

## **The weightless economy: No heavy lifting**

by

Danny T. Quah

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*If the Information Technology revolution is such a big deal, why aren't economies more productive? Danny Tyson Quah asks if it might be the nature of work in the weightless economy that makes measured average productivity seem low, when in fact true productivity is high. Along the way, he also describes how the abstract ideas of Alan Turing, John von Neumann, and Kenneth Arrow affect everyday economic life, not just new economic theorising.*

Is the weightless economy just faster, more reliable computers and telecommunications? If so, then perhaps working, adding value, and creating wealth can take place much as they always have done. There will simply be more beautiful and more advanced machines in the workplace. Those machines should make our every working minute more productive. In this view the weightless economy—as the most obvious manifestation of technical progress—ought to let workers generate ever more economic value with ever reduced labour input.

That it does not would signal abject failure.

Improving productivity from plugging in better machines is a fine way of thinking about technical progress in general. Useful technical progress is when a machine sits before a worker, and the two together make valuable output—more than the worker could before. Failed technical progress is when that machine seduces the worker to use it, but the resulting output is not so valuable after all. A “productivity paradox” arises if entire economies spend increasingly on technologically advanced machines while average labour productivity declines.

But if this is a good way to think about technical progress in general, it might not be for understanding information technology and the weightless economy.

## **Moving mountains to Muhammad**

Many of us tend to use a *black box* approach to technology, not only in how technology advances but also in how it is used. One form of technical progress is no different from any other, and all forms of technical progress are equivalent to better machines, i.e., improved physical capital.

A visual metaphor for technical progress in economic life is useful here. Suppose the decision has been taken to move the mountain to Muhammad, after all. One way to do this is to have a thousand workers digging up, carting over, and then piling up anew under Muhammad all that mountain material. Another way is to bring in heavy metal—piledrivers, earth movers, construction cranes, greasy lathes, steam engines—and work these machines in tandem with humans. The job gets done faster and, Muhammad willing, might even employ fewer workers. The end result is the same but labour input measured in people-hours is reduced. Average worker productivity has therefore risen, from substituting capital for labour. At the same time, the rewards to workers—their wages, determined in free markets as their marginal productivity—would also rise.

Yet a third way brings in new, improved machines—a specialised mountain-mover that can, in one gulp, store a whole mountain in its maw and then disgorge it wherever Muhammad wishes—requiring but a single worker. Labour productivity and worker wages have now skyrocketed, thanks to technical progress.

(Moreover, all of Muhammad's friends see how easily it is done—they're all wealthier now as well, having invested in the stocks of mountain-movers and things that make mountain-movers—and each wants his own mountain moved. Workers and mountain-movers are kept on the go.)

## **Turing, von Neumann, and Arrow: An O-ring in every backyard**

Most times, when observers lament the information technology revolution not improving worker productivity, they are seeking to fit

computers and software into a model of moving mountains: new tools for old jobs. The weightless economy comprises information and communications technology; name brands, advertising, and aesthetic designs; new media; and electronic databases in particular and intellectual property more generally. How do workers add value in such an economy; what are the new jobs for which new tools might create wealth?

The reason I put the categories of the weightless economy together is that they share a root property, that of *infinite expansibility*—where a single instance of an object never has its usefulness diminish, regardless of how much it gets used. This holds for an item of computer software, of a vivid advertising image or design, of a movie print in entertainment media, of an electronic database, and of a breakthrough scientific idea. (Indeed, the usefulness might actually increase, the more that instance is exploited—an example of positive network externalities—but this only strengthens my point below.)

Another key property, although not an obvious economic one, is that weightless-economy objects can all be readily translated into bitstrings—sequences of binary digits 1s and 0s. Every bitstring is infinitely expandable, but not all are economically valuable. To come to grips with a piece of computer software, the Nike logo, Derwent’s patent database, or the double helix structure of DNA, one needs a device for first encoding them into a bitstring, and then another for decoding the resulting bitstring back to the original. Such devices can, moreover, actually be the same physical machine and be relatively simple. Most of what makes the device function—the controlling instructions—can in turn be themselves bitstrings.

In 1936 Alan Turing at Cambridge established how such devices work. These universal Turing machines or computers are *symbol-processing* engines (thereby putting to death the misguided idea that in the future successful human workers will be symbol processors). Computers process symbols—many times faster and better than do people, and they have done so from the very beginning. Doing arithmetic—simulating models, solving equations, adding and multiplying numbers—is but one of the less imaginative uses for a computer. John von Neumann at Princeton, simultaneously with others

including Turing himself in England, carried the work forwards and made concrete the modern electronic computer, together with controlling software—the instruction bitstrings—stored in random-access memory.

Only one relatively simple physical device is needed. Instructions and data are, interchangeably and simultaneously, bitstrings. A different complicated machine isn't needed for every different task—just a single, physically-invariant machine reconfigurable on the fly by bitstrings. All economic value, flexibility, and usefulness is embedded in the bitstrings.

Noting that the weightless economy is all, in essence, bitstrings gives insight into how that economy functions. A bitstring, weightless economy is a lot like a community of research scientists seeking to make scientific knowledge. Kenneth Arrow, in 1962, studying the problem of resource allocation in knowledge production therefore also provided a model for the functioning of the weightless economy. Traditional markets do not work well—not for allocating resources in the scientific research community, and not in general for the weightless economy.

But how does this affect our interpretation of productivity measurements?

Scientific knowledge is a bitstring. Bitstrings build on one another (as does, more obviously, scientific knowledge); the usefulness of a bitstring is only as good as its weakest substring. Just as the space shuttle Challenger disaster occurred from a faulty O-ring, successful bitstrings depend critically on earlier bitstrings that, by themselves, are acknowledged to be neither successful nor glamorous. The sequence of ho-hum developments leading up to a single successful breakthrough product in biotech or pharmaceuticals is a ready example. A computer program failing because part of it became corrupted is another.

Working in the weightless economy is producing bitstrings. When a bitstring is useful, the worker—researcher or scientist, in Arrow's model—should get paid the appropriate amount. But because the use of that bitstring occurs without drawing down its inherent usefulness (“additional copies can be made for free”), the socially optimal

price for the worker’s product is zero. (This provides one neoclassical economic interpretation of the guiding principles proposed by those such as the GNU Project and the Free Software Foundation.) A well-functioning market achieving the ex-post efficient outcome should reward the successful worker exactly nothing for having produced a bitstring—useful or otherwise. This isn’t Robin-Hood nonsense; it is sound economic reasoning.

But if so, then rational, well-informed people will decide to do something other than produce bitstrings. As a result no bitstrings are produced, and the weightless economy grinds to a halt. This isn’t Microsoft/robber-baron propaganda; it too is sound economic reasoning.

### **The Sorcerer’s Apprentice:**

**“Ok, but which rats’ tails shouldn’t I have put in?”**

But, as does the Internet, reality reroutes around failures. In the weightless economy, society might agree to forsake the social efficiency that comes from flooding an economy with free copies of useful bitstrings. Instead, it might decide to endow enforceable monopoly property rights on particular bitstrings. This provides ex-ante incentives for workers in the weightless economy, but at the cost of social inefficiency, ex-post.

Since the first instance of a bitstring suffices to serve the entire market—remember, infinite expansibility—no producer beyond the first is ever needed. That first producer, the tournament superstar, owns the whole industry. All that matters for their reward is that they came in first. They gets everything regardless of whether they were far ahead of the rest of the pack, or just a smidgen so. (“First” needn’t mean literally “first in time”—examples abound of companies, countries even, who were technologically first but were unable to exploit that priority. The Xerox company is a well-known much-reported example; 14th-century China is another.) Society awards no prizes for those coming in second and re-inventing the wheel. Ex ante, before the winning worker has won, there is a frenzy of activity as everyone in the race gives up everything else and concentrates on

being the one to breast the tape.

But the story doesn't end there. Given the right platform to build on, bitstrings can be cheap to make, and the position of a winning bitstring is fragile and temporary. Someone else will come along with a bitstring that trumps if the current superstar simply sits idle.

Bitstring production occurs all the time while award-winning bitstrings are acknowledged only infrequently. Some ho-hum bitstrings will be critical parts of a prizewinner bitstring, but by themselves are not worth anything. In such a world, an external observer observes worker productivity (current economic value divided by current labour input) to be mostly low, although periodically a spurt of remarkably high productivity occurs. Averaging across workers at a point in time, productivity could be high or low: It depends on the relative mix in the population of winners and all others who happen to be just in the race.

A lot of zero-valued bitstring production is unrewarded, by definition, but is also necessary. Otherwise, high-valued bitstrings never get produced. Adding value in the weightless economy is like when someone admits that half her advertising budget is useless—the trouble is, no one knows which half.

As with most other economic reasoning, the predictions here fit some observations in the real world better than others. Software engineers in California work for peanuts in current wages relative to their industry's success, but take stock options instead: They are generating bitstrings at low value now, but are holding out for the winning bitstring in the future.

Of the world's wealthiest people in 1997, four worked in software; two in computer hardware; and two in media. Winning bitstrings evidently pay well.

Across a range of workplaces in the weightless economy, younger apprentices bide their time and accept relatively meagre rewards in the present, while anticipating their big breakthrough to become a superstar winner in the future. What are the implications for average productivity?

In the weightless economy measured value-added varies considerably across workers. When productivity, averaging across all workers,

is seen to be low, that might simply reflect the workings of the dynamic reward structure implicit in the apprentice/superstar system. Some contribute a lot to measured output; others only a little, in the anticipation that they will make a great deal more in the future. Measured average productivity and its growth could be high or low.

However, getting rid of the apparently low-productivity apprentices, by some external mechanism, in an attempt to raise average productivity could be itself counter-productive. Over time, the supply of superstar bitstrings dries up, and growth stops.

*Danny Tyson Quah is Director of the CEP's National Economy Programme, and Professor of Economics at the London School of Economics.*

**<http://econ.lse.ac.uk/~dquah>**

*1973 words*