

## **MACHINE LEARNING: ITS PARADOXICAL AND UNEXPECTED EFFECTS ON PRODUCTIVITY.**

Productivity outside South Asia has been stagnating. According to the Conference Board's comprehensive data base, published in March 2018, global productivity rose 2% in 2017, down from the average 2.7% for the period 1997 to 2017. In the US, the most advanced economy, non-business productivity was up 1.3% and for manufacturing only 0.3% (BLS report issued 6<sup>th</sup> June). The deceleration in productivity growth has been the most vexing of the questions facing economists.

There are a number of reasons for this, some obvious but others more obscure.

1. Faltering rates of investment in fixed assets is the most common reason given. Too much weight is given to this factor because the key figure, net investment, is the product of gross fixed investment less depreciation, and, when depreciation is overstated as it is by IP (Intellectual Property depreciation) then net investment will be understated.
2. The growth in employment is concentrated in the serving and servant sector, which is labour intensive and does not lend itself to productivity growth. As it is low value added, it contributes below average value to GDP while contributing above average hours to the calculation of productivity (which is the measure of total gross value added divided by total hours). It thus reduces average productivity and its growth rate.
3. The turnover of capital has fallen which has elongated the period of production and circulation. Lower turnovers mean value takes longer to be realised or added. If the same number of workers are employed, falling turnover will always be registered as a fall in productivity. This is a major reason for the slowdown in productivity in the advanced capitalist economies.
4. At least in the USA and Europe, the contribution to productivity by the under-pricing of imports (inputs) from places like China, is now reducing. As China and other Asian economies climb the value chain, so more value is realised in the producer countries instead of the importing countries like the US and the EU.
5. The growth of inequality resulting in the growth of luxury goods production. The means of production in this sector is directly consumed therefore wasted. For example, all the luxury jets in this sector are designed to circulate the rich rather than commodities. Secondly, many of the goods in this sector are handcrafted or bespoke and because price is not issue, there is little pressure to innovate or mass produce hence to raise the technical composition of capital. Watches are a good example. In 2015 Switzerland exported 2.5% of watches equal to 28.1 million units. China on the other hand exported 682.8 million units or 24x more. But because the average price of a Swiss watch was \$797.20 while that of the Chinese watch was only \$8.50 the value of Swiss watch exports was \$22.4 billion versus only \$5.8 billion for China. In total Switzerland produces and sells 95% of all watches costing over \$1,000 and 80% of the value of Swiss exports comprises mechanical watches whose production processes have hardly changed in a century.
6. The growth in corporate cash flow which has vastly exceeded investment during the twenty years between 1996 and 2016 created a low grade chronic realisation problem throughout the world economy through its depressive effect on aggregate demand. With the fall in the mass of profits since 2016 the gap between cash flow and investment has reduced which is why there has been an uptick in productivity from 1.4% in 2016 to 2.0% in 2017 (Conference Board data).
7. Points 7 and 8 look at the reverse side of productivity growth, namely what boosts productivity growth. The growth in the technical composition of capital increases the

relative weight of depreciation in the sales price of commodities. In other words, the share of dead labour increases relative to the share of living labour. Gross value added therefore increases not only because of the addition of living labour but because of the disproportionate increase in dead labour (wear and tear of the means of production transferred to the price of the product). As productivity is measured in terms of gross value (both living and dead labour) divided only by current hours (living labour), the relative rise in depreciation helps accelerate the increase in the rate of productivity growth. (The inflation of depreciation caused by IP investment is another factor.)

8. The changing value of money makes it difficult to measure productivity because it gives rise to inflation. The statistical bureaus calculate deflators to compensate. The purpose of deflators is to reduce price rises to zero. However, falling labour times means prices should actually fall not stand still. Hence deflators are understated and because of this the volume increase in production per hour is also understated and with it productivity. Digitisation will accelerate price falls making the problem with deflators more acute.

The capitalists both fear and welcome the digitisation of production (machine learning). They welcome it as the means to accelerate productivity. And it is this greed that will triumph over their fear of the social dislocations automation will cause. However, the way productivity is measured, the effect of digitisation on productivity is paradoxical at first.

### **Marx, value added, and the measurement of productivity.**

I use every opportunity to bring to the attention of the reader that the modern system of national accounts (SNA) has its origin in *Das Kapital*. Volume 2, the least read of Marx's trilogy, which contains the first input-output tables together with the instructions on how to avoid duplicated sales. Once duplication is avoided the value which is added throughout the economy can be tabulated thus revealing GDP and National Income. This knowledge, first applied in the early years of national accounting in the USSR, was conveyed to the West by two émigrés, Leontief and Kuznets who together with the English economist Clark, are the primary authors of the SNA. Marx may ultimately have wanted the head of capitalism, but in the mean time he gave them eyes with which to view and understand their economy.

Value added can be described in many ways:

Aggregate final sales price is equal to value newly added plus depreciation, which is equal to gross value added. Gross value less depreciation equals net value added or value newly added.

Value newly added is equal to necessary value and surplus value or more concretely, to compensation of employees plus rent, interest, profit and tax.

Value newly added can also be divided into the production of investment goods or articles of consumption or as Marx would have described it: the product of Department 1 and Department 2.

Finally, and most importantly total sales less intermediate sales equals the value of final sales which equals gross value, which equals GDP.

It is the last description that interests us. This is where Marx's instruction on how to avoid duplication comes in. Companies sell to each other and they sell to final consumers. When they sell to each other, this takes the form of intermediate goods, goods that will be worked up into their final form, like iron ore being turned into steel which is then turned into pots and pans (their final form). These intermediate goods are classified as intermediate sales or inputs.

Total sales will therefore comprise both the sales of intermediate goods and final sales; or iron ore (intermediate), plus steel plate (intermediate) plus pots and pans (final). A simple table will explain this.

**Table 1.**

	Inputs (intermediate)	Value Added	Sales price
Miner (iron)	0	10	10
Steel-maker	10	30	40
Pot-maker	40	20	60
TOTALS	50	60	110

We assume that the miner works with implements he or she has produced so there are no inputs. The labour needed to produce the iron to make the steel that will make a pot is 10 Value Added. The sales price of this iron is 10 to the steel-maker. The steel-maker smelts the iron worth ten and by adding 30 in labour produces steel worth 40, its sales price. This 40 is bought by the pot maker who presses and polishes the steel into its final form, a pot which is then sold for 60.

Total sales or gross output is equal to 110 comprising 10 for iron, 40 for steel and 60 for pots. By selling the pot for 60 the pot-maker recoups his or her 20 parts of labour plus 40 parts of inputs. The same applies to the steelmaker when selling steel for 40. They both recoup their intermediate costs or sales as well as the labour they add. Intermediate sales total 50 equal to 10 of iron and 40 of steel. If these 50 inputs are subtracted from total sales of 110, we arrive at 60 which is equal to the sales price of the pots which is equal to the value added also of 60. This was Marx's great discovery; that the final sales price contained the labour of the pot-maker as well as the miner and steel-maker, and, that it could be arrived at by subtracting intermediate sales from final sales, thus removing duplicated sales.

Once this is understood, we can address the issue of how value added is arrived at in the National Accounts. All industrial firms or corporations have three main accounting documents: The Trading Account, the Profit and Loss Account and the Balance Sheet. The Trading Account is concerned with the sales of the firm less the cost of these sales (inputs). Inputs are the elements needed for production, the main ones being raw materials, processed materials, components, and energy. Of course, the firm can reduce its inputs by producing some of them in house but that tends to be more expensive and so they tend to be sourced externally.

Hence the Trading Account provides the actual Value Added by the firm's workers. It is the price of the sales (sales revenue) less the cost price of the inputs. Alongside these costs the corporation incurs the cost of the wages of the workers and supervisors engaged in working up these inputs into their final form. Hence there are two species of cost in the Trading Account, inputs and wages. By subtracting wages and inputs from revenue, the operating income is obtained which will be transferred to the Profit and Loss Account.

No activity that takes place in the Profit and Loss Account adds value or sales or revenue to the firm. The profit on the one side is derived solely from the Trading Account. All the other items appearing in the Profit and Loss Account (P&L) represent losses (expenses). The P&L contains all the expenses private property unavoidably incurs administering, selling, marketing and accounting for the goods already produced. In turn, these losses or expenses reduces operating income into profit before depreciation, tax and interest which is then transferred to the Balance Sheet.

In common with the Trading Account there are two species of expenses in the P&L. First the wages and salaries of the white-collar workers employed there, and secondly, the inputs they need to work with like computers, phones, desks, chairs, coffee machines and so on. These clerical inputs have a different effect on value added compared to the industrial inputs in production. The former cannot increase the revenue of the firm while the latter does.

Nevertheless, the statistical bureaus are unconcerned by the differences between the two different types of inputs. They lump all inputs together. As far as they are concerned the value added by each firm is the balance remaining after sales revenue is reduced by the cost of all inputs. As the cost of industrial and clerical inputs is greater than the industrial inputs on their own, the SNA unavoidably understates the value added by each firm by deducting too much from sales revenue. This means the value added found in the Trading Account is always larger than the value added for the firm by the SNA. As the value added by the Trading Account is the correct figure, the SNA ends up understating the value added by individual firms.

Why is this important? It is important because value added depends as much on the value of output (sales revenue) as it does on the value of the inputs. The specific nature of clerical inputs means their increase or decrease leaves the value of output unchanged. This is distinct from the factory, where an increase in industrial inputs is usually associated with a rise in output during regular conditions. Thus, a rise in clerical inputs is normally associated with a reduction in value added, whereas a rise in industrial inputs is normally associated with a rise in value added because of its effect on output (ignoring the issue of hours).

In summation as far as the SNA is concerned, the productivity of the firm depends on the value of output less the value of inputs divided by the total number of hours worked by both industrial and clerical workers. Anything that increases output or reduces hours will increase productivity, but anything that increases inputs without affecting output can potentially reduce productivity.

### **The distinction between productive and unproductive labour.**

We can now begin to see the problem. While the statisticians have plagiarised Marx, they have omitted some of his most important methodologies. Specifically, they omitted the distinction between productive and unproductive labour. Productive labour produces, stores and transports commodities. As commodities are the substance of value, these workers alone produce value and therefore the profits of the capitalist class. Their labour is found in the Trading Account.

All other workers employed are unproductive, and by that we don't mean they are not exploited, but simply that they are unproductive of profit. Instead they are a cost to profit. Their labour is accounted for on the Loss side of the Profit and Loss Account. Their wages and inputs reduce operating income into gross profit which is transferred to the Balance Sheet, the document which records what the shareholders own or owe.

It is time to address the issue of inputs going into the Profit and Loss Account in greater detail. Let us assume that Company A is made aware of a new automated computer system based on machine learning which will streamline much of their clerical work. Let us say further that the equipment and software cost is \$3 billion. In turn this \$3 billion will save \$3 billion in wages and \$1 billion in clerical inputs like office rent, desks, chairs, coffee machines and so on p.a. Immediate savings add up to \$4 billion against an investment of \$3 billion, a net saving of \$1 billion.

While wages are reduced by \$3 billion throughout the company, inputs rise by \$2 billion. (The \$3 billion investment less the \$1 billion saved in clerical inputs.) This \$3 billion investment has an economic life

of 4 years so will be depreciated over 4 years at the rate of \$0.75 billion p.a. Hence from the viewpoint of annual profits, the addition to profits is not \$1 billion in year one, but \$3.25 billion each year for a total of four years (\$4.0 billion annual saving in wages + inputs - \$0.75 billion in annual depreciation).

What about productivity. The Statistical Bureau adds the difference between the value of new inputs (\$3 billion) less the value of inputs saved (\$1 billion) or \$2 billion. It has to take the full \$2 billion to avoid duplication. If it only added \$0.75 billion to intermediate sales (depreciation) this would not equate to the additional \$3 billion in sales by Acme Computer Corp who sold the computer and software to Company A, less the fall in sales by the Desk and Chair Corp, because Company A no longer replaces worn out desks and chairs as there are no workers to sit at them.

If we were to look at the accounts of Company A from the perspective of the statistical bureau compiling the figures for its industry, value added would have fallen. If Company A's sales have not increased, meaning its Trading Account is unaltered, the net increase in value added would have fallen by \$2 billion due to the increase in inputs. On the other hand, the total hours worked in the company will have fallen as well due to the reduction in employment of office workers. Hence there will be a rise in productivity, but this rise will be understated in year one because of the depressing effect the higher inputs have had on the value added by the firm which is used to calculate productivity.

This is the paradox. Viewed from the perspective of the national economy a rise in investment can be met by a moderation in productivity if that investment is dedicated to the clerical sphere of the economy where unproductive workers predominate. However, while it may decelerate productivity growth initially this is compensated for in subsequent years when clerical inputs fall away boosting value added and accelerating productivity. This explains why most corporate restructurings bear fruit only after a number of years. Costs are incurred before benefits are realised.

Let us return to Company A to flesh this out. In year two there are no additional inputs as the previous year's investment is good for four years. As a result, value added in that company will rise by \$4.75 billion. This is due to inputs falling by \$4 billion while depreciation has risen by \$0.75 billion. Accordingly, even if hours and output are unchanged, the rise in value added will boost productivity because of the change to inputs and depreciation.

Finally, we may assume a variation to this investment. It may be the case that instead of purchasing this new computer outright, Company A outsources this clerical work to Company B. Now there is no outright investment. Rather Company A pays company B \$2.0 billion annually to undertake this activity on its behalf. Under this condition inputs into Company A rise by only \$1.0 billion (\$2 billion less \$1 billion saved on previous clerical inputs.) From the point of view of the statistical bureau, value added in year 1 has decreased by \$1 billion because clerical inputs have risen from \$1 billion to \$2 billion.

However, nothing has changed in the Trading Account. The productivity of productive workers has not changed, only the accounting of inputs has changed. And they have changed differentially depending on whether software/hardware is bought outright or not. Thus because of the nature of private property and the preponderance of unproductive workers it is exceedingly difficult to determine actual rates of productivity. Often productivity rates change simply because of differences in the way inputs are accounted for.

### **The devaluation of output.**

It is now time to examine changes to the Trading Account. The monetary measurement of productivity, that is the price of revenue less inputs or gross value added divided by hours suffers from

one major flaw. Money itself is not an invariant measure. It depreciates or loses value and because it loses value more of it is needed to measure the same good. This is known as inflation.

Inflation confuses productivity readings. Workers could in fact be physically producing fewer products but because of rising inflation, in nominal terms, they appear to be producing more value added. They appear to be more productive when they are not. Their productivity is a monetary illusion. This is well understood by the statistical bureaus who use deflators to cancel out inflation.

Their purpose is to reduce price rises to zero. When there are no price rises, any rise in revenue can only be due to an increase in the number of goods being produced. In this way the physical increase in production per hour is revealed. Except that it is not. As Marx pointed out, reductions in labour time, the real measure of productivity, expressed through prices, should not yield a rise in price, it should result in price falls. Hence if real productivity is to be measured, then deflators should not return price rises to zero but to some minus figure. In other words, the deflator is understated because its purpose is to negate price rises not to measure prices in terms of labour time. Hence there is a perpetual propensity within capitalist statistics to underestimate productivity.

The gap between physical and value output is bigger than the deflators reveal. This point is being made because digitisation is going to accelerate the fall in labour times; it is going to accelerate the cheapening of production; it is going to accelerate the devaluation of production. The gap between the value of production and the volume of production is going to widen, and as it does so the understatement of productivity growth will increase and become acute.

There is a further factor that will modify productivity growth. It is the changing relation between the value of inputs and the value of output (the firm's sales revenue). Hitherto the relation between intellectual labour and physical labour in the context of the production process has been to minimise intellectual labour and maximise physical labour. The production process was broken down into a multitude of small simple repetitive steps in order to be performed by hundreds of millions of unskilled workers. Most of the work process was reduced to repetitive tasks requiring only physical activity, turning the worker into an unthinking, but dextrous biological machine.

Digitisation is turning this on its head. It is maximising intellectual labour and minimising physical labour by making it redundant. In aggregate, although one hour of intellectual labour counts as a number of hours of simple labour, the sheer scale in the reduction of this simple labour will result in a sharp fall in overall hours. There will now be a preponderance of intellectual labour for the first time in the capitalist economy. This will have a significant effects on the value of inputs which will now be dense with intellectual labour. On the other hand, the revenue of the firm will be reduced by the fall in the overall hours worked in its factories.

Let us examine this more closely. The inputs in the Trading Account will most probably be boosted by the cost of the Licences needed to run the automated production lines. Alternatively, instead of licences, specialist firms will be contracted to help plan, programme, and protect these programmes and the machinery that they run on. Already such Licences exist, for example Microsoft "Office".

How will this effect productivity? The input side will be boosted by computer programmes and algorithms which currently have a high labour input. (In years to come computer programmes could be written by computers themselves with little intellectual labour accompaniment.) On the other hand, the output side will already be victim to a savage reduction in the labour time needed to produce the product. Hence the input side will comprise a relatively larger slice of output and as we have seen, the larger the inputs relative to output, the more value added is compressed. This compression will artificially reduce productivity measurements.

### **The inputs relating to outsourcing are not the same as those relating to computer licenses.**

One area will be different. Since the 1980s, the outsourcing of clerical work, made possible by the internet, such as accounting and payroll, has not made much of an impact on productivity overall. The reason for this is that this outsourcing was merely the transfer of labour. Instead of these clerical functions being carried out in-house they were contracted out to specialist firms. No new value was produced. Instead value was transferred from the outsourcing firm to the specialist firm. Its cost of payroll and accounting functions now formed the revenue of the specialist firm. Often, as this cost was less than the original in-house cost, the amount of value transferred was reduced. This explains why the industries populated by these specialist firms in the service sector, had such a low value added per hour component (which is why some of this labour was exported to low-wage countries like India).

The relationship between the outsourcing firm and these specialist firms was that between principal and agent. A contract existed between them with the copyright being held by the principal. The relationship was not one of buyer and seller. If the specialist firm sold the accounting information of their principal, they would face criminal prosecution for fraud and civil prosecution for damages. Hence no commodity passed between them and so no new additional value could therefore be produced.

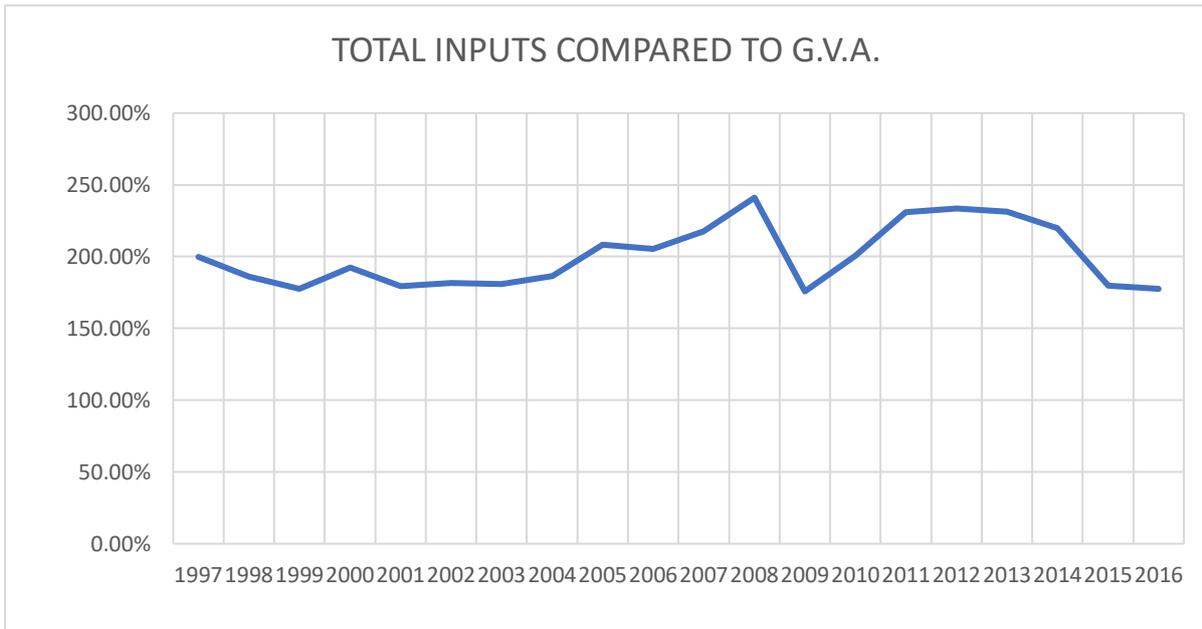
Matters are reversed between a company paying for a licence or a contract involving the transfer of computer programmes and algorithms. Here a commodity relation exists. The software company is selling a commodity which it owns called software, to the client firm. This sale of software adds value to the economy because it is a commodity. And because it involves immaterial production containing high levels of intellectual labour it will have a tangible effect on productivity rates in the economy because it requires minimal hours to reproduce. Unlike the client firms whose revenues will be slashed by a reduction in labour, these software firms will experience high and rising revenues. They will enjoy above average rates of productivity compared to client firms who will experience below average rates of productivity.

This expresses the re-ordering of the relationship between mental and physical labour. This is being noted by many bourgeois economists who recognise the monopolistic position that IP now commands. They note that value will now be concentrated in these Hitech firms. However, this monopolistic position is illusory. It is based on the destruction of value elsewhere in the economy. If these Hitech firms appear bigger it is because industries are now smaller. For example, the music industry is today smaller in value terms because of the destruction of the record and cd industry, together with the transport and retail activity related to it. So, if Apple's iTunes appears to have a commanding presence it does so in an industry that has been diminished by the reduction in the total amount of labour needed to produce and distribute music. But, because they do not recognise labour time to be the only cost of production, they cannot understand the phenomenon before them.

### **The evidence to date.**

The accessible data from the BEA interactive website only covers the period 1997 -2016. There is no release date later this year covering 2017. This 20-year period provides some insights but nothing conclusive as the two graphs below show. The first graph does not show an increase in inputs relative to gross value added. In stead it has shown a fall compared to the two recent peaks in 2008 and 2014. Tangential data on current turnover suggests the fall was reversed though insignificantly in 2017. Graph 2 goes on to look at whether it was industrial inputs or service inputs (where software is found) that accounted for the fall.

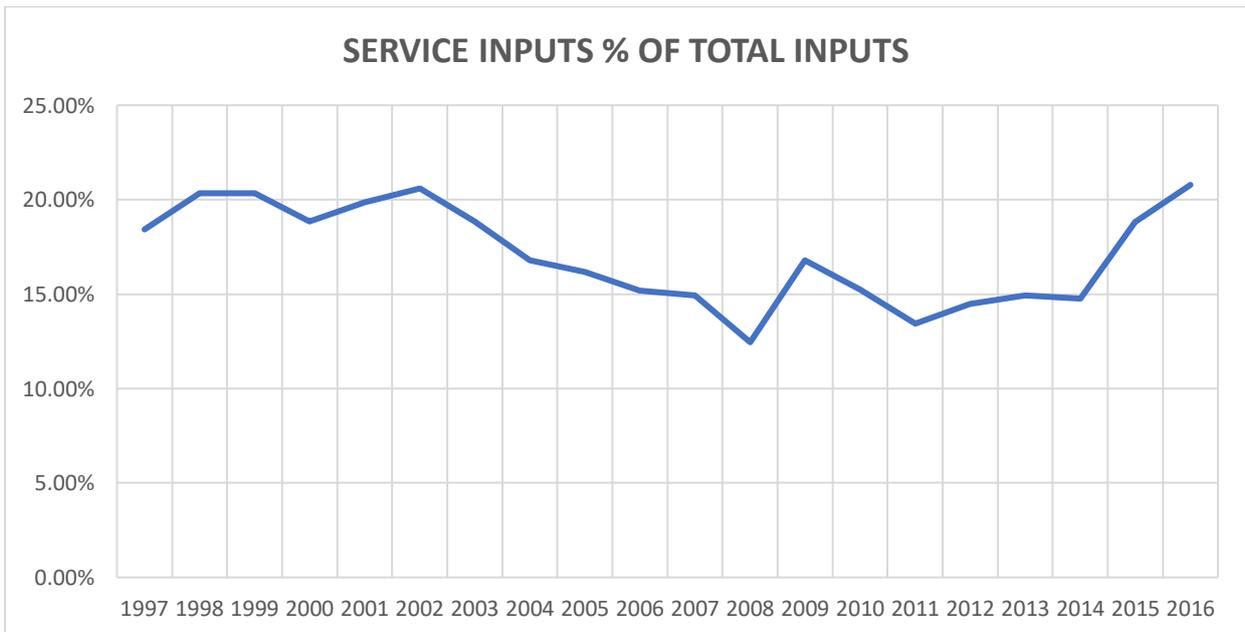
**Graph 1.**



(Source: BEA Interactive, GDP-by-industry, KLEMS, Composition of output tables.)

Fortunately, the KLEM'S ((K-capital, L-labour, E-energy, M-materials, and S-purchased services) data divides inputs into industrial and service. Examined in such detail it becomes clear that the fall in inputs is entirely due to the fall in industrial inputs. The coincides with the fall in the output of manufacturing from its peak in 2014. Output is in fact still 2.5% below its recent 2014 peak. (FRED Table: OUTMS 6<sup>th</sup> June) However, within that fall, service inputs increased their share (Graph 2). The sources for Graph 2 are the same as for Graph 1.

**Graph 2.**



This means that service sector inputs have not fallen which is interesting.

## **In conclusion.**

Only a socialist society based on an objective pricing system with an invariant standard of price can accurately reveal the extent of productivity and its changing rate. In such a society the general fall in prices will be a marker for rising productivity which when adjusted for changing hours, will accurately express the rate of physical output per hour worked. Productivity will become an accurate gauge because it is now tied directly to weighted average labour times.

This article was written to investigate the anomalies and paradoxes that capitalist accounting throws up in estimating real changes to productivity. Some of the more astute economists are beginning to sense the extent to which production will become devalued, and secondly, that it won't be compensated for by increased volumes. The braver economists admit that devalued production will rob, not only productivity of its vitality, but production itself.

Viewed from the perspective of the client firm's rate of profit, this is very perceptive. By client firms we mean the purchaser of machine learning from the producers of these algorithms and software packages. Or what is the same thing, commissioning the development of this software by outsiders. (Note 1.) In these client firms the amount of capital will increase because software is labour intensive (intellectual inputs). Against this, revenue will fall because production will become labour light, and this reduction of labour will in turn reduce the reservoir of unpaid labour.

What is the implication of the change in the balance between intellectual and physical labour for the rate of profit in the client firm. Marx observed repeatedly, that the stage may be reached where the absolute fall in the amount of labour overwhelms the relative rise in its exploitation. Digitisation may be that point because it could reduce the number of productive workers to such a degree, that any additional profits each one produces is overwhelmed by the reduction their number. At this point the mass of profits is reduced permanently.

On the other hand, inputs will become relatively more valuable, not because of hardware but because of software where most of the intellectual labour is found. (Hardware costs will fall because it will be cheaper to produce computers, communication equipment, peripherals and so on.) But because of the rise in software costs, there will be a rapid rise in the value of circulating capital relative to fixed capital (though IP has been misnamed as fixed capital). Hence client firms and industries will suffer rising capital costs while facing depressed profits and this will significantly reduce their rate of profit.

Now it can be argued that an equalisation process will take place. Capital will flow from these client firms or industries to more profitable areas of the economy including those producing intellectual labour. The result will be a contraction in production within these client industries, therefore to prices for their products rising and with it profits. However, the devaluation of production requires, as compensation, an increase in volume not a decrease in volume. The pressure on profits that this movement of capital will relieve will therefore only be partial.

There could very well be a more or less permanent crisis of profitability in the productive sphere of the economy. The process of digitisation could end up on the rocks even before it is able to scale the cliff. A sharp reduction in profitability in client industries could paralyse investment. To those who see only a dystopian future where machines produce everything and are owned by a tiny minority, leaving the majority to rot on the side-lines of history, the opposite may be the case, it could be capitalism breaking its back on digitisation.

Marx spoke eloquently about the forces of production coming into conflict with the relations of production. He understood the fluid relationship between intellectual and physical labour. Whether

he envisaged the extent to which the relationship between intellectual and physical labour would be reset by digitisation within the capitalist mode of production, is indeterminable. But he always understood the conflict between the forces and relations of production acts as the bulldozer of history, upending all in its path.

Digitisation has permanently reset the relation between intellectual labour and physical labour by increasing the former and reducing the latter. It has accelerated the automation of production and extended its reach. For this reason, it will diminish the total amount of productive labour expended, despite the growth in intellectual labour. This development fundamentally disorganises the rate of profit, the driver of capital.

In a socialist society on the other hand, at least in its formative years, the profit motive is replaced by the motive of falling prices which digitisation encourages. This change in motive expresses the fundamental reorganisation of the relations of production. It removes the conflict between the relations and forces of production. A socialist society will benefit from falling prices and it will benefit from the fall in hours digitisation makes possible. Capitalism will be broken by it. If history itself is not to be broken, the forces of production must be liberated from the fetters of private property, otherwise the forces of destruction will prevail.

Note 1. In a Financial Times article dated 18<sup>th</sup> June, titled *Car Chiefs ill-prepared for robotic age*, Patrick McGee reports on a survey conducted by Accenture on the preparedness of the car industry for impending digitisation. It questioned 100 executives and 1000 car workers. 84% of executives said that over the next three years their company would automate processes to a "large" or "very large" degree. Only 2% said they were willing to retrain workers. The only conclusion to be drawn from this (which Mr McGee avoids) is that these executives do not expect many of their workers will be employed in three years' time so why waste money on re-skilling. As an aside, the survey found workers had a much more intelligent approach to robots than did their bosses.

Brian Green, June 2018.