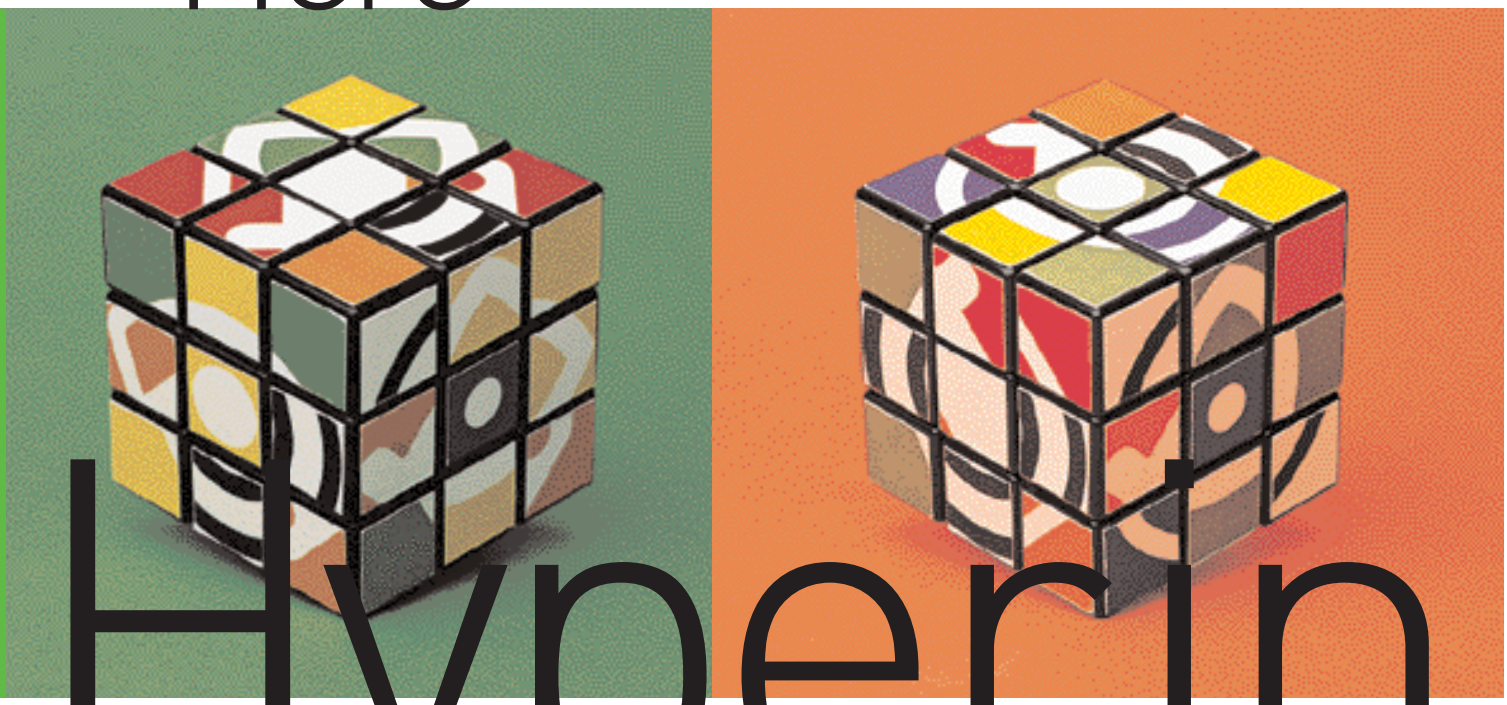
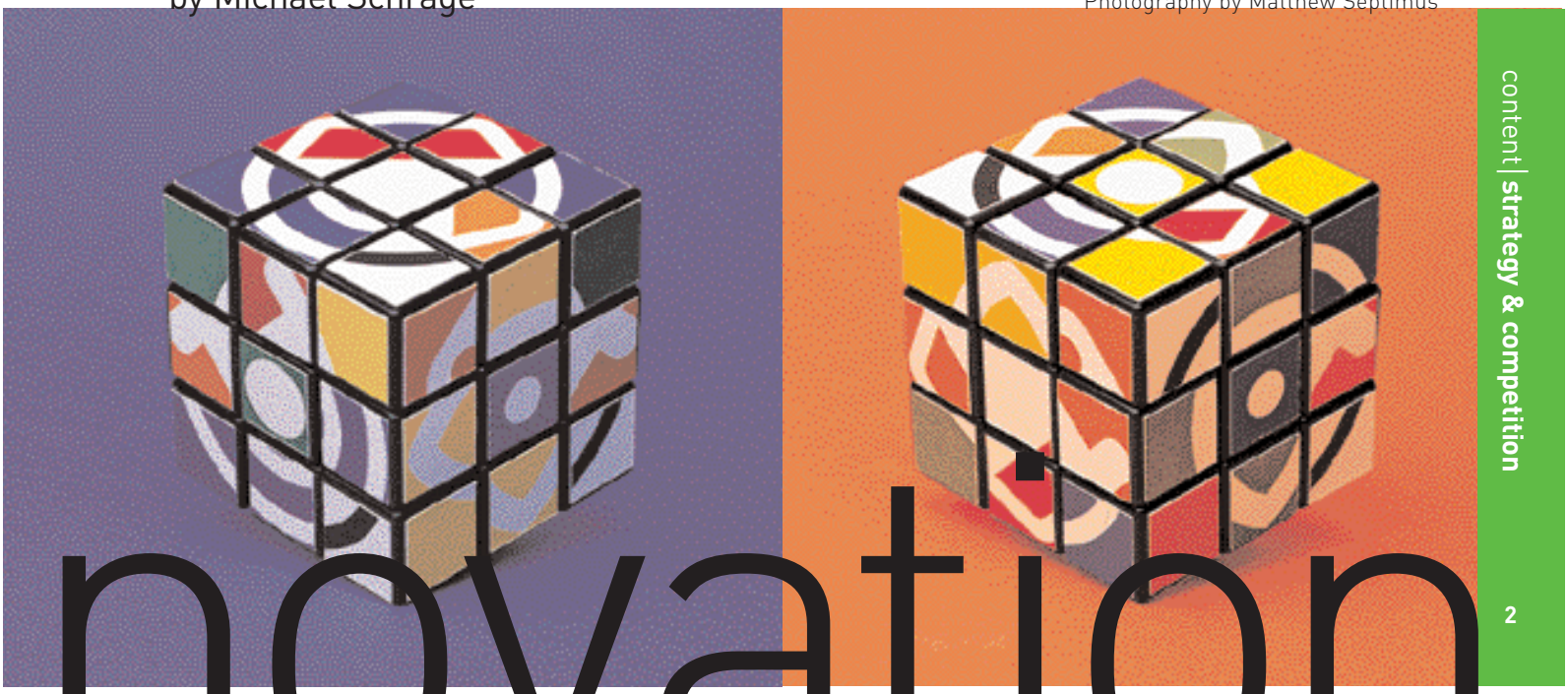
Here Comes Hyperin



New prototyping methods have radically reduced the cost of testing products, services, and business models — effectively creating a new financial resource: iterative capital. Be sure you spend it wisely.

by Michael Schrage

Photography by Matthew Septimus



novation

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A new economics of innovation is transforming global business. The marginal costs of prototyping products, simulating services, and modeling business systems are rapidly shriveling into insignificance. It's becoming ever cheaper and easier for ambitious organizations to explore new ideas faster. The inevitable result? Hyperinnovation.

Hyperinnovation is what happens to innovation when innovators upgrade from a scarcity of resources to an embarrassment of riches. Rules change. Opportunity and risk get redefined. Top management has to rethink its innovation strategy and tactics. Hyperinnovation forces even the most innovative firms to pick up their pace. They have little choice.

In their rapidly changing markets, Cisco Systems, Nokia, Goldman Sachs, and American Airlines have aggressively positioned themselves both as first-movers and as even faster followers. Firms like Boeing, Dell, DaimlerChrysler, Industrial Light & Magic, and Federal Express depend utterly on hyperinnovation infrastructures, built on networks of collaborative simulation systems, to hone their competitive edge. They know that the speed, creativity, and cost-effectiveness with which they model their innovations largely determine just how quickly, creatively, and cost-effectively they can bring those innovations to market.

From the outside, hyperinnovation may appear chaotic, a jumble of nonlinear pressures and processes. But the firms that engage in it most successfully understand that they are, in fact, investors in a rational marketplace that is being funded by a new form of capital. Not quite financial or human capital, this brand of capital has nonetheless become a rich and fast-growing source of disruptive wealth. Call it iterative capital: It is a resource that gives companies the ability to play seriously with more and more versions of various ideas in less and less time.

To appreciate the concept of "iterative capital," consider what might happen if the innovation budget of a new product development team unexpectedly tripled. In what might the team invest its sudden windfall? Exploring new ideas? Refining old ones? Hiring new people? Buying new equipment? Would this tripling of resources have a marginal or a major impact on the team's planned innovation initiatives? Now suppose the innovation budget is increased fivefold. Tenfold. One hundredfold. How about one thousandfold? Would *that* have an innovation impact? Of course it would.

The world's most innovative firms have in fact invested billions of dollars in tools and technologies that let them virtually model, prototype, and simulate their proposed innovations. Once these models are in the machines, the economics of iteration implode. The cost of making changes becomes essentially marginal. Want to alter a mission-critical assumption or test a pet hypothesis? Tap a key to do another iteration. Want to simulate the impact of a requirements change? Iterate, iterate, iterate. Digital media inherently makes iteration faster, cheaper, and easier. The fusion of Moore's Law, which predicts that the number of circuits that can be etched onto a silicon chip doubles every 18 months, and Metcalfe's Law — that the value of a network is the square of the sum of its nodes — ensures that the computational and network costs of doing iteration after iteration of a target model, prototype, or simulation will shrink to near-nothingness. Networked iterative capital is like networked financial

capital: Its velocity and impact increase as it hurtles toward opportunity.

Cisco Systems Inc., for example, uses software to simulate network architectures for customers deciding what kind of digital nervous systems they want to build for themselves. The Boeing Company and the Chrysler Group rely on a CAD/CAE package called Catia to prototype their airplanes and automobiles; Goldman Sachs Group Inc. depends on Monte Carlo simulations to stress-test its derivative and synthetic security innovations. American Airlines Inc. and the Federal Express Corporation digitally redesign their operations research models to manage their just-in-time logistics and pricing models.

As quickly and easily as word-processing programs alter text and spreadsheet software manipulates numbers, these "design processors" enable instant iteration in the pursuit of innovation. As networks link previously disparate parts of the organization with each other, with key suppliers, and with customers, "design processing networks" create new opportunities for collaborative iteration both between firms and within them. Iterative capital becomes an essential investment for firms managing strategic alliances and supply chains.

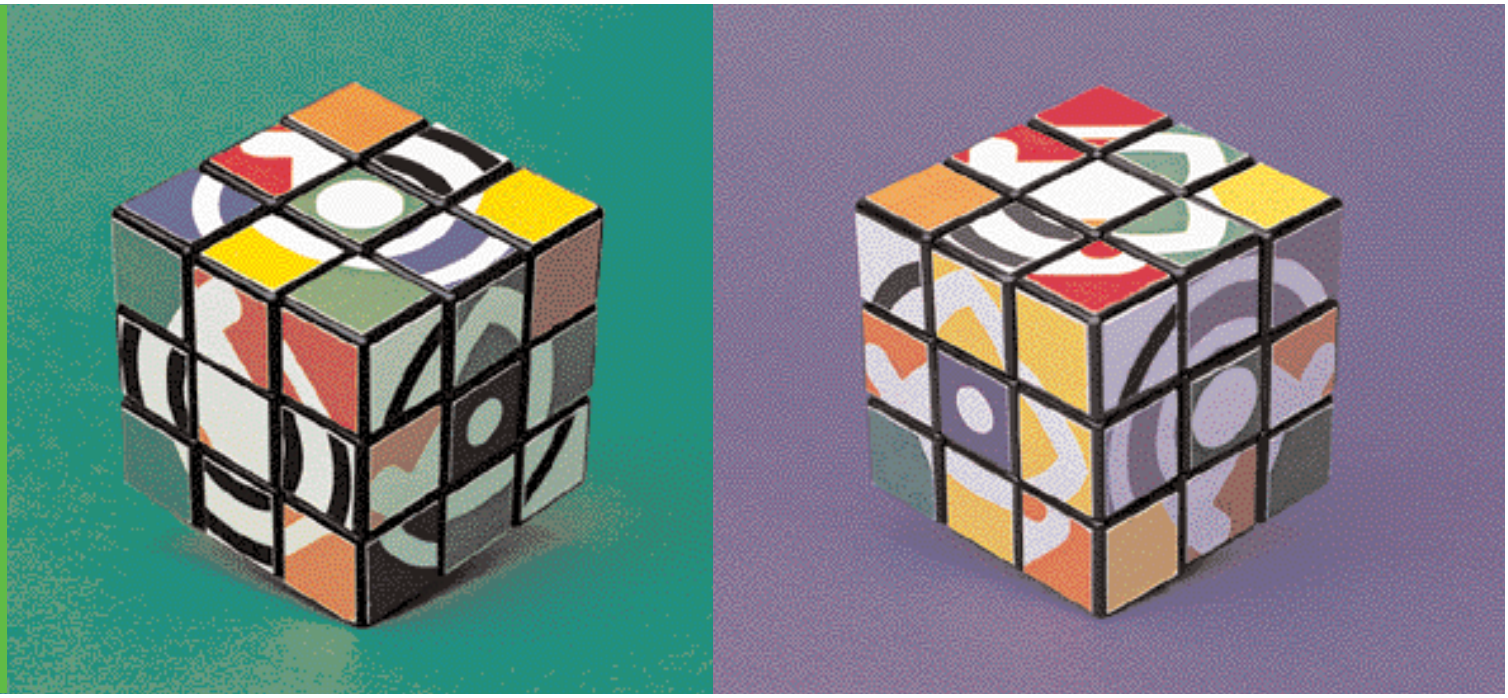
Capital Gains Explosion

Simple economics dictate that as the cost of iterations goes down, the number of iterations should go up. That's exactly what's happening. "Iterative capital" expenditures by leading innovators have grown by orders of magnitude. Instead of performing 10 or 20 iterations of a new product design or a manufacturing simulation, organizations can and do perform thousands or even tens of thousands. It's as if mere millionaires were becoming plutocratic billionaires. Organizations worldwide are becoming super-wealthy. The hyperinnovation story is the ongoing story of this iterative capital-gains explosion.

For example, as the Chrysler Corporation made the transition from drafting boards to digital media in 1995, the auto company used its Digital Model Assembly technologies to transform how it put together cars. Special software known as Chrysler Data Visualizer worked in conjunction with Catia to let engineers see if components interfered with one another or if they shared the same space in any way. The visualizer lent extraordinary speed to the once-mundane process of interference checks. In one case, while checking for interferences between sheet-metal components, the system performed 8,646 checks in 17 seconds. Two years before, back when Chrysler relied on physical models, comparable interference checks took well over three months. At this writing, there are DaimlerChrysler senior executives in Germany who still believe that Chrysler uses paper in the design and assembly of its automobiles.

Like financial capital, iterative capital, well invested, should yield real returns. The BMW Group uses specialized crash-simulation software to run thousands of virtual crashes of automobiles in its safety engineering efforts — a technology that has proven orders of magnitude less expensive and more reliable than crashing dozens of sheet-metal BMWs. Both German and American crash-test data confirms that BMW has built far safer and more crashworthy cars in far less time than before — value it is delivering to consumers, to dealers, and, ultimately, to shareholders. Boeing relies on digital media to manage not only the manufacturing interferences on its planes but to simulate tens of thousands of flight-control configurations. Virtual wings are tested and modified in virtual

Failure to wring new productivity from iterative capital isn't just an embarrassment. It's a postindustrial tragedy of epic proportions.

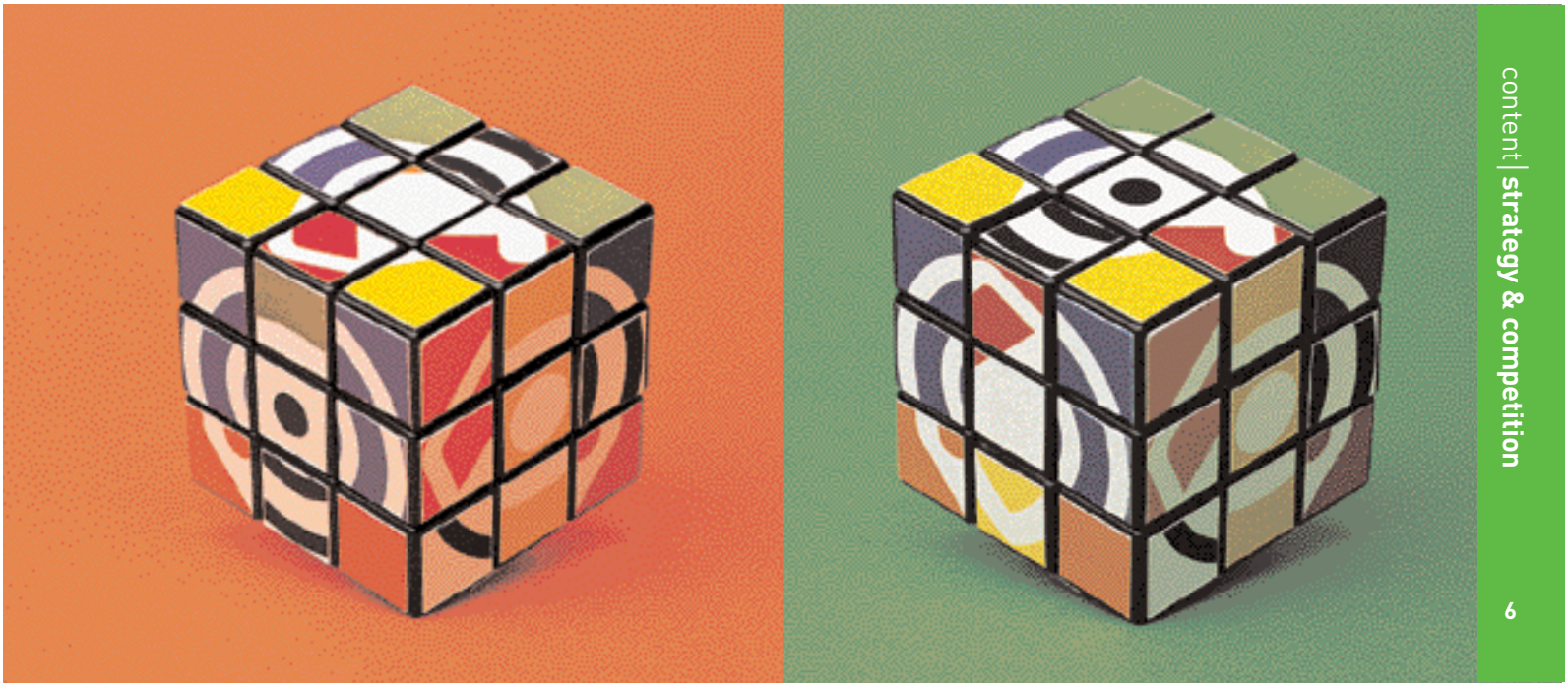


wind tunnels. The marginal cost of modification leads to greater testing and refinement of both design and engineering. A top Goldman Sachs "quant" reports that the banking giant performs anywhere between 10 and 100 times more mathematical "stress tests" of its more complicated derivative offerings than it did even five years ago. Risk managers and clients both insist on exploiting the iterative opportunity to test multiple financial scenarios. Central bankers say these risk management–modeling methodologies are making the global financial system safer.

Even Frank Gehry — the architect who designed the extravagant titanium-sheathed Guggenheim Museum in Bilbao, Spain — relies on Catia to manage the hundreds of tweaks, modifications, and iterations he performs on his building models. "The new computer and management systems allow us to unite all the players — the contractor, the engineer, the architect — with one modeling system," Mr. Gehry has observed. "It's the 'master builder' principle. I think it makes the architect more the parent and the contractor more the child — the reverse of the 20th-century system."

From "Bits" to "Its"

George Gilder, a rhapsodic observer of technology's productive charms, persuasively argues that there comes a moment when innovation vaporizes the economic assumptions the market has grown up with. He points to the microchips that have reduced the price of electronic circuitry by a factor of over 1 million since 1972.



Technology historians and consumers alike tend to focus on the end result of the microchip revolution: a world transformed by accessible computational power. But the design *process* by which that result has come about is equally revolutionary. As Mr. Gilder notes, electronics designers now treat transistors as a free commodity, not as a scarce resource. They throw them at problems, however small, with abandon. "Today you use millions of them to enhance your TV picture slightly or to play a game of solitaire or to fax *Doonesbury* to Grandma," Mr. Gilder observed. "If you do not use transistors in your cars, your offices, your telephone systems, your design centers, your factories, your farm gear, or your missiles, you go out of business. If you don't waste transistors, your cost structure will cripple you. Your product will be either too expensive, too slow, too late, or too low in quality."

What "free" transistors are to electronic design, "free" digital models are to product, process, and service design. Ingeniously "wasting" prototypes becomes essential to risk management. Throwing simulations at design problems becomes vital for detecting errors and discovering opportunities. Doing so gives birth to new ideas about new business models. The more models the merrier. Failure to wring new productivity from this embarrassment of virtual riches isn't just an embarrassment; it represents a postindustrial tragedy of epic proportions.

The rise of iterative capital is about the rise of choice. In fact, it is about the rise of choice by orders of magnitude. The more choices an organization has, the more its values matter. For the ordinary millionaire, venture-

capital investing doesn't make a lot of financial sense. But for a billionaire, *not* investing in venture capital doesn't make sense. Nobel Prize–winning economics research — the Capital Asset Pricing Model, for example — dictates that the truly wealthy should seek diversification in a wide variety of asset classes, including venture capital. In other words, the typical billionaire's investment portfolio should be different from your average millionaire's. The middle class has fewer investment choices than does the upper crust. Similarly, companies newly rich with iterative capital must profoundly revise their innovation portfolios. Companies that can invest tens of thousands of iterations should have different innovation profiles and portfolios than should firms that can invest only a paltry five or 10 iterations. More capital always means more choices. More choices means individuals and institutions must reexamine what they *really* want.

Ultimately, of course, almost all innovative organizations will become iterative capital investors. The question is, what kinds of investors will they be? Will they be speculators or value investors? What will their diversification philosophies be? Managing the iterative capital portfolio will define the hyperinnovation profile of the firm.

Tensions and Trade-offs

Consider this simple "thought experiment" to illustrate the tensions and trade-offs that digital modeling presents. A new rapid prototyping and seamless simulation infrastructure enables a manufacturing company to double the number of development cycles its product team can run. Under the old system, new product teams could perform 10 cycles during their 10-month development window. That is, the development team could do 10 iterations — or versions — of its product before the ship date. The new technologies now let the development team run up 20 full iterations at virtually no extra cost.

Think of those extra cycles as currency: Each additional cycle can "purchase" either a product improvement, a cost reduction, or a speed-up. Each cycle is as valuable as any other cycle. Unspent cycles are monies saved. The hyperinnovation management challenge emerges. Just how should the team "spend" or "invest" those 10 extra cycles? What expenditure of this iterative capital will give the best returns? Should these innovation teams:

- Spend all their cycles on speed to come to market in half the time?
- Spend their cycles on improvements and come to market with a product that is 50 percent "better" after 10 months?
- Spend their cycles on cost reduction to be able to cut prices by 30 percent?
- Spend all 10 cycles on the ideal blend of speed, price, and quality? Just what is that optimal blend? Why?
- Bet a couple of cycles on an intriguing but risky enhancement?
- Use a few cycles to test an alternate design approach?
- Save three cycles to keep the development costs down?
- Take those 10 cycles to develop an entirely new product concept?

There are no inherently right answers. Even worse, these hypothetical alternatives are far too simplistic. They lack the pain and menace that managers confront when hard organizational choices have to be made. Iterative capital investments, just like financial capital investments

and human capital investments, create political and cultural conflicts for organizations.

For example, the development team has to decide whether to use those extra iterative cycles to focus on particular product features or specific cost reductions. Allocating the new cycles can create rifts: Should design get three; manufacturing get three; marketing get three; and the remaining one be held in reserve for emergencies? Perhaps the product manager should "own" the cycles budget. Deciding when key customers and suppliers can be brought in to help spend cycles is unclear. Some innovation champions may want them there at the very beginning. A more conservative management may prefer to hold their participation until the end. It's also possible that doubling the number of cycles will have no impact at all on the way the firm manages its design relationships with suppliers and customers.

In truth, productively spending iterative capital may prove a greater management challenge than successfully investing new money. Iterative capital isn't as fungible as cash, but the ability to model, simulate, and prototype more options in less time ultimately must become a different organizing principle for managing value creation.

No doubt, many organizations will unhappily discover a "Parkinson's Law of Prototyping" in which, instead of work expanding to fill the time available, endless iterations of prototypes and simulations soak up time like sponges, while offering little but diminishing returns. That's a legitimate concern. The problem recalls the consumer product pathology of the 1980s, when mass marketers spun off flanker products and line extensions from existing brands. The vast majority of these marginal innovations did a better job of (briefly) capturing shelf space than of capturing either market share or profitability. They proved to be managerial distractions rather than meaningful brand equity investments.

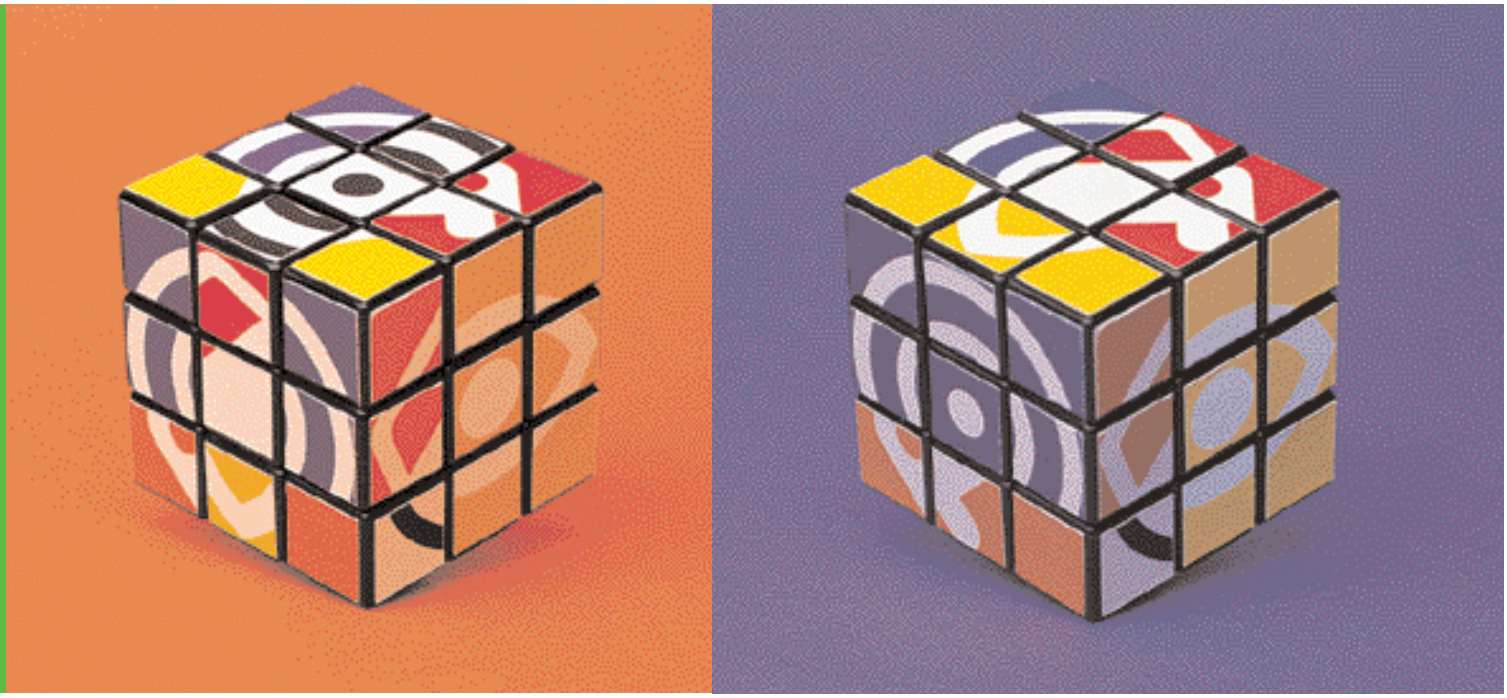
So iterative capital raises economic questions that diligent hyperinnovators have to answer: Is the 50th iteration of a prototype or simulation dramatically more valuable than the 35th? The 60th? The 110th? Or are the insights and information gleaned marginal? How does the organization know? Do the design discussions fundamentally shift? Or do they simply become more refined? Do design assumptions harden? Or do they become less constraining as the cost of testing them shrinks? Those questions are neither hypothetical nor simple. They are at the center of management's most important decision: Are we creating value, or are we just messing around?

Managing Hyperinnovation

When the ability to generate a thousand iterations is but keystrokes away, hyperinnovators must become hyper-editors. They have to establish priorities, filters, and screens that signal the onset of diminishing returns. Organizations hyperinnovating in the area of speed-to-market will surely have different diminishing return criteria than firms seeking to be the lowest-cost provider of innovative features and functionality.

But contrary to management mantras, the speed and cost-reduction benefits of iterative capital are not the ultimate destinies of these digital media; they are just the beginnings of the journey. Indeed, speed and cost reduction are what these modeling media turn into commodities. Just as spreadsheet software like Lotus 1-2-3 and Microsoft Excel commoditized financial modeling, digital design media commoditize cycle time compression. *Everyone* reaps the benefits of faster development cycles. That's inevitable. So the ultimate goal isn't innovating

Hyperinnovation and the iterative capital that fuels it represent a critical opportunity for organizations to boost their chances of success.

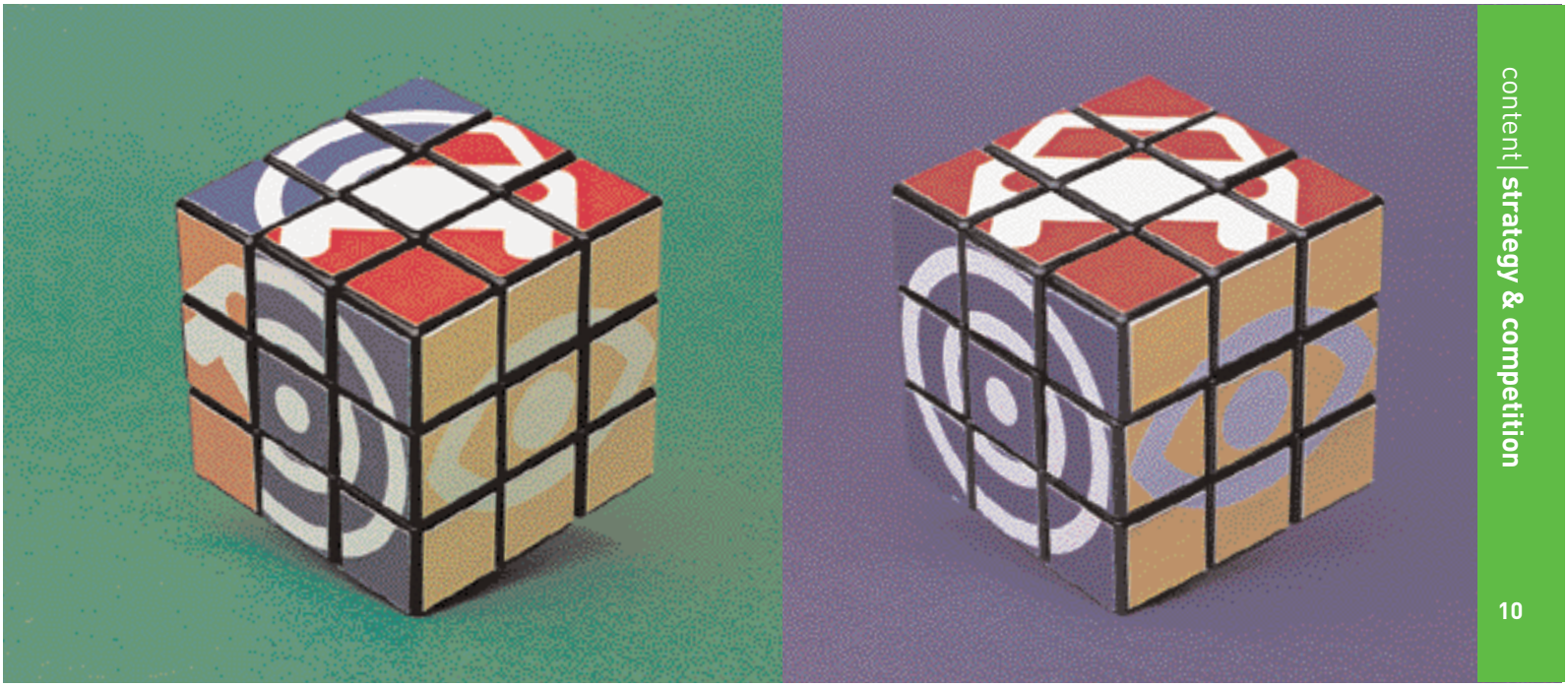


ever faster at lower cost; it's getting greater value from time and monies saved. Precisely what happens to competitive advantage as cycle-time differences between rival firms narrow and their innovation offerings hit the market at comparable times? Even worse, what happens when development cycles go faster than customers are ready, willing, or able to absorb?

As the rate of hyperinnovation accelerates, the gating factor shifts from the speed of the innovator to the speed of the adopter. The economics of hyperinnovation effectively dictate that hyperinnovators will have to collaborate with customers, not just to customize, but to facilitate the adoption of the innovation. Iterative capital becomes a shared resource, enabling shared creation. Hyperinnovators need hyperadopters.

So hyperinnovation has speed limits. Speed for the sake of speed is as valueless as innovation for the sake of innovation. That's not business; that's self-indulgence. The challenge is to treat the economic virtues of speed, cycle-time compression, and their concomitant savings less as ultimate ends and more as creative means.

That means hyperinnovative executives will need to look to all manner of methodologies to manage their hyperinnovation portfolio investments. The same quantitative techniques that investment managers use to manage their portfolio investments will surely be assimilated by hyperinnovators. Modern Portfolio Theory, with its rich brew of quantitative techniques to measure risk and reward, will be adopted and adapted by innovation investors.



An automobile company, for example, will consider how much iterative capital should be invested in improving a car's handling, its interior, its weight, its safety features, its performance, etc. Each category might be analogized to an "asset class" with its own "beta" or level of volatility. The hyperinnovation portfolio manager will also explore how much iterative capital should be invested in integrating these disparate features. What are the acceptable risks? What are the trade-offs?

No doubt, innovators will soon be managing options and futures based on iterative capital much as financiers now do with financial capital. "Real options," like Internal Rate of Return and Discounted Cash Flow, is becoming a tool to weigh R&D investments. The perspectives offered by iterative capital would allow an even more rigorous and robust options analysis of innovations.

Great wealth poses as many risks as it does opportunities. Great wealth forces both individuals and institutions to reevaluate what kind of impact they want to have. Hyperinnovation, above all else, concerns the future impact of innovation on the global marketplace. The tools to manage hyperinnovation and the iterative capital that fuels it represent a mission-critical opportunity for organizations worldwide to boost their chances of success. Squandering iterative capital is like burning money. Tomorrow's hyperinnovators will need to be as innovative with their iterative capital portfolio management techniques as they will be in creating hyperinnovative products and service offerings. +

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