

Global Equity Strategy

Tectonic shifts in global supply chains

Supply chains for USD22tn market cap are on the move

For many years it has been generally accepted that jobs that had moved from Developed Market (DM) economies to Emerging Markets (EM) would never come back, and that supply chains would continue to be increasingly global and complex. More recently there have been hints of a reversal of that trend and here we provide new evidence of that reversal. In a survey we conducted of our analysts who cover 3000 companies, we found that companies in more than 80% of 12 global sectors (USD22tn market cap) in each of North America, Europe and Asia-Pacific (ex-China) have implemented or announced plans to shift *at least* a portion of their supply chains from current locations. Granted, most of these relocations are small compared to their installed base, but the breadth of the shift suggests to us that the trend of globalization to localization is real.

What are the driving forces propelling the shift?

What is striking is that there are so many reasons why companies are re-assessing their supply chains. Importantly, some reasons are financial, but not all. On the financial side, tariffs are obvious, but newer automation has also meaningfully narrowed the labor cost differential that made the original outsourcing so attractive, and, in addition the tax arbitrage has narrowed. On the non-financial side, national security is a growing factor as are the ESG concerns of high carbon footprints associated with long supply chains and potentially problematic employment practices. In our view, these movements are “tectonic”: slow moving, persistent with major changes to the business environment for global companies.

SE Asia, India, notably N. America intended destinations

Not surprisingly, South East Asia and India were the planned destinations for half of North American and Asian supply chains. Much more surprising was that companies in about *half of all global sectors in North America declared an intent to ‘reshore’*. This was particularly true for high-tech sectors and industries for which energy is a key input. If borne out, this could represent the first reversal in a multi-decade trend.

Investors underexposed to beneficiaries

We don’t think investors are fully prepared for this tectonic shift. In our view, the US could be a significant beneficiary of this process, while Chinese firms are perhaps most at risk. Even more striking, our survey found almost universal intent to use automation. This suggests our forecast of a doubling in industrial robots to 5mn units by 2025 may prove conservative, with bullish implications for capex and manufacturing. While our Economics team expects a cyclical recovery in US manufacturing by mid-2020, valuations and fund positioning suggest investors are not positioned for a sustained recovery in manufacturing. Increased spend in automation and manufacturing would have multiplier effects on the broader economy and be beneficial for financial services that cater to them. We recommend investors add exposure in automation, industrials and banks stocks in North America, South East Asia and India.

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Refer to important disclosures on page 32 to 34.

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Executive Summary

The past three decades have witnessed a dramatic expansion in international trade and the globalization of supply chains. Our macro teams already see a [protracted pause in globalization](#). We go one step further and argue, in a break with the past, that the world has entered an unprecedented phase during which supply chains are brought home, moved closer to consumers, or redirected to strategic allies. This would have profound implications for automation and manufacturing, and creates myriad opportunities for the geographies to which supply chains are being redirected.

We conducted a survey of our fundamental equity analysts who cover >3,000 companies globally. Our observations are most relevant for 12 (out of 24 GICS) industries that operate global supply chains and have a collective market capitalization of USD 22tn. Our findings were striking. Companies in more than 80% of global sectors (USD22tn market cap) in each of North America, Europe and Asia-Pacific (ex-China) have implemented or announced plans to shift *at least* a portion of their supply chains from current locations.

While the *breadth* of this shift is striking, the *depth* is moderate at present. Many firms appear to be experimenting with a 'China Plus' strategy where they are keeping existing chains largely in place, while running 'pilot' programs in alternative locations. Over the next 12-24 months, we expect the success (or failure) of these pilots to help determine the velocity of future change.

Although supply chains have evolved for decades, the current shift appears qualitatively different due to 1) the *reasons* cited for change; 2) the *destination* of change; and 3) the *method* by which these changes are being facilitated.

To elaborate, tariffs and national security were the most frequently cited reasons for change. While trade negotiations, such as the recently signed US-China Phase 1 deal, may eventually cause tariffs to be rolled back, we believe that concerns about national security are unlikely to dissipate.

Turning to the direction of change, we were not surprised to find that South East Asia and India were the planned destinations for half of North American and Asian supply chains. This is a function of attractive labor costs in Asia-South (although we expect lower productivity and sub-optimal infrastructure to present challenges).

We were, however, surprised to find that companies in about half of all global sectors for North America have declared an intent to 'reshore'. This was particularly true for high-tech sectors and industries for which energy is a key input. This finding, if borne out, could represent the first reversal in a multi-decade trend. It is also worth noting that several Asian, as well as European responses cited North America as an intended destination, presumably in an effort to move closer to their customer base.

Finally, we were struck by the universal declaration of intent to use automation in future locations. This was equally true of North American, as well as Asian companies and may be meant to mitigate the higher cost of operation in DM and offset lower productivity in EM. Interestingly, we found a notable variation from European companies on this subject with an equal proportion of responses suggesting regulatory changes, tax benefits and subsidies likely also be used to mitigate the friction associated with shifting their supply chains.



Implications

Disruptive change creates opportunities, as well as risks. Shifting supply chains are no different. Countries that depended on labor-cost differentials could be worse off unless they innovate, possess a large pool of domestic consumers, or are strategically aligned with developed markets. North America and South Asia, the apparent destination for supply chains could benefit from increased capex, job creation and higher wages, as well as their multiplier effects on the broader economy. Industries like automation, manufacturing and financial services are likely beneficiaries, and we think investors should position for this.

On current trends, we project a doubling of the global installed base of robots to 5mn units by 2025. These forecasts might, in fact, prove to be conservative due to a trifecta of [demand and improved flexibility and productivity](#). To elaborate, our findings on automation imply a burgeoning of demand, the first signs of which might also be manifesting in our Factory Automation indicator, which is signaling an upward change. Our thematic research team believes better computing, along with improvements in optical sensing, machine vision, voice recognition, environmental sensors, motion actuators and touch haptics are driving improved productivity and opening new possibilities for automation.

These tectonic shifts could have *important implications for the capex cycle and the manufacturing sector*. This is particularly true for the US, which has faced long-term headwinds in manufacturing. Our Economics team expects a cyclical recovery in US manufacturing and are forecasting an [ISM rebound to 55 by mid-2020](#) (up from 47.2 at present). We also note that unfilled manufacturing jobs have grown to a multi-year high in the US and Mexico, which is highly integrated with the US manufacturing ecosystem, continues to experience a rising share of manufacturing as a proportion of GDP.

Market multiples and fund positioning suggest *investors are not positioned for a sustained US manufacturing recovery*. US industrials are currently trading one standard deviation below their long-term 12m forward P/E average (relative to the market) and our positioning analysis of 4,900 long-only funds with USD16tn in assets suggests they are underweight in US industrials.

Any sustained recovery in capex and manufacturing would have multiplier effects on the broader economy. These include jobs (an estimated six indirect jobs created for every new job in manufacturing), higher wages, greater R&D spend, more tax revenues and the creation of industrial clusters. *What is good for an economy is also good for financial services that cater to these economies*. We expect banks in North America and Asia South to benefit from greater activity in trade finance, working capital loans, forex and treasury services, middle market and transaction management services.

In sum, we recommend investors add exposure in automation, industrials and banks stocks in North America, South East Asia and India – likely beneficiaries of the shifts in supply chain.

Looking ahead, investors need to reflect on two broad questions. First, the current run in the US stock market is not only the longest since 1927, but is also supported by the longest expansion of the US economy since 1854. While valuation multiples are demanding, our strategists are recommending investors adopt hedging strategies, but stay invested. Although wary of near-term corrections, we are encouraged by green shoots of recovery from our Library of Indicators, a monthly compilation of 72 leading indicators from around the world. It shows the highest proportion of ‘bullish’ signals since we launched the Library in early 2019 (43% in January 2020 compared with 26% in December 2019).

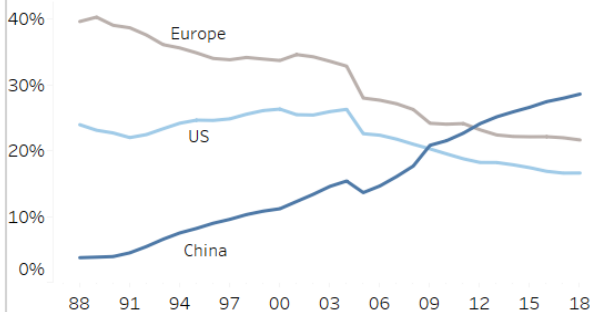
The final question is whether trade disputes escalate in 2020 and spill into technology and financial sectors (both of which are at incipient stages). Any escalation would, in our view, lower the overall value of risk assets, but accelerate the tectonic shifts we have described in supply chains. In other words, stock picking could get very important.



Figure 1: Tectonic shifts in global supply chains

#1: 30-year structural shift in manufacturing

The combined % of manufacturing value-add for US and EU has declined 25% over 30 years.



#4: Automation makes supply chains shift possible

Automation was cited as a key enabler of shifting supply chain in **90%** of instances for North America and Asia ex-China.

#7: Near record manufacturing job openings in the US

About 400K US factory jobs are unfilled - close to the highest level in nearly 2 decades.

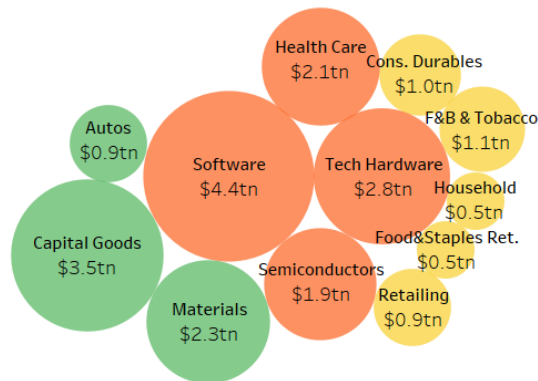


#8: Banks are likely beneficiaries

Banks in **North America** and **Asia South** will benefit from greater activity in trade finance, working capital loans, forex and treasury services, middle market and transaction management services.

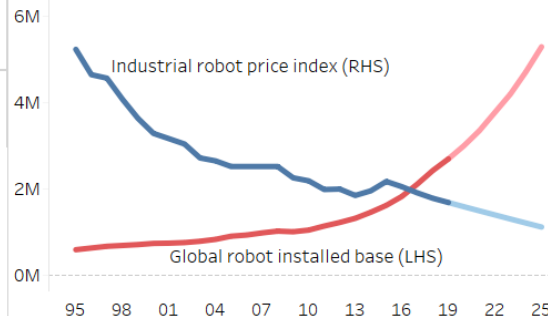
#2: Supply Chains are changing direction

12 'global sectors' with \$22tn MCap have started to move the direction of their supply chains.



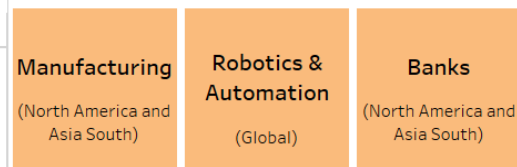
#5: We forecast a doubling of robots by 2025

Better technology and pricing will speed-up adoption.



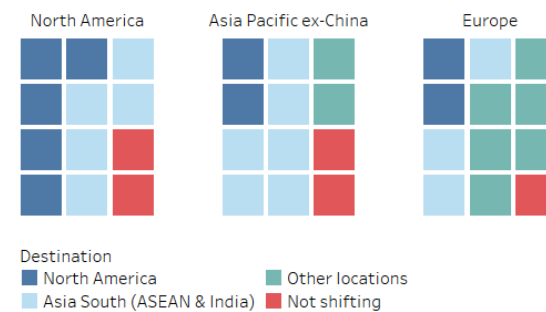
#9 Add exposure to industrials, automation, banks

Industrials, automation and banks are likely beneficiaries of the shifts in supply chain.



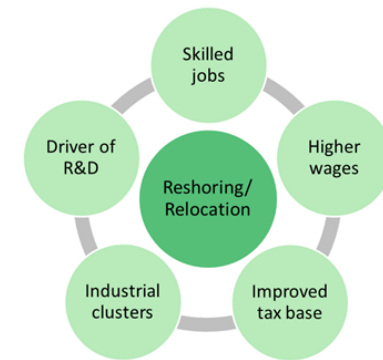
#3: Supply Chains are heading to N. America and Asia South

Companies in almost half of global sectors in North America intend to reshore and/or plan to move to Asia South.



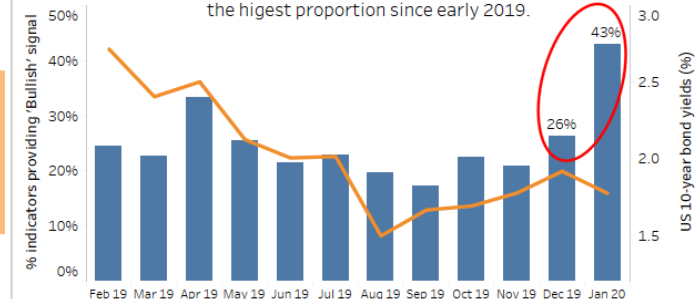
#6: Manufacturing has multiplier effects on the economy

6 indirect jobs are created for every new job in manufacturing.



#10: Our proprietary indicators show green shoots of recovery

43% of our indicators are 'bullish', the highest proportion since early 2019.



Source: BofA Global Research, UN, International Federation of Robotics (IFR), BCG, Bloomberg



Mapping shifts in global supply chains

The earliest signs of globalization¹ can be traced back to the days of the Mesopotamian civilization more than 4,000 years ago, but took off in earnest in the 15th to 18th centuries when European voyagers ventured out to explore the world. Since then, it has progressed in cycles: long periods of increased connectedness interspersed with shorter episodes of de-globalization. Global supply chains, being the backbone of a globalized ecosystem, map out a similar trajectory.










The wave of globalization that ushered in the aftermath of World War II was facilitated by the Third Industrial Revolution as the strategic competition between the US and the Soviet Union led to path-breaking scientific and technological advancements. It witnessed the invention of semiconductors, mainframe computing, personal computing, and the digital revolution. The fall of the Berlin Wall in 1988 and the subsequent collapse of the Soviet Union in 1991 created a new round of integration followed by the transforming force of the internet. The last leg of this wave saw electronics and information technology enable the creation of global supply chains and automate production.

However, starting as early as 2008, globalization has first paused and is now starting to reverse. Many of the factors driving this reversal are likely to be quite persistent:

- Continued automation is blunting labor-cost differentials between high- and low-wage economies.
- National security concerns are growing along with the rise of China as a rival to the US.
- Growing awareness of the uneven benefits of globalization has triggered nationalist pressures to contain or reverse global linkages. Tariffs and other protectionist measures are the most dramatic manifestation of this.
- The general trend of ageing societies is causing increased demand for services that are inherently local in nature.

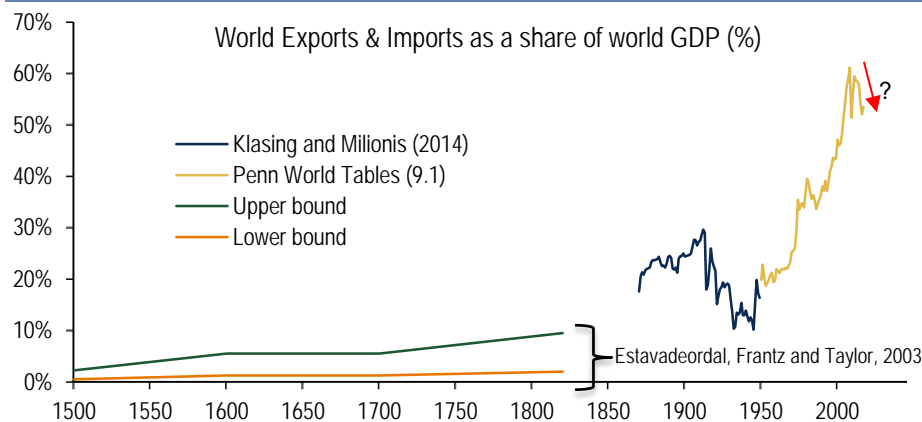
This is not all. High tax countries—most important, the US—have cut corporate tax rates reducing the incentive for tax arbitrage. Growing concerns about global warming are creating a push to reduce the carbon footprint and produce things closer to customers. Concerns about industrial espionage are motivating companies to restore control of their technology. And the reduced provision of trade finance also encourages localization.

Figure 2: The evolution of globalization

Globalization Era	Age of Discovery (15 th – 18 th century)	Globalization 1.0 (19 th century – 1914)	Globalization 2.0 (1945 – 1989)	Globalization 3.0 (1989 – 2008)	Globalization 4.0
Leading Exports	Raw Materials / Basic Goods	Textiles / Industrial Goods	Factories	Global Supply Chains	Digital Goods / Services
Leading Nations					
Exports as % World GDP	 <5%	 6 -> 14%	 5 -> 15%	 15 -> >20%	?
Enabling Era	Scientific Revolution (15 th – 17 th century)	1 st Industrial Revolution (1780s – mid 19 th century)	2 nd Industrial Revolution (1870s – 1910s)	3 rd Industrial Revolution (1960s – 1990s)	4 th Industrial Revolution (2000s – 2010s)
Enabling Innovations	Maritime Exploration Nautical Compass	Modern Factory Steam Engine	Automobile Aeroplane	Computer Internet	Cloud Computing Artificial Intelligence
Characterizing GDP Trend	Europe ↗	Britain ↗↗	World ↗	United States ↗↗↗	China ↗↗↗↗

Source: World Economic Forum

¹ Our working definition of Globalization - The spread of people, products, principles, piety and pestilence - across borders, driven by Traders, Adventurers, Warriors and Preachers for millennia. (*Bound Together: How Traders, Preachers, Adventurers and Warriors Shaped Globalization*, Nayan Chanda, Penguin Viking, 2007)

Figure 3: Globalization has peaked?

Source: Klasing and Milionis (2014), Estevadeordal, Frantz and Taylor (2003), Penn World Tables.

Tariffs: Snowballing the realignment of supply chains

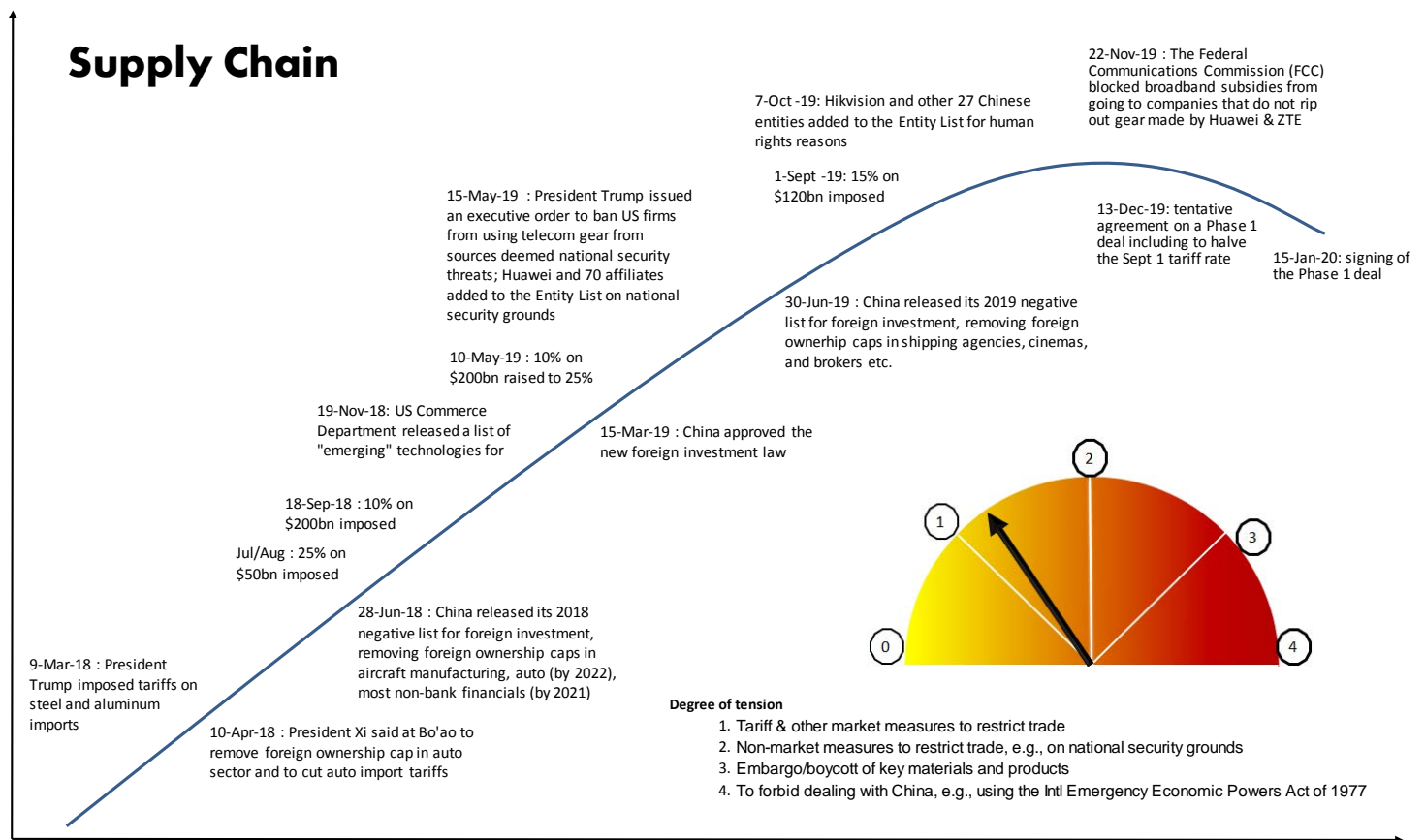
Let's take a closer look at the key accelerant in this process—the trade war—and then the survey results. One year into the office, the current US administration started working on bringing manufacturing and jobs back from Asia, especially China. We have identified four major signposts to gauge the intensity of the pressure on multinational companies (MNCs) to realign their supply chains. To incentivize companies to move their production out of China, the US, and potentially its allies, could:

- 1) use tariff and other “pricing” measures to discourage trade with China;
- 2) use non-tariff measures to restrict trade with China on national security grounds or even outrightly forbid its firms from dealing with China, eg, by invoking the International Emergency Economic Powers Act of 1977.
- 3) place embargo on key raw materials and products to China, and/or boycott a majority of Chinese imports;

So far, the US government's trade policy has predominantly revolved around the imposition of punitive tariffs on Chinese imports to the US. The US government has also enacted some measures aimed at recovering “tacit knowledge” embedded in overseas supply chains and preserving the US's technology advantage, in the garb of national security, eg, putting Huawei on the Entity List and barring US firms from using telecom gear from sources deemed national security threats. Additionally, the US is making efforts to convince its strategic allies to curtail buying from Chinese tech firms. As a result, we assess that at the moment, the pressure on MNCs to realign is just over signpost 2 with the US having used some non-tariff measures to limit trade with China, so far largely centered on the relatively narrow area of 5G.

The US trade policy has put an impetus on speeding up the process of moving supply chains. We believe in the medium to long term, the two countries' strategic aims are irreconcilable, notwithstanding the Phase-1 trade deal. In fact, we believe any form of truce may be temporary only, largely driven by the pursuit of the smooth passage of the US Presidential election cycle, with cracks reappearing at the end of it. We are sensing the business community has also realized the rift is here to stay and started making arrangements to relocate, whether or not the tariffs are removed. While both we and the markets have mainly focused on the threats to US-China supply chains, the “America First” policy implies shift in supply chains versus other countries as well. Thus far the threats are much stronger than the actual actions, with relatively small deals with Japan and Korea and steel and aluminum tariffs. The threats are more significant, including broadbased tariffs on autos and parts, Mexican exports and Vietnamese exports. Of course, this complicates the outlook in terms of where exactly supply chains shift.



Figure 4: Tariffs and technology restrictions have created supply chain disruptions

Source: BofA Global Research

BofA Global Research Survey: assessing de-globalization from bottom-up perspective

While there is a plethora of literature on the implications of de-globalization from a top-down basis, there is a dearth of coverage of what is happening at the grassroots level. To fill the void, we polled all of our fundamental equity analysts covering more than 3,000 companies globally with a total market capitalization of USD67tn, to gauge the dependence of listed companies on other countries/regions in terms of revenue, costs, and supply chain and technology. We designed four different questionnaires based on the geographical distribution of the company under coverage: (1) North America, (2) Europe, (3) Asia Pacific (ex-China) and (4) China. Each analyst filled in a survey for each of the 24 GICS Industry groups (used interchangeably with 'sectors' from here on) under their coverage.

Note: In our survey, the North America and Europe are considered as regions due to their high degree of interconnectedness. However 'Asia Pacific (excluding China)' refers to individual countries, not the region as a whole.

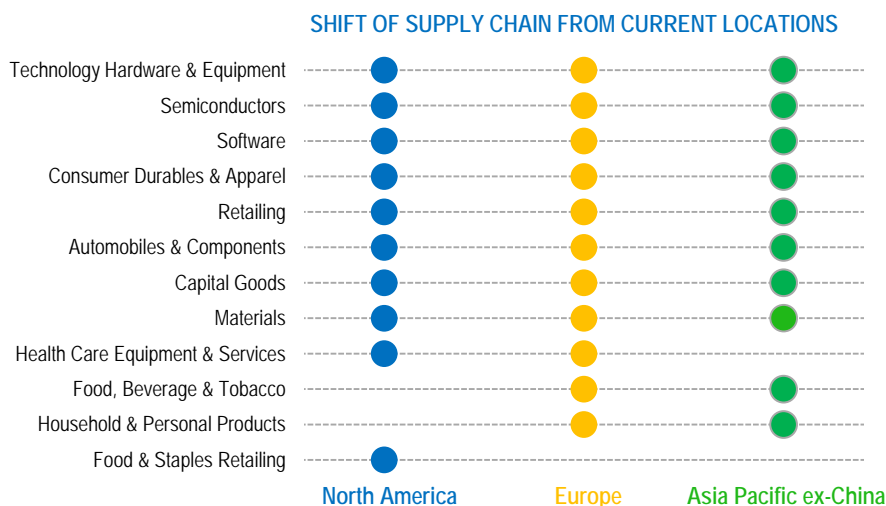
We analyzed the survey responses to curate the distinct trends emerging in global supply chains. We highlight the most telling ones below. To make the analysis more relevant, we limit ourselves to only those industries that operate global supply chains (hereafter referred to as 'global sectors').

BofA Survey Takeaway #1: Supply chains are moving...

Let's take a look at the three major takeaways from our survey: an inexorable movement in supply chains, the high cost and margin compression during the transition to new chains and the critical role of automation in the new global system.

We were surprised by the breadth of the shift in supply chains. Within North America, of the 12 sectors (out of 24) which depend on overseas supply chains, companies in about 83% of sectors with market capitalization of USD13.8tn have either implemented or announced plans to shift at least a minor portion of their supply chains from their current locations. Likewise, in the Asia Pacific region (excluding China), companies in 83% of the global sectors with market capitalization of USD3.8tn have either already moved or intend to move, while 90% of the global sectors in Europe with market capitalization of USD4.8tn are doing the same. Granted that most of these relocations are still quite small in magnitude as compared to their installed base, but the sheer scale of the shift is telling us that globalization to localization is for real. And the most frequently cited reasons for change were tariffs and national security.

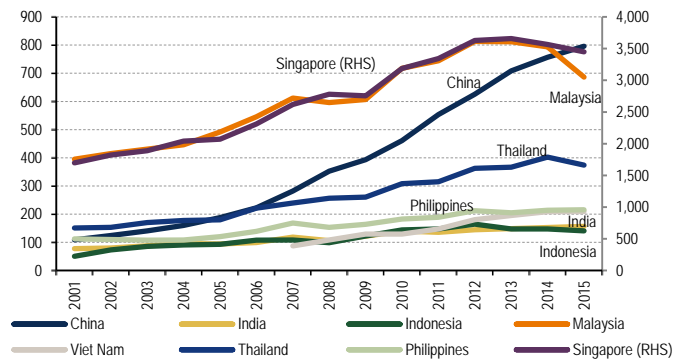
Figure 5: Supply Chain Shifts from their Current Locations – companies in 83% of global sectors in North America and in the Asia Pacific region (excluding China) have either implemented, or discussed plans to shift at least a portion of their supply chains from current locations, while 90% of global sectors in Europe are doing the same.



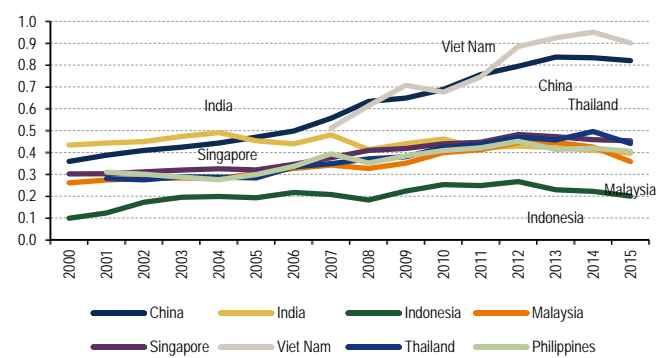
Source: BofA Global Research

...out of China...

China, which accounts for a quarter of the global manufacturing value added, has been at the center of US protectionist trade policies. Unsurprisingly, our survey validates the conjecture that a lot of companies are moving production facilities out of China. The trade war is only part of the story. Rising wages, stricter environmental norms, a complex regulatory framework, and the government focus to transform into a high-skill service oriented economy culminated into manufacturing exits starting a decade ago. The low-skill labor-intensive light tradable sectors like textiles and apparel, toys, footwear and furniture were the first to exit, and understandably so, given the lion's share of income (66%) in these industries goes to labor and labor costs in China have been rising rapidly over the past decade. To get a sense of the rise, Chinese labor costs (in USD terms per worker) were comparable to the rest of Asia in 2001, but are now a multiple of those in other large Asian countries. Even when adjusted for productivity, labor costs in China are well above other Emerging Asia markets (and even that in Singapore). So, the imposition of punitive tariffs and the ever-looming threat of even higher ones only exacerbated the exodus, not triggered it.

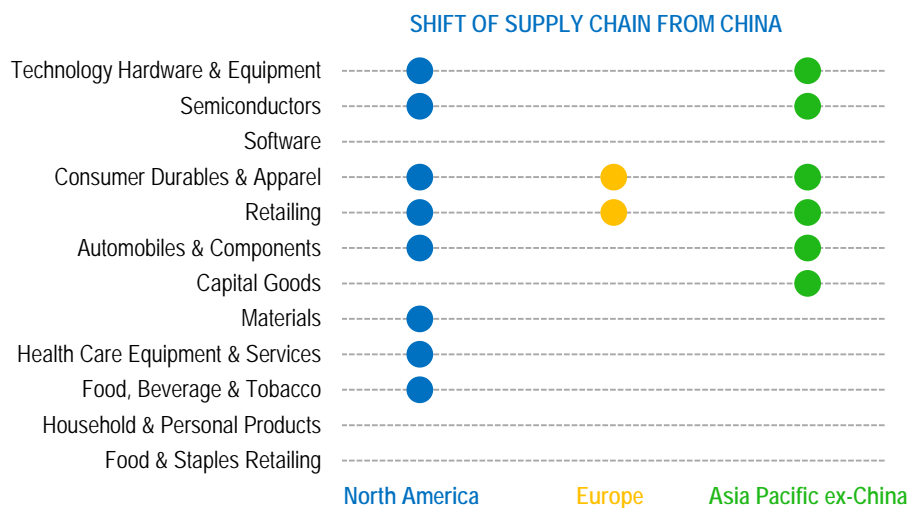
Figure 6: Average monthly nominal wages in USD

Source: ILO

Figure 7: Average monthly wages (USD), adjusted for output per worker

Source: ILO

Companies in two-thirds of global sectors in North America have either implemented or announced plans to pull at least a portion of their supply chains out of China, while companies in 50% of country-sectors in the Asia Pacific (ex-China) region are doing likewise. And the biggest shifts are being undertaken by the consumer durables, retailing, tech hardware and semiconductor sectors. The first two are shifting mainly due to the increased cost-effectiveness of automation, while the latter two are in the cross hairs of the super power competition between the US and China, and hence likely face policy restrictions. However, it is interesting to note that 83% of the global sectors in Europe that have supply chains in China, are staying put, with the rest deploying only a minor shift.

Figure 8: North American companies are ahead of their Asia Pacific (ex-China) and European counterparts in moving their supply chains out of China

Source: BofA Global Research

...and bound homeward and closer to the consumer

It is evident from our survey that companies are inclined to move their supply chains either back to within their national/regional borders or closer to the markets where their goods and services are consumed, which will lead to a more decentralized world.

Within North America, half of the global sectors are planning to relocate their supply chains back into the region, if not done so yet. South East Asia emerges as the other popular choice of destination for these companies.

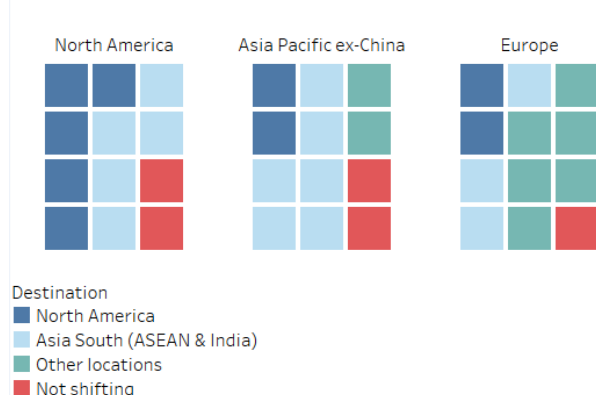
In Europe, only 2 (17%) of the 12 global sectors are homeward bound, although eight others are planning to shift their supply chains to their respective epicenters of

consumption. European retailers, on the other hand, are not doing any of the above – instead, they have either already moved or intend to move to South East Asia and India.

Similarly, in the Asia Pacific region (excluding China), barring Healthcare and Food & Staples Retailing, all others either have already moved or are planning to move their supply chains back within their national borders or their consumption centers. About 60% of the global sectors prefer South East Asia as their destination for relocation, followed by India (33%).

Chinese companies in global sectors have also started to warm-up to the idea of establishing/expanding supply chains in the markets where their end consumer resides. Similar to their Asian peers, South East Asia is their preferred choice for relocation, followed by India and North America.

Figure 9: Companies are inclined to move their supply chains to Asia South and North America



Source: BofA Global Research

South East Asia – the preferred destination

Clearly, as the above charts show, South East Asia is slated to be one of the biggest beneficiaries of the realignment of supply chains as companies perceive it as a viable alternative to China. In cases where companies refrain from relocating onshore, it is the favored destination for setting up new supply chains, followed by India.

Lest we forget, lower labor costs can be a significant advantage for an economy looking to export its way to growth, even in a moderately automated ecosystem. And South East Asia and India score really well on this parameter.

However, there are three caveats. First, there is a risk that the US trade war shifts towards non-China Asia, with Vietnam and other ASEAN countries at risk. In our view, we will learn a lot about the scope of that risk after the US election. Second, a significant further ramping up of production will require investing more in infrastructure. Again, Vietnam stands out as it is already running into capacity limits.

Third, capabilities are just as important as labor costs. To create a more holistic picture of the export competitiveness of a potential substitute for China, our strategists rank key Asian economies and Mexico on five key indicators: (1) average daily wages (in USD), (2) regulatory quality (from the World Bank), (3) logistics performance index (from the World Bank), (4) manufacturing intensity (manufacturing as a percentage of GDP) and (5) export base (exports as a percentage of GDP). Green means highly competitive; red uncompetitive.

Table 1: Country comparative analysis - most emerging economies score well on labor costs, whereas the more developed countries have an existing manufacturing and export base

Country	Avg. daily wages (\$)	Regulatory Quality	Logistics Performance Index	Manufacturing, value added (% of GDP)	Goods exports (% of GDP)	Country credit rating
Bangladesh	1	12	11	8	10	11
China	10	8	3	1	8	3
Indonesia	3	7	8	5	9	9
India	4	9	7	11	11	7
Korea, Rep.	11	2	2	2	5	2
Mexico	8	4	9	9	6	4
Malaysia	9	3	6	4	3	5
Pakistan	2	11	12	12	12	12
Philippines	6	6	10	6	7	8
Singapore	12	1	1	7	1	1
Thailand	7	5	4	3	4	6
Vietnam	5	10	5	10	2	10

Source: BofA Global Research

As expected, most emerging economies score well only on a few parameters (principally on labor costs), whereas the more developed countries have non-labor advantages (an existing manufacturing/export base). Many of them (except Thailand) are lagging behind in terms of adoption of industrial robots for performance enhancement.

Vietnam shows up as having the highest potential to benefit in South East Asia, given there is modest overlap of the composition of their exports to the US with China, indicating they already have some capacity/technology/ecosystem in place to gain market share. For details, please refer to [Equity Strategy - India and ASEAN: Shifting Supply Chain Series #6: Capability, not just costs 02 July 2019](#).

However, countries like India/Indonesia are unlikely to benefit significantly, as they do not currently export merchandise to the US in meaningful size. They have some of the lowest labor costs and very large (and growing) pools of labor, but need to create manufacturing supply chains/logistics from scratch, if they are to benefit from the relocation of factories away from China. What is encouraging though is that India has chalked out plans to attract some of the manufacturers leaving China to set up production units in the country and reduced corporate taxes to as low as 15% to enhance competitiveness.

Singaporean banks: a play on supply-chain shifts to South East Asia

Singaporean banks (DBS, UOB, OCBC) have become much stronger banks in the region since the global financial crisis (GFC), as the long entrenched European banks (HSBC/STAN) have de-emphasized some local markets due to capital constraints. During this period, all three Singaporean banks have worked on improving their Greater China presence either organically or via acquisitions. Compared to other local banks in the region, they also have the added advantage of much bigger balance sheets and access to USD funding.

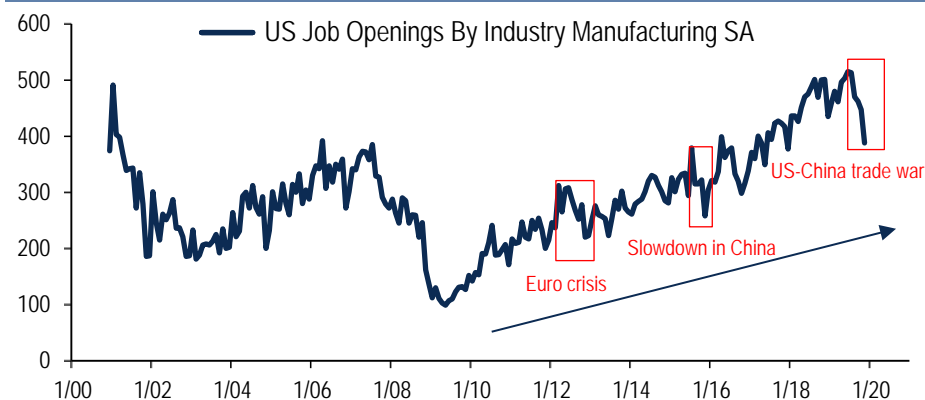
They now have one of the stronger ASEAN + Greater China platforms, which should appeal for companies looking for advisory/funding to move supply chains to ASEAN. Local banks in various ASEAN countries should also benefit eventually given their project finance/supply chain expertise in these countries.

Re-shoring to North America

Our survey suggests that the trend is clear: global supply chains are on course to be uprooted and brought home, or transplanted to strategic allies. Manufacturing is moving back to North America after a hiatus of three decades, as evident from the number of job vacancies in the US. About 400,000 US factory jobs are unfilled – close to the highest level in nearly two decades – as companies compete for skilled labor in the midst of record-low unemployment. This is forcing manufacturers to go out of their way

to entice job seekers, offering higher wages, signing bonuses, and relocation expenses, even for some hourly positions. The payouts are even more lucrative for specialist positions, such as welders, engineers and machine programmers, which are now in demand as production becomes more automated. To get around this, some companies have started grooming their current employees to perform sophisticated jobs such as programming computerized machines.

Figure 10: About 400,000 US factory jobs are unfilled – close to the highest level in nearly two decades

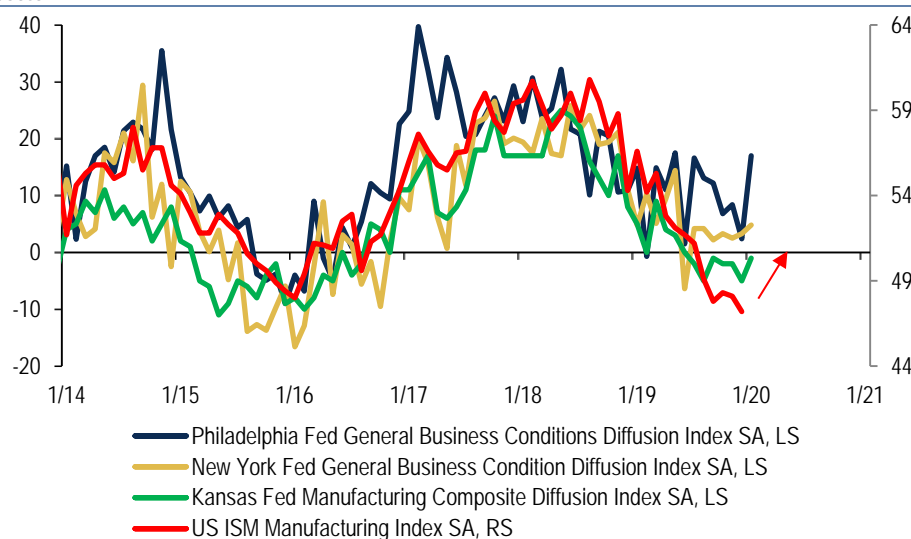


Source: BofA Global Research, Bloomberg

Cyclical and secular

Reshoring adds a “secular” component to a likely cycle recovery in US manufacturing. Currently the US manufacturing sector is in a mild recession, but regional surveys (Philadelphia, New York and Kansas Fed) hint at a turning point. The sector should benefit from continued strong demand from the US service sector, the US-China trade war ceasefire and the general rebound in global manufacturing trade. Our US economics team believes the manufacturing sector is on the cusp of recovery, with the likelihood of the US manufacturing ISM scaling a peak of around 55 by the summer.

Figure 11: Regional Fed business conditions signaling a cyclical recovery for the US manufacturing sector



Source: ISM, CEIC, Haver

Mexico: reaping the benefits of adjacency to the largest economy

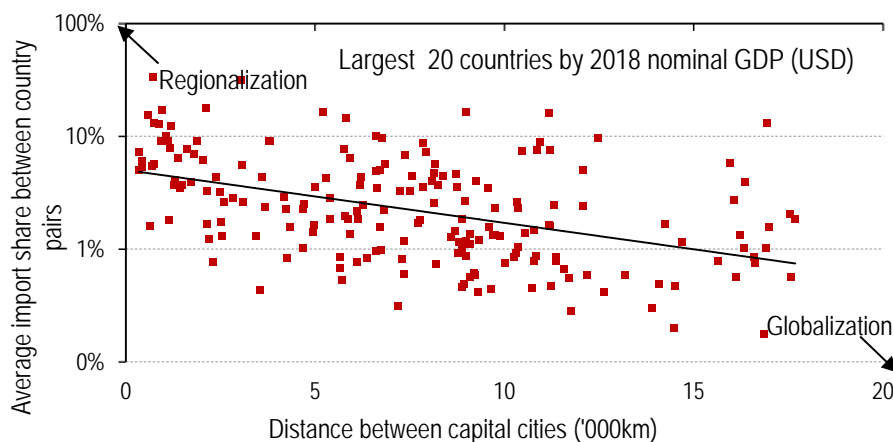
Historically, countries have traded most intensely with their neighbors. As companies sought lower labor costs and as products became smaller and cheaper to transport, supply chains had been going global. Concerns about climate change are undercutting



that trend. Goods that travel long distances, burning fossil fuels like “fast fashion” (a massive polluter because it is cheap, outsourced and turns over rapidly), methane-emitting meat, etc, are all likely to get increasingly unpopular as younger consumers, who are more concerned about climate change, acquire purchasing power. Border carbon taxes to punish goods coming from polluting countries, or great distances are also highly likely.

Consequently, as manufacturing companies flock back to their regional blocks with the notion of using automation to replace cheap manual labor (*more on this later*), countries that are contiguous to the US or Europe (like Mexico, Poland, etc) and ensconced in those developed market regional supply chains and security umbrellas, stand to benefit, especially if they can make their business environment more friendly, including improved infrastructure and tertiary education.

Figure 12: Trade intensity is inversely related to geographical distance



Source: BofA Global Research, Bloomberg, IMF

A key positive externality of the US-China trade conflict is the trading status of Mexico with the US. The US and Mexico are natural trading partners given their proximity and their workers' complimentary skills, and bilateral exchange between the two nations has grown considerably since the 1980s.

According to the US Census, the bilateral merchandise trade between the two neighbors last year, till November, amounted to USD568bn (15% of the overall US trade), surpassing Canada (USD562bn) and China (USD516bn).

Figure 13: Manufacturing as share of GDP in Mexico is on the rise since the financial crisis



Source: Bloomberg

Impact of local manufacturing

The reshoring of manufacturing facilities can have a multitude of far-reaching, lasting effects on the broader economy. It can boost the long-term growth potential of a country through productivity enhancement, research and development, jobs, creation of secondary and tertiary economies etc.

Figure 14: Impact of local manufacturing

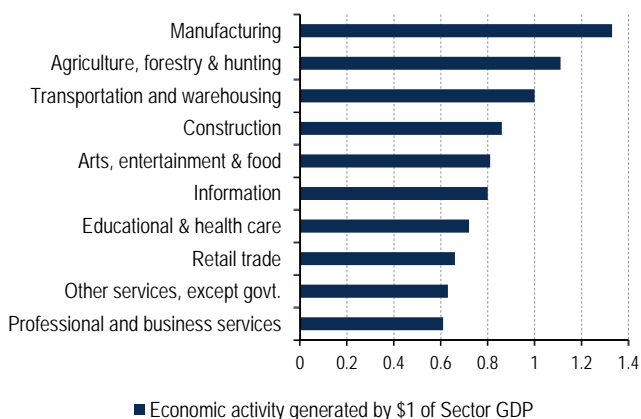


Source: BofA Global Research

Manufacturing industries have the highest multiplier effects on the economy:

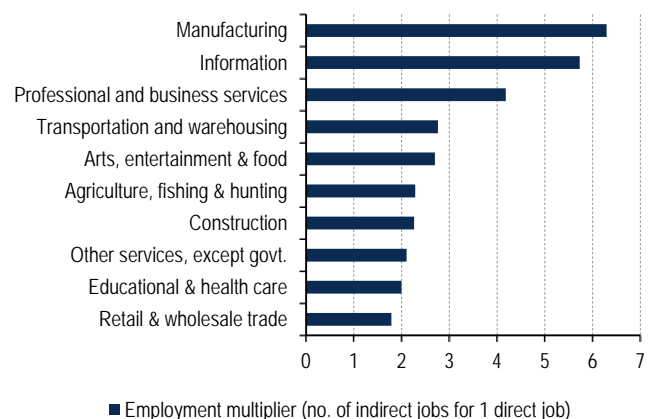
Data from the US Bureau of Economic Analysis suggests a dollar spent on a manufacturing facility generates the highest economic activity and employment multiplier among all sectors. Taking secondary and tertiary effects into consideration, estimates suggest every dollar in final sales of manufactured products supports USD1.33 in output from other sectors, while six indirect jobs are created for every new job in a manufacturing business.

Figure 15: Every dollar in final sales of manufactured products supports USD1.33 in output from other sectors



Source: Bureau of Economic Analysis

Figure 16: Indirect employment generated by different sectors

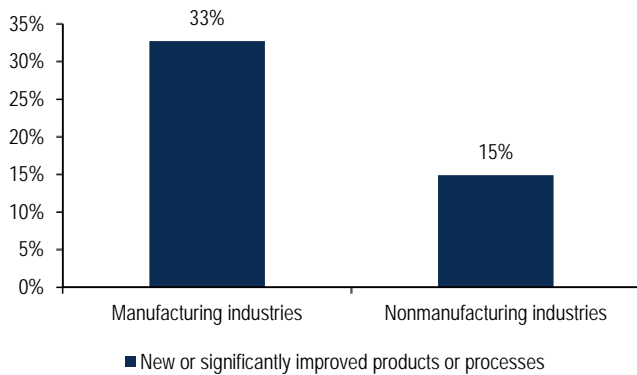


Source: Economic Policy Institute

Manufacturing industries drive innovation through R&D and industrial clusters

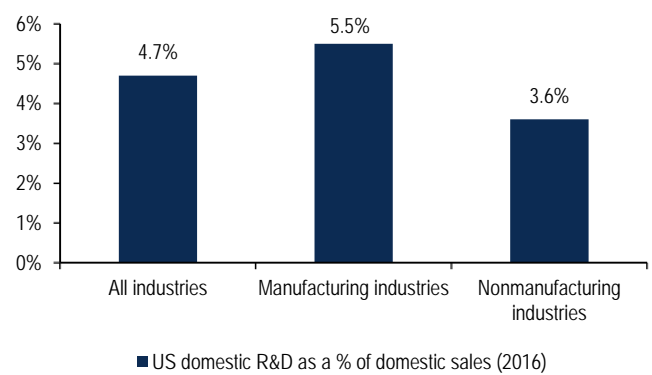
According to a survey of businesses on R&D and innovation in the US, the ratio of domestic R&D spend-to-sales is significantly higher for manufacturing (5.5%) than non-manufacturing industries (3.6%). As a result, manufacturing industries have a much higher intensity of product/service launches as compared with non-manufacturing industries.

Figure 17: Only 15% of all non-manufacturing companies introduced a new product or service between 2014 and 2016, while 33% of manufacturing companies did so



Source: National Science Foundation, National Center for Science and Engineering Statistics, and U.S. Census Bureau, Business R&D and Innovation Survey

Figure 18: Domestic R&D as a % of domestic net sales is higher for manufacturing vs non-manufacturing



Source: National Science Foundation, National Center for Science and Engineering Statistics

Further, the establishment of a manufacturing facility generally leads to the development of an industrial cluster around that region over time that has numerous entrenched advantages. Michael Porter has highlighted three ways in which the immediate business environment outside companies plays a vital role on its businesses:

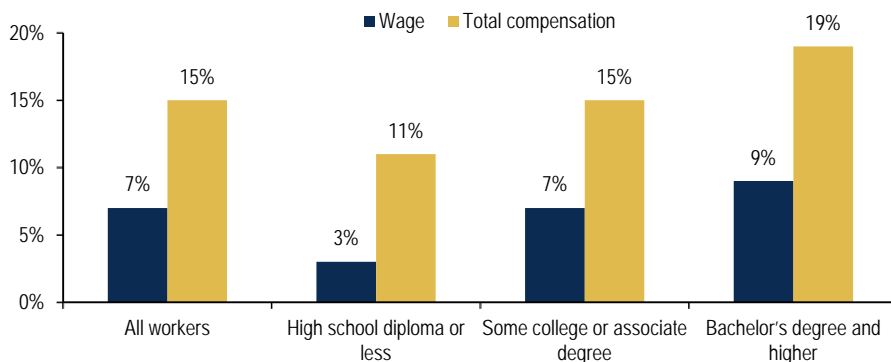
- Increasing productivity of companies, as if they had greater scale
- Driving direction and pace of innovation
- Forming new businesses that further strengthen the cluster

By creating a 'collective scale', industrial clusters can help even mid-sized firms overcome cost disadvantages and drive technological advancement.

Manufacturing industries improve wages of skilled workers

According to the Congressional Research Service's report (U.S. Manufacturing in International Perspective, [February 2018](#)), US manufacturing workers typically see a significant wage premium over peers in the non-manufacturing sectors. The wage and compensation premium for a manufacturing worker in the US ranges from 3% to as high as 19% relative to a comparable nonmanufacturing worker in the private sector.

Figure 19: The manufacturing premium (wage and compensation) shows how much more a manufacturing worker in the US makes per hour than a comparable nonmanufacturing worker in the private sector (Regression-adjusted manufacturing wage and compensation premium, 2011)



Source: Economic Policy Institute (Adapted from Langdon and Lehrman 2012, Figure 9)

Note: Data is for workers aged 25 and older

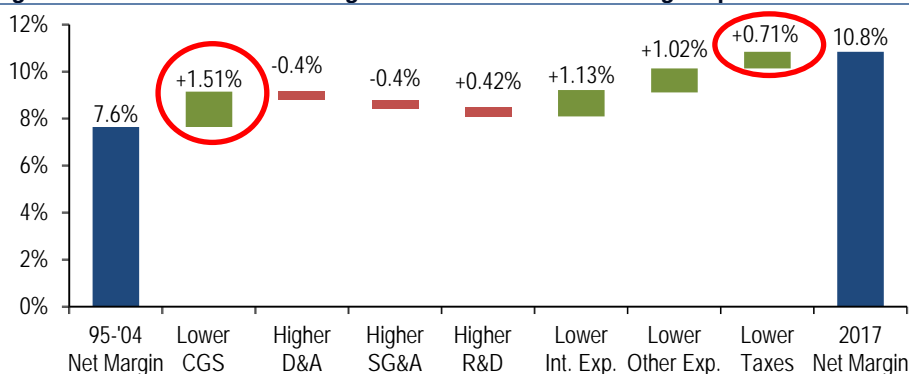
BofA Survey Takeaway #2: Shifts in supply chain are time consuming and costly

Rome was not built in a day

Shifting the entire supply chain for a company is not a day's work. It is a structural shift with long gestation periods. Given such decisions invariably factor in the cost of sourcing, they require clarity on tariff policy and significant effort on the part of the importing companies. It is a glacial process, implying the current wave of supply chain moves underway is just the tip of the iceberg.

The case for globalization is rooted in Ricardo's theory of comparative advantage. A key reason why stuff travels long distances is because each country has comparative cost advantage in different industries. By our estimates, [globalization has contributed](#) to net margin expansion of about 2.2ppt through lower cost of goods sold and lower taxes in 2004-17. A reversal of these benefits will be costly. The costs are particularly high during the transition to the new supply chain when old capital is "stranded" in the wrong place and hence is no longer productive.

Figure 20: Globalization has been a big contributor to S&P 500 net margin expansion since 2004

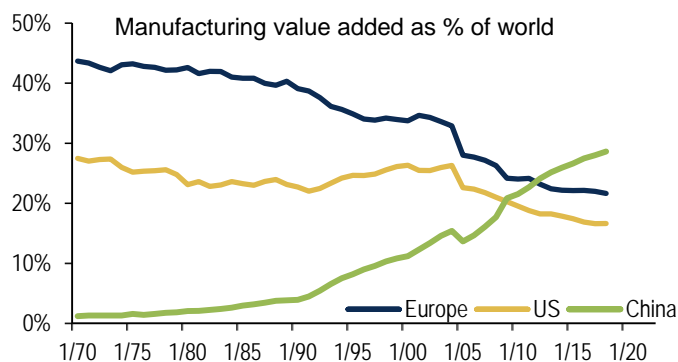


Source: FactSet, BofA US Equity & Quant Strategy

Leaving China is not easy

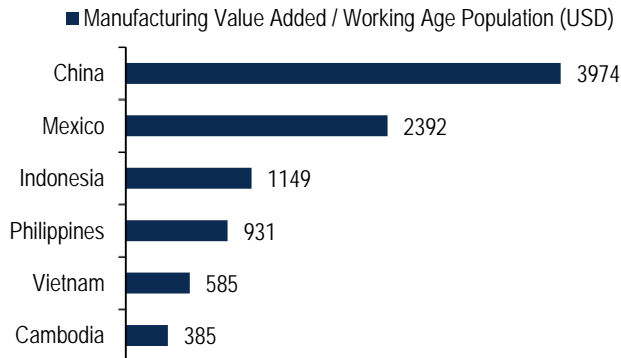
The industrial heartland of China has been touted as the "Goldilocks Zone" for offering the optimum mix of costs, quality, efficiency, human resources and infrastructure for the past 30 years. No wonder, it accounts for a quarter of the world's manufacturing value added. To get a sense of the cost of leaving China, it is estimated one Chinese worker can manufacture about the same value of goods as four workers from four ASEAN countries combined. Take another example: the lead time to hit the shelves in US stores can take up to 40 days from Thailand, almost twice as long as from China.

Figure 21: Manufacturing – a 30-year shift from the US and Europe to China, are we at a pivotal point today?



Source: United Nations

Figure 22: Labor productivity - one Chinese worker can manufacture about the same value of goods as four workers from ASEAN countries



Source: United Nations Population Database, World Bank



And yet, the relocations are coming through. There are a number of reasons behind this: rising wages, stricter environmental norms, a complex regulatory framework, the government focus to transform into a high-skill service-oriented economy, and, of course, the tariffs and the uncertainty around them.

Cost increases are coming; how well are companies prepared to handle them?

Unsurprisingly, the supply chain shifts are likely to be associated with rising costs.

Our survey reveals that in North America, companies in about half of the global sectors will experience moderate to high margin compression when they relocate onshore. With unemployment near 50-year lows, higher wages are going to eat into the profits of US corporates.

In Europe, we expect moderate to high margin compression in about 75% of the global sectors when relocating onshore, including four (Software, Retailing, Healthcare Equipment & Services, and Food, Beverage & Tobacco) that will experience significant cost inflation.

As expected, the impact on margins is less severe for companies in Asia Pacific (excluding China), with substantially weaker margins expected in roughly one-thirds of the global sectors post relocation within national borders. Most of the countries in this region are low cost to begin with, weakening the argument for a shift from these countries from a cost perspective.

A key finding from our survey is that Chinese companies in global sectors are expecting some help from the government in terms of favorable regulations, tax benefits and subsidies.

BofA Survey Takeaway #3: Automation is almost automatic

Companies in about 60% of the sectors in North America have reasonable pricing power to offset the higher costs given the oligopolistic nature of most US corporates. Our analysts think companies in half of these sectors are likely to depend on subsidies, and regulatory and tax benefits to compensate for the additional costs. But the unanimous (*almost*) weapon to combat rising costs seems to be automation; our analysts report that all sectors but Software and Food, Beverage & Tobacco are considering it.

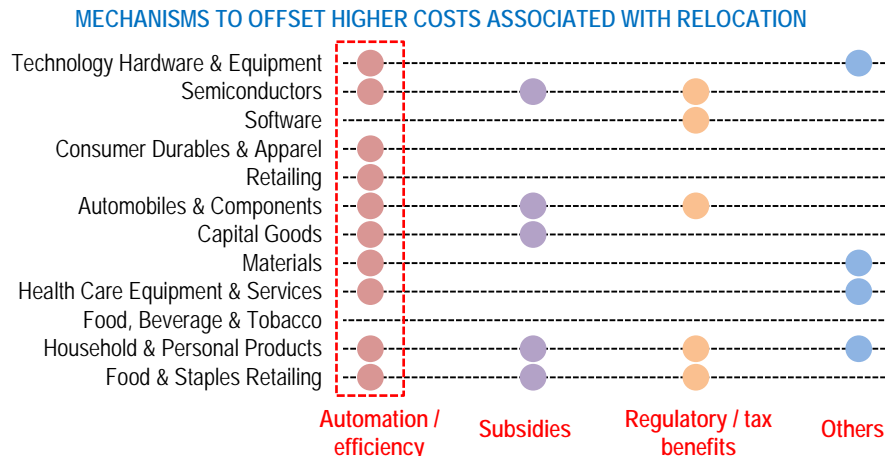
It is interesting to note while Consumer Durables & Apparel and Semiconductors are likely to be the worst affected sectors in terms of margin compression, neither has significant pricing power and would need to use other mechanisms, primarily automation, to stay competitive.

The cost story is a bit different for Europe. As with the US, our analysts think that companies in two-thirds of the global sectors in Europe can employ cost pass-through techniques meaningfully to maintain margins. But surprisingly, European companies do not appear geared up adequately to use automation as a mitigant against margin compression – only a third has some form of automation/efficiency plan in place. They also expect limited support from the government (subsidies, regulatory/tax benefits, etc).

We believe all global sectors in Asia Pacific have low to moderate pricing power, diminishing their ability to sustain current margins. But as in North America, companies in the Asia Pacific (ex-China) region appear to be empowering themselves with automation and other productivity enhancements to alleviate the impact of rising costs. Our analysts advise that close to half the sectors are also hoping to get either subsidies, or tax benefits, or some combination of them to ease the impact on them.

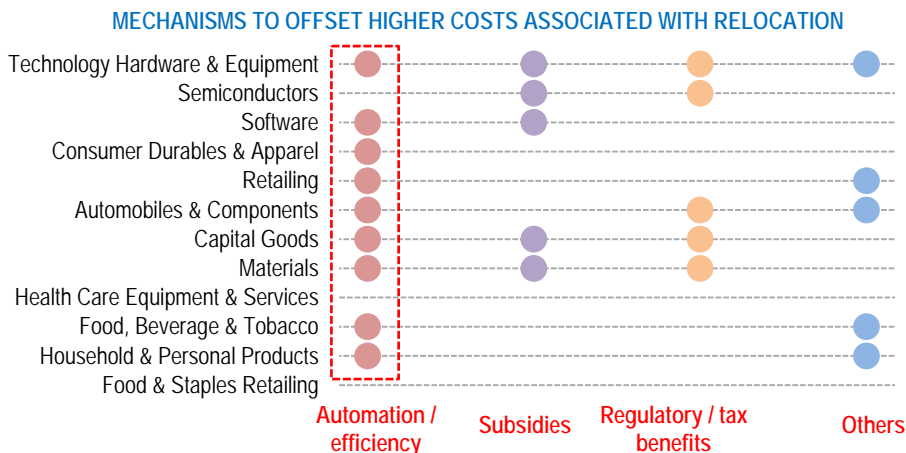


Figure 23: North America - the unanimous (almost) weapon to combat against rising costs seems to be automation – all but Software and Food, Beverage & Tobacco are considering it.



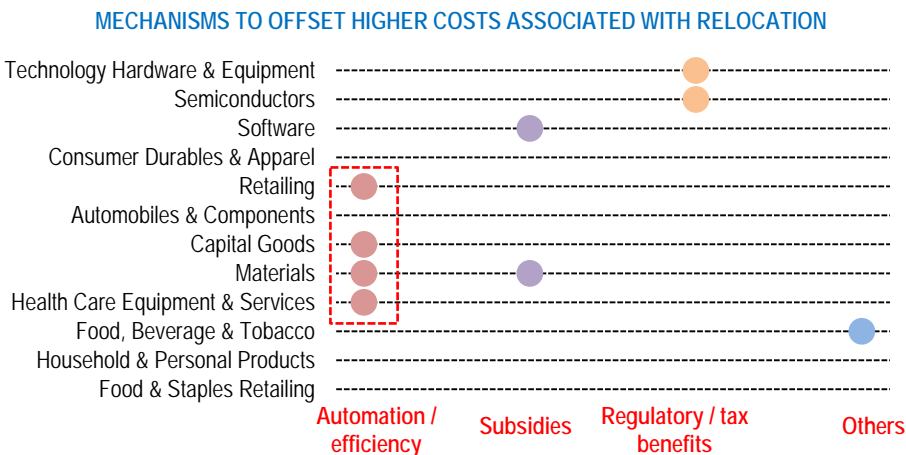
Source: BofA Global Research

Figure 24: Asia Pacific (Ex-China) - As in N. America, companies in Asia Pacific (ex-China) appear to be empowering themselves with automation and efficiency techniques to alleviate the impact of rising costs.



Source: BofA Global Research

Figure 25: European companies do not appear geared up adequately to use automation to mitigate margin compression – only one-third has some form of automation/efficiency technique in place.



Source: BofA Global Research

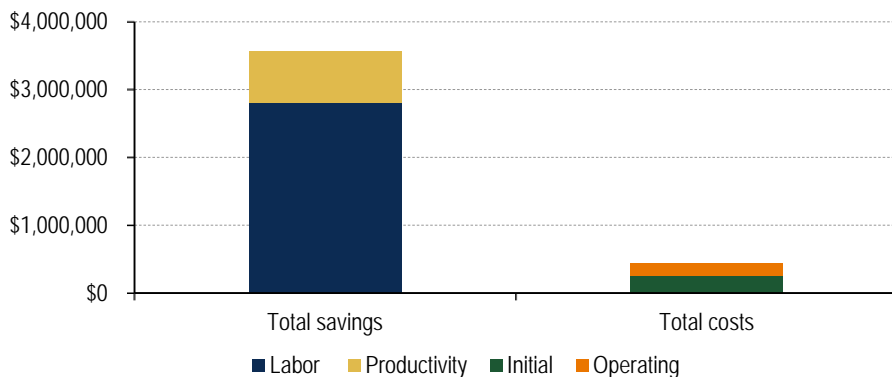


Automation and Robotics: Validating the case for reshoring

It is evident from our survey that supply chain shifts, whether already implemented or in the planning stage, are largely enabled by automation and productivity enhancements. Robotics and automation is the single biggest answer to supply chain resiliency questions. This is especially true for those relocating to higher labor cost regions.

Automation is a kind of “process technology.” It originated in 1945 at the Ford Motor Company to describe machines that mechanically unloaded stamping from body presses and positioned them in front of machine tools. Today, it refers to any production process that is controlled by a machine, with little or no input from an operator to produce in a highly automatic way. There are many technologies that can enable a production process to be automated, robotics being an increasingly important one. Generally, automation not only leads to increased efficiency and quality consistency, but also helps in cutting costs. Based on the ROI Robot System Value Calculator provided by the Robot Industries Association (RIA), a standard robotic system, over the course of its 15 year cycle, delivers a total savings of about USD3.5mn vs an initial outlay of USD250,000 and operational costs of about USD187,000. Even if these estimates overstate the case for robotics, the savings are likely substantial.

Figure 26: Total robotic system costs vs current operational costs



Source: RIA ROI Calculator. Note: Based on the default option provided by the RIA. More details available on their website.

While new production systems are beneficial for both developed and emerging economies, there is a stronger economic case for the former given the labor cost savings much larger, justifying the initial investments in robots. In addition, these new systems facilitate shorter production runs, smaller production units and higher productivity, all of which strengthen the case for more decentralized and geographically dispersed manufacturing facilities to serve local markets, and provide a fillip to reshoring to developed nations. Indeed, Krenz, Prettnner, and Strulik estimate an increase of one robot per 1,000 workers in a manufacturing sector is associated with 3.5% incremental reshoring².

Make no mistake, manufacturing is not the only domain of automation and robotics. A new automation technique that is more suited to the services sector is Robotic Process Automation (RPA), which uses software to replace a whole host of human activities in the workplace (e.g., automating the accounts payable process), suggesting reshoring will increasingly replace outsourcing.

² Robots, Reshoring, and the Lot of Low-Skilled Workers (Center for European, Governance and Economic Development Research (CEGE), No. 351, July 2018)

Automation and robotics: Driving productivity growth

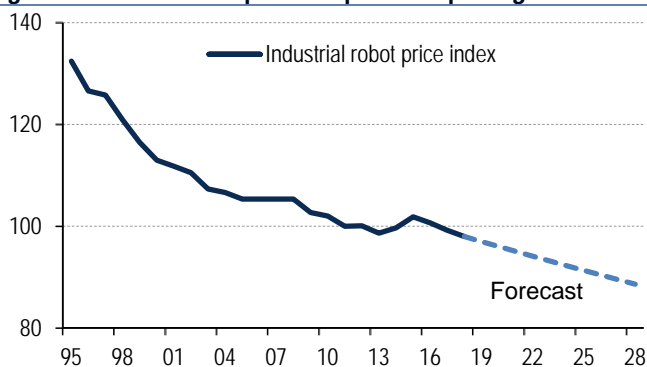
The world economy is old, indebted and unequal, and is much in need of rejuvenation of productivity and growth. As cited in the Information Technology & Innovation Foundation's October 2019 report titled '*Robotics and the Future of Production and Work*', the Conference Board estimates that the growth in global GDP per person employed has slowed from 2.6% a year from 1999 to 2006 to around 2.0% a year from 2012 to 2014, with the bulk of it attributable to developed economies (the EU, Japan, and US), where productivity growth fell more than half after 2007, compared with from 1999 to 2006.

Robots are important to turning around this trend. As cited in the same report, there was a 0.42 correlation between a country's wage-adjusted manufacturing robot adoption and productivity growth in 2010-17 for OECD countries. They added that a one-unit increase in robotics density (measured as the number of robots per million hours worked) is associated with a 0.04% increase in labor productivity. Similarly, Koch, Manuylov, and Smolka concluded the introduction of industrial robots in Spanish manufacturing firms boosted output by 20-25% in a span of four years, while reducing labor-cost share by about 6%.

Robot installed base could double by 2025

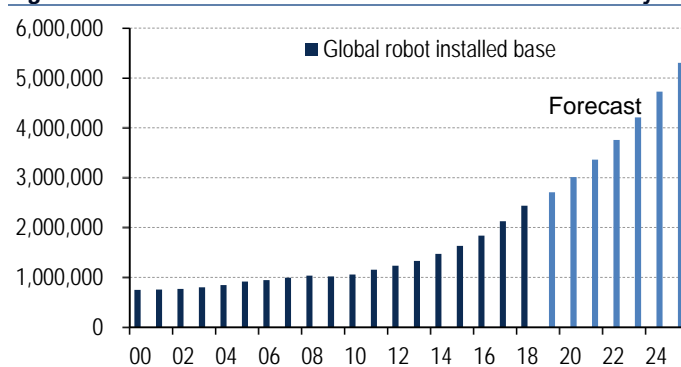
Based on the World Bank's projections for global GDP growth up to 2024 (for 2025 we assumed the average of the previous five years) and our assumptions around the installed-base growth rate relative to global GDP growth, we believe the global installed base can hit 5mn units by 2025, doubling 2019 levels, as they become more affordable, and more flexible and autonomous by virtue of artificial intelligence. The Boston Consulting Group estimates 1% reduction in robot prices and 5% improvement in productivity annually over the next decade.

Figure 27: Industrial robot prices – expect to keep falling



Source: BoJ, BofA Global Research, BCG. Price indexed to 100 in 2011

Figure 28: Global industrial robot installed base to double in next 5 years



Source: IFR, BofA Global Research estimates, World Bank

Case studies

Appendix I and II present case studies on **Nike** and **Apple** highlighting use of automation and potential shifts in their supply chain.

Case Study I

Nike has shifted its supply chain three times in the company's 50+ year history. It was an early mover to outsource production to Asia starting in the early 1970s. The next phase of Nike's supply-chain shifts was based on the twin dynamics of lower labor cost and automation. The single largest production base for Nike has moved from China to Vietnam with growing operations in India and Indonesia. Nike has also been successful in using automation over the last 10 years to double revenues while reducing labor input by 20%. It continues to create a flexible supply chain in multiple locations using automation to offset cost pressures and boost productivity. Nike's key manufacturing partners are planning to roughly double production capacity over the next 10 years while reducing the direct labor needs on a per unit basis by approximately 50%.



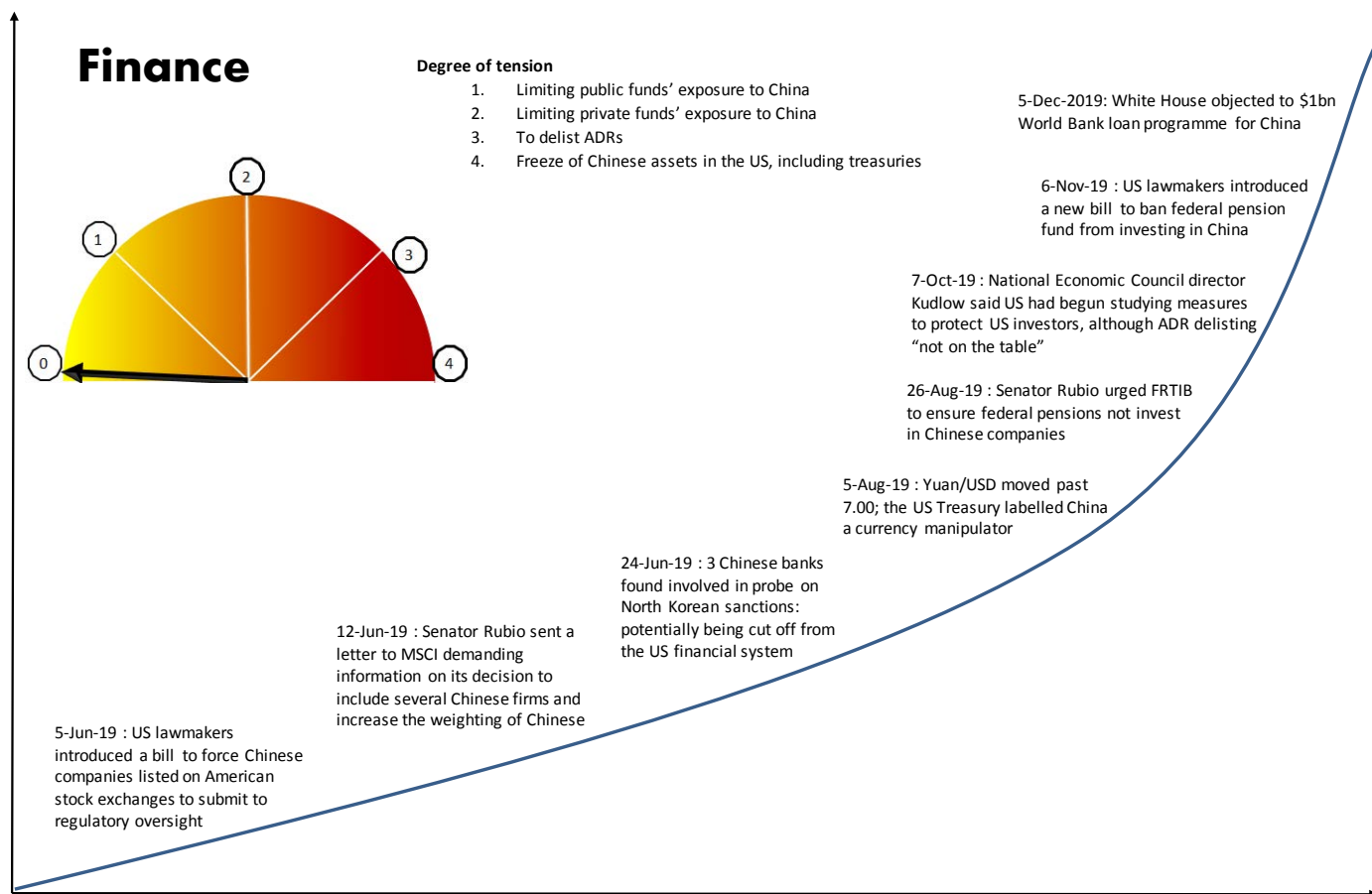
Case Study II

Given the complexity of iPhone's assembly, we believe it is likely Apple will reconfigure its supply chain over time and in stages. It is likely to use a three pronged approach: (1) continuing automation of existing supply chains (e.g. Hon Hai, a key Apple supplier, reduced its workforce from 1.3mn to 1mn and intends to further reduce to 700,000 over the next year); (2) relocate non-iPhone production to other countries or reshore (e.g. AirPods and Apple Watch in Vietnam, Mac assembly in Texas); (3) to reshore final assembly to end markets over time. In our opinion, this will require further product reengineering, and modularized design innovation, which argues for greater automation of Apple's supply chain.

The shape of things to come

The trade discord that has started out with concerns around large imbalances may take a back seat as the US-China Phase 1 trade deal is finally signed, but after the US presidential election it may spread to other sectors, in our view. Especially, we see potential conflicts brewing in the financial and technology sectors, risking the decoupling of China and the US in these spheres. So far, the developments are largely in the realm of rhetoric as far as financial decoupling is concerned. But there are emerging risks worth monitoring. Post-WWII dominance of the US dollar, US dollar payment networks, SWIFT, multilateral lenders (IMF, World Bank) are all likely to be contested. The renminbi is the most likely candidate for internationalization, although it will likely be a slow process. Some of the potential risks around financial markets that we are tracking are highlighted below.

Figure 29: Increasingly hard-hitting sound bites around financial markets



Source: BofA Global Research

The US may undertake measures to restrict portfolios flows into China such as restricting public pension funds' exposure to China and putting pressure on American Index providers to exclude Chinese companies on US restricted lists, including the Entity List. On 13 June, US Senator Marco Rubio wrote to the CEO of MSCI, seeking information on why the company had included certain Chinese stocks in its emerging market indexes. The index providers may come under pressure to slow their A-share inclusion pace. In fact, MSCI has already ruled out the potential for further inclusion of A-shares into its benchmark Emerging Market Index unless pending issues are addressed, which include access to hedging tools, and problems with its settlement cycle and holiday schedule.

Some American Depositary Receipts (ADRs) may choose to delist. In our view, there is a moderate risk that some ADRs could choose to de-list. In an April letter, a bipartisan group of senators urged the Trump administration to increase disclosure requirements for Chinese companies listed in the US that “pose national security dangers or are complicit in human rights abuses”. This could have been one factor behind SMIC's recent decision to de-list from the NYSE, by our assessment. Please see [US Equity Strategy Year Ahead: Ch-ch-ch-changes 19 November 2019](#) for Top 10 China ADRs holdings by long-only and hedge funds.

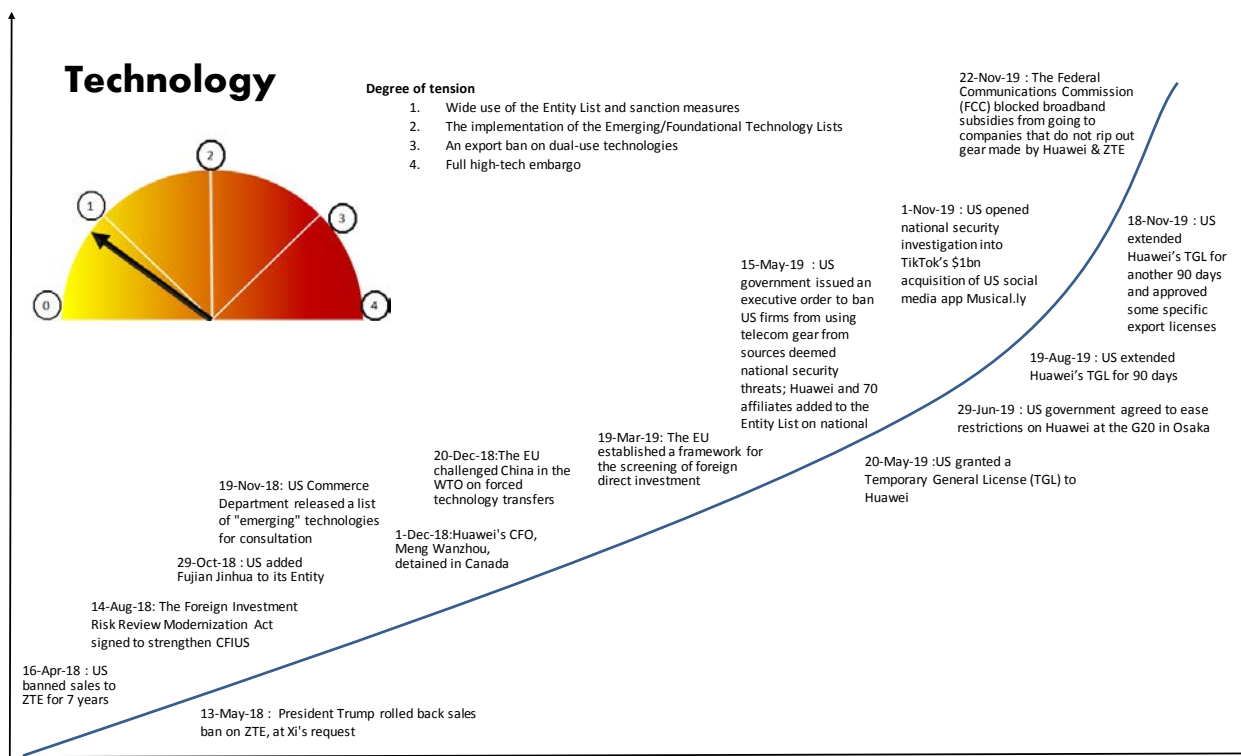
IPOs may shift from the US to HK/China – a potential negative for new economy sectors in China, which are the primary US listing candidates. This is because the US capital market is much deeper and also offers other benefits such as access to expertise.

The attempt of the Chinese government to strengthen the RMB's role in the global payment and financial services market will likely challenge the hegemony of the US dollar (62% of world allocated reserves). The SWIFT payment system will also likely be challenged by alternatives from China/Russia. However, these attempts of the Chinese government may prompt a potential US government response. As a result, we believe some of the Chinese companies pursuing a global payment platform could be vulnerable to adverse US government actions.

China may divest some of its US bond holdings, including treasuries. This would potentially lead to a gradual sell-down of its holdings, rather than a large one-off sale.

All these moves imply financing will increasingly be more local, relying on domestic savings and local financial firms, products and systems.

In our view, these moves are not about a trade war, but about disengaging from, while degrading and diluting Chinese expertise in civil-military spheres that challenge US dominance mainly in technology. We are closely monitoring US policies on China's technology companies.

Figure 30: Keep an eye on tensions brewing around technology sector

Source: BofA Global Research

Any escalation on the capital and technology front, in our view, would accelerate the tectonic shifts we have described in supply chains.

Appendix I

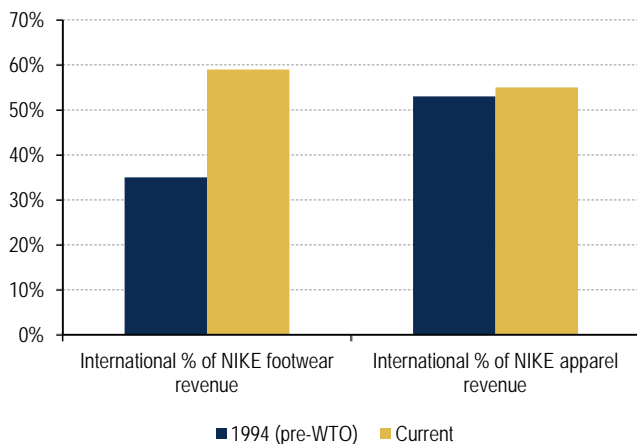
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Nike: Poster Child for Globalized Supply Chains

Nike has shifted its supply chain three times in the company's 50+ year history. It was an early mover to outsource production to Asia starting in the early 1970s. The next phase of Nike's supply-chain shifts was based on the twin dynamics of South Asia and automation. The single largest production base for Nike has moved from China to Vietnam with growing operation in India and Indonesia. Nike has also been successful in using automation over the last 10 years to double revenues while reducing labor input by 20%. It continues to create a flexible supply chain in multiple locations using automation to offset cost pressures and boost productivity. Nike's key manufacturing partners are planning to roughly double production capacity over the next 10 years while reducing the direct labor needs on a per unit basis by approximately 50%.

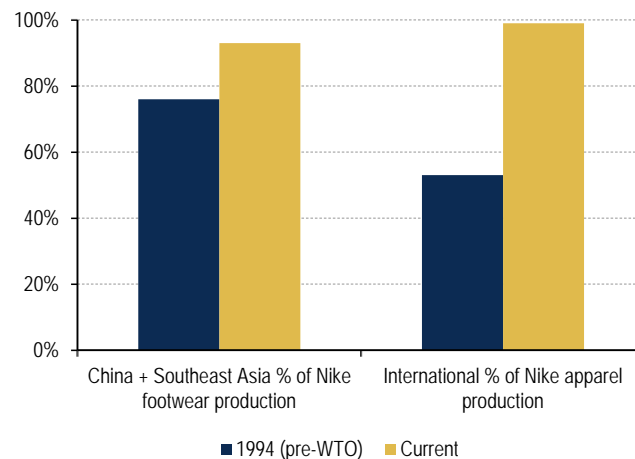
Globalization has helped facilitate Nike's growth into a global brand. The elimination of protectionist import taxes in the US (1980), China's entry into the General Agreement on Trade & Tariffs (1986), and formation of the World Trade Organization (1995) supported significant supply-chain investment overseas by Nike's sourcing partners. Moving supply chains to Asia also helped Nike to transform into a global brand with international sales now contributing over half of its revenues.

Figure 31: Nike now generates nearly 60% of footwear revenue outside of North America



Source: Company filings

Figure 32: Nike now produces nearly 100% of footwear and apparel outside of North America

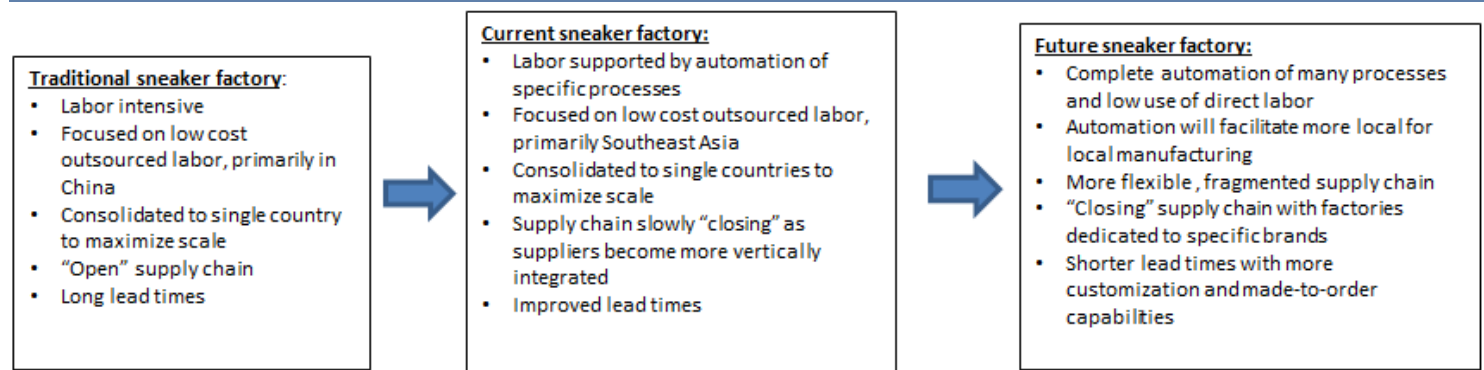


Source: Company filings

Supply chain to become more fragmented and automated

A global shift to more regional trade zones will likely make Nike's geographically consolidated supply chain less efficient and exposed to an uncertain tariff environment. We expect Nike to create a more flexible and fragmented supply chain with the ability to produce the same product at factories in multiple countries. A shift to a more fragmented manufacturing base in higher-cost countries would reduce the labor efficiency advantages that come with higher scale. To offset the lower labor efficiency, Nike and its manufacturing partners will continue to make significant investments in automation.



Figure 33: We expect the diversification of Nike's production to continue**Figure 34: Sneaker manufacturing to continue to evolve**

Source: BofA Global Research

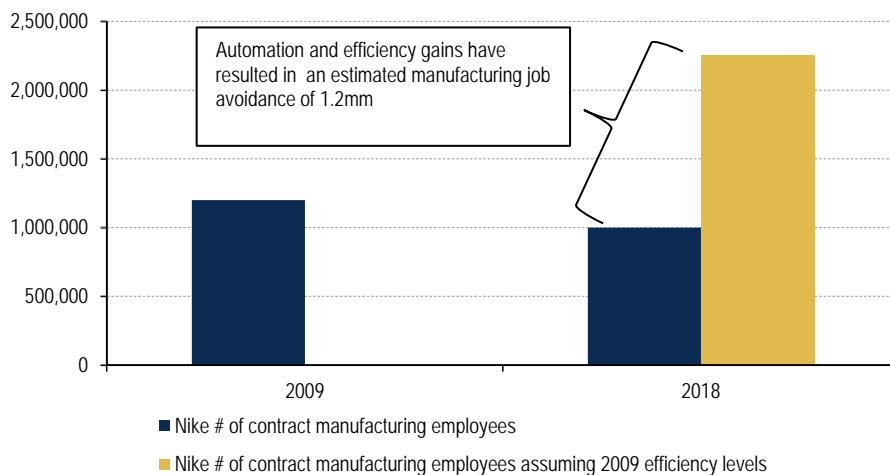
Innovation in automation is changing the way sneakers are made

We expect Nike to partner with its manufacturers to increase automation across its supply chain. New technology including machines for knitting, laser auto-cutting, direct soling, and radio frequency identification will help reduce the reliance on labor, shorten lead times and shift to more local-for-local production. Many of Nike's key manufacturers are already automating certain processes, including cutting and stitching and inventory management. We believe new innovation will support further expansion of automation into more processes. In 2013, Nike purchased a minority stake in Silicon Valley-based startup Grabit, a robotics company that produces electroadhesion-based robotic grippers. Material handling is one of the most labor-intensive and expensive aspects of manufacturing. Assembling a pair of Nike sneakers requires up to 40 pieces of material to be stacked and heated to create the shoe upper. This process can take a human worker up to 20 minutes to arrange those materials. Using Grabit's robotic grippers, Nike can assemble shoe uppers more than 20 times faster than humans reducing the manufacturing time to as little as 50 seconds per upper. Nike uses Grabit's Stackit material handling robot system to produce up to 600 pairs of shoes in an eight-hour shift.

Improving efficiency from automation is key to more localized manufacturing

Automation in the apparel and footwear supply chain is still in its early stages, but investments are already yielding significant efficiency gains. Yue Yuen, the largest sneaker manufacturer in the world, is currently automating just 30% of cutting and stitching and 20% of assembly, which has facilitated a roughly 30% increase in pairs produced per manufacturing employee since 2014. Since 2009, Nike has doubled its revenue while the number of its contract manufacturing employees has declined by 20%. We estimate the increase in automation has resulted in the job avoidance of approximately 150,000 contract manufacturing employees for Nike annually. Longer term, automation could also shorten lead times, increase customization capabilities, reduce design iterations and material waste, and improve product quality and consistency.

Figure 35: Automation driving efficiency gains - Nike more than doubled revenue since 2009 while manufacturing employees fell 20%



Source: Company filings, BofA Global Research

Automation could reduce labor reliance and shorten lead times for NIKE

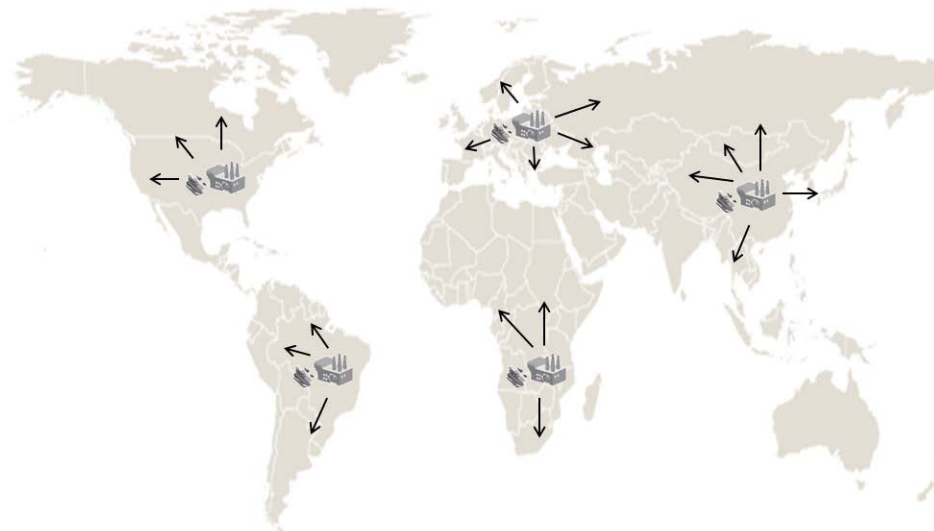
Nike's key manufacturing partners are making significant investments in automation and innovation to reduce the direct labor necessary to supply Nike's business. Longer term, automation could also shorten lead times, increase customization capabilities, reduce design iterations and material waste, and improve product quality and consistency.

We're scaling a process we call the Express Lane, which allows us to go from creation to market in weeks instead of months. By digitizing our supply chain from end-to-end, we're amplifying our ability to sense the market, drive efficiency, and manufacture more sustainably.

Mark Parker, Executive Chairman of NIKE, Inc.

More closed supply chain also important for local-for-local

Automation is essential to a more localized supply chains given the higher labor cost in the largest apparel and footwear consumption markets. "Edge-to-edge" factories that are able to produce the components in addition to assembling the sneaker could ultimately result in an increase of local-for-local manufacturing.

Figure 36: “Edge-to-edge” factories could be deployed for local-to-local manufacturing

Source: BofA Global Research

Nike: Shifting supply chains, a timeline

- **1971-76:** Nike sources majority of footwear from Japan and New England
- **1977-85:** Nike shifts production to Taiwan and Korea from Japan after US breaks the yen-to-dollar peg (1972) causing significant appreciation in JPY vs USD. US removes athletic footwear with synthetic uppers from the protectionist “American Selling Price” import tax in 1980 partially due to Nike lobbying efforts.
- **1986-2008:** Nike opens first factory in China in 1981 allowing it to be the first US footwear brand to sell products into China. China joins General Agreement on Tariffs & Trade in 1986. China peaks at 43% of Nike footwear production in 1999.
- **2008-18:** Nike factory opens in Vietnam after US lifts trade embargo in 1994. Vietnam surpasses China in 2008 due rising labor costs, unfavorable demographics and government policies favoring higher tech industries.

Nike to rely on its key manufacturing partners to invest in automation

Nike is using its existing Asia-based suppliers to expand capacity globally. It has been consolidating its footwear supply chain to its larger partners that are able to make long-term investments in automation, vertical integration and production in new countries.

Appendix II

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Apple: Automation and location diversification, the likely trajectory of its supply chain evolution

Given the complexity of iPhone's assembly, we believe it is likely Apple will reconfigure its supply chain over time and in stages. It is likely to use a three pronged approach: (1) continuing automation of existing supply chains (e.g. Hon Hai, a key Apple supplier, reduced its workforce from 1.3mn to 1mn and intends to further reduce to 700,000 over the next year); (2) relocate non-iPhone production to other countries or reshore (e.g. AirPods and Apple Watch in Vietnam, Mac assembly in Texas); (3) to reshore final assembly to end markets over time. In our opinion, this will require further product reengineering, and modularized design innovation, which argues for greater automation of Apple's supply chain.

Over the longer term, we believe the likely path of supply-chain evolution for Apple will be based on: modularization, automation, and relocation.

Modularization: Integration of multiple components into modules to reduce manufacturing complexity

- iPhone's manufacturing process is complicated and labor intensive. However, as we have argued and highlighted with our iPhone tear-apart analysis, we believe Apple has gradually used SiP (system in packaging) and more modularized design to help production automation.
- SiP is a number of integrated circuits that are enclosed in one or more packages. These packages are then stacked upon each other. SiP generally performs most if not all of the functions of an electronic system that are used inside mobile phones, wearables and IoT.
- The trend is indicated by the following:
 - o From our iPhone tear-apart vs Huawei's Phone's tear-apart – we see significantly higher level of modularized of design in iPhone's relative to Huawei.
 - o Continue growth in SiP sales of ASE, USI's sales, Hon Hai and Luxshare's move into system in packaging
 - o Apple Watch has also started to conduct SiP processes
- The advantages of SiP are:
 - o Higher production flexibility and better control of assembly yield
 - o May prove to be more cost effective in the long run as level of automation increases
- Over the next few years, we expect iPhones to be composed of three big modules:
 - o Top module – this includes the display/touch panel, front camera and face ID
 - o Mid module – This is the main circuit board that carries all the key semiconductor chips including the Application processor, modem chips, memory chips, power management, sensor and many others, all neatly packaged into small boxes.

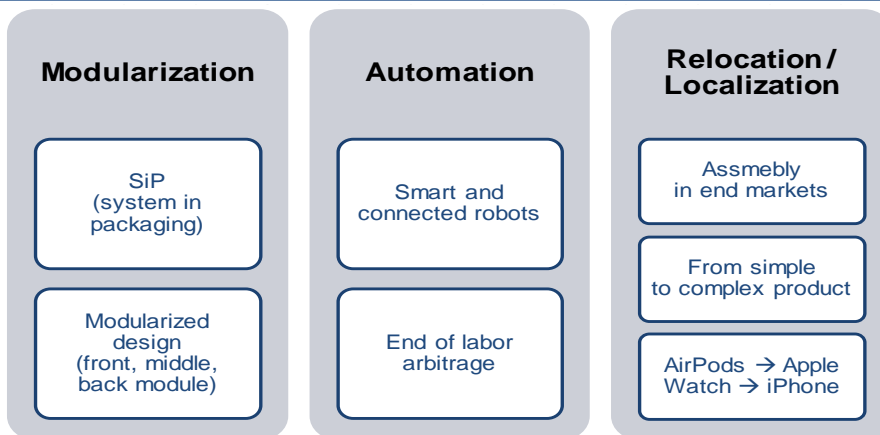


- Back module – this includes the metal/glass casing, battery packs, main cameras
- We expect a level of modularization over the next few years that allows for significant automation of final assembly.
- Currently, iPhone production is still primarily completed in China. However, Hon Hai is planning to build a highly automated production line in its Wisconsin factory. This facility when completed is likely to facilitate the move of some iPhone assembly to North America
- We also believe Hon Hai will upgrade its production sites to take advantage of automation globally. This increasing automation will likely include locations in Brazil, Taiwan, India, Czech Republic and US.

Automation: Smart and connected robots; the end of labor arbitrage

- With higher modularization of components, the level of automated production increases more effectively and in a cost-effective manner
- With aging demographic and rising wages in China, the country with the world's largest labor force, it can no longer sustain its productivity gains as it has in the past. This will in itself require a rethink of supply chains.
- However, we highlight that it is difficult to find another country with the combination of labor productivity, infrastructure sufficiency and supportive government policies as China. A China-plus strategy will have to account the cost and disruption of relocation. Automation of supply chains is a potentially effective way to offset most if not all the concerns.
- Apple has been at the forefront of innovation – and this includes automating and streamlining its supply chain. Based on our observation we highlight:
 - Hon Hai indicated its employee numbers dropped from 1.3 mn to 1mn in 2019 due to increasing automation.

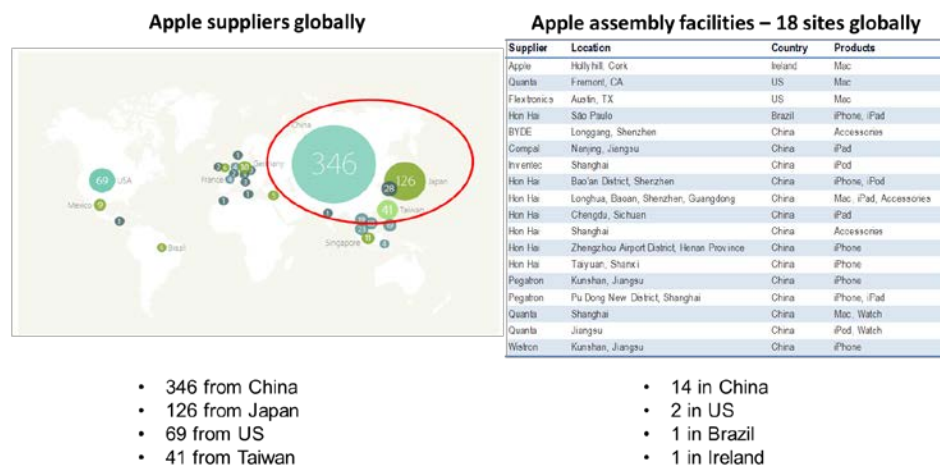
Figure 37: Modularization, Automation, and Re-location



Source: BofA Global Research

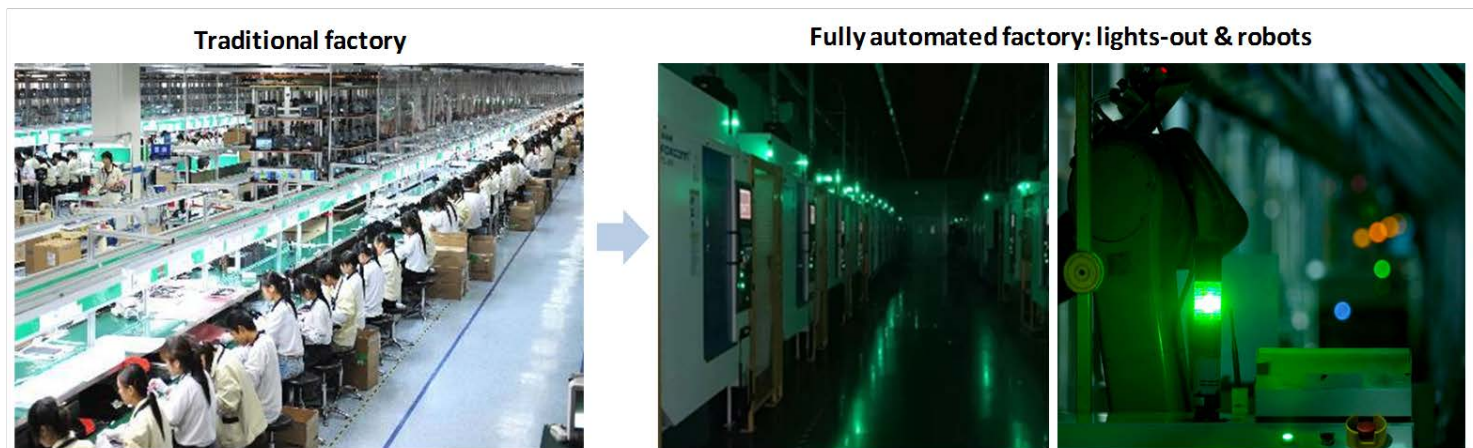
Figure 38: iPhone Tear Apart Analysis

Source: BofA Global Research

Figure 39: Apple suppliers globally: Assembly Concentrated in China

Source: Apple



Figure 40: Automation Efficiency: Accelerating Productivity Increases**Light out factory by Foxconn Industrial Internet (FII)****Increasing sales per employee: Hon Hai**

Source: Company & BofA Global Research

Increasing sales per employee: Zhen Ding Tech

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