Corporate Cornucopia: Examining the Special Implications of Commercial MNT Development

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The development of molecular nanotechnology (MNT) promises to lead rapidly to cheap superior replacements for a large majority of durable goods, a substantial fraction of all non-durable goods, *all* existing utilities, and some services. For this reason and due to the relatively low expected cost of developing nanofactories,[1] MNT represents the largest commercial opportunity of all time. Unfortunately, the very size of the opportunity—combined with its extreme suddenness, military significance, potential for disruption of existing institutions, and ease of duplication—creates certain severe complications that lead to difficulties in capturing the value created.

MNT also has the potential to impact the timeframes and severities of a number of major global risks such as those of terrorism, emergent disease, global warming, omnicidal war, and human extinction due to competition by either intelligent or unintelligent robotic competitors, for which reason there are important non-commercial motivations for preventing its unrestricted utilization. As a result of these difficulties, and of the intrinsic uncertainty associated with any particular attempt to develop MNT, commercial development of MNT is likely to be much less rapid than would be predicted from a simple consideration of the value to be created, relevant time horizon, and risk-adjusted discount rate.

Despite this, it remains highly probable that MNT will first be realized by a commercial project for the simple reason that probabilistic priors so strongly favor commercial development of new technologies. A slew of militarily relevant technologies were developed by the US, German, and Russian governments during the Second World War and in its aftermath, but that was at a time when the commercial and public sectors were far more fully integrated than they are today and when the external pressures forcing governmental efficacy were greater. By contrast, over the last few decades, virtually every significant technological development has been commercial in origin (or even recreational, e.g. the Open Source movement and SpaceShip One) rather than public. Governmental R&D initiatives, such as those aimed at curing cancer and AIDS and at developing space travel and fusion power have tended to fail totally or almost totally during the past 30 years.

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1 "Molecular Manufacturing: What, Why and How" by Chris Phoenix (http://wise-nano.org/w/Doing_MM).

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Given that an important subset of possible scenarios are driven by commercial development, it seems prudent to examine in some detail the major features of most commercial scenarios and to identify the ways in which developers may experience unique difficulties distinct from those associated with the development of other products and the ways in which they may manage those difficulties. This paper will attempt to do that, examining the probable implications of both relatively open and relatively secretive development programs in the event of successful development of MNT. It will be assumed that the developers are highly rational and informed, and that they are attempting to maximize profit in the relatively short term while avoiding the most serious risks of MNT. Development will be assumed to occur within the next 20 years, over the backdrop of a world politically and technologically fairly similar to our own, and with a historically typical gap of a few years between the initial development of the technology and its successful imitation or implementation by competing projects. It also will be assumed that the more powerful MNT applications, such as those in intelligence amplification, neuroscience, extremely powerful distributed robotic systems, and artificial intelligence (AI) will take some time to emerge even given nanofactories and massive funding.

Part 1. Competitive strategy

a) Pricing

The simplest and most traditional of the problems facing MNT developers is competitive pricing. Setting the prices of MNT goods close to the cost of production provides little profit with which to expand or compensate for risk undertaken, while setting prices too high threatens both to unnecessarily reduce consumption below the optimal level and to draw both legal and illegal competitors into the field. In addition, given the number of industries in which MNT products are likely to compete and the political clout of many of those industries, either high or low prices could motivate antitrust concerns. Theoretically, a higher price is indicative of a monopoly while a lower price indicates competition, but a lower price will also lead to more successful and rapid competition with existing companies and to greater market share, and this could be seen as evidence of monopoly status or of anticompetitive tactics.

Motivating competitors to develop MNT is probably the most serious risk associated with high pricing. In order to minimize this risk it will be necessary for prices to be relatively low, and also for expenses to appear as great as possible. It will be particularly desirable (from the commercial developer's point of view) that the *apparent* cost of developing MNT be as great as possible, as this is the expense that can most easily be inflated. One way in which this can be done is to publicly spend as much money as possible on research ostensibly aimed at developing nanofactories over a fairly long period of time *after* nanofactories actually have been developed. Money can soundly be borrowed in order to fund this research, even at high interest rates, due to the certainty of eventual success. Meanwhile, profits can be generated via the sale of supposedly incremental results of the nanofactory research such as gem quality or better diamonds, doped silicon computers modestly more powerful than those otherwise available at a given price, and inexpensive carbon nanotubes.

Once the nanofactories are publicly acknowledged to exist, the apparent "low hanging fruit" associated with the supposed development trajectory will be depleted, and a substantial fraction of the global pool of technical experts plausibly capable of relevant work will have already been recruited, discouraging imitation. In addition, the creditors will constitute a class of stakeholders in the new technology who are nonetheless integrated into the existing economic system. Loan repayment will contribute to the justification of profit to the public and to the government. In general, the public appears to accept the legitimacy of high profit margins most readily when the product in question is an extremely expensive luxury, an extremely inexpensive everyday item, or a new product with an explicit need to amortize development costs. It is important to point out that it is excessive profit *margins*, not excessive profits, that usually are considered objectionable. For this reason, actual profits will be greater if expenses can be increased, because the dollar value of a 200% markup is larger on a product costing $100 to produce than on one costing $10. Wasteful expenditures on supposed inputs also can create stakeholders.

Like software, restricted versions of MNT products can easily be designed and can be sold for lower prices than unrestricted versions. For instance, less expensive copies of a given product can be sold to less wealthy countries, or even less wealthy regions within a country. This might be accomplished without competing with the products sold to wealthier regions by installing GPS or inertial locators to monitor product location and disable them from functioning outside of their licensed area. In this manner, profitability can be maximized by selling to all potential customers for prices that constitute a reasonable fraction of their willingness to pay. With built-in biometric sensors, some MNT devices could even be assigned prices based on the personal characteristics of their purchaser. In addition to maximizing profit, this sort of strategy should greatly reduce any humanitarian concerns regarding the distribution of MNT products. The public generally accepts the existence of restricted software without resentment. Nanostructured physical objects can be made more difficult to hack than either software or contemporary hardware, so the restrictions on use built into MNT products can be more robust than those built into today's printers or software.

b) IP protection

The most likely outcome of patenting nanofactories in any given country would be widespread patent violation both by other countries and by many criminal organizations. This would probably be followed by the slew of problems[2] that long have been predicted to accompany uncontrolled MNT development, such as unstable arms races, malicious grey goo, and massively oppressive MNT-empowered governments. In addition, pirate nanofactories would be used to build nanofactories of unpatented design, which then would be patented.

All this does not mean that IP law cannot contribute some value to an MNT "first mover." A large number of patents of variable scope can be produced to restrict the products that a competing MNT developer can produce legally. Patents on key components can obstruct possible commercial efforts to develop competing nanofactories without revealing too much about the workings of existing nanofactories. In a field as large and as unexplored as nanotechnology, there surely will be room for a number of extremely broad patents that can be used to slow down competitors. In such a fast moving field, even a patent that delays competition by a few months before being overturned could be extremely valuable. Potential patents might include mechanochemistry, carbon mechanochemistry, self-replicating machines,

[2] See "Dangers of Molecular Manufacturing" (http://www.crnano.org/dangers.htm).

self-replicating programmable productive systems, diamondoid nanoscale machines, and more, but should be chosen to avoid revealing too much about how a nanofactory can be built.

Governments may attempt to force developers to share MNT production capabilities or may simply steal such capabilities. When high-level officials finally begin to distinguish between reality and science fantasy and to recognize the technology's potential, they rightly will see MNT as a national security issue. However, preventing simple theft is relatively easy. Nanofactories can be made large enough that they can't be stolen covertly and/or lost. They can also be networked wirelessly or otherwise equipped for easy inventory. It would add little complexity to equip all nanofactories with oxidative self-destruction systems. The best way to resist forceful interrogation is probably to not have any individuals within the company who know everything or almost everything that is needed in order to build a new nanofactory, and to hold out the threat of not doing business with countries that violate the company's rights. Directly threatening a country like the United States in this manner would be unwise. Rather than doing that, an indirect threat could be delivered by setting up production facilities in some high political risk countries with little respect for private property. If this is done, it is likely that one of these countries will attempt to steal MNT production capabilities prior to any developed country doing so. If the company responds by destroying all stolen assets, not sharing information, and refusing to trade with that country, this will deter other nations from repeating their mistake, at least in the short term. The desire not to imitate the behavior of disreputable states will be another incentive for countries to respect the rights of the developing company.

Throughout the early commercialization of MNT, the continual borrowing of as much money as possible will be a major imperative. This is true for several reasons. The first of these is that it is important to retain control of the company and associated technology in order to implement a relatively long-term plan rather than one that might maximize shareholder profits in the very short term, for which reason stock should not be sold to raise capital. The second is that over the first decade or so, the scale of operation associated with the developing company will be continually increasing at such a rate as to make even ludicrous debts from a few years back trivial. The third reason is to acquire the previously mentioned sets of justificatory expenses and of influential stake-holding creditors. A fourth reason will become relevant later in development, once the potential of MNT is well established and the broader public and public intellectuals become hostile. Hostility is a nearly certain early result of any massive technological disruption regardless of the quality of life improvements it makes available (aging reversal technologies may turn out to be an exception to this generalization, since their psychological impact will be unprecedented in scope and is not easily predicted, but thus far even aging reversal seems to fit this generalization). As hostility develops in response to massive technological impact, it may be both possible and desirable to slow governmental activity by reducing governmental access to funds. This might be accomplished by competing with the government to drive up the price of debt and by releasing products which make an attractive lifestyle achievable on the interest payments from a moderate amount of high yield debt, reducing the size of the work-force and thus increasing the cost of running a large bureaucracy. Such actions should be undertaken gradually so that they are not interpreted as an attack on borrowers and bureaucracies, as that would lead to escalation. By raising both the interest rate and the wages of skilled labor, potential competitors can be further prevented from developing MNT independently.

c) Dealing with opposition

Due to the potential for economic and social disruption, some countries may refuse to allow the import of MNT-derived products. This is not a serious problem for an MNT producer. A general boycott by all major nations is extremely unlikely, especially considering the magnitude of the benefits that MNT will make available. Tariffs would take some time to put into effect and whatever nation stood to improve its trade balance via MNT exports would petition the WTO for tariff elimination. In addition, MNT can be used to produce traditional capital for the production of non-MNT products.

One of the earliest products released by an MNT developer is likely to be inexpensive hydrocarbons for fuel and other applications. These can be made by harvesting solar energy over the oceans, using it to hydrolyze water, and using the hydrogen to reduce atmospheric or other (limestone?) CO_2. The machinery for all of this can be produced quickly in any quantity with MNT. Floating solar platforms can be made with either hydrocarbon production or MNT manufacturing capabilities. The manufacturing centers should be designed to utilize the hydrocarbons as feedstock and solar energy as a power source in order to rapidly produce more platforms of both types. Design and control for such platforms should be non-problematic, and their products could be sold on the global petrochemicals and natural gas market. In this case, there would be no practical difference between a country that chooses to purchase oil from traditional sources and one that purchases MNT-derived oil, as both would apply demand to the same pool of global production and impacting the same global price, making boycotts ineffective unless they were extremely broad. Hydrocarbon storage facilities probably will have to conform to all normal laws regarding the storage and transport of hydrocarbons, complicating implementation somewhat. However, simply violating regulations and hiring legal teams to delay the imposition of fines until they are no longer relevant may be an acceptable strategy for faster implementation if the regulatory framework would otherwise slow development overly much.

While MNT will accelerate the development of new products, it will reduce the time required to build new capital even more. As a result, production capabilities sufficient to satisfy global petrochemical demand should take much less time to develop than designs capable of competing in a wide variety of industries. The revenue generated via the initial products will be an important part of what enables the rapid development of newer products.

The revenue from this early activity will be more than sufficient to hire as many researchers and administrators as can be productively utilized to develop new MNT designs. Integrating so many new employees without critical security risks will be a difficult problem, but it should be a manageable one as there are already many companies that face similar difficulties. At this point, the MNT developers also should have enough money to purchase both public opinion and political influence in so far as these goods can be rapidly purchased.

In order to minimize opposition it will be critically important for the developers not to be seen as a non-competitive monolith. This will be particularly difficult if MNT development is overt as opposed to remaining a secret, but it is probably possible under either secret or public development. The company may be best able to avoid conveying the impression of monopoly if it carefully and legally shares its technology with a few select partners who thoroughly appreciate the dangers associated with MNT (especially the critical dangers of uncontrolled AI and unstable arms races), the need to avoid them, and the consequent need to avoid further disseminating the basic technology. If these partners compete in the production and sale of relatively safe MNT products, it is possible that the market generally will be seen as saturated and further entrants will be discouraged. This decision would constitute a non-secretive alternative to the earlier prospect of inflating the apparent cost and difficulty of MNT development, although both strategies could be pursued sequentially. In the case of such a strategy, as in contemporary oligopoly arrangements, branding will become an extremely important part of profit maximization. A more trusted brand probably would be able to charge a substantial premium, especially for nanomedical products and services once those are developed.

d) First mover advantages

A large fraction of the profitability associated with nanomedicine, and to a lesser degree that associated with any new MNT product, is likely to occur during the period of initial release. This is true because MNT products often will solve problems cleanly and completely, leaving no significant vestigial market. For instance, one of the first novel nanomedical devices produced using MNT is likely to be a powder of biocompatible glucose oxygen fuel cells with internal temperature sensors to avoid excess waste heat and a binding site for later removal from the bloodstream. The purpose of this device would be simply to burn fuel, producing waste heat. From the public's perspective it will be a rapid weight loss infusion capable of safely producing one to two pounds of weight loss per day (or several times that in extremely cold weather or while the body is immersed in cool water). Once this system is safely developed and successfully marketed, the market effectively will be gone. People may continue to become overweight, but the world's accumulated pool of overweight people willing to use nanomedicine will be expended. Those overweight people who are reluctant to use new medical technologies will surely still prefer, when they eventually decide to use one, to use the established brand even if it costs somewhat more than its competition, as its safety will have been more thoroughly established. Furthermore, later nanomedical devices will incorporate the weight loss function as a mere side effect of their other capabilities, making this design obsolete. In other fields, the advantages from safety, branding, superior R&D, and expansion into a technological frontier will not favor the first mover as completely, but it is a basic economic result that, all else being equal, oligopoly quantity competition leaves first movers with dominant market share even in the long run.[3]

[3] In price competition, producers compete to sell for the lowest possible price. They choose what price they will sell at and then sell as many as the public demands at that price. In practice, this requires that the company be able to match supply precisely to demand. Economically this is equivalent to perfect competition and eliminates all profit. In quantity competition, producers sell undifferentiated products to wholesalers, setting the quantity sold to maximize profits. As the number of competitors increases this becomes more like perfect competition because each producer has increasingly little incentive to restrict quantity in order to maintain demand. By committing to a particular level of production in advance, earlier entrants can establish equilibria where they sell larger volumes than later entrants. With a linear demand curve, each entrant will sell half the volume of its predecessor. In monopolistic competition, companies sell similar but branded goods and use marketing and reputation to maintain a willingness to pay a premium over the market price for branded products. Branded goods are imperfect substitutes with high cross elasticities of demand, so as the price of one brand increases, consumers gradually switch over to its competition.

Given the above result, are competing MNT producers likely to engage in the alternation of *de facto* collusion and quantity or monopolistic competition typical of contemporary oligopolies? The simple answer is yes, at least in the short term, as this behavior maximizes short run profits for all competitors under the constraints imposed by antitrust law and prisoner's dilemmas. However, MNT will be associated with novel productive powers that may call the default assumption into doubt. For instance, the traditional MNT vision of home manufacturing, the software metaphor of unlimited manufacturing capacity matching production precisely to demand, and even the growing paradigm of online agent-based purchasing all suggest price competition as a plausible alternative. Still, there seem to be few large examples of actual price competition in the world of retail, even where they would be most expected, such as in the sale of bottled water, public domain IP, internet retailing, and the like. Even freelance service work such as housekeeping, therapy, tutoring, and most other examples of work by the self-employed are far from perfectly competitive, with agencies matching consumers to producers and keeping large commissions and with many producers spending more time searching for clients than working, and demanding far more for an hour of work than the value of an hour of their time.

By reducing the scale of manufacture, in addition to improving the ability to match supply to demand, MNT and nanoblock[4] assembly seem likely to produce a world where retail is relatively more important and wholesale less. Wal-Mart or its successor still may sell MNT-built products, but if they do, they probably will sell them primarily through large factory/grocery stores rather than from giant wholesale stores, as the combination of a nanofactory with virtual reality environments for trying out products will greatly reduce the necessary floor space and inventory space. It is also reasonable to suggest that members of a much wealthier society will be less inclined to travel substantial distances in order to shop, and less likely to accept uninteresting work for under ten dollars an hour. Smaller stores that offer a better atmosphere and knowledgeable service thus will have both more customers and less difficulty finding employees. As a result, brands will be easily differentiated and price competition will be even less prevalent than it is today.

The sale of energy will provide the first MNT mover with yet another advantage over later competitors. If claims can be established to solar energy streams sufficient to satisfy global energy demand, and environmental laws can be passed to restrict the utilization of solar energy streams other than those initially tapped, competitors may have to pay a larger amount for solar energy inputs than first movers.

At this point, it is still far from clear whether the developers of MNT will or should choose to publicize their achievement. Their decision probably will be driven in part by the nature of the company that makes the final enabling innovations, and in part by the intensity of the technological competition. If MNT is developed in a world where it is still widely considered a retro-futurist fantasy, competition will be much less intense than in one where it is developed as the result of intense international competition. I personally expect a scenario reminiscent of that

[4] For an explanation of nanoblock manufacturing, see "Safe Utilization of Advanced Nanotechnology" by Chris Phoenix and Mike Treder (http://www.crnano.org/safe.htm). See also "Safer Molecular Manufacturing Through Nanoblocks" by Tom Craver (pp. 155 ff of this issue).

accompanying the birth pangs of the airplane, i.e. many competitors all over the world but no very large and competent concerted efforts aiming at a technology that was still taken by consensus to be impossible despite a technological infrastructure that was making its achievement noticeably less difficult every year. In such a scenario, a private company that wishes to utilize MNT productive capabilities will be able to do so rather overtly without creating widespread awareness of what is happening. Inexpensive solar panels are surely within the range of what they can publicly produce, but rapidly deployed macroscale floating solar oil factories are not. In a world where MNT is seen as completely discredited, or in one where ubiquitous but mundane "nanotechnology" had made Drexlerian predictions seem as quaint as those once made about nuclear energy or space travel, even the solar oil factories might not lead to widespread correct conclusions without an accurate explanation; conversely, if MNT was the 21st century's space race, there would be little point in secrecy and every reason to develop and market all important and possible applications as quickly as possible.

Unfortunately, it is hard to imagine a world where the replacement of traditional industry by molecular manufacturing is taken for granted by everyone even moderately future-oriented in the same way that today all such people see as inevitable the digital replacement of analogue film-making, Chinese dominance of durable goods manufacture, or the transition to HDTV. The economic and political havoc that would be expected to result from a widespread belief in truly radically near-future change is difficult to calculate, and might even be sufficient to make such a prophesy self-preventing. For this reason among others, it is fair to say that even weeks after the development of MNT is announced, the majority of investors still will not know about it. Even those who do will probably understand it less well than today's typical science fiction author, and will thus not base any informed investment decisions on their knowledge of MNT. It is also easy to imagine a near-future world filled with constant inaccurate claims of MNT breakthroughs, such that accurate information would not trigger immediate market adjustments upon its release.

Part 2. MNT risk management

a) Economic disruption

Much has been made of the large number of jobs that might be eliminated with the advent of molecular manufacturing. If all or nearly all jobs were to rapidly become unnecessary, the resulting economic disruption would not necessarily cause major hardship, as some have feared. However, most work is not associated with the production of objects that can easily be replaced by MNT. Instead, early MNT products will almost eliminate certain sectors, such as manufacturing; will greatly reduce the need for workers in some others, such as mining, utilities, construction, and transportation/warehousing of goods; will have little direct impact on the demand for work in some fields, such as educational services, management, and food services; and will greatly increase the demand for a few professions, especially information technology and possibly scientific and technical services. Theoretically, capital can be substituted for most varieties of labor, and MNT also will greatly expand the ease of creation of capital while devaluing existing capital, but it will take time for new capital to replace most workers. For instance, in the short term, trash-collecting robots are unlikely, but in the long term, home recycling and incineration units are likely.

I estimate that MNT will make 10%–20% of all current US jobs obsolete within a year of development, 20%–40% within two years, and in the absence of strong AI will make 60%–80% of current work unnecessary within a decade of development, as more powerful tools multiply the capabilities of service workers in fields like waste management and accommodation/food services. Many workers probably will be retained by their employers for months or years after their services are no longer necessary due either to contractual stipulations or simply to slow managerial reaction times. In addition, laws may be passed further restricting the elimination of jobs, but ultimately obsolete industries will disappear even with government life support and will eliminate jobs by closing if they can't do so with layoffs.

At the same time that many jobs disappear, so will many workers. Great uncertainty, high discount rates, high interest rates, and novel low cost lifestyle options will provide many workers with strong incentives to leave their jobs and either retire or try to found businesses more suited to the new economy. This will drive the expenses faced by many employers upwards, as noted earlier, but will do little to mitigate the problem of unemployment, as the workers who have the capital to invest and retire are by definition not those most threatened by the loss of their jobs and typically cannot be easily replaced by even larger numbers of inappropriately trained workers.

Most of the neediest workers will be covered by state unemployment insurance, which will have the added benefit of increasing non-discretionary governmental spending. Increases in the duration of unemployment payouts should be lobbied for, but even if these are successful, more will be needed. Further subsidies for the unemployed may be possible through investments in companies (such as MyRichUncle.com) that give loans in exchange for a fraction of the borrower's future earnings. However, several million people still will be in need of both money to live on and meaningful work that they are not able to find for themselves. Dealing with those people is not a core business function, but providing low-cost goods to any agencies that show competence in doing so (groups such as Habitat for Humanity, etc.) probably will be a very sound investment in good will.

By contrast, although it would be possible to support all of the displaced people or hire them for make-work, spending money directly to do so generally would be expected to aggravate the resentment that was supposed to be mitigated. One of the most important things to do when mitigating resentment is to work hard to fight the impression that people with MNT can do anything and that all remaining problems are therefore their fault. For PR purposes, it is probably best to downplay what the technology is capable of. This also will tend to reduce governmental fear, public paranoia, and pressure to share dangerous technologies with militaries that cannot be trusted with them.

b) Abuse of novel capabilities

The second major class of risk that must be avoided is that associated with intentional abuse. This includes everything from the production of self-replicating robots to rapid military build-ups to universal intrusive surveillance (even, possibly, surveillance of brain activity, hence of thoughts). The extreme number of potentially disastrous abuses that MNT lends itself to is a very strong argument for making every possible effort to either maintain secrecy regarding MNT techniques, or at least to limiting access to extremely trustworthy parties. Other essays in this collection discuss the consequences of failing to maintain secrecy, but for the purposes of this paper, it should suffice to assert that so long as MNT remains tightly controlled these risks should be manageable.

c) Dangerous consequences of excessive computing power

The final and most critical danger associated with MNT is that it will lead to the release of massive computing power and the acquisition of neurological knowledge that will make it easier to develop AI (artificial intelligence) than to control it, leading to a total loss of control and human extinction. It is obviously best to respond to this by being extremely judicious with respect to the distribution of devices for studying the brain and by limiting the available computing power available for a dollar to a level significantly greater than that being produced by competing companies but far less than what could be made available. It is best if the gap between available MNT computers and traditional computers is great enough to dominate the market and end incremental development of computing power, but small enough not to contribute substantially to reducing the cost of parallel projects aimed at developing MNT or AI. Despite such precautions, MNT development will accelerate AI development in many ways. The most significant of these may be the increased ability to spend time on long-term personal projects resulting from increased personal freedom.

The largest risks are likely to be of an internal origin, as some of the thousands of researchers in the company may attempt to evolve an AI on internal nanocomputers. An obvious way to alleviate this problem is to limit design and production to low-power computers, or to dedicated computers for running molecular simulations and designing products, or for other very specific purposes. In the long run, though, this is a stopgap measure. Some strategy must be developed for ensuring that mankind is not accidentally wiped out by an AI. The scope of this problem goes beyond that of this paper, but it is probably a good starting place to assert the desirability of doing whatever is possible to direct global R&D towards the development of technology for making people more intelligent and away from technology for making machines more intelligent.

Ultimately, it does appear that AI can be developed safely and that preventing unsafe AI permanently should be possible, but it also appears that the level of intelligence required to safely develop AI is approximately independent of the available level of computing power, while that required to unsafely develop AI decreases with computing power. For this reason, increasing intelligence and reducing available computing power both contribute to risk reduction. Anti-aging technology also may contribute, because it provides a *de facto* increase in the amount of thought that a person can ultimately apply to any given problem, although the development of anti-aging technology will be strongly commercially and PR driven in any event, and thus requires no further justification.

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