# The surprising future of manufacturing

## Why the industrial internet will reverse globalisation

Perhaps the defining trait of globalisation is how companies stretched their assembly lines around the world so that goods were made across many countries a long way from where they were sold. Innovations such as barcoding, the pallet, the shipping container (especially) and industrial forklifts that reduced transport costs and times, the arrival of instant communications that allowed management to coordinate production, the welcoming of foreign investment in emerging countries and the cheap labour found in these places prompted western companies to create 'global supply chains' over the past three decades. Importantly, the inexpensive workers of the emerging world didn't need to be highly educated to operate the machinery in the factories that were moved to China or elsewhere.

The shifting of low-paid factory jobs to the emerging world (where they became sought-after well-paid work) has had vast longer-term political consequences because it boosted inequality within countries while it reduced inequality between countries. The changes wrought by globalisation that have the most political currency are the US trade deficit with China and the widening inequality in the US that helped elect Donald Trump as president in 2016. A rise in protectionism and the rebuilding of immigration barriers that could occur over Trump's time in power are often flagged as the greatest threat to the free flow of goods, people and money around the globe.

But there is a larger, longer-term development that is likely to lead to a faster unwinding of globalisation. This catalyst is the coming of the industrial internet, a term coined by General Electric in 2012.[1] Advances driving artificial intelligence and the internet of things (when devices communicate with one another), and their offshoots such as 3D or additive printing, robotics and automation will revitalise manufacturing in the developed world while dimming the appeal of locating factories in the emerging world for two reasons. The first is that western industry will rely more on highly educated workforces to commercialise the latest technology and to build and operate smart factories, and these skilled people can be found at home. The other is the digital world will be a capital-intensive one. Thus, western manufacturers will have less need for the cheap labour found in the emerging world. The economic, investment, social and political consequences that will follow as technological advances unwind globalisation are vast. They will unfold for decades.

To be sure, the economics of making uncomplicated (or low-end) manufactured goods may still justify global production chains sprinkled through the world's poorer countries where cheap labour abounds. Today's robots can't yet do every intricate task traditionally done by hand. Smart factories still employ lower-skilled staff. The workers supervising robots at Amazon's distribution centres don't have to be highly educated. Western countries will still encounter much tech-driven disruption, while the coming home of US manufacturing might feel empty when it doesn't create enough jobs to compensate for those lost in recent decades. (US manufacturing employment has fallen from 17.6 million workers in 1987 to 12.4 million now.[2]) Rather than being spurred by technology, it's higher labour costs in China that is prompting many western companies to relocate factories back home (or to elsewhere in Asia). Other businesses may favour production at home for political reasons.

But partisan deliberations, wage relativities and rising protectionism are shorter-term considerations. The technology advancements associated with what many call the fourth industrial revolution are long term. Today's technological leaps point to western companies locating factories close to their customers; and for western companies their most important markets are in the west. The winners when global supply chains crumble will be the developed countries that are home to the most innovative companies, the smartest workforces and the largest consumer markets but also developing countries with big markets and large pools of educated workers at reasonable cost. The losers stand to be the world's poorest countries that will miss out on attracting foreign investment, the world's most basic manufacturing hubs, and advanced countries that fail to take advantage of the shift, a list that could include Australia.

### The 3D difference

Technology has always driven the greatest developments in manufacturing. Before the steam revolution of the 1830s, villages produced most of what they consumed. The invention of railways and steamships in the 19th century slashed transport costs so much that production and consumption became separated for two reasons. The first was that cheap transport created the economies of scale that justified mass production. The other was that industry found that locating in clusters reduced the cost of coordinating bulk

[1] General Electric. 'Everything you need to know about the industrial internet of things.' ge.com/digital/blog/everything-you-need-know-about-industrial-internet-things

[2] US Bureau of Labor Statistics. Series Id: CES3000000001. 'All employees, thousands, manufacturing, seasonally adjusted.' 18 August 2017. Numbers are from July 1987 to July 2017. data.bls.gov/timeseries/CES3000000001.

production.[3] The result was the modern world's first globalisation from 1870 to 1914, which was centred in parts of Europe, Japan and North America.

The world's second great globalisation from 1980 occurred because technological advances allowed western businesses to exploit the cheap unskilled labour of the emerging world. The world of artificial intelligence and the internet of things heralds consequences of similar magnitude. But in reverse.

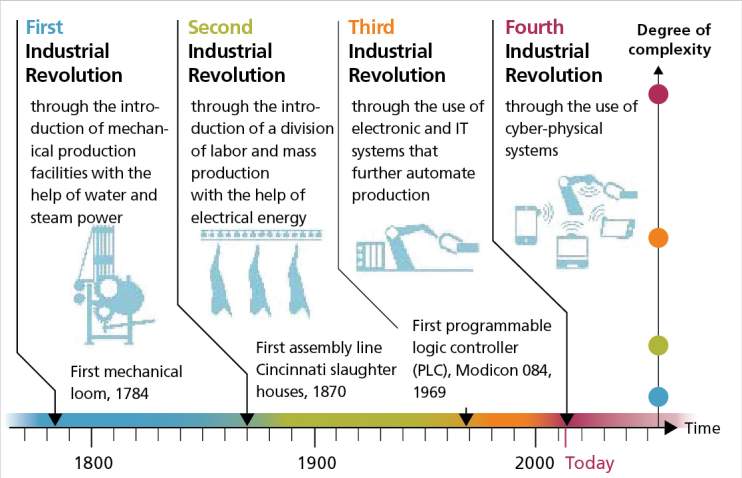
Consider the microeconomic consequences to be provided by 3D printing, which forms part of robotics and relies on the internet of things. Additive manufacturing (3D printing's other name) was invented in 1983 by Chuck Hall of the US who, when using UV light to place plastic veneer on furniture, thought of a way to create three-dimensional products. His innovation was to develop a process that shone light on photopolymer, which solidifies under light, while tracing the shape of one level of an object. Subsequent layers are printed until the product is finished. By 1988, the first commercial products were being 3D printed.[4] Nowadays, software using a virtual representation prints items layer by layer.

The commercial value of additive manufacturing traces to the fact that fine-tuning software is cheaper and quicker than resetting machinery on factory production lines, especially when it comes to one-off or low-volume goods. This attribute reduces the need for multiple specialist factories and overturns the theory underpinning economies of scale, which is built on the finding that the average and marginal costs of making items decline with volume – or, looked at another way, that mass production denotes greater efficiency. Reduced economies of scale and the need for fewer factory assembly plants undercut the justification for global supply chains.

An acceleration of 3D-printing speeds (by using digital light synthesis rather than polymer-based processes) has allowed its use in mass production, and further dented the economics driving global production lines. Adidas, for example, is setting up 3D-printing factories in Germany and the US that will allow the footwear maker to deliver fashionable trainers to western shopping centres within weeks of design, whereas it takes months to fulfil orders via Asian-based factories using traditional techniques. Another advantage of mass 3D printing is that it reduces the need for warehouses full of spare parts. Thanks to 3D printing, US construction equipment makers Caterpillar and John Deere are moving their warehouse to the cloud.[5] That brings production home to where head office and tech skills are located. Every advance in additive manufacturing gives western companies more incentives to bring home production.

The way 3D printing undermines the raison d'être of global supply chains is echoed across other forms and uses of artificial intelligence and the internet of things. Twenty-four-hour industrial robots lower marginal production costs while displacing the need for cheap human labour to perform tricky tasks. The digitalised world enables robots and devices to communicate across production chains to maximise efficiency, placing a premium on the skilled labour who can build and oversee high-tech plants. Sensors compiling 'big data' that is then run through software (algorithms) boosts efficiency, by forecasting interruptions to production better than factory foremen can. Other sensors will let customers know their items are about to break down, allowing for better client service.

**Figure 1: From Industry 1.0 to Industry 4.0**




Source: DFKI 2011 (German Research Center for Artificial Intelligence).

The internet of things will propel driverless vehicles, robotrucks, pilotless planes and automated drones and boost the economics of local, land-based logistics far more than it will smooth international delivery across the seas. Smart grids will lower energy costs in advanced countries, another reason for factories to head homeward.[6]

## Future traits

The localisation and regionalisation of production will have huge macroeconomic and political consequences. The rich world, with its corporate titans, educated labour force, financial centres, innovation edge, more stable politics, well-regulated institutions and its large consumer market, is better placed to benefit from smart manufacturing. Europe (especially Germany), Japan and the US are likely to host more sophisticated manufacturing. Singapore, South Korea and Taiwan are advanced enough to do likewise, but to a lesser extent, if other advantages make up for their distance from western consumers. Emerging countries such as Mexico that are located close to western markets and have enough skilled labour will attract high-end factories.

Evidence is mounting that US manufacturing is already enjoying better health. US manufacturing output reached a record high in real terms this year, when it topped the previous record set in 2008

[3] See Richard Baldwin. 'Global supply chains: why they emerged, why they matter, and where they are going.' Chapter 1 in 'Global value chains in a changing world.' World Trade Organisation and the Fung Global Institute. Temasek Foundation Centre for Trade & Negotiation. 2013. (pdf) wto.org/english/res_e/booksp_e/aid4tradeglobalvalue13_e.pdf

[4] 'Chuck Hull: the father of 3D printing who shaped technology.' The Guardian. 22 June 2014. theguardian.com/business/2014/jun/22/chuck-hull-father-3d-printing-shaped-technology

[5] The Economist. '3D printers start to build factories of the future." 29 June 2017. economist.com/news/briefing/21724368-recent-advances-make-3d-printing-powerful-competitor-conventional-mass-production-3d

[6] Stratfor. 'Smart factories: The next industrial revolution.' 21 May 2015

(and did so with 1.4 million fewer workers[7]), to be 29% above its level of 1987.[8] In 2016, for the first time since the 1970s, more manufacturing jobs returned to the US than left, according to Reshoring Initiative, which says that 25,000 factory jobs returned to the US last year – parity was reached in 2014 and 2015.[9] Companies are commonly citing "skilled workforce" as the motive for bringing back jobs to the US, said the group, which advises US companies on 'onshoring'. US companies such as IBM[10] and Intel[11] have said they will expand US workforces in coming years while Taiwan's electronics firm Foxconn[12] and South Korea's LG Electronics[13] are expanding US operations.

Boston Consulting says many US companies have the same intent. The consultant's 2015 survey of manufacturers that have US$1 billion or more in revenue found that 31% of responding companies said they are likely to boost production in the US within five years for goods sold in the US, while only 20% said they will add to capacity in China. This compares with the results of 2013 when 26% said they would add to US capacity while 31% opted for more production in China. "Moreover, the share of executives saying that their companies are actively reshoring production increased … by about 250% since 2012," the group said.[14] In another positive sign, government reports show that since 2012 in the US the number of manufacturing job openings has exceeded hires.[15] These results are fulfilling the predictions of those who for years have tipped technological change and more competitive labour costs would inspire a "US manufacturing renaissance".[16]

Losing out from the industrial internet will be the world's poorest countries located far away from the industrialised west. Poverty in Africa, the Middle East and southern Asia is likely to become entrenched now that the 20th-century pathway to rising living standards will be much narrower. Sewing technologies that allow machines to produce clothing such as Sewbots™ developed by US-based SoftWear Automation[17] or Amazon's custom-clothing patent[18] threaten to hamper the clothing industry in South Asia that employs millions of people (estimates vary) across countries such as Bangladesh, India and Sri Lanka. Economist Dani Rodrik of Harvard University calls the threat from technology that will stall industrialisation in such countries at much lower levels of income "premature deindustrialisation'. As the rise of organised factory labour helped build modern democratic states, the "weakness of organised labour in today's developing societies is likely to foster different paths of political development, not necessarily friendly to liberal democracy," Rodrik warns.[19] The world, in short, will host more failing autocratic states.

The changes heralded by the industrial internet will do little to help rich countries such as Australia that are a long way from western markets attract manufacturing investment from multinationals.

China, which was losing low-end production to countries such as Bangladesh and Vietnam because Chinese wages have risen, is taking steps to attract high-end manufacturing to ensure unemployment stays low to minimise social unrest. China's vast domestic market including its high number of internet users, its large pool of tech-savvy workers, the presence of local tech manufacturers such as telecom Huawei and electronics maker Xiaomi, and government coercion, subtle or not, is likely to ensure that foreign companies locate modern factories in China. One sign of this occurring is that China last year overtook Japan as the country with the most industrial robots.[20]

More robots in select countries and more idle workers in poorer places will be a common feature as the industrial internet breaks up global supply chains in coming decades.

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[7] US Bureau of Labor Statistics. Op. cit.

[8] Federal Reserve Bank of St Louis. Chart showing 'Manufacturing sector: Real output' since 1988. Updated 9 August 2017. fred.stlouisfed.org/series/OUTMS

[9] Reshoring Initiative. 'Reshoring initiative 2016 data report: The tide has turned.' 9 May 2017. reshorenow.org/blog/reshoring-initiative-2016-data-report-the-tide-has-turned/

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[11] Bloomberg News. 'Intel uses Trump meeting to tout plans to finish Arizona factory.' 9 February 2017. bloomberg.com/news/articles/2017-02-08/intel-pledges-7-billion-arizona-investment-in-trump-meeting

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[13] The Wall Street Journal. 'LG Electronics to build factory for electric car parts in Michigan.' 22 August 2017. wsj.com/articles/lg-electronics-to-build-factory-for-electric-car-parts-in-michigan-1503454452

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[19] Dani Rodrik. 'Premature deindustrialisation.' John F Kennedy School of Government, Harvard University. November 2015. Page 25. drodrik.scholar.harvard.edu/files/dani-rodrik/files/premature_deindustrialization_revised2.pdf

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