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There's a knitting calculus. An irrepressible batch of wool gets twisted and fed into a rotating wheel, a wooden machine about as high-tech as an abacus that binds fibers to a single strand of yarn. This yarn, in turn, is so wowomand into geometric patterns composed of equations: A certain number of rows in combination with certain stitches brings something functional and beautiful. In the right hands, knitting produces precise but almost magical alchemy-chaos into order. You can see why he would appeal to Brenda Dietrich.Dietrich, 47, runs a mathematical science department at IBM's renowned Thomas J. Watson Research Center-top mathematical manager at arguably the largest and most important mathematical department in corporate America. He loves mathematical beauty and complexity. Yet she often spends conference calls and meetings spinning yarn on the steering wheel next to her ThinkPad. And she knit an incessantly-scarf, coat, scarf, and hat during the simultaneous. That beautiful blue and purple cashmere scarf in her office? This was last year's meeting of research software strategy, he says. I sat in the back row knitting for three days. Dietrich, who has co-authored 13 patents and was twice named one of IBM's best inventors, likes to make things-tangible things, not just a sentence. As a mathematician, she has a rare ability to travel between two very different worlds, says Paul Horn, head of IBM research. She can listen to the customer describe the chaotic details of the business, then translate these specifications into mathematical problems for her team to solve. And he thinks mathematics should live in the real world, in the world of customers. When she took over the math department in 2001, she encouraged researchers to venture beyond Watson, which she calls that beautiful stone building on the hill, and work with IBM consultants in the field. These days, her team is, in fact, rearing from years of behind-the-scenes, mostly theoretical research to address an impressive array of real-world issues within IBM and beyond. How to assemble a project team from consultants scattered around the world. How to combat large-scale forest fires more effectively. How to identify the best sales leads in the pipeline. OnTarget, a sales-prediction software that grew out of mathematical research, generated \$100 million in new revenue as a pilot program in Canada. Last year, it brought in about \$500 million in worldwide use, an amount that makes Dietrich giggle as if she can't quite believe it. Dietrich's 160 researchers are in fact increasingly among the most valuable problem solvers at IBM. Historically, the stars here were physicist who took technology that went into chips and systems, and then it was computer scientists and engineers, says Horn. Now we are witnessing the emergence of mathematicians. They're embedded everywhere. This is partly due to IBM's transition from hardware to software and services. And part of it, surely, is the function of Dietrich's marketing and political savvy: geek but far cry Personality-challenged stereotype, she understands how to get attention and resources in the organization of 330,000 people. More than that, her department's growing influence reflects a larger real-world shift. A generation ago, businesses at best called on mathematicians to optimise production lines and perhaps support pricing decisions. What more could contribute to the bottom line? Today, companies measure almost every aspect of what they do, and computers are fast enough to crunch numbers in time for execs to act on the analysis. In the hands of talented mathematicians, data creates an invaluable advantage. Sophisticated algorithms reveal the company's inefficiencies and opportunities – invisible supply chain barriers or hidden customer shopping patterns. Entire companies–I think Google–are built almost entirely around math. And others, like IBM, integrate mathematics into operations and decision-making in ways they have never seen before. This is what the industrial age must be like for mechanical engineers. It's a great time, says Dietrich, to be a computational mathematician. The number-theory class at the University of North Carolina at Chapel Hill changed Dietrich's mind about becoming a doctor. Mathematics was a revelation of how to hear music for the first time. There's structure and symmetry and the most beautiful theory, he says. It made me believe in some basic ranking in the world. Dietrich, whose husband is an IBM software architect, joined the company in 1984 after winning her PhD in operations research and industrial engineering at Cornell, and she used that wonderful theory to design a more-efficient chip-production line. It was exciting to see how useful mathematics could be. In the mid-1990s, she was bored between projects – a dangerous situation, laughing and watching a new set of problems that spent six months in the field with IBM consultants and customers. They couldn't tell dependent and independent variables, he says. But she could, and that ability to translate practical into theoretical (and back) was powerful. In some ways, her experience was the basis for how her research department now works. If you are not a mathematician, the deep mathematics that Dietrich and her team perform sounds of completely alien-combining auctions, integer programming, conditional logic, and so on. Their blackboard doodles on Watson look incomprehensible, such as Thesis or Greek (then again, many symbols are Greek). But these mysterious equations represent the real world and how it works. When mathematics model the problem, they create a numerical snapshot of the dynamic system and its variables. Take the forest-fire project Dietrich and the researchers are working on. Extinguishing rapidly spreading flames on tens of thousands of acres is an expensive and complicated business. In 2000, a particularly devastating year, the federal government spent more than \$1 billion and still lost then 8 million acres. Its fire planners want to reduce costs and damage through better coordination between the five agencies involved. Armed with seven years of data, IBM mathematics are creating a huge model that shows how resources-every firefighter, truck, plane, etc.-have been used in the past, how much each effort costs, and how many acres burned. Algorithms describe the likely costs and results for any number of fire fighting strategies. How many bulldozers and buckets do you have in Yellowstone Park? Dietrich asks. And if you need to move elsewhere, how much will it cost and how long will it take? He speaks quickly, describing unruly variables that mathematics makes sense. It's a nice project. Complicated, what? Uh, yes. For years, mathematics have been so focused on basic research that they would be close to projects like this-and they weren't asked to, either. It was like working at a university without the burden of teaching, says longtime researcher Baruch Schieber. When you decided what to work on, the first consideration was not how it would affect society? If the researchers wanted to, they could close the door of their office and focus on the most esoteric research, uninterrupted and isolated. At first, Horn says, putting math specialists in front of clients made everyone nervous, not least of all clients. The researchers are undeniably brilliant, he says, laughing, but you'll wonder how some of them get home at night. Watson, located an hour north of New York City, has a carefree, collegiate feel; sneakers and jeans, along with the occasional bushy moustache and ponytail, are the norm. Stubborn, professorial types fit right in. Dietrich may seem brilliant and charmingly quirky, but when he sticks to the intricacies of mathematics, he can be intimidating. He doesn't suffer from fools and enjoys a good debate. But Dietrich has learned to soften his approach to avoid disrupting consultants' relationships with clients. She helped create a class for researchers that explains the consultation process and culture. Perfectionism mathematics must give way to deadlines. The smartest-person-in-the-room vibe is considered off-putting, rather than an invitation to match wits. Instead of forcing an argument about logic that we're trained to do-it's a little adversarial-you have to shut up and listen, he says. And you have to stay away from the technical muck. Some longtime mathematicians initially feared that the research would suffer under Dietrich. Instead, they lead a double life. In fact, says researcher Robin Lougee-Heimer, projects like the one she's working on now, a nationwide distribution puzzle for a brand-name customer, reveal prolific research topics. I'm still exposed to big problems, he says, with ugly details and complexity. It used to be that Schieber, a senior manager in optimization, would hear about the project within IBM and occasionally reach out to consultants. rarely returned their calls. Now he says, I'm the one who's selective. When we first started asking what resources consultants use for projects, they said that each project is different. That just made me crazy. The word is out: The math team can help. Dietrich fields several dozen requests per month, half of which are rejected because the problem has already been solved or is not challenging enough. We want to push the boundaries of what is solvable, he says. Otherwise, what's the point? In a sense, Dietrich does what she liked as a young math whiz-solving verbal problem. Here's the doozy: After IBM's sales team signs a consulting contract, the company often has to assemble a project team to term-say, 50 Java developers in Chicago by next Monday. It can choose from 190,000 consultants around the world with different skills, personalities and availability. It has to do this for thousands of projects a year for clients of all sizes in every representative industry. Meanwhile, the mix of projects and available consultants is constantly changing. When we first started asking what resources consultants use for projects, they said each project was different, dietrich says. That just made me crazy. Poring over two years of project data, mathematicumatics identify which skills were most commonly used in certain types of tasks. You may not know exactly what the customer wants, but now you have a rough idea of who you need for the \$5 million project versus the \$50 million project, says Dan Connors, optimization manager for the workforce management program. This staffing analysis tool has helped managers anticipate demand and plan accordingly, increasing consultants' productivity by 7% and reducing travel costs and the use of external contractors. The savings exceeded \$500 million. So does the math: Add in sales from OnTarget's forecasting tool, and that's a \$1 billion contribution to Dietrich's math whizz. Brainiacs solves another problem whose solution could be just as valuable: how to select the best teams. Project managers tend to select the most talented developers and engineers who are available or who already know them. This may work well for the project on the side, but in the long run, it doesn't necessarily benefit IBM as a whole; better spread the talent around. The researchers also produce a social networking analysis to assess traces of emails, instant messages and phone calls to determine which teams function as flat organizations and which ones are hierarchical, who works well together and who doesn't. But the problem that is really grabbing Dietrich involves predicting the workforce's future. By analyzing population trends, the demographics and skills of employees and the demand for certain technologies, its researchers hope to identify labour shortages in various functions and professions before this happens. This work, almost unthinkably complex and far-reaching, is far from Each response generates generates questions, and that's fine, that's good, that's good. Even mathematicumatics don't have all the answers. Dietrich will not be bored and will turn out her beautiful knitting. Ultimately, she will have numbers to help us think differently about the world and where it's headed-up and IBM and its customers will hire or train employees accordingly. It may well turn out, of course, that what they need are more mathematicians. Mathematicians.

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