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Interview with W. Brian Arthur

Over the years, the research coming out of the Santa Fe Institute (SFI) has been helpful in shaping our investment process. Founded over 20 years ago, SFI is dedicated to the multidisciplinary study of complex systems. Markets and economies are excellent examples of such systems. Interaction with SFI scientists has deepened and enhanced our appreciation for important concepts like increasing returns, the importance of diversity, network effects, and the significance of power laws among other useful topics.

One particularly influential SFI scientist is W. Brian Arthur (his bio follows the interview). Brian has been at the research forefront in a number of areas, including many issues surrounding technology: what it is, how it evolves, how it shapes economies, and its implications for individual companies.

Concerns about the global competitiveness of the United States have persisted for decades. In the 1950s, Eastern bloc countries were the main perceived threat; in the 1970s and 1980s worries focused on Japan; today, China and India are the focal points. The real question is: should we worry about U.S. competitiveness? In this brief interview, Brian shares his views on the U.S.'s competitive position. While noting points of concern, his analysis supports the conclusion that the competitiveness game is one for the U.S. to lose. We hope you enjoy Brian's thoughts.

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MM. In recent years there has been a lot of concern about the competitive strength of the United States waning and the rise of emerging markets, especially China and India. What is your perspective on the prospects for the U.S.'s competitive position vis-à-vis other economies?

WBA. Well, things look gloomy at the moment. China and India indeed seem to have come out of nowhere and are taking away jobs. And China certainly is putting pressure on oil and commodities prices. Let me speak first about China, because it dwarfs anything India is causing.

Certainly some of the fears about China are justified. China is becoming the world's manufacturer and is starting to dominate many markets: shoes and textiles, copying machines, DVD players. The situation is like it was with Japan 20 years ago, and a lot of what is getting said about China reminds me of what was said about Japan then.

Some manufacturing jobs are indeed disappearing to China, but the overall situation is by no means a loss for U.S. competitiveness. What's actually happening is that China has greatly cheapened a lot of the things we buy in the U.S. The price of shoes and clothing went down by 30 percent in the U.S. in the last 10 years. We get high quality digital cameras and PCs from China for lower cost than otherwise. This means that spending that would have gone on these items becomes available for other purposes, which grows other industries. The U.S. is mainly a service economy, and much of our manufacturing is being done offshore for less than we could have done it. That's a net gain. And the competition is forcing U.S. manufacturing to shift up the food chain to higher skill and higher productivity items.

It has been doing that for decades anyway. The U.S. is being forced to specialize in advanced technologies: airliners, telecommunications equipment, genetic engineering, the management and production of intellectual property. If anything, all this relatively low-end competition is strengthening the U.S. at the high end, just as it did with Japan. Jobs are indeed being lost, but that I believe is being caused more by the digitization of the economy than anything else.

MM. Are you saying that all things considered, the U.S. relationship with China is positive?

WBA. Yes, on balance it is. There's no question that China is exerting pressure on the prices of oil and raw materials and commodities. And on certain manufacturing industries. But suddenly a new cheap supplier has come on the world scene, and a huge market has suddenly appeared. When California and the West were joined to the rest of the U.S. economy by the railroad in the late 1800s, for sure some businesses disappeared in the East. But overall a huge new supplier came on the scene, and a huge new market opened up. The East benefited greatly. One of the drivers was scale economies; the broadening of markets reduces costs in many industries. The coming of China is repeating this. True, the U.S. is running a trade deficit with China. But internationally China's imports balance its exports—Japan and East Asia in particular are benefiting by supplying equipment and materials for China's rapid growth. China is floating a lot of boats and a healthy world economy does the U.S. no harm. Overall, China is a cheap supplier; it is forcing the U.S. up the technology ladder; and with its voracious appetite for supplies it is helping many economies grow faster than otherwise. That's a net gain for the U.S.

MM. What about other countries? India for example? And Europe?

WBA. These are interesting, especially India. But none are large enough—not even India yet—to make much of a difference. What strikes me as interesting is that the economies that are opening up and growing rapidly—India, China, and countries on the rim of Europe such as Ireland and Finland—are economies that by and large were living in the pre-20th century until recently. They didn't have much more than agriculture. I think these economies are benefiting from two things: a supply of well-educated people, and an absence of all the regulation and institutions that have encrusted industrial economies and impeded their transition to a post-heavy-industry world. Overall, this is remarkable to watch. Economies are on the move all over the world suddenly. Again, as long as the U.S. can keep its high-end lead, this should do it no harm at all.

MM. One of the things that strengthened U.S. competitiveness in the 1990s was information technology. Will this continue in the future?

WBA. Well, after the tech crash of 2001, there was a lot of moaning that the information revolution is over. Nick Carr told us that information technology (IT) didn't matter any more, and Larry Ellison and Peter Drucker pronounced that the information revolution had played itself out. I think that's nonsense. If you look at the digital revolution merely as the sales of computers and digital equipment you'd come to this conclusion. There is only so much digital stuff we need and only so much you can do with computers. But I don't see it that way. Something much more subtle is going on.

Digitization isn't about the purchase of computers and communications equipment. Nor is it merely about speeding up traditional operations by computers. The economy doesn't adopt IT, it encounters IT, and as a result creates completely new activities, and new industries. The banking industry encountered computation and used it to compute combinations of options, futures, and swaps to manage risk. These were new activities and they created the enormous financial derivatives industry, which is impossible without digital technologies. Similarly the new genetic technologies have been created as much by computation as by molecular biology. Gene sequencing and synthetic biology are impossible without computation on any industrial scale. Digitization is creating new industries continually. It is also causing existing business processes to be re-architected. We used to check in at an airline desk and be processed by a human airline agent. Now we present our electronic ticket to a digital machine and much of this process is transacted digitally.

This re-architecting of the economy is going on everywhere, in every industry, at all scales. Oil drilling, oil exploration, oil refining and production—all these are becoming digitized, and bringing in new possibilities as this happens. New technologies based on digital sensing and control are allowing extraction from previously difficult to reach oil and gas deposits. This continual addition of functionalities and re-architecting is so common it is almost invisible to us, but it reflects in the U.S. productivity figures. Since 1995, U.S. productivity has been growing at an average rate of 3 percent or more, most of it due to digitization. The technology downturn hardly affected this: productivity still grew 3.8 percent annually between 2001 and 2004.¹ A 3 percent growth rate doesn't sound terribly exciting. But in the long run it is huge. It amounts to a doubling of the U.S. economy in the next 24 years, something like creating another U.S. economy anchored off California to supply the same number of people. But there is a downside. If productivity is growing at 3 percent per year, that means either that the same 150 million workers in the U.S. economy produce 3 percent more, or that 3 percent fewer workers can produce the same output. The reality of course falls in between. This means that jobs are indeed being lost, not to China but to digitization. So all this means creating jobs—if you do the math about 375,000 new jobs (in the worst case) per month. This is not easy. And it is one of the main challenges in the U.S. economy.

The digital revolution, I believe, is still in its beginnings. It is not about the purchase of digital equipment, or about the provision of information. It is about a long and deep and almost unnoticeable re-architecting of the processes by which business works, and the inception of new industries. This takes time—a lot of time. History shows that these large revolutions—the railroad revolution, the mass production revolution—take decades to play themselves out. The digital revolution will provide productivity gains and thereby assure the U.S.'s competitive position not just for years but decades. We are still at the beginning of this.

MM. IT is not the only thing happening. What about the very long run? What about the rest of high tech? Can the U.S. retain its position as the dominant innovator in high technology?

WBA. I believe so. Here again the signs are positive. I don't think the U.S. will lose its edge here in the foreseeable future.

Any economy—the U.S. now, or Germany 100 years ago—retains its competitiveness as long as it can continue to introduce new important industries. New industries are birthed from novel technologies and these in turn are formed from the sciences that the country in question dominates. Germany owes a great deal of its innovation position a hundred years ago to its dominance in science, particularly in chemistry and the understanding of electricity. You can see the same thing at work today in the U.S. Many of the industries that make the U.S. currently competitive did not exist 60 years ago, and they arose in no small degree out of basic science and the application of science. Modern telecommunications relies heavily on photonics which comes out of quantum understandings. Computation itself relies heavily on the physics behind very large scale integrated circuits. Now we are moving toward revolutions powered by genomic technologies and nanotechnology. Nanotech grows out of materials science and quantum physics, and genomics out of modern molecular biology and the genetic sciences. Other countries will not be unimportant in these, but the U.S. will have a lead as long as it dominates the sciences out of which these technologies grow. So far the U.S. has done so. And I think it will continue to do so.

MM. What's to prevent other countries from overtaking the U.S. in science and from there in innovation? England and Germany didn't retain their dominance.

WBA. That's true. We can't take anything for granted, and it is possible that other countries can take the lead here and get ahead of the U.S. I don't rule that out. But a lead in science and in the innovations based on science takes a really long time to build up. You can't just put in government funding and accomplish this in a decade. Advanced technology comes out of a very deep understanding of the theory and grammar of certain scientific phenomena. It took a huge amount of understanding of quantum physics to produce the laser for example (which lies at the heart of modern telecommunications). And similarly it takes a lot of understanding to translate

these scientific understandings into technologies. This sort of understanding can't just be lifted from data or knowledge published in technical journals. What counts in these areas is knowing what methods work and what ones don't, how exactly to "cook" the thing, what ways help to cut through obstacles, and what new directions to pursue next. This sort of expertise is no more easily transferable than is Cordon Bleu cooking. It is a craft—a collection of knowings—of hundreds of particular methods and details. As a craft it resides implicitly in people's minds and over time, over years, it builds up within small groups in particular high-tech labs and in particular localities. The result is that once a region or a country gets ahead in a set of specific advanced technologies it becomes hard to challenge.

I am not saying that other countries don't have advanced science. I am saying that because of its deep understandings of the sciences behind genomics and proteomics and nanotech, the U.S. is well placed to lead in these new technologies and in the industries they will create. But there is no call for complacency. I don't see the base of science shifting out of the U.S. for some time yet. But to assure this, the U.S. needs to continue to pay close attention to education and advanced science.

All this I believe is not just optimistic, it is realistic. The U.S.'s competitive position will benefit from globalization, the digital revolution, and its strong position in science and innovation. And barring catastrophes such as pandemics and wars, or severe government bungling, this will continue for several decades.

¹ Source: Federal Reserve Board of San Francisco, 2005.

W. Brian Arthur

A widely-acclaimed economist and strategist, W. Brian Arthur teaches companies, especially technology-driven firms, how to build their businesses to market dominance. He was among the first economists to explore the dynamics of increasing returns: how products that have gained market share find it easier to gain further market share and go on to lock-in and dominate their market. Brian Arthur left an endowed chair at Stanford University to help start the Santa Fe Institute, where he was Citibank Professor. He is currently writing a book on how technology has radically changed the economics of competition, the character of business, and economics itself.

Arthur's work on increasing returns revolutionized economic thinking and won him a Guggenheim Fellowship and the International Schumpeter Prize in Economics. He has specialized in researching how success tends to generate further success and how this dynamic drives much of the economy and the high-tech economy, especially. His work provides an approach to strategy and timing that allows firms, regions, even whole countries to lock in dominant market shares.

The information revolution is far from over, says the internationally-acclaimed economist. We are only now on the verge of a build-out phase in technology that will realize the full wealth-creating potential of the recent high tech expansion. Past technological revolutions have shown their greatest growth *after* speculative crashes, and this is precisely where we are now with the high tech economy.

Arthur's ideas have had a huge impact on corporate strategy for companies struggling to respond to the new technologies washing over their industries. He sees the economy shifting from an old structure of stand-alone factories to a new structure in which companies fluidly combine "intelligent" technologies, "converse" digitally, and continually undertake new tasks. This shift will bring a new era of prosperity, but it calls for different thinking on the part of business.

Arthur is also one of the pioneers of the science of complexity. He ran the Santa Fe Institute's first research program in 1988 on the economy as an evolving complex system, and his odyssey in the field is featured in M. Mitchell Waldrop's popular science book *Complexity*.

CREDENTIALS

- Former Citibank Professor, Santa Fe Institute
- Former Dean and Virginia Morrison Professor of Economics and Population Studies, Stanford
- At 37 was the youngest endowed chair holder at Stanford
- Directed the Santa Fe Institute's first Research Program (in Economics)
- Fellow of the Econometric Society; former Guggenheim Fellow
- Fellow of the World Economic Forum
- Honorary doctorate from the National University of Ireland
- Ph.D. at UC Berkeley, Masters Degrees in Economics, Mathematics, and Operations Research

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