The productivity paradox, part II

Julien Garran & Andy Lees
10 June 2016

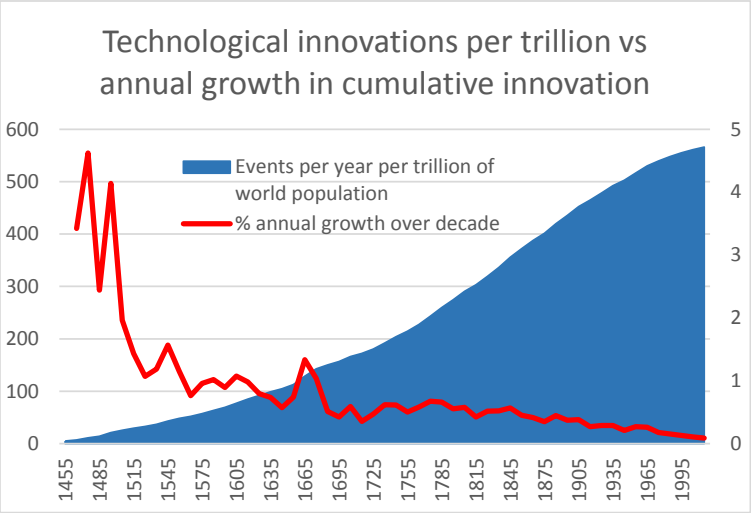
Introduction

In part II of this note my colleague Andy Lees & I address more key questions that clients are asking on productivity and the capital stock.

We argue that a combination of physical constraints (and the constraints of physics), a lack of major innovation and misallocated capital have caused productivity to collapse and the capital stock to deteriorate. We believe that this has taken potential growth into negative territory, and it means that without massive liquidity injections from the Fed & other central banks, the US & the global economy will fall into a deflationary bust.

The key questions we'll answer in this note are;

- Is computer productivity over?
- Is productivity falling in healthcare?
- Does a rising level of debt or QE affect productivity?
- Isn't the capital-light model more efficient?
- Aren't robots driving productivity higher?
- What are the implications of your view?



Source; Jonathan Heubner

Is computer productivity over?

In 'What fourth industrial revolution?', April 2016, Andy highlighted the damage the breakdown in Dennard scaling, the reduction in energy use in transistors as they got smaller, has done to the prospects not just for computer power, but for the subsequent productivity gains in a wide array of industries.

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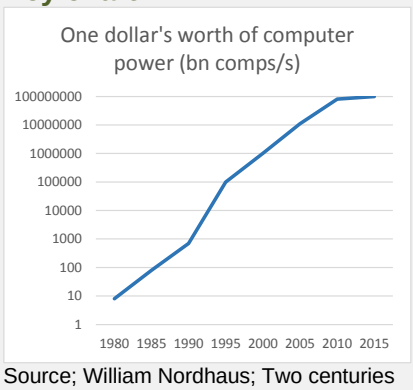
Recommendations

- **Short US equity indices.**
- **Long gold & gold stocks.**
- **Short silver/gold ratio.**
- **Long the US$.**
- **Long volatility.**
- **Short US non-bank lenders**
- **Short US auto sector.**
- **Short UK Miners.**

Key chart



Source; William Nordhaus; Two centuries of productivity growth in computers

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The breakdown of the Dennard Scaling back in 2005 has meant that semiconductors have not become any more powerful since, hitting the "Power Wall". Computer performance is not dependent on the number of transistors, but rather the number of transistors you can operate, and the speed at which they are operated. As the transistor got smaller, its energy consumption fell proportionately to the area of the transistor, reducing the cost of the computational power.

Once the size became sufficiently small however, the gate between the transistor plates has leaked electrons, creating heat. In 2005 the Power Wall was hit at which point the leakage became dominant. The higher temperatures from the power leakage meant the frequency and time utilisation of a chip's transistors actually decreased. The only way to increase the computer power has been to use the semiconductors in parallel, but without the smaller transistor, the energy cost has gone up accordingly. There is also a declining marginal return from running more semiconductors in parallel.

The implications for industry are enormous, both upstream and downstream. The growth in traffic volumes the airline industry expects for example are based on assumed aircraft efficiency gains that are dependent on increasing computational power many thousand fold. Downstream, even Robert Gordon's water utilities will suffer.

Despite using ever more powerful supercomputers, the cost of drug development continues to soar and is becoming prohibitively expensive for anything but long-term diseases as the complexity of the disease scales more rapidly than computing power.

The rising cost of computing means the Fourth Industrial Revolution is likely to be prohibitively expensive for the benefit it delivers. **It is already apparent that a large element of the technology we have added since hitting the Power Wall has been reliant on the growth in debt relative to GDP, and has therefore taxed rather than boosted productivity.**

With the Dennard Scaling broken down, all industries, both upstream and downstream of computing, and seemingly unrelated industries, will suffer. Global growth will increasingly be dependent on additional debt, needing ever lower interest rates and base monetary expansion.

This is an enormous change. The cost of individual transistors is not going to come down.

If Andy is right, and this has now peaked, this will have profound implications for productivity and potential growth going forward.

Greenspan started counting the improvement in computer power in GDP in the 90s through 'hedonic adjustment'. That double counted GDP for the reasons described above, and it gave a false impression of the value of computers to the monetary economy.

An important part of the slowdown in growth we are experiencing is because computer hardware productivity has collapsed. So that decline is not just bad for productivity and growth, it is doubly bad for reported growth numbers, as the authorities can no longer double count the benefit.

Wasshausen & Moulton's data (The role of hedonic adjustment, 31st CEIES Seminar on 'Are we measuring productivity correctly') shows that there was an 11.5% quality adjustment to computers & equipment from 2001-2005. Applying this to the tech industry as a whole at 7% of GDP, suggests double counting of around 0.2% of GDP per year over the period, on top of the productivity gain achieved by improving computer power of 0.2% per year. **This means that the collapse in Dennard scaling on its own may be taking up to 0.4% off reported US growth today relative to 2005.**

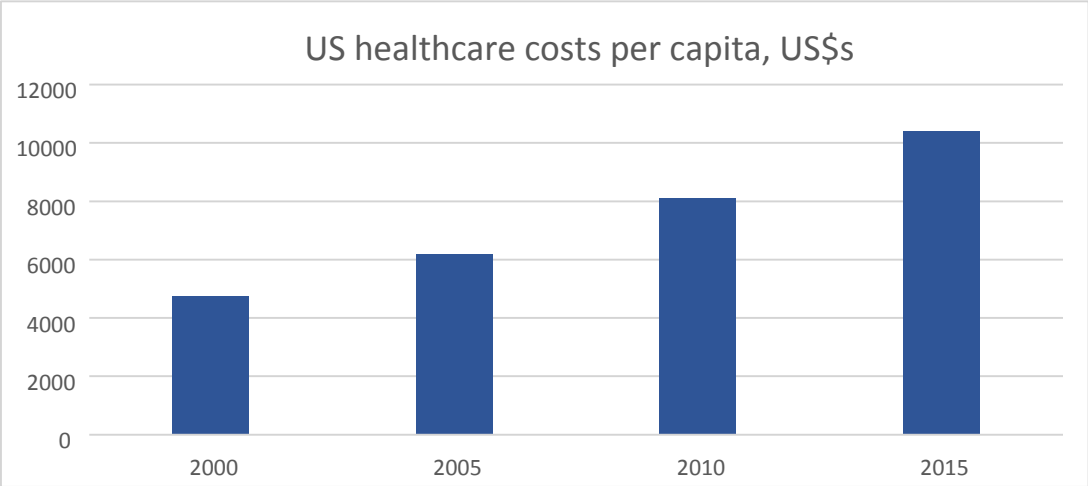
In 1987, Robert Solow identified the first 'productivity paradox' when he said 'you can see computers everywhere except in the productivity numbers'. However, computers' impact on the economy as a whole was diminished by two things; the scale of historical innovation imbedded in the capital stock, and deteriorating productivity in oil, healthcare & the state. Now computer productivity is peaking, the risk is that the negative factors will come to the fore.

What is the impact of falling productivity in healthcare?

In 'Bad State' I argued that falling productivity in healthcare & college education alone has already taken 6.3% off potential US GDP in 15 years, and it continues to erode it at 0.4% a year.

A central flaw in conventional productivity analysis in the US is that no one seeks to measure the productivity of the government. When the statisticians include government activity in GDP, they value it at cost. In the case of healthcare I would argue strongly that the productivity is the outcome; health, relative to the quantity of inputs.

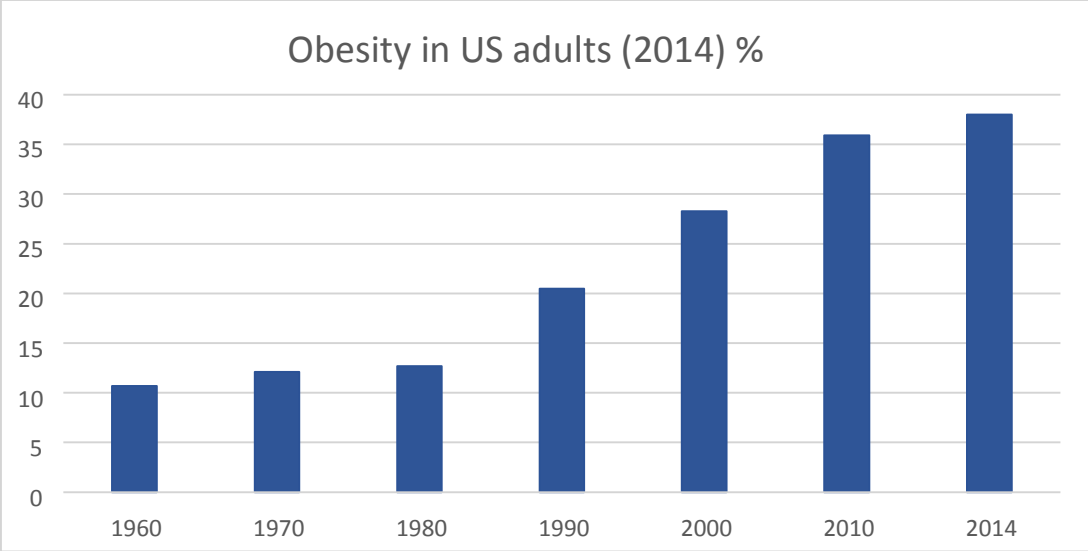
If we take the Institute of Medicine study's estimate of 30% of avoidable waste in the healthcare system, and we assume that number is closer to 15% for the broader economy, simply the rise in the share of healthcare in GDP since 2000 has increased waste, and reduced potential GDP, by 1.4%. But that assumes that the outcome from the healthcare industry; health, rises in proportion to spending.



Source; OECD, the Commonwealth Fund

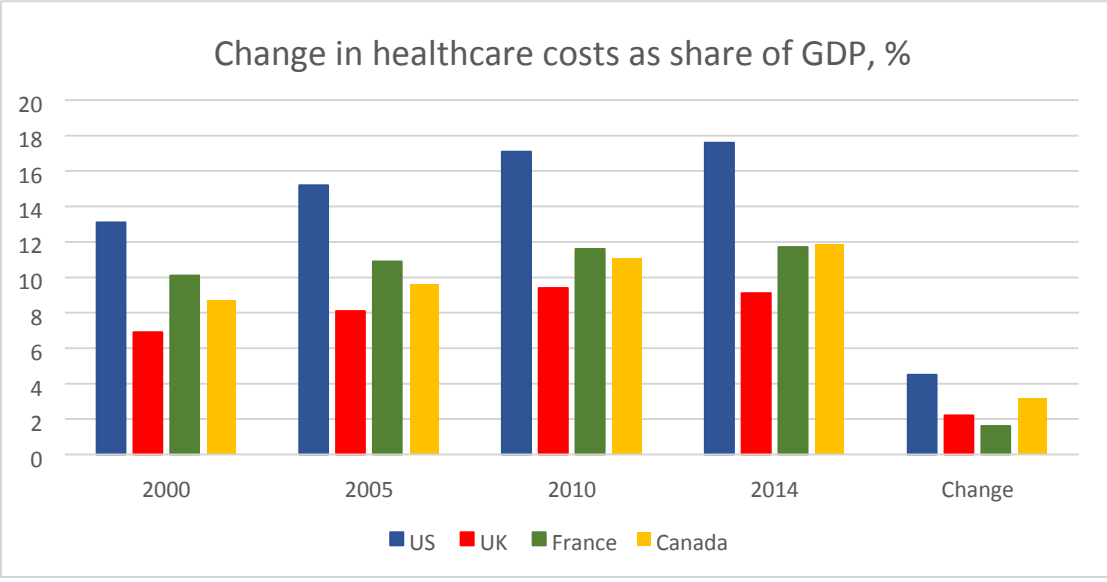
However, health has not improved as a result of this higher spending. Nobel Prize winning economist Angus Deaton reports that death rates among middle aged white

Americans increased dramatically over the past 15 years. Data out last week showed the overall death rate now rising. Obesity rates also show a deterioration in health.



Source; National Health & Nutrition Examination Survey.

As healthcare is in part a discretionary good, I took the increase in GDP spent on healthcare in the US over the last 14 years, and subtracted the average increase in three similarly developed countries (UK, France, Canada). This strips out changes in tastes and requirements that comes with age and income, and leaves 'enforced spending' created by runaway costs and overtreatment in the system. This suggests that the non-discretionary cost has risen by 2.2% of GDP in the US over 14 years, or by 0.16% of GDP per year.



Source; World Bank

Next, to estimate the output, I'm going to use two very simple metrics to estimate health; longevity & obesity.

From 2000-2014, US healthcare spending has risen 34% faster than GDP – rising to a 17.8% share of total GDP. Cross country analysis suggests that just under two

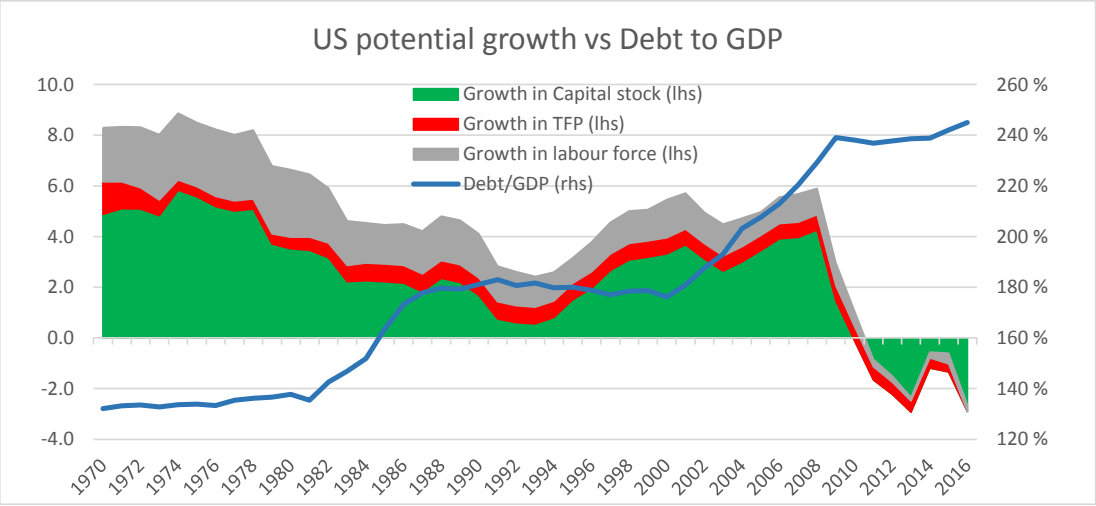
thirds of the increase was unrelated to demographics or discretionary spend. Despite this increase, the health of the US population deteriorated – as measured by a combined index of longevity & obesity.

The MacroStrategy Partnership US healthcare productivity index fell from 100 in 2000 to 77.4 in 2014. I estimate that deteriorating productivity in the healthcare sector led to a 3.8% reduction in potential GDP over 14 years, or a reduction of 0.27% decline in potential GDP per year. And that is in addition to the 1.3% loss to GDP from the higher share of spending on a more wasteful industry. The total reduction in potential GDP is 5.1%.

The WSJ highlights that US birth rates fell 0.3% last year to 3.98m, while at the other end the US death rate rose in 2015 for example from 723.2 deaths per 100,000 to 729.5, a 0.87% deterioration, the first rise since 2005 when flu affected people. While death rates had been rising among certain groups - in particular less educated whites who had been hit hardest by the prescription drug epidemic, increases for the entire population hadn't happened for a decade. "It's an uptick in mortality, and that doesn't usually happen, so it's significant" according to the National Centre for Health Statistics. If it continues this year, it will be much more significant. The article suggests this trend of slowing population growth, if it were to continue, will limit GDP growth. Whilst demographers project growth in the world population to about 9.55bn by 2050, even within that projection is a rapidly slowing rate of growth. This projection is based off a simple extrapolation, yet the medication etc. needed to extend life expectancy will be unaffordable if productivity continues to fall.

Does a rising level of debt or QE affect productivity?

Rising debt on its own doesn't necessarily hurt productivity, and might increase it if it is invested in activity that makes a return on the cost of capital. Rising debt to GDP over time always hurts. It is effectively synonymous with deteriorating productivity.



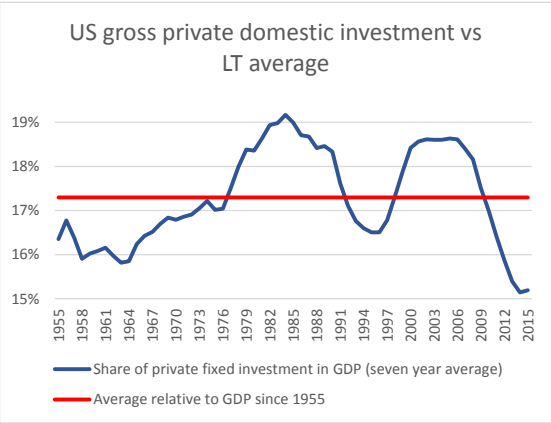
Sources; BEA, Conference board, BLS, Bloomberg, The MacroStrategy Partnership.

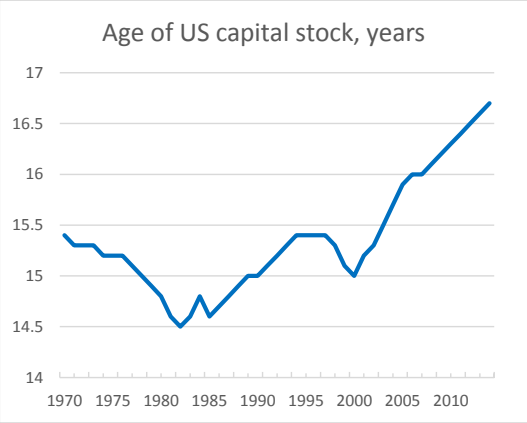
When private credit grows faster than GDP a more subtle deterioration takes place. At the margin, businessmen and investors are stimulated to invest in activities that only makes a profit while credit is expanding faster than GDP – they misallocate capital.

There are two clearly quantifiable ways that misallocated capital undermines the capital stock.

The easiest to quantify is ageing. QE has induced corporates to gear up to buy back stock, at the expense of investing in the capital stock.

The degree of underinvestment is shown in the chart below. This has nothing to do with a new 'capital light' model of investment (see below). Instead it is almost entirely due to companies, governments, and consumers consuming their capital stock to enhance their living standards today, at the expense of living standards in the future. This should be put in the context of GDP growth that has already slowed heavily.





Sources; BEA, Bloomberg

At present, the capital stock is ageing by 3.5 months every year. If we multiply that by the value of the us capital stock (US50trn), then by the depreciation rate (I've used a conservative 3% as the capital stock includes houses and commercial structures that age slowly, as well as software and IT equipment that ages fast) and then divide all that by GDP of US$18trn. That tells you that ageing the capital stock is reducing potential GDP by 2.9% a year.

Then there is the obvious destruction of capital in the shales. In ‘Destructive destruction’, November 2015, we estimated this at around 3% of the capital stock.

What is unquantifiable is how much capital is wasted, and how much productivity growth is dimmed, by the asset culture fostered by excess credit & QE. We will find out what across the cycle returns are in some of the asset servicing businesses when we see how many real estate agents and stockbrokers are still working when debt to GDP stops growing.

What we won't find out is what would have happened if half the world's estate agents, stockbrokers and government legislators (who also stay in work because of QE) were actually doing something productive, like working on cheap energy, or on room temperature superconductors - (which may then open the door to highly efficient batteries). My view is that the world would be a very different, and profoundly better, place.

Isn’t the capital light model more efficient?

It may be, but we'd question whether this is happening faster than in the past, and we dispute that the productivity data is failing to pick it up.

First, we've been getting more capital light since the industrial revolution, and certainly since manufacturing peaked as a share of GDP in the 1960s. There's no particular reason to believe that we're getting lighter faster.

Second, a desk job isn't that capital light. You need an office, desk, phone, a car or access to public transport infrastructure. And you need a power grid to power generation for your lights and computer, server stations to support your internet, and software packages to run on your computer. You need expensive universities to train your staff. Just manufacturing the computer is no small effort. In 'Information; the new language of science', Hans Christian von Baeyer points out that the manufacture of a 2g microchip consumes 36x its weight in chemicals, 800x its weight in fuel & 1600x its weight in water.

And now, with the rapid acceleration of energy use in the home you need pretty much the same suite of capital intensive support for your leisure activities and your home life. Fancy a salad for lunch? Did you know that it takes 50x the energy to grow and deliver a tomato to your door than you get from consuming it? (See Vaclav Smil's 'Energy for beginners' for a run-down of how energy consumption has risen with income). When we add in the increased use of energy and other resources in the home, we would argue that the economy is becoming more energy & capital intense, not less.

That certainly fits with the insights from information theory, a critical but little known foundation of modern physics, first conceived of by Claude Shannon in the Bell labs in the 50s (see the excellent BBC documentary 'From order to disorder', or the 'information' book cited above). Two key elements of this theory apply to tech. First, all information must be embedded in a physical system. And writing information into a physical system takes energy. Jonathan Koomey estimates that datacentres use around 2.4% of the US electricity consumption or around 112m mwh/year.

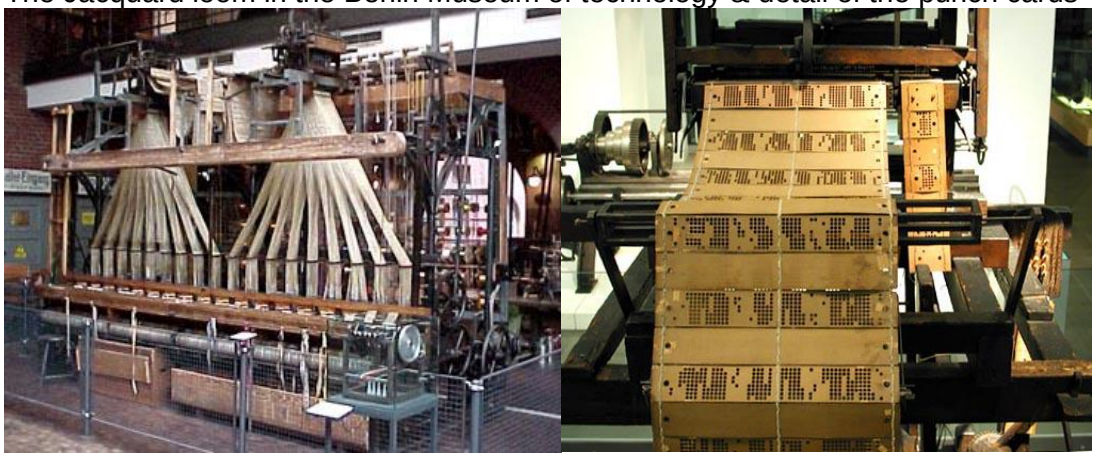
If we're wrong in our analysis above, and the economy is actually getting more efficient at using the using the capital stock, then it means that we should be able to create more GDP with the same capital stock, and without recourse to an increased ratio of debt to GDP. Productivity would be rising rapidly. But of course, the very fact that this is not happening is the reason we've written this note.

Aren't robots driving productivity higher?

No. The first problem with this idea is that robots have been around for a very long time. It is widely reported that GM introduced the first industrial robot into a car plant in 1951. When our colleague James Fergusson visited the Fanuc robot factory in Japan in 1985, he found that it was fully automated; robots were building the robots.

But GM's robot wasn't the first robot. If you think of a robot as a programmable machine that can autonomously produce work, and that is a pretty good definition, then the Jacquard loom, patented in 1804, is clearly a programmable robot.

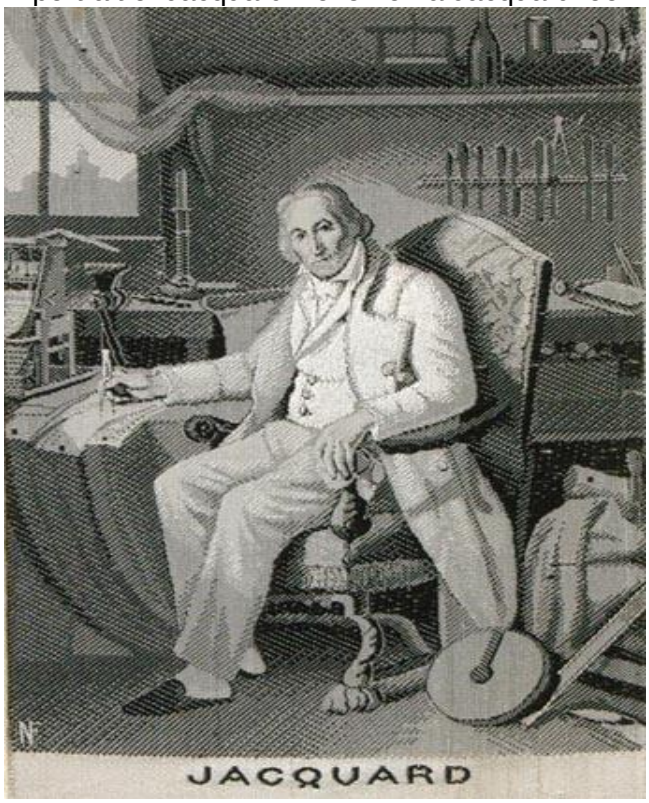
The Jacquard loom in the Berlin Museum of technology & detail of the punch cards



Sources; Berlin museum of technology

The picture of Jacquard reproduced below was woven using 24000 separate punch cards. It resembles pictures drawn by the early dot matrix printers – and for a good reason, both required similar programming

A portrait of Jacquard woven on a Jacquard loom.



And it was no obscure technology. It changed the world.

My definition of a transformational technology is one that cuts the cost of a commercial operation by 90%+ or which creates a significant new industry. Jacquard's programmable loom was transformational.

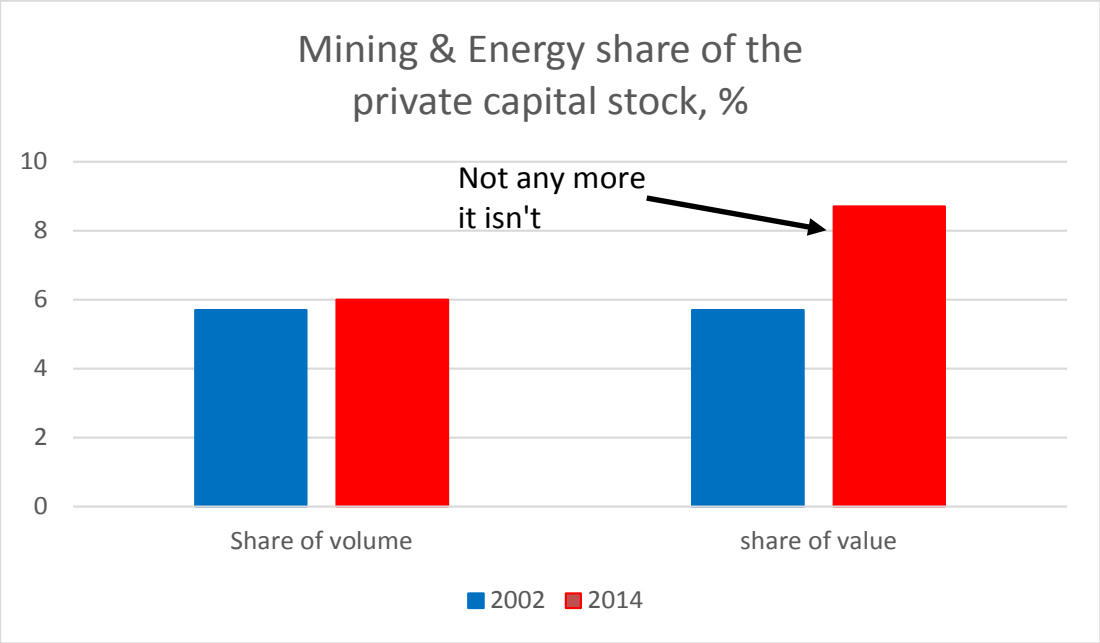
How transformation can be seen by the isolated pockets in the world that today have not adopted the programmable loom or its successors. In Kashan in Iran, a city that was built as a caravanserai on the original Silk Road, they are still weaving carpets by hand. It takes eight women two years to weave the best carpets. In antiquity, Iran was one of the richest nations in the world. Its slow progress is one reason why Iran today has a per capita income just over 1/10th of that in the US.

Andy also asks whether those people that are being made redundant by the robots are finding new productive roles. Given that these people are the market for the robots' output, if they are not finding a productive role, and are instead dependent on debt - (not necessarily their own debt, but rather system wide debt) - then the robotics have actually introduced a new layer of capital and have therefore reduced productivity. This is when the 'trickle down' effect stops working, and an increased use of robots can actually reduce system wide productivity (and the world starts to resemble Kurt Vonnegut's debut novel 'Player Piano' rather than Frederic Bastiat's 'That which is seen & that which is not seen' Bastiat link)

What are the implications?

In this cycle, the two big misallocations have been into the high cost energy of the shales in the US, tar sands in Canada & deep salt wells off Brazil, and the misallocation of debt funding into share buybacks.

For the US economy, I estimate that the destruction of capital in the shale industry has shrunk the US capital stock by 3%. If you amortise that, that's a 0.6% annual drag on GDP for the next five years.



Source; The BEA, The MacroStrategy Partnership

The underinvestment in the US economy that accompanied the buyback boom has robbed the US of the productivity growth that takes place when innovations are embedded in the capital stock. It has also caused the capital stock to age rapidly.

Age of the US Capital stock

	2007	2008	2009	2010	2011	2012	2013	2014
Fixed assets	**20.6**	**20.7**	**21.0**	**21.3**	**21.6**	**21.9**	**22.3**	**22.7**
Private	20.3	20.4	20.7	21.1	21.4	21.6	22.0	22.3
Commercial	15.2	15.3	15.5	15.7	15.9	16.0	16.1	16.1
Equipment	7.0	7.1	7.4	7.5	7.5	7.4	7.4	7.3
Structures	21.0	21.0	21.4	21.7	22.0	22.2	22.4	22.6
Intellectual property products	4.2	4.2	4.3	4.4	4.4	4.4	4.5	4.5
Residential	25.8	26.3	26.9	27.4	28.0	28.6	29.0	29.5
Government	21.7	21.8	21.8	21.9	22.4	22.7	23.2	23.7

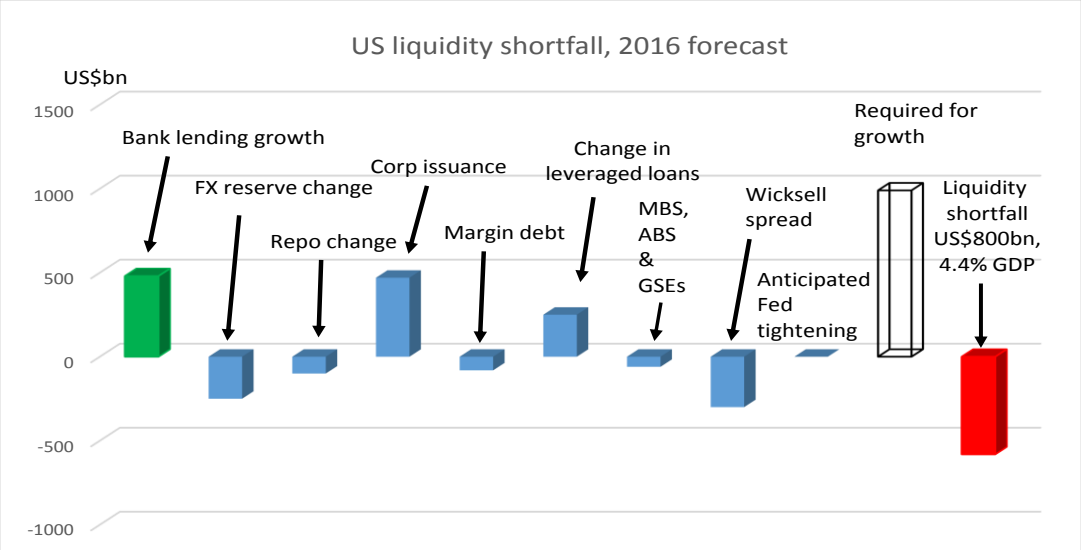
Source; Bureau of economic analysis

But if we use a conservative 3% depreciation rate on the official US capital stock data from the BEA, this means that the capital stock is capable of supporting 2.9% less GDP per year at the current rate of ageing. So if we look at the sources of potential growth in the US, we're in for a big shock.

- The quality adjusted labour force is barely growing, as baby boomers retire, as educational standards slip, and as younger workers in low quality jobs learn low value skills.
- Total factor productivity has stalled.
- The productive capital stock is shrinking by 3.5% per annum.

This is the fundamental problem today. Potential growth is negative. But the debtors in the system need nominal growth of 3%+, or they will struggle to pay interest and principal, and the US will fall into a deflationary bust.

Absent excess credit, we will revert to the deteriorating trend. Why? Because, the bigger the shortfall in potential growth. The more fresh liquidity is needed. In the absence of QE and foreign central bank treasury buying, I estimate that the US faces a US$800bn liquidity shortfall this year.

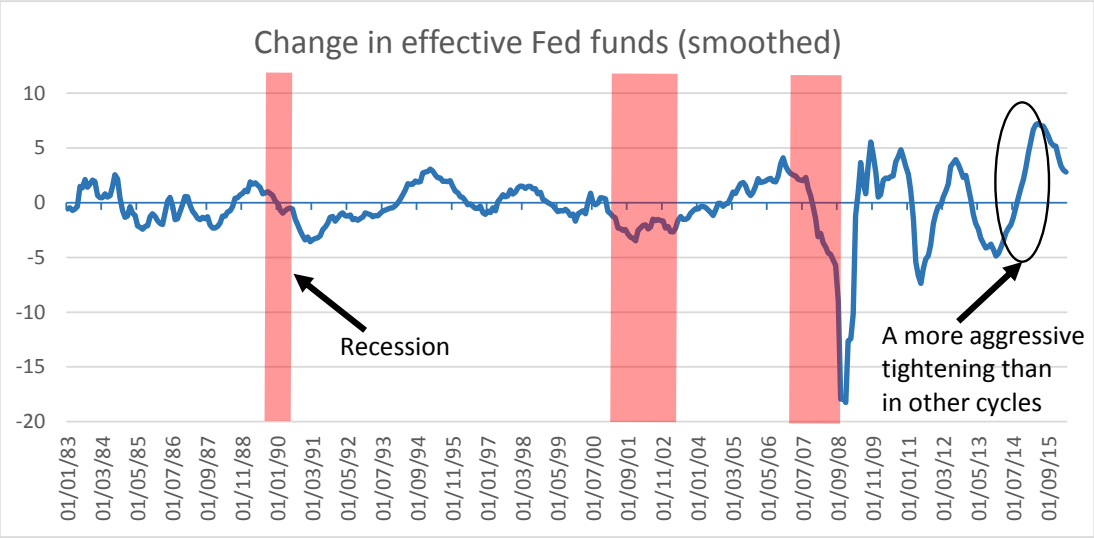


Sources; Bank Lending – Fed H8 report. FX reserves; Bloomberg. Repo – NY Fed. Corp Issuance; SIFMA. Margin Debt – Bloomberg. Leveraged loans – S&P. MBS, ABS & Money market – SIFMA. Wicksell Spread – Macrostrategy Partnership calcs, bberg data. Fed tightening – Bloomberg. Required for growth – MacroStrategy partnership calculations, conference board, Fed data.

The US economic bulls are arguing that cycles don't end with one or two rate hikes. That of course ignores that high debt/low productivity economies need much more liquidity than low debt/high productivity economies.

And it ignores the fact that removing QE removes liquidity. Not exactly like a rate hike, but similar. In my ongoing work on the Wicksell spread and my efforts to quantify the US liquidity shortfall - it became clear that you can quantify a 25bp rate hike as removing 25bp of GDP of liquidity - or US$45bn. Likewise, you can translate Fed QE back into rates.

So here's a chart of the change in the Fed's effective real interest rates going back to 1980. The formula is the fed funds rate minus annualised QE/180bn.



Sources; The MacroStrategy Partnership, Bloomberg

Through this lens, the Fed has tightened more than prior to previous recessions at a time when the economy is in much greater need of liquidity.

In our view, this tightening, after a sustained period of easy money, will trigger a deflationary bust.

APPENDIX 1 - NOTICE AND DISCLAIMER