

# Some Thoughts on the Economic Impacts of Assembler-Era Nanotechnology

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## **Introduction**

Imagine a world where objects can be built without human intervention. In this future world, very small machines called “assemblers” can position in precise ways nanoscale constructs (individual atoms, molecules, or sub-assemblies of the same) that could theoretically be made from any raw material (e.g., carbon, silicon)<sup>1</sup>, and could be based on blueprints that are patentable, and transportable through high speed networks like the Internet. This world may seem like something from the realm of science fiction, and may be an example of what I call “nano-hype”<sup>2</sup>, but it is steadily becoming a reality due to advances in nanoscience. What possible economic impacts can we expect from such a fundamental shift in the functioning of the global economy once assembler technology becomes a reality?

## **The Assembler Stage**

For many in the investment community, nanotechnology is a lightning rod for both criticism and promise. Having been stung by the rapid growth and collapse of the so-called “dot.com” sector, and now by problems facing the agricultural biotechnology sector, investors have become wary of claims that sound like nano-hype, or worse still science fiction. A significant obstacle faced by scientists, which reverberates throughout the investment community, is the scaling up of nanoscale processes and products to the macroscale level. Although existing nanoscale products like powders, coatings and crystals are lucrative (and stimulate a race for

new patents), the true breakthrough will occur when nanoscientists can encourage directed self-assembly at the nanoscale, and when so-called universal assemblers are developed.

Directed self-assembly may involve developing processes where molecules mimic biology (known as biomimetics) by constructing nanostructures based on properties like the folding of proteins, by manipulating nucleic acid sequences and using cellular fuels like ATP to power hybrid organic-inorganic motors, pumps, and actuators.<sup>3</sup> By contrast, the search for a universal assembler involves developing a mechanism for positioning atoms and molecules in pre-defined ways using non-biological processes. Texas-based corporation Zyvex has developed a crude prototype of a nano assembler that picks up and places atoms using a modified atomic force microscope.<sup>4</sup> For Eric Drexler, a universal assembler could be a positioning device with different tools and tips that place, mill, add reactants and allow for the assembly of nanoscale components into larger structures (somewhat like assembling Ikea furniture!).<sup>5</sup> Following the laws of nature, the universal assembler should be able to build almost any object (including other assemblers). If, and when, this breakthrough in universal assembler technology occurs, nanotechnology will usher in a new kind of industrial revolution where existing manufacturing processes will be replaced, the concept of human labour reconsidered and the current basis of the economy and global trade transformed. Could these changes usher in a new form of mercantilism?



## What is Mercantilism?

Mercantilism was a form of economic nationalism that was concerned primarily with questions of competition and the role that governments could play in protecting local merchants, generating employment opportunities in manufacturing, and promoting a more secure state. Tariffs and other protectionist policies were used to create a positive balance of trade (a surplus), facilitated the accumulation of precious metals (especially bullion) and supported the expansion of military power and shipping. Mercantilist policies helped forge new alliances between the state and the growing merchant classes. In Europe, the mercantile system protected and encouraged the growth of merchants like the British East India Company, and was ultimately a driver of colonialism.

The origins of mercantilism, as a system of economic and political practice, is shadowy and a subject of debate. It is assumed generally that mercantilism began in Rome, so that profits from the expansion of the empire could be maximized by creating a system for trading goods that helped build a wealthy and powerful state.<sup>6</sup> By the eighth century,

mercantilism played a minor role in Europe since many European countries tended to localize both economically and culturally.<sup>7</sup> However, mercantilism flourished in Arabic cultures and spread rapidly through North Africa, Spain and Asia. In the fourteenth century, European interest in mercantilism was re-ignited, and a system of trade was established that would eventually evolve into what we now call capitalism.

Most contemporary writers on mercantilism focus their attention on Europe during the sixteenth through eighteenth centuries. This period in history is punctuated by bloody religious wars that required large standing armies and additional resources to support a newly emerging form of civil government. To pay for these wars and other politically motivated reforms, roads and canals were built, guilds were systematically weakened, and venture capitalists were rewarded by the state. By stimulating commerce and extra-territorial trade, the state was able to increase taxes, support manufacturing by importing raw materials at low cost while exporting finished goods at a premium, and to add bullion to the monarch's treasury.

**Table 1. Elements of mercantilism**

Economic self-sufficiency	A political economy dominated by empiricism, questions of competition and protection by the state. Economic activities should be subordinated to state interests. Frequent state intervention in the economy.
Favourable balance of trade and protection against foreign competition	More exports than imports. High tariffs on imported manufactured items and low tariffs on imported raw material. A trade surplus was desirable. Assumed that economic relations were “zero sum” (my win is your loss!)
Bullionism	Belief that the economic health of a nation could be measured by stocks of precious metals like gold.
Colonialism and captive markets	Colonies were ideal places to sell manufactured goods and to secure raw material.
Shipping	Shipping and military infrastructure were key.
Social agenda	Supported a greater role for government and social welfare initiatives. This was used to achieve economic unity and political control (often in the interest of merchants and producers).



Although no definition of mercantilism is entirely satisfactory, it is important to emphasize that mercantilist thinking was heavily influenced by a desire to achieve economic unity and political control, and that it usually contained a blend of the following elements (see Table 1).

It is widely recognized that the end of the mercantile period coincided with debates stimulated by scholars like Adam Smith. Smith's *The Wealth of Nations* helped put an end to mercantilism by demonstrating its incompatibility with economic liberalism, by questioning the role of the state in directing rather than simply setting the national economic agenda, and by pointing out that specialization in production allowed for more efficient economies of scale.<sup>8</sup> The mercantilist doctrine also supported monopolies and strong protectionist measures that were becoming increasingly a hindrance to trade.<sup>9</sup> Mercantilism was eventually replaced with capitalism in many parts of the world. Although mercantile thinking, especially when it comes to protectionism has been revived periodically in what is called neo-mercantilism, capitalism with its emphasis on accumulating the means of production (e.g., materials, labour and land) instead of bullion, on efficiency and the division of labour, with its teleological (forward directed) stance and its focus on the individual and the Enlightenment ideal of progress, still dominates. However, can this change once advances in nanotechnology make possible the use of universal assemblers?

### ***How can Nanotechnology Stimulate a New Era of Mercantilism?***

A return to mercantilist policies by states that have access to assembler technology is likely to develop slowly. In the first phase of this transition, devices that can perform molecular self-assembly in a directed fashion will have minimal impacts on the foundations of capitalism, as they are currently understood. Devices that mimic biological processes and help us bridge the so-called dry-wet interface (mechanical-biological) will probably magnify existing practices of specialization of labour, deepen international trade and the rush to harmonize intellectual property rights and create

new convergences within the life science and computer industries. In other words, this would be business-as-usual for capitalism in an era of economic globalization. However, the development of universal assembler technology may foster what I call nano-mercantilism for the following reasons.

#### ***Reason #1***

Assembler-era nanotechnology vitiates the relevance of organized matter. In theory, universal assemblers decouple manufacturing from traditional raw material markets. As the current global processed food market demonstrates, the interchangeability of inputs, and flexibility of formulation, have improved efficiency and profitability for the food industry. In a nano-based economy, universal assemblers can use almost any atomic or molecular building block to create manufactured goods. Instead of relying upon the importation of steel for manufacturing automobiles, countries like Japan could use assembler technology to “grow” automobiles from

other materials that may be lower in cost or that are available from domestic sources. An economy based on these principles will require a large number of individuals trained in software development and testing, advanced information and communication infrastructures for processing, storing and transporting blueprints, and an environment for intellectual property rights where patents are granted for reverse engineering a wide range of products. Although whimsical, I can imagine museums, like New York's Metropolitan Museum, becoming the malls of the future. One day, consumers interested in purchasing works of art may be able to custom order a nano-fabrication of a scanned artifact.

#### ***Reason #2***

Assemblers distort international trade by capitalizing on differential levels of access to nanotechnology. Like with mercantilism, trade between nano “have” and nano “have-not” countries will involve the shipment of low-priced raw commodities from the supplying country and higher-priced shipments of nano-manufactured products back. The impacts on labour, and on the global distribution of wealth, are areas sorely in need of study. This kind of trade relationship echoes the colonial arrangement of the mercantilist period, and

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may fuel louder calls for measures to ensure economic self-sufficiency. As well, heightened concerns about national security in countries like the United States, and the staggering potential of nanotechnology in a range of military applications, means that the exchange of knowledge about how to construct a universal assembler will be a closely guarded secret.

### Reason #3

Assembler era nanotechnology will create a new kind of bullionism. A central doctrine of mercantilism was that bullion could be stockpiled by creating the necessary economic and social conditions for promoting a positive balance of trade. This zero sum logic was based on a belief that resources were finite. A nano-based economy is filled with several internal contradictions when it comes to this issue. On one level, the use of universal assemblers means that scarcity of raw materials becomes an obsolete concept. Two of the most common elements on Earth, carbon and silicon, can probably be used to manufacture many objects. On another level, access to universal assembler technology and to the blueprints used for coordinating the construction of objects, is likely to be restricted. In the assembler era of nanotechnology, the new bullion will be the assemblers themselves and the intellectual property for objects that these devices can build. In this instance, mechanisms for ensuring a positive balance of trade (e.g. protectionist measures like tariffs), coupled with differential levels of access to this technology, may help stimulate a new era of mercantilism.

### Conclusion

This paper, although highly speculative, is cautionary in tone. Since nanotechnology has the potential to transform so many facets of our existence, it is essential to consider both the benefits and risks of this suite of technologies. The traditional ways of examining both risks and benefits has been to treat technologies in an application-specific fashion, and to focus attention on environmental and human health risks and on economic benefits. Rarely are there opportunities to explore other kinds of risks like the potential threats posed by new technologies to entire economies, like the threat of nano-mercantilism.

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