

Q&A with Richard A. D'Aveni author of *The Pan-Industrial Revolution*

What are the implications of 3D printing for our future, and why have these been underestimated?

3D printing, or more generally additive manufacturing, came out with a lot of hype several years ago, when the techniques were still slow, expensive, and limited to a few materials. Many people therefore dismissed it as a niche technology good mainly for trinkets and prototyping. But since then printer manufacturers have been working under the radar, and they've solved all three of these problems. We're now seeing a wave of companies announcing that they'll use additive for their mass-market products. But additive will do more than simply replace conventional (subtractive and formative) manufacturing equipment in factories. It will also change the structure of the industrial economy and how companies compete.

Why will 3D printing transform global competition in almost every industry?

3D printing offers unprecedented flexibility to manufacturers, and will enable multi-industry companies to gain operational synergies across their diverse operations. These "pan-industrial" firms will gain market share over focused companies and develop powerful platforms to manage supply and distribution chains. Industry boundaries will fade away and be replaced by pan-industrial marketplaces conducted by these far-reaching platforms. All of this will change the balance of power among companies worldwide, and many firms will realize they can't stay independent – they have to join a platform.

What are "pan-industrials" and how will they dominate the global economy?

Unlike conglomerates, pan-industrials are highly integrated with intertwined operations, using 3D printing to operate factories that make parts for multiple industries. With the printers they can switch from one kind of product to another with minimal time and cost, unlike conventional manufacturing where changeovers can take weeks. Pan-industrials will also operate much more broadly than companies with related diversification. And they will handle all these diverse products because they have sophisticated digital platforms to coordinate and optimize operations.

Imagine something like "Universal Metal" that makes cars, appliances, heavy equipment, and other metal products. Over time, its suppliers, distributors and other companies in the broad ecosystem will likely join UM's digital platform, attracted by its efficiencies and optimization. UM will gain network effects over time, just as Apple and Facebook have gained network effects from their media platforms, which in turn makes its platform more powerful and attractive.

Which companies are positioned to become pan-industrials?

General Electric may be the closest, because it has invested heavily in additive and already operates in multiple industries. But we'll see how it emerges from its current cash crisis. Its archrival, **Siemens**, has also taken several steps in the right direction. Jabil, the big contract electronics manufacturer, has the most advanced software platform for

managing diverse operations, and it has been buying a lot of 3D printers lately. The **Sumitomo Corporation**, a Japanese conglomerate, has also been investing in additive.

What kind of political power will these new pan-industrials wield?

Pan-industrials will gain influence simply because of their size and breadth of involvement in the economy. They will resemble the Zaibatsu business groups that dominated pre-World War II Japan. But additive gives them a second power boost, because its factories don't need enormous volume to be economical. Companies will move from a few giant, focused plants supplying the world, to a great many smaller, multi-industry factories located near customers. That will give pan-industrials a much broader geographical presence than they have now. Think about how powerful car dealerships are, because they have a strong presence in every city and state. The biggest pan-industrials could even start to dictate foreign policy for countries, as the giant conglomerate ITT was supposed to have done in the 1960s.

What are some of additive manufacturing innovations you are most excited about?

"Big Area Additive Manufacturing" is making it possible to rapidly build large products. The U.S. military is working on setting up facilities to quickly generate a small fleet of fighter jets or ships close to emerging threats. Honeycombing and other intricate additive structures are making high-performance parts much lighter, which will greatly reduce our use of fossil fuels in transportation. In healthcare, we're developing everything from artificial bones to precise drug delivery systems using 3D printed nanobots. And new techniques to embed electronic directly onto plastic parts will likely make consumer electronics much more affordable and multi-functional.

Why should investors pay attention to additive manufacturing and the race among companies to become the first pan-industrials?

Pan-industrials will resemble the software giants that have gained dominant positions in the information and media world. The first companies to build a pan-industrial platform will likely attract other companies eager to enjoy the powerful optimization capabilities of these platforms. These network effects will give early pan-industrials a sustainable competitive advantage.

How can entrepreneurs leverage the potential of additive manufacturing?

Once pan-industrials are firmly in place, it's going to be hard for entrepreneurs to compete head-on with them. On the bright side, the marketplaces created by pan-industrial platforms will make it easier for startups to develop and gain scale. Over time, entrepreneurs can serve as R&D engines for pan-industrials, much as Google and Facebook rely on startups for some of their innovation. Maybe they can develop a breakthrough process like "4D printing," where the product changes its shape over time in response to water, temperature, or sunlight. Or additive "self-assembly," where products emerge from reactions at the molecular level.

Can manufacturing with 3D technology speed up the pace of growth in developing countries?

Yes, but it's complicated. On the one hand, poor countries won't be able to get a boost from operating as a low-wage manufacturing center for rich countries, because the latter will use additive to produce more at home. So poor countries will have to focus on their domestic markets, which are small. On the other hand, with additive they'll have a much broader array of manufacturing techniques to serve that market than they do now, so different from their current narrow set of export industries such as textiles and electronics. And they'll get lots of assistance from pan-industrials eager to set up shop in their markets. So they'll likely be better off in the long run.

Can trade wars be prevented when companies have the ability to print almost anything anywhere their customers want?

Yes. Because additive doesn't depend on huge economies of scale, production will gradually shift closer to the customer, with small factories that focus on nearby markets rather than export globally. In the absence of large economies of scale, localized production will save inventory carrying costs, shipping costs, insurance costs, supply chain management costs, business interruption costs, and a host of other distance-related costs and risks. So global trade in manufactured goods will decline, and trade disputes won't matter as much as they do now. 3D printing will make countries more self-sufficient.

Is 3D printing good for the environment?

Yes, in all sorts of ways, especially transportation. From lighter weight trains, planes and cars, to localized production with shorter supply and distribution chains, we'll burn a lot less fossil fuel. Additive products will be more customized and higher performance, so manufacturers will have less unsold inventory at year-end, and we'll have less of a throwaway culture. Finally, new products will be printed using bio-degradable and recycled materials, such as cellulose and Chitosan, which lobsters use to make their shells.

How will 3D printing technologies affect the job market? Will this lead to technological unemployment?

Yes: additive will further automate most factory production, so we're likely to get technological unemployment. But geography matters. China and other big Asian producers are going to be hit hardest, as they have a lot of labor-intensive manufacturing that 3D printing will either eliminate or move back to Western countries. This movement in turn will create a small number of high skilled, high paid jobs in the West, perhaps enough to make up for factory jobs in the West that will be automated away. Asian countries will have to make up for some of their lost jobs by creating new product and service offerings for their domestic consumers.

What is the first step businesses can take to incorporate 3D printing in their business strategy?

Additive isn't just about swapping out traditional factory equipment for 3D printers, or making some of your parts in a new way. Companies need to change their mindset and priorities if they're going to compete in the pan-industrial economy. The long term goal is to not to replace elements of the assembly and supply chains, but to eliminate them

altogether by making products in single print jobs without parts. Still, to be practical, it's best to start with small steps, adopting additive for prototyping and small batches, so engineers and workers can get used to the technology; and then move to higher volumes and redesigned products. This incremental approach will reduce the resistance that has bedeviled other technological transitions, such as the shift from analog to digital phones.

When pan-industrials dominate, what will our future look like to businesses, governments and consumers?

Pan-industrials will lead the way in realizing the many benefits of additive manufacturing. They'll make the economy run more efficiently and with greater customer satisfaction. They will generate products that never imagined or possible before. With their broad digital platforms, they collect new information about suppliers, distributors, and customers. Companies that try to stay independent of the pan-industrials and their networks may be shut out of the most profitable marketplaces.

Consequently the very nature of free markets will change, with less reliance on "free" and more on "computer controlled or ecosystem-based" markets. A new form of capitalism is emerging. Wall Street will look very different with fewer independent companies.

At the same time, the concentrated power of pan-industrials could threaten democratic governments. Pan-industrials can support or undermine governments or by allocating investments into the districts of favored leaders. They can make one country rich and another one poor, destabilizing some, while shifting the regional balance of power to others. Democracies will need new ways of ensuring that the people's voice is heard.

The good news is that physical objects are different from software bits. Unlike the "winner-take-all" markets in the information economy, pan-industrials may well end up competing against each other. GM will not want to share information with Ford, so they would never join the same pan-industrial.

How well is the United States positioned to thrive in this pan-industrial world?

The U.S. is a world leader in additive technology, and will benefit from greater self-sufficiency and a more productive economy generally – in sharp contrast to China, which will struggle to deal with the loss of manufacturing exports and jobs. With China contained, America will regain its earlier spheres of influence, and its democratic ideals will gain renewed prestige. The future still includes plenty of challenges, but the stability and affluence provided by additive manufacturing will give the country resilience.