. It's going to take a while to open it up across the country because the program needs to be approved by the Appropriations Committee, so we hope that won't be a stumbling block.

Ludwig Chincarini: A number of portfolio managers who have left Renaissance's Medallion Fund—I'm thinking in particular of Sandor Straus[6]—have not been able to replicate the

performance of Medallion. What is the secret of the success of the Medallion Fund, in terms of broad investment strategies? If you want, please touch on matters like whether you have automatic trading or traders, what types of data and price predictors you rely on, how you save on transaction costs, and what types of assets you invest in globally—futures, equities?

James Simons: The secret of Medallion's success is hard work over a long period of time by a team of world-class scientists who take a mathematical approach to investing.

Ludwig Chincarini: Who leads that team of world-class scientists now?

James Simons: Peter Brown has served as Co-CEO and then as sole CEO since I left Renaissance 13 years ago.

Ludwig Chincarini: My original question was simply what is the trick or the secret sauce that makes Medallion successful? But when you said it's hard to replicate, I also asked why it's so hard to replicate.

James Simons: It's hard to replicate because it took thousands of person-years to build it.

Ludwig Chincarini: Do most of Medallion's model-building math and statistics basically rely on predictions from those tools? Or do you also consider other popular trends, such as behavioral bias, in which some funds and some people believe humans make mistakes and investors can take advantage of those mistakes? Or do you have an agnostic view regarding those types of considerations and simply stick to the math and the predictions?

James Simons: We stick to the math.

Arun Muralidhar: The big issue in our business is separating signal from noise or skill versus luck. Would you elaborate on how math helped you as you went about identifying good strategies or separating the signal from the noise?

James Simons: The mathematics I did was essentially training my mind; none of it had anything to do with making money. Although Chern-Simons was wonderful, it does not help at all with making money.

Edward Baker: What sort of longevity do you expect from your model?

James Simons: We are constantly changing the model to incorporate new information. Some aspects of it last for a very long time, others not as long, and some are just wrong from the beginning because we've mistaken noise for signal.

Edward Baker: Market cycles change, things don't work for a while, and then they'll work again. How do you deal with that?

James Simons: We have only one model, one system, which is improved continuously on the basis of new signals and market behavior in general.

Edward Baker: Do you sometimes change your model one way and then later find you have to change it back?

James Simons: Yes, that can happen.

Ludwig Chincarini: Correct me if I'm wrong, but is some of the testing you do a bit like data mining—meaning, are you testing lots of strategies until you find one that works well? And is that good or bad?

James Simons: Yes, we do a lot of data mining. We have thousands of computers scouring data for information related to the movement of tradeable instruments. Sometimes what we find works, and sometimes it does not.

Edward Baker: Do you think it's become harder to make money using quantitative approaches like this? There's certainly more competition, more people using this approach. Has that made it harder or not?

James Simons: I think this has made it harder. The more quantitative funds there are, the more competition we'll have. In business, you need to beat the competition. It's true that when we started, there were few quantitative funds. Maybe there were one or two. But you just have to try to stay ahead of the pack. We don't know what they're doing, but we know what we're doing, and we just have to get better and better at it.

Edward Baker: Obviously, one of the things that's changed since you started is the availability of massive datasets. Has that changed your approach?

James Simons: As new datasets become available, they are incorporated into what we're doing.

Arun Muralidhar: How has the field of artificial intelligence and machine learning influenced investment strategies in general, and how has it affected your own experience? When I talk to folks who operate funds in that space, one of the challenges they sometimes cite is their inability, in a machine learning system, to explain why they got the signal. The machine simply did it. What are your thoughts on this area of investments?

James Simons: Machine learning has come a long way, and is very important to our work at Renaissance and at Flatiron.

Edward Baker: Have you found that people coming from quantitative training in finance programs are sufficiently well qualified for what you do? Or do you only look for pure mathematicians and scientists?

James Simons: We look for mathematicians and scientists and statisticians. We don't look for anyone who has worked in the financial industry before. We look for very good scientists who are interested in making some money, and we interview them. I believe there's too much emphasis on a person's being able to answer questions quickly when being interviewed. I remember a guy who gave slow answers during his interview, but it seemed to me he would be a good addition to our firm. So I called his thesis advisor at Harvard and asked about him. The advisor said: "Well, I had a number of problems that students could work on. He chose to work on the hardest one and did a great job." I overruled the interviewing group and said, "We're going to hire this guy." And he was very good indeed.

Ludwig Chincarini: That's a great point, Jim. I remember when they asked derivative group questions on Wall Street. Just as you were starting to answer, after 30 seconds they put the next question on the table. So it's great to hear this from you.

James Simons: I would never have done well at a math competition. I'm not an extremely fast thinker myself; I just work hard. That was all I needed to do—work hard, not fast. A paper of mine that was published in 1968 took me five years to write. But it has had 1,850 citations in the mathematics literature. For a math paper, that's an awful lot of citations.

Margaret Towle: What do you see as some of the challenges in the world of quant investing today in addition to the space being crowded? And looking ahead, what do you see as opportunities for this type of investing, given that quant investing is model-driven?

James Simons: A few months ago, a friend of mine won the Abel Prize, which is the biggest prize in mathematics.[7] It's given out in Norway, and my wife and I accompanied him when he traveled to receive the prize from the King of Norway. However, I was the one who was interviewed. One interview was conducted by the group that manages Norway's money, which is a treasure trove. I think they have $1.2 trillion under management because the country has offshore oil. This group asked me about quantitative methods, which they apparently didn't use. I suggested that it wouldn't be a bad idea for them to hire some quants. There were probably a hundred people in the room who were doing quantitative work. I said: "It wouldn't be a bad idea to bring on some people who could do quantitative investing."

Arun Muralidhar: Jim, I'd like to go back to your comment about the lack of educational resources in math and science, because it is personal to me. My wife was teaching a kindergarten-level curriculum called STEAM—science, technology, engineering, art, and math—and was getting paid less than an assistant. The school system was trying to introduce this curriculum in its elementary schools, but there was no budget for it. So what does this country need to do to change that, apart from pure funding? Where does the needed leadership come from?

James Simons: I hope some of it will come from this new national program. Its a shame that teachers in general, not just math and science teachers, get paid so little. And they don't receive enough respect from other workers. Finland, for example, has outstanding teachers. They are paid well, and their students get a very good education. I have four grandchildren, and two of them were scientifically oriented. One got his PhD in astrophysics and wrote a great thesis. I thought, "Oh, a great scientist in the family." Then he announced that he wanted to be a high school teacher. At first, I was slightly disappointed, but then I realized that if you're a good high school teacher, you're going to touch maybe as many as a thousand students over the course of your career. And if you're a very good teacher, maybe ten or so of those students will become astrophysicists. So I'm proud of him; he just got a job outside of Boston.

My granddaughter went to Columbia, where she majored in math and computer science. After she graduated, she came to work at Flatiron for a year, and she was terrific. Then she went to Harvard and got a masters degree in math and computer science, and a couple of weeks ago she also became a teacher, here in New York. So of my four grandchildren, two are math or science teachers, and that's very nice.

Ludwig Chincarini: How much do you think success is the result of genetics, the nurture and training your family provides, and luck? How would you rank the importance of those three influences?

James Simons: I'm writing my memoirs at the moment. The title is *Mathematics, Common Sense, and Good Luck*. You can't forget good luck. You have to be a little lucky. I was not raised to simply do well in school. My parents didn't think about my being a mathematician or anything of that sort. Our family doctor kept urging me to be a physician. I told him: "I don't want to be a doctor. I want to be a scientist of some sort." And he said to me, "Well, you'll never make any money doing that." I wish he was around today to see how wrong he was.

Edward Baker: However, if you'd stayed purely in the field of mathematics, your fortunes would be different. When you changed your career path by leaving mathematics and entering

the investment business, that's when you generated your fortune. So I agree with you that pure scientists are not particularly driven by economic potential.

James Simons: That's right. Most good scientists just want to keep doing good science. But some—and this is the type of person Renaissance seeks to recruit—some decide they would like to make money at some point in their career. There's nothing wrong with making money. But most good scientists just work hard and get a lot of satisfaction.

Edward Baker: There's also the issue of visibility. When you're a scientist, you publish; you might have a paper that's cited 1,850 times. But do you publish research at Renaissance? Do your scientists have an opportunity to publish? Or is everything kept close to the vest?

James Simons: I don't know of any scientists at Renaissance who have published papers in their field after coming to Renaissance. There may be somebody, but I don't know of anyone. When I was young, I worked at the Institute for Defense Analysis for four years, located in Princeton, New Jersey, at the time. It was a code-cracking outfit, indirectly in support of the Department of Defense. The job paid well, and you could spend up to half of your time on your own work and the other half or more on the agency's work. Although I didn't know anything about code-cracking, I learned some things, and I actually solved a longstanding problem. The National Security Agency built a special-purpose computer to implement that algorithm. As far as I know, it's still operating. But it was during this four-year period that I wrote the paper I referenced earlier, so I took advantage of both aspects of the job. It was fun.

Edward Baker: Speaking of code-cracking, cybersecurity is currently an important issue, and I presume you worry about people sneaking in through cyber cracks to steal secrets. Is that a big area of concern and expenditure for you?

James Simons: At the foundation, not especially. As for Renaissance, I don't know what they do to stay secure, but I'm certain they're extremely careful and have systems that prevent people from breaking into the store, so to speak.

Arun Muralidhar: Jim, I'd like to ask for your thoughts about a fairly new trend in the investment space, which is ESG [environmental, social, and governance] investing. It's more common in Europe than in the United States. Do you think this is something that's going to stick? I work with Dutch pension funds, for example, and ESG is a prominent part of their investments.

James Simons: I don't really have many thoughts on this subject. Obviously, it will not be the best for your portfolio if you restrict yourself to certain areas and people, even if they are doing well in some sense. You won't make more money by limiting yourself in that way; it will cut into your earnings.

Margaret Towle: It's interesting that there's such a division of thought regarding ESG. One faction might be labeled the do-gooders. The other group favors eliminating the governance component and considering environmental and social factors, which are potentially nonfinancial drivers of return or risk. In the past, we used machine learning and big data to identify risk outside the scope of what the company was reporting, because self-reporting is almost always good reporting. An example might be Starbucks. At one time its biggest risk factor in terms of governance was employee turnover, which is expensive for a company. In an attempt to keep baristas, the corporation gave them access to a college education, and that seemed to reduce turnover.

In the future, I expect people won't use the term ESG investing. Instead, they likely will say, "We're adding this framework of nonfinancial drivers of return or risk that are not being measured by return on equity or debt level or any of the other conventional measures."

James Simons: It's interesting that Starbucks implemented programs to reduce employee turnover; that had to improve the company's bottom line.

Edward Baker: That's an element of the S side of ESG investing that some people consider when they invest in companies. They want firms that are doing good for their employees, and presumably that can and should be good for the bottom line as well.

James Simons: Yes, it should be.

Ludwig Chincarini: Still, many people are making ESG investments in order to support what they consider good causes. So we can't ignore that a sizable portion of the money is being applied toward these goals.

James Simons: Well, I'm not a do-gooder.

Edward Baker: Oh, you are, in a way. You support issues that are concerned with climate change, for example. You support a foundation that your son runs.

James Simons: Yes, my son runs the Sea Change Foundation, which focuses on climate change.[8] It's a very good cause, and he worries, rightly so, that the atmosphere is going to get warmer and warmer unless we do something about it. I don't think he expects to make a great deal of money doing these things, but we don't make money running our foundation

either. Although our foundation is devoted primarily to science, about 10 percent of its resources go toward education and outreach, such as supporting Math for America and publishing a magazine called *Quanta*.[9] Do any of you read *Quanta*?

Inna Okounkova: Yes—wonderful material always.

James Simons: It's a wonderful magazine. It's online and it's free. Among other accolades it has received for its science journalism, *Quanta* won a 2022 Pulitzer Prize in Explanatory Reporting and a 2020 National Magazine Award for general excellence.

Edward Baker: Of course, it's science and technology that will help us solve our climate problems, so we need fundamental research. But we don't know which aspects of the research will ultimately be used to help solve the problems.

James Simons: You're right; you never know how new science will be applied. Did you ever hear the story of I. I. Rabi?[10]

Edward Baker: No.

James Simons: Rabi was a physicist in the first half of the twentieth century, and he won a Nobel Prize for discovering nuclear magnetic resonance. Later, two other researchers realized they could use this technology to measure and analyze materials, and they also won a Nobel Prize.[11] Subsequently, some other scientists discovered that the technology could be used to take pictures, and they called this technology magnetic resonance imaging (MRI).

Now, thanks to I. I. Rabi's work in pure science some eighty years ago, there are thousands and thousands of MRI machines in hospitals all over the world. This is an example of pure science having a tremendous impact on the world.

Arun Muralidhar: Over the past decade or so, we've had more interventionist central banks in markets around the world—the Federal Reserve, the European Central Bank, and a number of other central banks. Do you consider that a good thing or a bad thing for markets? We're hanging on their every word at every press conference.

James Simons: I really don't know. Central banks have always intervened in markets. The most notable example was [former Fed Chairman] Paul Volcker; when inflation was running rampant, he raised interest rates to 20 percent in 1981. That did it, and inflation stopped. Volcker is actually one of my heroes, although I don't have many. My real hero is Abraham Lincoln.

Ludwig Chincarini: When you create your investment models, do the models explicitly take into account things like the monetary environment, including what the Fed is doing? Or do they simply rely on statistical analysis?

James Simons: We use statistics and mathematics to formalize our understanding of things like the monetary environment.

Edward Baker: I'll ask just one more question, Jim. If a young mathematician came to you today and said, "I'm looking to get into the investment business," would you encourage that person? And what advice would you offer?

James Simons: I would encourage mathematicians who want to make money, and I would direct them to apply to Renaissance and see if they could be hired there. I think there's still plenty of opportunity.

ENDNOTES

1. Shiing-Shen Chern (1911–2004) was a Chinese American mathematician and poet. He made fundamental contributions to differential geometry and topology. He has been called the "father of modern differential geometry" and is widely regarded as a leader in the field of geometry and one of the greatest mathematicians of the twentieth century, winning numerous recognition and awards, including the Wolf Prize and the inaugural Shaw Prize.
2. The Chern–Simons theory is a three-dimensional topological quantum field theory of Schwarz type developed by Edward Witten. First discovered by mathematical physicist Albert Schwarz, it is named after mathematicians Shiing-Shen Chern and James H. Simons, who introduced the Chern–Simons three-form. In the Chern–Simons theory, the action is proportional to the integral of the Chern–Simons three-form.
3. The mission of the Flatiron Institute is to advance scientific research through computational methods, including data analysis, theory, modeling, and simulation. https://www.simonsfoundation.org/flatiron/.
4. Learn more at https://www.mathforamerica.org/.
5. Refers to the CHIPS and Science Act of 2022.
6. Sandor Straus is president of the Firedoll Foundation, a private foundation founded by himself and his wife, Faye Straus. He is the managing member of Tigmera, LLC, his family office. He was previously a partner of investment firms Edgestream Partners, L.P. and Renaissance Technologies Corp.
7. The Abel Prize is named after Niels Henrik Abel, Norway's greatest mathematician throughout history. Abel left lasting marks on the mathematical world. His mathematics have served as a basis for a number of major technological breakthroughs, among them the development of the internet. The Abel Prize was established by the Norwegian Parliament in 2002, on the occasion of the 200-year anniversary of Abel's birth. See https://abelprize.no/.
8. Founded in 2006 by Nat Simons and Laura Baxter-Simons as a private family foundation, Sea Change Foundation is dedicated to achieving meaningful social impact through strategic philanthropy that addresses the most pressing problems facing the world today. The foundation is currently working to address the serious threats posed by global climate change, focusing primarily on climate change mitigation and clean energy policy. See https://www.seachange.org/.
9. *Quanta Magazine*, https://www.quantamagazine.org/.
10. Isidor Isaac Rabi was an American physicist who won the Nobel Prize in Physics in 1944 for his discovery of nuclear magnetic resonance, which is used in magnetic resonance imaging.
11. Felix Bloch and Edward Mills Purcell received the 1952 Nobel Prize in Physics "for their development of new methods for nuclear magnetic precision measurements and discoveries in connection therewith."

REFERENCE

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