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How The Universe Story and MBM Can Save Business, Society, and the Earth
from the Dictatorship of Strategic Financial Management ©

by
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The theme of this Second Annual Forum of the In2:InThinking Network – “What’s New? What’s Next?” –invites us to explore where the work of W. Edwards Deming (1900-1993) might have taken him in the past ten years, were he still alive, and where his work now would be focused. In that context, I think we should consider the message in one of the overheads that Dr. Paul MacCready showed in his opening presentation on Friday night, April 4. It was the overhead that compares all vertebrate mass in the human system -- humans plus domesticated animals (including pets) -- with all “wild” vertebrate mass on the land and in the air, from 1850 to 2050. The vertebrate mass in the wild stood at about 85 to 90 percent of the total in 1850 and steadily declined to about 2 percent of the total by 2000. Under current conditions the percentage of wild vertebrate mass will fall to an insignificant fraction of one percent by 2050, about the same percent at which the mass in the human system stood some 10,000 years ago, according to Dr. MacCready.

What might Dr. Deming have said about this data? Recall that he was born and raised on the Wyoming frontier in the early 1900s, before there were automobiles and highways, before the rivers were dammed, before oil wells dotted the landscape, before internal combustion tractors and combines had transformed the last remnants of North America’s grassland into grain farms. Dr. Deming grew up in a world much closer to the one that Lewis and Clark had seen in the early 1800s than to the world we see today in the early 2000s. He knew “wild” better than any of us living today could possibly know. He grew up surrounded by it.

I like to think that Dr. Deming might have chosen Dr. MacCready’s data to supply the primary topic for discussion at this conference. Pointing to the declining share of “wild” in our world he would have asked “what does this mean?” I am sure he would have said, “We are killing diversity, the inherent diversity of natural systems that sustains the

robustness of the ecosystem and makes human life possible and tolerable. We are eliminating variation from the natural system that sustains us, and by so doing we threaten our very existence on this Earth.” He might have gone on to say, “This is a *crisis!* Our well-being, our very existence, depends on finding a way *out of the crisis.*”

Indeed, the crisis portended in Dr. MacCready’s overhead poses, I think, the ultimate question of our time, perhaps of all human time: is there a way out of the looming crisis that is caused by disappearance of wild? What can we do to reverse the trend that has brought us to a point where the human sphere of activity on Earth now contains most of the protoplasm embodied in animal life? Alternatively, what drives humans to occupy almost all of Earth’s living habitat and to consume most of the photosynthetic output produced by the Sun’s daily gift of photons, that ultimate source for all the energy that ever has or ever will sustain human activity? One estimate suggests that humans themselves, not including domesticated animals, consumed in 1990 some 40 percent of the Earth’s “net primary product” (NPP) – the amount of photosynthetic material produced each day above and beyond what plants require to sustain themselves. Since the human population is expected to more or less double its 1990 level by the middle of this century, the conclusion is that humans will be consuming at least 80 percent of Earth’s NPP by the third quarter of the 21st century.¹ What the condition of human life will be when that point is reached is hard to say today, but it is not likely to be very pleasant by the standards of someone who grew up in the past fifty years or more.

I believe that the only way out of this looming crisis is to start by asking questions about why the current economic system seems to drive humans relentlessly to produce, consume, and occupy more – always more, never enough. That economic system evolved over hundreds of millennia out of human efforts to earn a livelihood. Could the human economy have evolved into a system in which humans earn satisfactory livelihoods without jeopardizing the needs of all other living species on Earth? I can’t answer that question at this moment. All I can say for sure is that the system now seems to embody a growth dynamic that is eliminating from the Earth’s ecosystem the variation and diversity that sustains the conditions needed for tolerable human existence. Why did things work out this way?

The reason, I think, has been brewing for at least 10,000 years. It is implicit in the awesome technological capacity that evolved in humans, giving the human the unique power among all species to move constraints that stand in the way of its consuming without limit the resources other species require for their livelihood. Beginning several hundred millennia ago with the use of fire to ward off cold, to clear land, to shape tools, and to cook grains and wild meat, humans then moved some ten to fifteen millennia ago to domesticate plants and animals. The resulting increase and security of food supplies brought steady growth and territorial extension of human population, until humans by modern times had become the dominant animal species on Earth. It is said that today the only other animal species embodying a similar quantity of protoplasm as humans is the ant, a life form that also seems to thrive almost everywhere. But ants have lived tens of millions of years longer than humans and have always coexisted as part of a richly diversifying ecosystem, whereas human expansion, after mere thousands of years, is now contributing to one of the largest destructions of diversity witnessed in some 4 billion years of life on Earth.

Although the power to remove constraints to growth and extension has been implicit in human technology for thousands of years, it did not lead to exponentially relentless consumption threatening the survival of other species until the last century or so. If the rate of human expansion that existed before the 19th century had continued unchanged, we might not have reached the crisis we face today for another thousand years, or more. However, a sharp increase in that rate of expansion occurred in the past century or so. I attribute that inflection in the rate of expansion to two very recent changes in the human economic system.

First, beginning in the 19th century, we discovered seemingly limitless supplies of stored solar energy in the form of coal, oil, and natural gas. Humans had long used the stored solar energy in trees to exceed the Sun's daily supply of photons, but their ability to fell trees, at least up to the 19th century, was puny compared to the Earth's ability to restore forests and to regenerate pollutants thrown into the atmosphere by human burning. Then in the 19th and 20th centuries humans found an energy supply so vast that its use caused them to lose all sense of the connection between their burgeoning

economic activity and the Earth's limited power to absorb and regenerate the waste created by that activity.

Perhaps more important than this discovery of stored solar energy was a second condition that caused the rate of human consumption to rise sharply in the past century; namely, people started to view the economic system through the lens of quantity. In a classic example of what the great 20th-century philosopher Alfred North Whitehead referred to as "the fallacy of misplaced concreteness," humans by the late 1800s increasingly defined economic affairs in terms of quantitative abstractions such as spending, incomes, revenue, cost, profit, investment, and shareholder wealth, rather than in terms of concrete activities that provide for human livelihoods. Abstract quantities, by definition, can grow without limit, whereas activities that involve consumption and production are necessarily constrained by Earth's finite limits. By viewing economic activity increasingly and exclusively in terms of abstract quantitative variables, humans in the past century have ignored signs of over-consumption that surely would have been more apparent had they continued to view economic activity only through the physical lens of people, material resources, community, and the expanse of wild space. Thus, access to vast supplies of stored solar energy and capitulation to an abstract quantitative view of economic and business activity, working together like two pincers, have brought the human system in just one hundred years to a point where to continue operating in its present manner for another century seems very unlikely, if not impossible.

The answer to this crisis requires, ultimately, that human economic activity operate at a scale that ensures all other life species their place in Earth's ecosystem. We must take steps to stop further reduction in the already sharply truncated diversity of Earth's life forms. That is a tall order that will not be filled soon by simply tampering at the edges of the current business system, the approach offered by most advocates of "sustainable economic growth." It almost certainly will require a cessation of human population growth, perhaps followed by a decline of population to about 2 billion people, the number who lived on the Earth only some 70 years ago. But that change could take a century or more. More immediately, I believe there must be a complete rethinking, especially in the so-called "developed" economies, of why and how humans conduct economic activity. If people were to rethink what they regard as necessary consumption standards

and appropriate production techniques, perhaps more than 2 billion humans could eventually live comfortably and in balance with the rest of nature.

This new way of thinking about economic activity would, hopefully, create an economy of eco-mindful local businesses, each guided by an impulse to *produce only enough* to satisfy the needs of a community that wishes to *consume only enough*, all within the limits of current solar “income” and the requirements of all other species.

I see two primary steps on the pathway to achieving this economy. One is to wean the human economy of its dependence on the stored energy found in trees, coal, oil, and gas. To some degree, this is a technical, engineering problem that already is receiving significant attention from myriad organizations around the world, including Paul MacCready’s AeroVironment company. I won’t delve further into that step in the remainder of this talk. Instead, I will concentrate on a second step that entails a deep change in human thinking and human culture that, once achieved, will automatically reinforce efforts to reach the first step.

This second step has business, as the key institution shaping our economic system, adopt the view that its primary purpose is to provide for human livelihoods. Business must see itself as employing human talents to satisfy human needs. Moreover, businesses must operate in a manner that harmonizes with the rhythms of the larger human and natural systems in which the economy is embedded. Instead, most businesses today, especially large publicly-traded corporations, see their purpose as maximizing the financial wealth of the organization’s shareholders. Their obsession with that financial abstraction causes businesses to do whatever it takes, no matter how destructive to society or to the Earth’s ecosystem, to enhance shareholder value. Companies today show little or no concern for the concrete reality of providing opportunities for humans to earn livelihoods in a manner that harmonizes with the Earth’s capacity to sustain non-human diversity.

It was when society started viewing business through the lens of quantity, mentioned above, that people began to see the purpose of business more in terms of abstract financial targets and less in terms of human livelihoods. That change becomes noticeable only some fifty or sixty years ago. One sees it shortly after World War II when business people increasingly discuss *providing for customer needs* in terms of “revenue” and

employing human talents in terms of “cost.” Profit, the quantitative difference between revenue and cost, was increasingly viewed as the primary goal of business, especially as more widespread share ownership steadily separated the ownership of business from the activities of running business operations. By the 1970s maximization of shareholder wealth had become widely accepted as the one and only goal of business, particularly in the large publicly-traded corporations that control the commanding heights of the economic system.

Today, top managers of such corporations are viewed exclusively as agents of the shareholders. Their only task is to meet, at all cost, the financial targets for growth set by the market. The financial spreadsheet has become the focal point of top management’s attention, so much that top managers now view the organization entirely through the lens of financial (and other) quantities, almost oblivious to the concrete operations from which the financial results emerge. Indeed, operations in most large businesses today has come to mean the electronic coordination and integration of myriad human activities around the world, including design, order fulfillment, logistics, production, and whatever else it takes to market and sell products and services. Increasingly, large corporations outsource hands-on human work to millions of contract agents all over the world, usually far removed from the corporation or its final customers. In this world, often referred to as “the new economy,” hand-offs from supplier to customer occur increasingly with no awareness of the effect that economic activity has on human communities or the Earth’s natural processes.

The popular image of corporate leadership in this new world is conveyed in case studies and media stories where executives run large global organizations with “balanced scorecards” embodied in electronic “dashboards.” In truth, one has to believe that most top executives today see their role as negotiating supply-chain contracts and making financial deals. They probably do not understand, nor do they care, how human activities give rise to the financial results seen on the spreadsheets and “dashboards.” Moreover, I honestly believe most of them doubt that human operations are the locus of what is real in business. What they see as real are the numbers – the financial and other quantities that influence share valuations in the market.

This lost sense of concreteness was confirmed to me recently in a conversation I had with a corporate finance controller who had expressed disagreement with several of my recent writings about the danger of using abstract financial targets to drive business operations. He disputed my claim that executives who look only at spreadsheets, dashboards, and the like are mistaken in their belief that the quantitative targets they impose on operating personnel lead to predictable long-term results, not to instability and undesirable performance. He said, “Tom, when you say that financial quantities are ‘abstract,’ I think you actually mean that the numbers aren’t the real thing that executives manage to achieve results. I don’t agree. I believe that the numbers aren’t simply abstractions from some deeper reality. They are the reality.” I was speechless! Reflecting on what this man said to me, I realized, of course, that he views his company’s many manufacturing sites and numerous selling and distribution enterprises as very real. I think his comment about numbers being the reality means that for him, and probably for most of his bosses, operations as such don’t really make a difference to the financial outcomes. He seems to believe that all competitors have access to pretty much the same knowledge and technology for making and selling stuff. What makes for a competitive difference, as far as he is concerned, is how adroitly his management team can find and tap into external opportunities to unload “underperforming” assets, to seduce customers into buying more stuff or paying higher prices, and to cut costs, by outsourcing at lower and lower prices, and so forth.

This disdain toward operations permeates the approach to strategic financial management that is currently popular among leaders of large publicly-traded companies and among leading executive education programs. The modern executives’ claim that “operations are not strategic” had its roots in the 1970s, particularly in the works of Michael Porter, an economist teaching at the Harvard Business School. According to Porter, a company should fashion its operations so as to compete effectively as a differentiator or as a mass producer, but never as both. His central idea, based on earlier production and operations management research at Harvard Business School, is that existing modes of operation permit a single business to produce either high variety or low cost but not both high variety and low cost. A company’s key to success, then, is to discover its appropriate strategic focus – differentiation or low cost – and then select a

mode of operations appropriate for that focus. Top management in this case does not concentrate its attention on how to design and conduct operations. Those issues are believed to be technical matters addressed by “off the shelf” solutions that are the same for one company as another. Instead, top management concentrates on continuously analyzing, monitoring, and responding to the “forces” that affect the company’s competitive advantage in its chosen strategic domain. ²

This emphasis on managing strategy reinforced and widened a schism between top managers and operational managers that began to appear in large corporations by the 1950s as top managers increasingly defined their role and communicated with others exclusively through the language of quantity. Divorced from operations, they translated strategic goals into quantitative targets that operating managers were then expected to translate into concrete operational activities that somehow would produce the desired results. The logic underlying this transit from quantitative targets to action to quantitative results assumes that the affairs of a business can be neatly separated into an abstract strategic domain and a concrete operational domain. In the strategic domain, quantities arrayed in spreadsheets, scorecards, computer screens, or dashboards all connect according to a linear additive logic that is embodied in an abstract financial model of profitability or shareholder value. The operational domain is assumed to contain physical parts – people, equipment, and other resources – that also can be denominated in the quantities found in the strategic domain, such as price, cost, investment, and other financial terms. By increasing, decreasing, and otherwise moving these physical pieces, and motivated by the carrots and sticks of compensation incentives, operational managers somehow reach the top-down goals and targets spelled out in the abstract strategic domain.

Countless observers in the past fifty years, notably Dr. Deming himself, decried this “manage-by-results” (MBR) approach to doing business. Dr. Deming often noted that the financial results a business can achieve in the long term are a function of the system of relationships that connects customers and suppliers in the business. Using targets to motivate results greater than the system is capable of producing only leads, according to Deming, to instability and disappointment. To improve results, change the system –

don't drive people with quantitative targets that encourage them to manipulate and weaken the system.³

I believe that strategic financial management is a concept doomed from the start because it rests on a fallacious belief, a version of Whitehead's "fallacy of misplaced concreteness," that an abstract model of mechanical connections among linear one-dimensional quantities – scalars – can help one understand and control results that emerge from a non-linear web of multi-dimensional relationships, i.e., a self-organizing natural system. The operations that link customers and suppliers in a business organization constitute a natural system, not a machine. While quantitative information can both describe the results of a *mechanical* system and also explain how that system's inner workings produce the result, it can only describe the results that emerge from a *natural* system, it cannot explain how a natural system gives rise to those results.⁴ Failure to see this difference in the ability of quantitative information to describe and to prescribe is, in my opinion, a fatal flaw that invalidates virtually all business practices that fall under the heading "strategic financial management."

Indeed, strategic financial management necessarily views business through the lens of the 17th-century Cartesian mind-body duality that 20th-century science has declared erroneous. Top managers who believe they control results through the tools of strategic finance implicitly view operations as being like material substance that is separated radically from mind or spirit. Financial control models and quantitative information are, in effect, seen as disembodied spirit or mind in control of matter. To the practitioner of top-down strategic financial management, the operations of a business would never be seen as embodying a self-referencing pattern, an intrinsic spirit or implicate order. Instead, the strategic financial manager views operations as a collection of inert parts put together according to an external plan or blueprint to achieve a planned result. In other words, that manager views the business as a machine, not a self-organizing natural system.

The concept I refer to as "the strategic financial management fallacy" reflects the fact, expressed countless times by Dr. Deming, that the consequences of manipulating the operations of a business to achieve financial targets are "unknown and unknowable." Financial models of business results invariably assume a world in which results can be

traced to neat cause-effect connections. There is nothing wrong with that assumption, as long as one believes the world “out there” behaves according to the rules that govern quantitative relationships in a financial spreadsheet. Those relationships always imply that the financial results of a business can be explained entirely by linear and additive combinations of one-dimensional scalars. Indeed, that is the fallacy of strategic management – the fallacy of assuming that the linear logic and mechanistic language for communicating with scalars can also be used to understand, control, and evaluate a non-linear natural system of multi-dimensional vectors. I firmly contend that the language one needs to penetrate and explain how a natural system produces its results must differ from the quantitative language that is used to describe and communicate the results. Encouraging people to change a business system’s results by driving their actions with quantitative targets simply imposes on them an injunction or prescription with a language that is appropriate only for description. Basically, this is just another way to describe what Dr. Deming referred to as “tampering.” To bring about stable and long-term change in business results requires that conversations about operations be conducted in another language than the linear, additive language of quantity. Those conversations must be in a language that is appropriate to the non-linear patterns observed in natural systems.

In my latest book *Profit Beyond Measure* (The Free Press, 2000), I have described one example of this different language and logic with the phrase “management by means,” or MBM, an alternative to the MBR approach that is implicit in modern strategic financial management. MBM says, in effect, that in natural systems the means are the results in the making. In natural systems, such as business organizations, results sufficient for the long run are already there. We don’t create or control the results, the system does. We do, however, discover and nurture the means that give rise to the results. That is the essence of “managing by means.”⁵

From the perspective of MBM, the key to stable, sufficient and sustainable long-term business results is operations that emulate the patterns scientists observe in natural systems. One of the most profound insights of 20th-century science, grounded in the branch of physics popularly known as evolutionary cosmology, is that the cosmos – from giant galaxies and the trillions of stars contained in them to sub-atomic quanta and the

smallest single-cell creatures here on Earth – is an evolving system of natural systems that arise and function according to a very small number of patterns and principles that infuse all matter and energy everywhere.⁶ In particular, patterns and principles of interrelatedness, self-organization, and diversity seem to be embodied in every natural system in the universe. MBM rests on the belief that these same patterns and principles should also guide all human business and economic organizations, themselves a cultural evolution resulting naturally from human evolution itself.⁷

Indeed, I believe the failure of modern business to nurture patterns resembling those found in natural systems underlies the ecosystemic crisis that I referred to at the start of this talk. It is especially the strategic management focus on driving operations with quantitative targets that causes the human economic system to be such a destructive force to man and nature. The strategic financial model's obsession with unchecked growth is absolutely contrary to the pattern observed in all other natural systems on Earth. A necessary alternative to strategic financial management, I believe, is to shift top management's attention from achieving quantitative targets at any cost, to cultivating a business system that provides for human livelihoods by connecting customers and suppliers in efficacious ways that build healthy communities and a robust natural environment. To survive, the business must of course balance financial outflows with financial inflows – managers must balance the energy expended on business activities with the energy provided by customer receipts. But managers now must be trained and motivated to believe that this balance is achieved best **not** by manipulating parts of the business piecemeal to achieve quantitative targets, but by nurturing relationships that connect customer's needs with the talents of people in every facet of the company's work.

Is there an example of a business that has achieved healthy long-run results by managing relationships instead of driving operations with quantitative targets? In truth, I cannot name a single company that today “manages by means” as comprehensively as I would like to see. However, the operations of one well-known publicly-traded company do stand apart from all others to such a degree that they can properly be said to follow MBM principles, even though the company's overall impact on the community and the Earth still leaves much to be desired. That company is Toyota.

For over a decade I have had the privilege to spend long hours with hundreds of Toyota people in many of the company's plants and offices, from Durban in South Africa to Melbourne in Australia, from Georgetown and Erlanger in Kentucky to Fremont in California and in Toyota City itself in Japan. In particular I visited the giant plant in Georgetown, Kentucky at least sixty times between 1992 and 2000. Because I have described what I learned at Georgetown in some depth in the book *Profit Beyond Measure* I won't spend time here discussing detailed features of the Toyota Production System. What I want to discuss are general observations about how I think Toyota's operations fulfill the conditions of "management by means."

It is useful to start with two observations often made by people who write about Toyota. One is that the company for over forty years has far surpassed the performance of all its competitors in the industry in terms of product quality, reliability, design-to-delivery leadtimes, customer satisfaction, employee morale, productivity and cost, and overall financial performance. If there are objectives that automakers seek to fulfill, Toyota has managed to excel at **all** of them, not just some. Toyota is the exemplar that disproves the central assumption of strategic financial management that companies can have variety or low cost, but not both. Toyota has it all. The second observation that Toyota-watchers make is that it takes a long time and many visits to its plants to begin to see what is different about Toyota's operations. For over twenty-five years, countless consultants and academics touring Toyota plants have "seen" many things – "zero" inventory, clean well-marked floors and work areas, spotless machines, fast changeovers, teamwork, kanban replenishment, continuous flow, line workers solving problems, andon cords and pokayoke, mixed models on the same line, standardized work, and much, much more. Still, no company seems ever to have matched Toyota's performance, right down to the present day. Companies are better for having studied and implemented in their own plants what they see in Toyota's plants, but it appears that no one has seen the whole picture. Not yet.

So what explains the persistence of this "knowledge gap?" I can't pretend myself to have the answer, but I can say that I have thought long and hard about the problem. Lately I am coming to the conclusion that people – Americans and Europeans especially – are hindered in their efforts to understand Toyota by their tendency to see business

operations through the lens of abstract quantity and the worldview of 17th-century science rather than through the lens of concrete relationships and the worldview of 21st-century science. Again, Whitehead's "fallacy of misplaced concreteness" helps explain why we fail to "see" what matters in Toyota.

Relationships are the reality that makes the difference in Toyota. Financial results and quantitative outcomes matter to them, of course, but Toyota people seem to understand that how relationships are orchestrated between people – specifically, between worker-as-customer and worker-as-supplier – determines how good those results and outcomes will be. Basically, a Toyota plant has the same materials and parts, the same machine technologies, the same workforce, and the same types of customers as one would see in any of its competitors' plants. What is different in the Toyota plant is how work is organized.⁸ Material always flows in direct, simple pathways and workers always are linked through unambiguous supplier-customer connections that permit one to know at any moment if something is abnormal and, if it is, to stop, correct the problem and countermeasure against it happening again. As a result of these carefully orchestrated relationships, everyone's work at any moment is focused on only one order at a time, with features in place to insure, as much as humanly possible, that no more resources are consumed than enough to complete that one order, and pass the work on to the next step in the pathway.

The relationships created by the way the work is organized virtually guarantee that every step in the process is performed at the highest quality and at the lowest cost, including time. Moreover, the design of the work also insures maximum flexibility to vary types and volume of product made in the plant. And every step in the work, every moment, embodies hypotheses to be continually tested, leading to continual awareness of opportunities for change and improvement. If one observes the overall scene in a Toyota plant long enough and carefully enough, one begins to see a pattern that resembles the working of a self-organizing and self-referencing natural system. At least that has been my experience.

In that regard, it is interesting to note a couple of things one does not see in a Toyota plant. One is the absence of quantitative targets being used to drive operations. The only external signal ever entering a Toyota plant's system is customer vehicle orders. Those

orders are, in a sense, all that “drives” operations. Information about how material will be released to the floor and how the work will be done to transform material into finished product comes only from the work itself, not from any source external to the work such as a computer information system. The material is pulled through the system one cell at a time, like the blood and the lymph flowing through an animal’s body, and it flows everywhere at the same rate, or takt time, like the beat of an animal’s pulse. In a Toyota plant, no MRP system directs the flow of material in day-to-day operations nor do any standard cost targets motivate the pace and volume of that work.

In effect, a Toyota plant resembles a “black box” that admits no entry to either external production controls or external financial and cost accounting controls. Everything happening inside the box is under the guidance of the Toyota Production System, the inherent pattern of operations that permeates all work throughout the company. Production costs are low and quality and variety of output are high because of the way the operating system itself is designed, not because people are responding to top-down quantitative targets. In this regard, I find it interesting that many consultants and others who currently write about and teach so-called “lean manufacturing” – a buzzword that not only cheapens and demeans, but often reveals gross misunderstanding of what Toyota does – are fond of talking about “lean accounting.” I warn people to be alert whenever someone talks about the need for shopfloor accounting systems to control costs in a “lean” operation. Generally I find that the talk about “lean accounting” disguises a failure to truly understand what one observes in a Toyota plant. Operational cost control systems, like operational MRP systems, resemble a “dog that does not bark” in a Toyota plant. Companies that install such control systems in their “lean” operations clearly fail to understand something that one does not see in a Toyota plant. I suspect that consultants who advocate “lean accounting” often do so as a concession to the powerful dictatorship that the barons of strategic financial management impose on the modern business world. Many of them know better, I am sure, but they also know who pays their fees. I say it is time to stand up and overthrow this destructive dictatorial power.

Indeed, Toyota’s operations suggest strongly that this company has never succumbed to what I call the “strategic financial management fallacy.” They seem always to have kept separate in their minds the distinction between abstract quantitative outcomes and

the concrete relationships from which those outcomes emerge. To improve the outcomes they strive to nurture and improve the relationships. They seem to understand that the system in the long run cannot achieve outcomes that exceed its natural capability. This awareness is quite in tune with both Dr. Deming's admonishments against tampering and with the principles of MBM.

Returning to a theme that I discussed earlier, Toyota's operations seem to me to reflect a restored unity of the separation between mind and body, spirit and matter, that Galileo and Descartes articulated for the western world over 300 years ago. The pervasive presence of this unity in the universe is a centerpiece of modern science that has yet to influence modern management thinking. Modern management thought and practice remain firmly rooted in the worldview of 17th-century science. In a sense, strategic financial management and modern management accounting separate matter from spirit in the business world in the same way that Galileo and Descartes did for the world of physics and mechanics before the time of Newton. Surely it is time for the business world to recognize how out of step with reality are its most fundamental practices. It is time for business to see that its proper model is not the mechanistic model of financial economics, but nature. It is time, in other words, for managers to begin find the pattern, the spirit in concrete operations that are designed to emulate natural systems, not machines. In such operations, every step of work consumes just enough for one customer's needs this moment. Nothing is done to accumulate for growth's sake. Companies whose operations embody such principles can, I believe, lead our economic system onto a path that is harmonious with the Earth's ecosystem. I think that is what Dr. Deming would have us discuss were he here today.

Modern science gives further insight into the deeper meaning of this message. This insight concerns the word "force," a central concept in modern management thinking that physicists for over three centuries have used to explain matter and motion. One of Newton's most brilliant insights was to explain all motion in the universe with the concept "force." The same force, he said, moves all matter, from the motion of planets to the trajectory of an apple falling from its tree. Modern business, building implicitly on the foundations set down in Newtonian mechanics, took this concept to mean that

managers apply force to motivate and control people and things – “matter” – in an organization. Motion, action, and behavior never originate within the people or things “moving.” They always originate from the influence of outside “force.”

But Einstein changed forever this view of things. He removed force as a concept needed to explain motion, thereby resolving numerous controversies raised by Newton’s theories and opening the door to a new evolutionary cosmology that has withstood countless tests of its veracity in the last 80 or so years. Unlike Newton, who viewed space and time as an inert background against which motion and force are measured, Einstein reasoned that space-time is a curving manifold, like the surface of a giant rubber sheet, that itself participates in and helps cause what we see as “motion.”⁹ Moreover, matter moving across the manifold influences the curvature of space-time so that, in the words of the great Princeton physicist John Wheeler, “space tells matter where to move and matter tells space where to bend.” Today, this pattern provides the foundation for explaining all that has evolved in the last 15 billion years of this universe’s history.

What insights can this powerful worldview of modern science provide to business?¹⁰ For starters, it should cause business leaders to reconsider their practices that aim at bringing about change through force, such as imposing top-down quantitative targets as “levers of control,” using incentive compensation to motivate performance, instilling fear through performance ranking, selecting suppliers on the basis of price rather than total cost, exhorting workers with slogans and quotas, managing by blame, and much more. In place of such practices would be efforts to discover and nurture patterns in the web of relationships that enable humans to earn livelihoods by connecting naturally with other humans and with the Earth’s ecosystem. These patterns would include linking production with consumption for current needs rather than accumulating for growth’s sake, assessing outcomes real-time and not after the fact, creating change through cooperation rather than competition, doing no harm, finding the spirit within rather than expecting to look outside for instructions, nurturing leadership in everyone, having everyone viewed as both a doer and a knower, and much more. In short, the worldview arising from modern science suggests that satisfactory long-term results are had only by surrendering to the pattern, following natural “geodesics,” and never attempting by control and intervention to force results exceeding the system’s capability.

How can we know that these practices will work? Are there case examples that confirm their validity? Yes, two examples come to mind. One case is the evolution of the universe itself over the past 15 billion years.¹¹ The universe story, not known to humans until some sixty or seventy years ago, is a primary means for humans to align their practices with the worldview of modern science. This is the remarkable story of how a constant budget of matter and energy (i.e., a system that works at zero marginal cost) evolved and continuously diversified from homogeneous plasma to sub-atomic particles, then to simple atoms of hydrogen and helium, to billions of hydrogen- and helium-dense galaxies that became nurseries for the birth of trillions of stars, some of which formed supernova that gave rise to the higher orders of elements from which rose planets such as our Earth, on which the continuing transformation between matter and energy led to self-replicating chains of carbon molecules that one day appeared as dolphins dancing in the sunset and humans wondering where they came from. Human cultures everywhere should now focus the education of their youth on this story and on the messages that it embodies, so that generations to come might grow up aware of how humans can function as a part of, not apart from the system from which they evolved, the system that nurtures and sustains all life.¹²

The other case confirming the validity of the practices, alluded to before, is the story of Toyota. I caution, however, that the Toyota story, powerful though it is, is still far from being as perfect an example as the universe story itself. I only claim that Toyota excels in its industry because its operations embody practices emulating those that modern scientists observe in natural systems throughout the universe. However, Toyota's operations exist in a context of financial goals one can reach only through global economic growth that is inherently unsustainable. The "next step" on the path to sustainable operations is to discover how Toyota-style practices might somehow spawn the rise of human economic organizations that exist primarily to sustain human livelihoods in balance with the needs of healthy human communities and a robust, diversifying ecosystem.

In the remainder of this talk I can comment only briefly on how business organizations that satisfy these criteria might look. Briefly, they would focus on providing employment and meeting customer needs in a fairly localized regional

economy, perhaps one defined by the boundaries of a watershed. One key point is that consumers and businesses would satisfy most of their needs with resources available in a local region. The current focus in the business world on building global supply chains would all but disappear, with the result that much less material would travel vast distances in the holds of giant cargo aircraft, in containers on the decks of mega-ships, and in trailers hauled by large trucks. As much as possible, material replenishment and final product shipments would occur entirely in the local region.

Some might argue that a world economy of diverse local bioregions would cause consumers' standards of living to fall because it would reduce the economies and efficiencies of large-scale production and distribution systems that we ostensibly have in the world today. Here is where it is important to begin educating people in the fallacies of scale-economy thinking. It is time to raise awareness of how production systems designed along the lines of Toyota's system turn scale-economy thinking completely on its head, making it possible to build manufacturing capacity on a much smaller scale than ever before thought possible, yet produce at unit costs equal to or lower than in those large-scale facilities now thought necessary for cost-effective operations.¹³

An example of this is in Toyota's organization. Compare the plant that makes Camry and Avalon models in Melbourne, Australia with the plant that makes the same models in Georgetown, Kentucky. Located within or nearby each plant are complete facilities for engine build, axle build, plastic trim and bumper production, stamping, body weld, seat build, and final assembly. According to Toyota, these two vertically-integrated plants are equally efficient and effective on all dimensions that matter to Toyota customers. However, the Melbourne Toyota plant currently produces at an annual rate of about 90,000 vehicles, whereas the Georgetown Toyota plant produces at an annual rate of about 500,000 vehicles.

If a five-times difference in capacity yields no unit cost differences between two plants organized along Toyota's lines, then what is to be said on behalf of scale economies? In fact, I have heard Toyota people say they probably will not build another plant as large as Georgetown in the future. The company currently is building new plants smaller in scale, located as closely as possible to customer markets. Carried to its logical extent, I think that Toyota's example shows how bioregional economies of 10 million or

so people might be able to support high-variety and low-cost manufacturing facilities for a wide range of products. Indeed, the relatively isolated Australian economy, with about 20 million people and a vast land area, supports several auto manufacturing operations in addition to Toyota's, not to mention facilities that make a wide array of other manufactured products just for Australian consumers.

There are now ample technologies available to support efficient small-scale operation of almost every activity humans conduct in the economic world today. Examples include the continuous-casting mini-mill technology that transformed steel making in the last 30 years, small scale refineries and chemical plants for almost all the petroleum and chemical processes known to man, Japanese paper products plants that efficiently produce on a much smaller scale than, say, American paper makers think possible, micro-breweries that have transformed beer making in the United States in the past decade, and more. These technologies and more are discussed in many places, but two good examples are the recent book *Natural Capitalism* by Paul Hawken, Amory Lovins and Hunter Lovins and the somewhat older book *The Soul of the Enterprise* by Robert Hall.¹⁴

Especially interesting are Amory Lovins's paradigm-breaking examples of how the industrial economy can function far more effectively at much smaller scale than ever thought possible by rethinking, for example, the design of automobiles (e.g., hypercar with carbon composite body and hydrogen-cell power train), the design of buildings (better insulation, use of solar power, absorbent roofs to obviate need for drains and storm sewers), and the design of power systems. In the latter context, Lovins convincingly shows that the time is here for the world to free itself from large-scale power generation and vast power transmission grids. Solar, wind, water, conservation, and co-generation all play a role in this transformation. An important rallying cry of the bioregional economy could be "off the grid!"

Underlying so many of the smaller-scale but more efficient processes that Lovins talks about are capital items that often raise initial project costs, but have incredibly fast and long-lasting paybacks (e.g., solar panels, better insulation, bigger diameter pipes that require smaller pumps, better lighting, heavier refrigerators, and so forth). His proposals for "small is beautiful" technologies run up against many of the same hurdles that one

encounters trying to get people to change from mass-production to a Toyota-style production design. Traditional designers' efforts to optimize the parts – insulation, windows, roofs, pipes – lead to decisions that invariably “pessimize” the whole, as he says.

Thus, it would seem there are no serious technological constraints to organizing human economic activity more and more along regional lines, in harmony with the resources and regenerative capacities of the Earth's major watersheds, and less in line with the current march toward scale, global homogeneity, and eco-destruction. The constraints to downsizing are political, social, and intellectual, not economic. They are constraints imposed by old thinking. Fortunately, the new thinking so sorely needed is no different than that which arises from the new worldview coming out of modern science. In that regard, efforts to achieve the transformation to a sustainable bioregional economy will require a new approach to business school education that is grounded in that new worldview.

The transformation to a local bioregional economic system is a long-term proposition, obviously, even under the best of circumstances. In the meantime, individuals can do much to bring their consumption more in line with Earth's regenerative capacity. Moreover, while simplifying their consumption habits, individuals can enrich their standards of living. A fine book to get people started on this journey to simplicity is *Your Money or Your Life*.¹⁵ In time, individual's efforts to achieve simplicity and the steps we take collectively to build a viable bioregional economy will complement each other in a mutually reinforcing pattern.

Conclusion: There is much that businesses and individuals can do stop and perhaps even reverse the destructive trajectory our economic system has followed in the past century. A key step is to understand how the quest of abstract quantitative targets in businesses traps us in a vortex that leads toward annihilation of Earth's eco-diversity. The need is to shift attention from pursuing quantitative goals that lead inevitably to greater and greater homogenization of our environment and move to nurturing relationships that sustain variation and diversity. Dr. Deming long ago provided us with much of the knowledge and many of the tools we need to do the job. What is lacking,

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what only we can provide, is the will to take seriously the challenge to stop, hopefully reverse, the disappearance of WILD.

¹ Herman E. Daly and John B. Cobb, Jr., For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future (Boston: Beacon Press, 1994), pp. 143-148.

² Michael E. Porter, Competitive Strategy: Techniques for Analyzing Industries and Competitors (New York: The Free Press, 1980) and Competitive Advantage: Creating and Sustaining Superior Performance (New York: The Free Press, 1985).

³ W. Edwards Deming, *Out of the Crisis* (Cambridge, MA: Massachusetts Institute of Technology CAES, 1986), p. 76 and The New Economics for Industry, Government, and Education (Cambridge MA: Massachusetts Institute of Technology CAES, 1994), pp. 31, 33, 41.

⁴ The issue here is the distinction between one-dimensional scalars, or quantities, and webs or matrixes of multi-dimensional vectors. My claim is that a map of scalars cannot explain the workings of a system of vectors.

⁵ H. Thomas Johnson and Anders Broms, Profit Beyond Measure: Extraordinary Results through Attention to Work and People (New York: The Free Press, 2000).

⁶ Eric Chaisson, Cosmic Evolution: The Rise of Complexity in Nature (Cambridge, MA: Harvard University Press, 2001); Brian Swimme and Thomas Berry, The Universe Story (New York: Harper Collins, 1992).

⁷ This is the central thesis developed in Johnson and Broms, Profit Beyond Measure.

⁸ Johnson and Broms, Profit Beyond Measure, chapters 2 – 3; Steven J. Spear and H. Kent Bowen, “Decoding the DNA of the Toyota Production System,” Harvard Business Review (Sept./Oct. 1999).

⁹ Edward Harrison, Cosmology: The Science of the Universe (Cambridge, UK: Cambridge University Press, 2000), p. 199; Stephen Hawking, The Universe in a Nutshell (New York: Bantam Books, 2001), pp. 17-19.

¹⁰ For more extensive discussion of this topic see Johnson and Broms, Profit Beyond Measure, ch. 6.

¹¹ Swimme and Berry, The Universe Story.

¹² Thomas Berry, The Great Work: Our Way into the Future (New York: Bell Tower, 1999).

¹³ Charles Perrow, Organizing America: Wealth, Power, and the Origins of Corporate Capitalism (Princeton, NJ: Princeton University Press, 2002); Michael Piore and Charles Sable, The Second Industrial Divide (New York: Basic Books, 1984); E.F. Schumacher, Small is Beautiful: A Study of Economics as if People Mattered (London, UK: Abacus, 1974).

¹⁴ Paul Hawken, Amory Lovins, and Hunter Lovins, Natural Capitalism: Creating the Next Industrial Revolution (Boston, MA: Little, Brown and Company, 1999); Robert Hall, The Soul of the Enterprise: Creating a Dynamic Vision for American Manufacturing (New York: Harper Business, 1993).

¹⁵ Joe Dominguez and Vicki Robin, Your Money or Your Life (New York: Penguin Books, 1992).