Chapter Five
The Small Workshop, Desktop Manufacturing, and Household Production

A. Neighborhood and Backyard Industry

A recurring theme among early writers on decentralized production and the informal and household economies is the community workshop, and its use in particular for repair and recycling. Even in the 1970s, when the price of the smallest machine tools was much higher in real terms, it was feasible by means of cooperative organization to spread the capital outlay cost over a large pool of users.

Kirkpatrick Sale speculated that neighborhood recycling and repair centers would put back into service the almost endless supply of defunct appliances currently sitting in closets or basements—as well as serving as "remanufacturing centers" for (say) diesel engines and refrigerators.[1]

Writing along similar lines, Colin Ward suggested “the pooling of equipment in a neighborhood group.”

> Suppose that each member of the group had a powerful and robust basic tool, while the group as a whole had, for example, a bench drill, lathes and a saw bench to relieve the members from the attempt to cope with work which required these machines with inadequate tools of their own, or wasting their resources on under-used individually-owned plant. This in turn demands some kind of building to house the machinery: the Community Workshop.
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> But is the Community Workshop idea nothing more than an aspect of the leisure industry, a compensation for the tedium of work?[2]

In other words, is it just a “hobby”? Ward argued, to the contrary, that it would bridge the growing gap between the worlds of work and leisure by making productive activity in one's free time a source of real use-value.

> Could [the unemployed] make a livelihood for themselves today in the community workshop? If the workshop is conceived merely as a social service for 'creative leisure' the answer is that it would probably be against the rules.... But if the workshop were conceived on more imaginative lines than any existing venture of this kind, its potentialities could become a source of livelihood in the truest sense. In several of the New Towns in Britain, for example, it has been found necessary and desirable to build groups of small workshops for individuals and small businesses engaged in such work as repairing electrical equipment or car bodies, woodworking and the manufacture of small components. The Community Workshop would be enhanced by its cluster of separate workplaces for 'gainful' work. Couldn't the workshop become the community factory, providing work or a place for work for anyone in the locality who wanted to work that way, not as an optional extra to the economy of the affluent society which rejects an increasing proportion of its members, but as one of the prerequisites of the worker-controlled economy of the future?
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> Keith Paton..., in a far-sighted pamphlet addressed to members of the Claimants' Union, urged them not to compete for meaningless jobs in the economy which has thrown them out as redundant, but to use their skills to serve their own community. (One of the characteristics of the affluent world is that it denies its poor the opportunity to feed, clothe, or house *themselves*, or to meet their own and their families' needs, except

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1 Kirkpatrick Sale, *Human Scale* (New York: Coward, McCann, & Geoghegan, 1980), p. 406.
2 Colin Ward, *Anarchy in Action* (London: Freedom Press, 1982), p. 94.

from grudgingly doled-out welfare payments). He explains that:

> *...[E]lectrical power and 'affluence' have brought a spread of intermediate machines, some of them very sophisticated, to ordinary working class communities. Even if they do not own them (as many claimants do not) the possibility exists of borrowing them from neighbours, relatives, ex-workmates. Knitting and sewing machines, power tools and other do-it-yourself equipment comes in this category. Garages can be converted into little workshops, home-brew kits are popular, parts and machinery can be taken from old cars and other gadgets. If they saw their opportunity, trained metallurgists and mechanics could get into advanced scrap technology, recycling the metal wastes of the consumer society for things which could be used again regardless of whether they would fetch anything in a shop. Many hobby enthusiasts could begin to see their interests in a new light.*[1]

Karl Hess also discussed community workshops—or as he called them, "shared machine shops"—in *Community Technology*.

> The machine shop should have enough basic tools, both hand and power, to make the building of demonstration models or test facilities a practical and everyday activity. The shared shop might just be part of some other public facility, used in its off hours. Or the shop might be separate and stocked with cast-off industrial tools, with tools bought from government surplus through the local school system... Work can, of course, be done as well in home shops or in commercial shops of people who like the community technology approach....
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> Thinking of such a shared workshop in an inner city, you can think of its use... for the maintenance of appliances and other household goods whose replacement might represent a real economic burden in the neighborhood....
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> ...The machine shop could regularly redesign cast-off items into useful ones. Discarded refrigerators, for instance, suggest an infinity of new uses, from fish tanks, after removing doors, to numerous small parts as each discarded one is stripped for its components, which include small compressors, copper tubing, heat transfer arrays, and so on. The same goes for washing machines....[2]

Hess's choice of words, by the way, evidenced a failure to anticipate the extent to which flexible networked manufacturing would blur the line between “demonstration models” or test facilities and serial production.

Sharing is a way of maximizing the utilization of idle productive goods owned by individuals. Just about any tool or appliance you need for a current project, but lack, is probably gathering dust on the shelf of someone within a few blocks of where you live. If the pooling of such idle resources doesn't seem like much of a deal for the person with the unused appliances, keep in mind first that he isn't getting anything at all out of them now, second that he may trade access to them for access to other people's tools that *he* needs, and third that the arrangement may increase the variety of goods and services he has to choose from outside the wage system.

The same idea has appeared in the San Francisco Bay area, albeit in a commercial rather than communitarian form, as TechShop:[3]

> TechShop is a 15,000 square-foot membership-based workshop that provides members with access to tools and equipment, instruction, and a creative and supportive community of like-minded people so you can

1 Keith Paton, *The Right to Work or the Fight to Live?* (Stoke-on-Trent, 1972), in Ward, *Anarchy in Action*, pp. 108-109.
2 Karl Hess, *Community Technology*, pp. 96-97.
3 <http://techshop.ws/>.

> build the things you have always wanted to make....
>
> TechShop provides you with access to a wide variety of machinery and tools, including milling machines and lathes, welding stations and a CNC plasma cutter, sheet metal working equipment, drill presses and band saws, industrial sewing machines, hand tools, plastic and wood working equipment including a 4' x 8' ShopBot CNC router, electronics design and fabrication facilities, Epilog laser cutters, tubing and metal bending machines, a Dimension SST 3-D printer, electrical supplies and tools, and pretty much everything you'd ever need to make just about anything.

Hess linked his idea for a shared machine shop to another idea, "[s]imilar in spirit," the shared warehouse:

> A community decision to share a space in which discarded materials can be stored, categorized, and made easily available is a decision to use an otherwise wasted resource....
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> The shared warehouse... should collect a trove of bits and pieces of building materials.... There always seems to be a bundle of wood at the end of any project that is too good to burn, too junky to sell, and too insignificant to store. Put a lot of those bundles together and the picture changes to more and more practical possibilities of building materials for the public space.
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> Spare parts are fair game for the community warehouse. Thus it can serve as a parts cabinet for the community technology experimenter....
>
> A problem common to many communities is the plight of more resources leaving than coming back in.... The shared work space and the shared warehouse space involve a community in taking a first look at this problem at a homely and nonideological level.[1]

This ties in closely with Jane Jacobs' recurring themes of the development of local, diversified economies through the discovery of creative uses for locally generated waste and byproducts, and the use of such innovative technologies to replace imports.[2]

E. F. Schumacher recounted his experiences with the Scott Bader Commonwealth, encouraging (often successfully) the worker-owners to undertake such ventures as a community auto repair shop, communally owned tools and other support for household gardening, a community woodworking shop for building and repairing furniture, and so forth. The effect of such measures was to take off some of the pressure to earn wages, so that workers might scale back their work hours.[3]

The potential for such common workspaces increases by an order of magnitude, of course, with the kinds of small, cheap, computerized machine tools we will consider later in this chapter.

The building, bottom-up, of local economies based on small-scale production with multiple-purpose machinery might well take place piecemeal, beginning with such small shops, at first engaged primarily in repair and remanufacture of existing machinery and appliances. As Peak Oil and the degradation of the national transportation system cause corporate logistic chains for spare parts to dry up, small garage and backyard machine shops may begin out of sheer necessity to take up the slack, custom-machining the spare parts needed to keep aging appliances in operation. From this, the natural progression would be to farming out the production of components among a number of such small

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1 Karl Hess, *Community Technology* (New York, Cambridge, Hagerstown, Philadelphia, San Francisco, London, Mexico City, Sao Paulo, Sydney: Harper & Row, Publishers, 1979), pp. 96-98.
2 Jane Jacobs, *The Economy of Cities* (New York: Vintage Books, 1969, 1970)
3 E. F. Schumacher, *Good Work* (New York, Hagerstown, San Fransisco, London: Harper & Row, 1979), pp. 80-83.

shops, and perhaps designing and producing simple appliances from scratch. (An intermediate step might be "mass customization," the custom design of modular accessories for mass-produced platforms.) In this manner, networked production of spare parts by small shops might be the foundation for a new industrial revolution.

As Jacobs described it, the Japanese bicycle industry had its origins in just such networking between custom producers of spare parts.

> To replace these imports with locally made bicycles, the Japanese could have invited a big American or European bicycle manufacturer to establish a factory in Japan... Or the Japanese could have built a factory that was a slavish imitation of a European or American bicycle factory. They would have had to import most or all of the factory's machinery, as well as hiring foreign production managers or having Japanese production managers trained abroad....
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> ...[Instead], shops to repair [imported bicycles] had sprung up in the big cities.... Imported spare parts were expensive and broken bicycles were too valuable to cannibalize the parts. Many repair shops thus found it worthwhile to make replacement parts themselves—not difficult if a man specialized in one kind of part, as many repairmen did. In this way, groups of bicycle repair shops were almost doing the work of manufacturing entire bicycles. That step was taken by bicycle assemblers, who bought parts, on contract, from repairmen: the repairmen had become "light manufacturers."[1]

Karl Hess and David Morris, in *Neighborhood Power*, suggested a progression from retail to repair to manufacturing as the natural model for a transition to relocalized manufacturing. They wrote of a process by which "repair shops begin to transform themselves into basic manufacturing facilities..."[2] Almost directly echoing Jacobs, they envisioned a bicycle collective's retail shop adding maintenance facilities, and then:

> After a number of people have learned the skills in repairs in a neighborhood, a factory could be initiated to produce a few vital parts, like chains or wheels or tires. Finally, if the need arises, full-scale production of bicycles could be attempted.

Interestingly enough, Don Tapscott and Anthony Williams describe just such a process taking place in micromanufacturing facilities (about which more below) which have been introduced in the Third World. Indian villagers are using fab labs (again, see below) "to make replacement gears for out-of date copying machines...."[3]

The same process could be replicated in many areas of production. Retail collectives might support community-supported agriculture as a primary source of supply, followed by a small canning factory and then by a glass recycling center to trade broken bottles and jars for usable ones on an arrangement with the bottling companies.[4] Again, the parallels with Jane Jacobs are striking:

> Cities that replace imports significantly replace not only finished goods but, concurrently, many, many items of producers' goods and services. They do it in swiftly emerging, logical chains. For example, first comes the local processing of fruit preserves that were formerly imported, then the production of jars or wrappings formerly imported for which there was no local market of producers until the first step had been taken. Or first comes the assembly of formerly imported pumps for which, once the assembly step has been

1 Jacobs, *Economy of Cities*, pp. 63-64.
2 Karl Hess and David Morris, *Neighborhood Power: The New Localism* (Boston: Beacon Press, 1975), p. 69.
3 Don Tapscott and Anthony D. Williams, *Wikinomics: How Mass Collaboration Changes Everything* (New York: Portfolio, 2006), p. 213.
4 Hess and Morris, p. 142.

> taken, parts are imported; then the making of parts for which metal is imported; then possibly even the smelting of metal for these and other import-replacements. The process pays for itself as it goes along. When Tokyo went into the bicycle business, first came repair work cannibalizing imported bicycles, then manufacture of some of the parts most in demand for repair work, then manufacture of still more parts, finally assembly of whole, Tokyo-made bicycles. And almost as soon as Tokyo began exporting bicycles to other Japanese cities, there arose in some of those customer cities much the same process of replacing bicycles imported from Tokyo, ...as had happened with many items sent from city to city in the United States.[1]

A directly analogous process of import substitution can take place in the informal economy, with production for barter at the household and neighborhood level using household capital goods (about which more below) replacing the purchase of consumption goods in the wage economy.

Paul and Percival Goodman wrote, in *Communitas*, of the possibility of decentralized machining of parts by domestic industry, given the universal availability of power and the ingenuity of small machinery, coupled with assembly at a centralized location. It is, they wrote, "almost always cheaper to transport material than men."[2]

A good example of this phenomenon in practice is the Japanese "shadow factories" during World War II. Small shops attached to family homes played an important role in the Japanese industrial economy, according to Nicholas Wood. Many components and subprocesses were farmed out for household manufacture, in home shops consisting of perhaps a few lathes, drill presses or milling machines. In the war, the government had actively promoted such "shadow factories," distributing machine tools in workers' homes in order to disperse concentrated industry and reduce its vulnerability to American strategic bombing.[3] After the war, the government encouraged workers to purchase the machinery.[4] As late as the late fifties, such home manufacturers were still typically tied to particular companies, in what amounted to industrial serfdom. But according to Wood, by the time of his writing (1964), many home manufacturers had become free agents, contracting out to whatever firm made the best offer.[5] The overhead costs of home production, after the war, were reduced by standardization and modular design. For example, household optical companies found it impossible at first to produce and stock the many sizes of lenses and prisms for the many different models. But subsequently all Japanese companies standardized their designs to a few models.[6]

A similar shadow factory movement emerged in England during the war, as described by Goodman: "Home manufacture of machined parts was obligatory in England during the last war because of the bombings, and it succeeded."[7]

The Chinese pursued a system of localized production along roughly similar lines in the 1970s. According to Lyman van Slyke, they went a long way toward meeting their small machinery needs in this way. This was part of a policy known as the "Five Smalls," which involved agricultural communes supplying their own needs locally (hydroelectric energy, agro-chemicals, cement, iron and steel

1 Jacobs, *Cities and the Wealth of Nations: Principles of Economic* Life (New York: Vintage Books, 1984), p. 38.
2 p. 83.
3 Nicholas Wood, "The 'Family Firm'—Base of Japan's Growing Economy," *The American Journal of Economics and Sociology*, vol. 23 no. 3 (1964), p. 316.
4 Ibid., p. 319.
5 Ibid., p. 317.
6 Ibid., p. 318.
7 *Paul Goodman, People or Personnel*, in *People or Personnel* and *Like a Conquered Province* (New York: Vintage Books, 1965, 1967, 1968), p. 95.

smelting, and machinery) in order to relieve large-scale industry of the burden. In the case of machinery, specifically, van Slyke gives the example of the hand tractor:

> ...[O]ne of the most commonly seen pieces of farm equipment is the hand tractor, which looks like a large rototiller. It is driven in the field by a person walking behind it.... This particular design is common in many parts of Asia, not simply in China. Now, at the small-scale level, it is impossible for these relatively small machine shops and machinery plants to manufacture all parts of the tractor. In general, they do not manufacture the engine, the headlights, or the tires, and these are imported from other parts of China. But the transmission and the sheet-metal work and many of the other components may well be manufactured at the small plants. Water pumps of a variety of types, both gasoline and electric, are often made in such plants, as are a variety of other farm implements, right down to simple hand tools. In addition, in many of these shops, a portion of plant capacity is used to build machine tools. That is, some lathes and drill presses were being used not to make the farm machinery but to make additional lathes and drill presses. These plants were thus increasing their own future capabilities at the local level. Equally important is a machinery-repair capability. It is crucial, in a country where there isn't a Ford agency just down the road, that the local unit be able to maintain and repair its own equipment. Indeed, in the busy agricultural season many small farm machinery plants close down temporarily, and the work force forms mobile repair units that go to the fields with spare parts and tools in order to repair equipment on the spot.
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> Finally, a very important element is the training function played in all parts of the small-scale industry spectrum, but particularly in the machinery plants. Countless times we saw two people on a machine. One was a journeyman, the regular worker, and the second was an apprentice, a younger person, often a young woman, who was learning to operate the machine.[1]

It should be stressed that this wasn't simply a repeat of the disastrous Great Leap Forward, which was imposed from above in the late 1950s. It was, rather, an example of local ingenuity in filling a vacuum left by the centrally planned economy. If anything, in the 1970s—as opposed to the 1950s—the policy was considered a painful concession to necessity, to be abandoned as soon as possible, rather than a vision pursued for its own sake. Van Slyke was told by those responsible for small-scale industry, "over and over again," that their goals were to move "from small to large, from primitive to modern, and from here-and-there to everywhere."[2] Aimin Chen reported in 2002 that the government was actually cracking down on local production under the "Five Smalls" in order to reduce idle capacity in the beleaguered state sector.[3] The centrally planned economy under state socialism, like the corporate economy, can only survive by suppressing small-scale competition.

The raw materials for such relocalized production are already in place in most neighborhoods, to a large extent, in the form of unused or underused appliances, power tools gathering dust in basements and garages, and the like. It's all just waiting to be integrated onto a local economy, as soon as producers can be hooked up to needs, and people realize that every need met by such means reduces their dependence on wage labor by an equal amount—and probably involves less labor and more satisfaction than working for the money. The problem is figuring out what's lying around, who has what skills, and how to connect supply to demand. As Hess and Morris put it,

> In one block in Washington, D.C., such a survey uncovered plumbers, electricians, engineers, amateur gardeners, lawyers, and teachers. In addition, a vast number of tools were discovered; complete workshops,

1 Lyman P. van Slyke, "Rural Small-Scale Industry in China," in Richard C. Dorf and Yvonne L. Hunter, eds., *Appropriate Visions: Technology the Environment and the Individual* (San Francisco: Boyd & Fraser Publishing Company, 1978) pp. 193-194.
2 Ibid., p. 196.
3 Aimin Chen, "The structure of Chinese industry and the impact from China's WTO entry," *Comparative Economic Studies* (Spring 2002) <http://www.entrepreneur.com/tradejournals/article/print/86234198.html>.

> incomplete machine-tool shops, and extended family relationships which added to the neighborhood's inventory—an uncle in the hardware business, an aunt in the cosmetics industry, a brother teaching biology downtown. The organizing of a directory of human resources can be an organizing tool itself.[1]

Arguably the neighborhood workshop and the household microenterprise (which we will examine later in this chapter) achieve an optimal economy of scale, determined by the threshold at which a household producer good is fully utilized, but the overhead for a permanent hired staff and a stand-alone dedicated building is not required.

The various thinkers quoted above wrote on community workshops at a time when the true potential of small-scale production machinery was just starting to emerge.

B. The Desktop Revolution and Peer Production in the Immaterial Sphere

Since the desktop revolution of the 1970s, computers have promised to be a decentralizing force on the same scale as electrical power a century earlier. The computer, according to Michel Piore and Charles Sabel, is “a machine that meets Marx's definition of an artisan's tool: it is an instrument that responds to and extends the productive capacities of the user.”

> It is therefore tempting to sum the observations of engineers and ethnographers to the conclusion that technology has ended the domination of specialized machines over un- and semiskilled workers, and redirected progress down the path of craft production. The advent of the computer restores human control over the production process; machinery again is subordinated to the operator.[2]

As Johan Soderberg argues, “[t]he universally applicable computer run on free software and connected to an open network... have [sic] in some respects leveled the playing field. Through the global communication network, hackers are matching the coordinating and logistic capabilities of state and capital.”[3]

Indeed, the computer itself is the primary item of capital equipment in a growing number of industries, like music, desktop publishing and software design. The desktop computer, supplemented by assorted packages of increasingly cheap printing or sound editing equipment, is capable of doing what previously required a minimum investment of hundreds of thousands of dollars.

The growing importance of human capital, and the implosion of capital outlay costs required to enter the market, have had revolutionary implications for production in the immaterial sphere. In the old days, the immense outlay for physical assets was the primary basis for the corporate hierarchy's power, and in particular for its control over human capital and other intangible assets.

As Luigi Zingales observes, the declining importance of physical assets relative to human capital has changed this. Physical assets, "which used to be the major source of rents, have become less unique and are not commanding large rents anymore." And "the demand for process innovation and quality improvement... can only be generated by talented employees," which increases the importance of human capital.[4] This is even more true since Zingales wrote, with the rise of what has been

1 Hess and Morris, *Neighborhood Power*, p. 127.
2 Piore and Sabel, p. 261.
3 Johan Soderberg, *Hacking Capitalism: The Free and Open Source Software Movement* (New York and London: Routledge, 2008), p. 2.
4 Luigi Zingales, "In Search of New Foundations," *The Journal of Finance*, vol. lv, no. 4 (August 2000), pp. 1641-1642.

variously called the wikified workplace,[1] the hyperlinked organization,[2] etc. What Niall Cook calls Enterprise 2.0[3] is the application of the networked platform technologies (blogs, wikis, etc.) associated with Web 2.0 to the internal organization of the business enterprise. It refers to the spread of self-managed peer network organization *inside* the corporation, with the internal governance of the corporation increasingly resembling the organization of the Linux developer community.

Tom Peters remarked in quite similar language, some six years earlier in *The Tom Peters Seminar*, on the changing balance of physical and human capital. Of *Inc*. magazine's 500 top-growth companies, which included a good number of information, computer technology and biotech firms, 34% were launched on initial capital of less than $10,000, 59% on less than $50,000, and 75% on less than $100,000.[4] The only reason those companies remain viable is that they control the value created by their human capital. And the only way to do that is through the ownership of artificial property rights like patents, copyrights and trademarks.

In many information and culture industries, the initial outlay for entering the market in the broadcast days was in the hundreds of thousands of dollars or more. The old broadcast mass media, for instance, were "typified by high-cost hubs and cheap, ubiquitous, reception-only systems at the end. This led to a limited range of organizational models for production: those that could collect sufficient funds to set up a hub."[5] The same was true of print periodicals, with the increasing cost of printing equipment from the mid-nineteenth century on serving as the main entry barrier for organizing the hubs. Between 1835 and 1850, the typical startup cost of a newspaper increased from $500 to $100,000--or from roughly $10,000 to $2.38 million in 2005 dollars.[6]

The networked economy, in contrast, is distinguished by "network architecture and the [low] cost of becoming a speaker."

> The first element is the shift from a hub-and-spoke architecture with unidirectional links to the end points in the mass media, to distributed architecture with multidirectional connections among all nodes in the networked information environment. The second is the practical elimination of communications costs as a barrier to speaking across associational boundaries. Together, these characteristics have fundamentally altered the capacity of individuals, acting alone or with others, to be active participants in the public sphere as opposed to its passive readers, listeners, or viewers.[7]

In the old days, the owners of the hubs—CBS News, the Associated Press, etc.—decided what you could hear. Today you can set up a blog, or record a podcast, and anybody in the world who cares enough to go to your URL can look at it free of charge (and anyone who agrees with it—or wants to tear it apart—can provide a hyperlink to his readers).

The central change that makes these things possible is that "the basic physical capital necessary to

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1 Don Tapscott and Anthony D. Williams, *Wikinomics: How Mass Collaboration Changes Everything* (New York: Portfolio, 2006), pp. 239-267.
2 Chapter Five, "The Hyperlinked Organization," in Rick Levine, Christopher Locke, Doc Searls and David Weinberger. *The Cluetrain Manifesto: The End of Business as Usual* (Perseus Books Group, 2001) <http://www.cluetrain.com/book/index.html>.
3 Niall Cook, *Enterprise 2.0: How Social Software Will Change the Future of Work* (Burlington, Vt.: Gower, 2008).
4 Tom Peters. *The Tom Peters Seminar: Crazy Times Call for Crazy Organizations* (New York: Vintage Books, 1994), p. 35.
5 Yochai Benkler, *The Wealth of Networks: How Social Production Transforms Markets and Freedom* (New Haven and London: Yale University Press, 2006), p. 179.
6 Ibid., p. 188.
7 Ibid., pp. 212-13.

express and communicate human meaning is the connected personal computer."

> The core functionalities of processing, storage, and communications are widely owned throughout the population of users.... The high capital costs that were a prerequisite to gathering, working, and communicating information, knowledge, and culture, have now been widely distributed in the society. The entry barrier they posed no longer offers a condensation point for the large organizations that once dominated the information environment.[1]

The desktop revolution and the Internet mean that the minimum capital outlay for entering most of the entertainment and information industry has fallen to a few thousand dollars at most, and the marginal cost of reproduction is zero. If anything that overstates the cost of entry in many cases, considering how rapidly computer value depreciates and the relatively miniscule cost of buying a five-year-old computer and adding RAM.

The networked environment, combined with endless varieties of cheap software for creating and editing content, makes it possible for the amateur to produce output of a quality once associated with giant publishing houses and recording companies.[2] That is true of the software industry, desktop publishing, and to a certain extent even to film (as witnessed by affordable editing technology and the success of *Sky Captain*).

In the case of the music industry, thanks to cheap equipment and software for high quality recording and sound editing, the costs of independently producing and distributing a high-quality album have fallen through the floor. Bassist Steve Lawson writes:

> ...[T]he recording process - studio time and expertise used to be hugely expensive. But the cost of recording equipment has plummeted, just as the quality of the same has soared. Sure, expertise is still chargeable, but it’s no longer a non-negotiable part of the deal. A smart band with a fast computer can now realistically make a release quality album-length body of songs for less than a grand....
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> What does this actually mean? Well, it means that for me—and the hundreds of thousands of others like me—the process of making and releasing music has never been easier. The task of finding an audience, of seeding the discovery process, has never cost less or been more fun. It’s now possible for me to update my audience and friends (the cross-over between the two is happening on a daily basis thanks to social media tools) about what I’m doing—musically or otherwise---and to hear from them, to get involved in their lives, and for my music to be inspired by them....
>
> So, if things are so great for the indies, does that mean loads of people are making loads of money? Not at all. But the false notion there is that any musicians were before! We haven’t moved from an age of riches in music to an age of poverty in music. We’ve moved from an age of massive debt and no creative control in music to an age of solvency and creative autonomy. It really is win/win.[3]

As Tom Coates put it, "the gap between what can be accomplished at home and what can be accomplished in a work environment has narrowed dramatically over the last ten to fifteen years."[4]

Podcasting makes it possible to distribute "radio" and "television" programming, at virtually no cost, to anyone with a broadband connection. As radio historian Jesse Walker notes, satellite radio's

1 Ibid., pp. 32-33.
2 Ibid., p. 54.
3 Steve Lawson, “The Future of Music is... Indie!” *Agit8*, September 10, 2009 <http://agit8.org.uk/?p=336>.
4 Tom Coates, "(Weblogs and) The Mass Amateurisation of (Nearly) Everything..." Plasticbag.org, September 3, 2003 <http://www.plasticbag.org/archives/2003/09/weblogs_and_the_mass_ amateurisation_of_nearly_everything>.

lackadaisical economic performance doesn't mean people prefer to stick with AM and FM radio; it means, rather, that the ipod has replaced the transistor radio as the primary portable listening medium, and that downloaded files have replaced the live broadcast as the primary form of content.[1]

A network of amateur contributors has peer-produced an encyclopedia, Wikipedia, which Britannica sees as a rival.

It's also true of news, with ever-expanding networks of amateurs in venues like Indymedia, with alternative new operations like those of Robert Parry, Bob Giordano and Greg Palast, and with natives and American troops blogging news firsthand from Iraq—all at the very same time the traditional broadcasting networks are relegating themselves to the stenographic regurgitation of press releases and press conference statements by corporate and government spokespersons, and “reporting” on celebrity gossip. Even conceding that the vast majority of shoe-leather reporting of original news is still done by hired professionals from a traditional journalistic background, blogs and other news aggregators are increasingly becoming the “new newspapers,” making better use of reporter-generated content than the old, high-overhead news organizations. But in fact most of the traditional media's “original content” consists of verbatim conveyance of official press releases, which could just as easily be achieved by bloggers and news aggregators linking directly to the press releases at the original institutional sites. Genuine investigative reporting consumes an ever shrinking portion of news organizations' budgets.

The network revolution has drastically lowered the transaction costs of organizing education outside the conventional institutional framework. In most cases, the industrial model of education, based on transporting human raw material to a centrally located “learning factory” for processing, is obsolete. Over thirty years ago Ivan Illich, in *Deschooling Society*, proposed decentralized community learning nets that would put people in contact with the teachers they wished to learn from, and provide an indexed repository of learning materials. The Internet has made this a reality beyond Illich's wildest dreams. MIT's Open Courseware project was one early step in this direction. But most universities, even if they don't have a full database of lectures, at least have some sort of online course catalog with bare-bones syllabi and assigned readings for many individual courses.

A more recent proprietary attempt at the same thing is the online university StraighterLine.[2] Critics like to point to various human elements of the learning process that students are missing, like individualized attention to students with problems grasping the material. This criticism might be valid, if StraighterLine were competing primarily with the intellectual atmosphere of small liberal arts colleges, with their low student-to-instructor ratios. But StraighterLine's primary competition is the community college and state university, and its catalog[3] is weighted mainly toward the kinds of mandatory first- and second-year introductory courses that are taught by overworked grad assistants to auditoriums full of freshmen and sophomores.[4] The cost, around $400 per course,[5] is free of the conventional university's activity fees and all the assorted overhead that comes from trying to manage thousands of people and physical plant at a single location. What's more, StraighterLine offers the option of purchasing live tutorials.[6] *Washington Monthly* describes the thinking behind the business model:

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1 Jesse Walker, “The Satellite Radio Blues: Why is XM Sirius on the verge of bankruptcy?,” *Reason*, February 27, 2009 <http://reason.com/news/show/131905.html>.

2 <http://www.straighterline.com/>.

3 <http://www.straighterline.com/courses/>.

4 Kevin Carey, “College for $99 a Month,” *Washington Monthly*, September/October 2009 <http://www.washingtonmonthly.com/college_guide/feature/college_for_99_a_month.php>.

5 <http://www.straighterline.com/costs/>.

6 <http://smarthinking.com/static/sampleTutorials/>.

> Even as the cost of educating students fell, tuition rose at nearly three times the rate of inflation. Web-based courses weren't providing the promised price competition—in fact, many traditional universities were charging extra for online classes, tacking a "technology fee" onto their standard (and rising) rates. Rather than trying to overturn the status quo, big, publicly traded companies like Phoenix were profiting from it by cutting costs, charging rates similar to those at traditional universities, and pocketing the difference.
>
> This, Smith explained, was where StraighterLine came in. The cost of storing and communicating information over the Internet had fallen to almost nothing. Electronic course content in standard introductory classes had become a low-cost commodity. The only expensive thing left in higher education was the labor, the price of hiring a smart, knowledgeable person to help students when only a person would do. And the unique Smarthinking call- center model made that much cheaper, too. By putting these things together, Smith could offer introductory college courses à la carte, at a price that seemed to be missing a digit or two, or three: $99 per month, by subscription. Economics tells us that prices fall to marginal cost in the long run. Burck Smith simply decided to get there first.

StraighterLine, he argues, threatens to do to universities what Craigslist did to newspapers. Freshman intro courses, with auditoriums stuffed like cattle cars and low-paid grad students presiding over the operation, are the cash cow that supports the expensive stuff—like upper-level and grad courses, not to mention a lot of administrative perks. If the cash cow is killed off by cheap competition, it will have the same effect on universities that Craigslist is having on newspapers.[1]

Of course StraighterLine is far costlier and less user-friendly than it might be, if it were peer-organized and open-source. Imagine a similar project with open-source textbooks (or which assigned, with a wink and a nudge, digitized proprietary texts available via a file-sharing network), free lecture materials like those of MIT's Open Courseware, and the creative use of email lists, blogs and wikis for the student community to help each other (much like the use of social networking tools for problem-solving among user communities for various kinds of computers or software).

For that matter, unauthorized course blogs and email lists created by students may have the same effect on StraighterLine that it is having on the traditional university—just as Wikipedia did to Encarta what Encarta did to the traditional encyclopedia industry.

The same model of organization can be extended to fields of employment outside the information and entertainment industries—particularly labor-intensive service industries, where human capital likewise outweighs physical capital in importance. The basic model is applicable in any industry with low requirements for initial capitalization and low or non-existent overhead. Perhaps the most revolutionary possibilities are in the temp industry. In my own work experience, I've seen that hospitals using agency nursing staff typically pay the staffing agency about three times what the agency nurse receives in pay. Cutting out the middleman, perhaps by means of some sort of cross between a workers' co-op and a longshoremen's union hiring hall, seems like a no-brainer. An AFL-CIO organizer in the San Francisco Bay area has attempted just such a project, as recounted by Daniel Levine.[2]

The chief obstacle to such attempts is non-competition agreements signed by temp workers at their previous places of employment. Typically, a temp worker signs an agreement not to work independently for any of the firm's clients, or work for them through another agency, for some period (usually three to six months) after quitting. Of course, this can be evaded fairly easily, if the new

1 Carey, "College for $99 a Month."
2 Daniel S. Levine, *Disgruntled: The Darker Side of the World of Work* (New York: Berkley Boulevard Books, 1998), p. 160.

cooperative firm has a large enough pool of workers to direct particular assignments to those who aren't covered by a non-competition clause in relation to that particular client.

And as we shall see in the next section, the implosion of capital outlay requirements even for physical production has had a similar effect on the relative importance of human and physical capital, in a considerable portion of manufacturing, and on the weakening of firm boundaries.

These developments have profoundly weakened corporate hierarchies in the information and entertainment industries, and created enormous agency problems as well. As the value of human capital increases, and the cost of physical capital investments needed for independent production by human capital decreases, the power of corporate hierarchies becomes less and less relevant. As the value of human relative to physical capital increases, the entry barriers become progressively lower for workers to take their human capital outside the firm and start new firms under their own control. Zingales gives the example of the Saatchi and Saatchi advertising agency. The largest block of shareholders, U.S. fund managers who controlled 30% of stock, thought that gave them effective control of the firm. They attempted to exercise this perceived control by voting down Maurice Saatchi's proposed increased option package for himself. In response, the Saatchi brothers took their human capital (in actuality the lion's share of the firm's value) elsewhere to start a new firm, and left a hollow shell owned by the shareholders.[1]

> Interestingly, in 1994 a firm like Saatchi and Saatchi, with few physical assets and a lot of human capital, could have been considered an exception. Not any more. The wave of initial public offerings of purely human capital firms, such as consultant firms, and even technology firms whose main assets are the key employees, is changing the very nature of the firm. Employees are not merely automata in charge of operating valuable assets but valuable assets themselves, operating with commodity-like physical assets.[2]

In another, similar example, the former head of Salomon Brothers' bond trading group formed a new group with former Salomon traders responsible for 87% of the firm's profits.

> ...if we take the standpoint that the boundary of the firm is the point up to which top management has the ability to exercise power..., the group was not an integral part of Salomon. It merely rented space, Salomon's name, and capital, and turned over some share of its profits as rent.[3]

Marjorie Kelly gave the breakup of the Chiat/Day ad agency as an example of the same phenomenon.

> ...What is a corporation worth without its employees?
>
> This question was acted out... in London, with the revolutionary birth of St. Luke's ad agency, which was formerly the London office of Chiat/Day. In 1995, the owners of Chiat/Day decided to sell the company to Omnicon—which meant layoffs were looming and Andy Law in the London office wanted none of it. He and his fellow employees decided to rebel. They phoned clients and found them happy to join the rebellion. And so at one blow, London employees and clients were leaving.
>
> Thus arose a fascinating question: What exactly did the "owners" of the London office now own? A few desks and files? Without employees and clients, what was the London branch worth? One dollar, it turned

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1 Zingales, "In Search of New Foundations," p. 1641.
2 Ibid., p. 1641.
3 Raghuram Rajan and Luigi Zingales, "The Governance of the New Enterprise," in Xavier Vives, ed., *Corporate Governance: Theoretical and Empirical Perspectives* (Cambridge: Cambridge University Press, 2000), pp. 211-212.

> out. That was the purchase price—plus a percentage of profits for seven years—when Omnicon sold the London branch to Law and his cohorts after the merger. They renamed it St. Luke's.... All employees became equal owners... Every year now the company is re-valued, with new shares awarded equally to all.[1]

David Prychitko remarked on the same phenomenon in the tech industry, the so-called "break-away" firms, as far back as 1991:

> Old firms act as embryos for new firms. If a worker or group of workers is not satisfied with the existing firm, each has a skill which he or she controls, and can leave the firm with those skills and establish a new one. In the information age it is becoming more evident that a boss cannot control the workers as one did in the days when the assembly line was dominant. People cannot be treated as workhorses any longer, for the value of the production process is becoming increasingly embodied in the intellectual skills of the worker. This poses a new threat to the traditional firm if it denies participatory organization.
>
> The appearance of break-away computer firms leads one to question the extent to which our existing system of property rights in ideas and information actually protects bosses in other industries against the countervailing power of workers. Perhaps our current system of patents, copyrights, and other intellectual property rights not only impedes competition and fosters monopoly, as some Austrians argue. Intellectual property rights may also reduce the likelihood of break-away firms in general, and discourage the shift to more participatory, cooperative formats.[2]

C. The Expansion of the Desktop Revolution and Peer Production into the Physical Realm

Although peer production first emerged in the immaterial realm—i.e., information industries like software and entertainment—its transferability to the realm of physical production is also a matter of great interest.

1. Open-Source Design: Removal of Proprietary Rents from the Design Stage, and Modular Design. One effect of the shift in importance from tangible to intangible assets is the growing portion of product prices that reflects embedded rents on "intellectual property" and other artificial property rights rather than the material costs of production.

The radical nature of the peer economy, especially as "intellectual property" becomes increasingly unenforceable, lies in its potential to cause the portion of existing commodity price that results from such embedded rents to implode.

Open source hardware refers, at the most basic level, to the development and improvement of designs for physical goods on an open-source basis, with no particular mode of physical production being specified. The design stage ceases to be a source of proprietary value, but the physical production stage is not necessarily affected. To take it in Richard Stallman's terms, 'free speech" only affects the portion of beer's price that results from the cost of a proprietary design phase: open source hardware means the design is free as in free speech, not free beer. Although the manufacturer is not hindered by patents on the design, he must still bear the costs of physical production. Edy Ferreira defined open-source hardware as

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1 Marjorie Kelly, "The Corporation as Feudal Estate" (an excerpt from *The Divine Right of Capital*) *Business Ethics*, Summer 2001. Quoted in *GreenMoney Journal*, Fall 2008 <http://greenmoneyjournal.com/article.mpl?articleid=60&newsletterid=15>.

2 David L Prychitko, *Marxism and Workers' Self-Management: The Essential Tension* (New York; London; Westport, Conn.: Greenwood Press, 1991), p. 121n.

> any piece of hardware whose manufacturing information is distributed using a license that provides specific rights to users without the need to pay royalties to the original developers. These rights include freedom to use the hardware for any purpose, freedom to study and modify the design, and freedom to redistribute copies of either the original or modified manufacturing information....
>
> In the case of open source software (OSS), the information that is shared is software code. In OSH, what is shared is hardware manufacturing information, such as... the diagrams and schematics that describe a piece of hardware.[1]

At the simplest level, a peer network may develop a product design and make it publicly available; it may be subsequently built by any and all individuals or firms with the necessary production machinery, without coordinating their efforts with the original designer(s). A conventional manufacturer may produce open source designs, with feedback from the user community providing the main source of innovation.

Karim Lakhani describes this general phenomenon, the separation of open-source design from an independent production stage, as "communities driving manufacturers out of the design space," with

> users innovating and developing products that can out compete traditional manufacturers. But this effect is not just limited to software. In physical products..., users have been shown to be the dominant source of functionally novel innovations. Communities can supercharge this innovation mechanism. And may ultimately force companies out of the product design space. Just think about it—for any given company—there are more people outside the company that have smarts about a particular technology or a particular use situation then [sic] all the R&D engineers combined. So a community around a product category may have more smart people working on the product then [sic] the firm it self. So in the end manufacturers may end up doing what they are supposed to—manufacture—and the design activity might move... into the community.[2]

As one example, Vinay Gupta has proposed a large-scale library of open-source hardware designs as an aid to international development:

> An open library of designs for refrigerators, lighting, heating, cooling, motors, and other systems will encourage manufacturers, particularly in the developing world, to leapfrog directly to the most sustainable technologies, which are much cheaper in the long run. Manufacturers will be encouraged to use the efficient designs because they are free, while inefficient designs still have to be paid for. The library could also include green chemistry and biological solutions to industry challenges.... This library should be free of all intellectual property restrictions and open for use by any manufacturer, in any nation, without charge.[3]

One item of his own design, the Hexayurt, is “a refugee shelter system that uses an approach based on "autonomous building" to provide not just a shelter, but a comprehensive family support unit which includes drinking water purification, composting toilets, fuel-efficient stoves and solar electric

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1 "Open Source Hardware," *P2P Foundation Wiki* <http://www.p2pfoundation.net/Open_Source_Hardware>.

2 Karim Lakhana, "Communities Driving Manufacturers Out of the Design Space," *The Future of Communities Blog*, March 25, 2007 <http://www.futureofcommunities.com/2007/03/25/communities-driving-manufacturers-out-of-the-design-space/>.

3 Vinay Gupta, "Facilitating International Development Through Free/Open Source," <http://guptaoption.com/5.open_source_development.php> Quoted from Beatrice Anarow, Catherine Greener, Vinay Gupta, Michael Kinsley, Joanie Henderson, Chris Page and Kate Parrot, Rocky Mountain Institute, "Whole-Systems Framework for Sustainable Consumption and Production." Environmental Project No. 807 (Danish Environmental Protection Agency, Ministry of the Environment, 2003), p. 24. <http://files.howtolivewiki.com/A%20Whole%20Systems%20Framework%20for%20Sustainable%20Production%20and%20Consumption.pdf>

lighting."[1] The basic construction materials for the floor, walls and roof cost about $200.[2]

Michel Bauwens, of the P2P foundation, provides a small list of some of the more prominent open-design projects:

> The Grid Beam Building System, at http://www.p2pfoundation.net/Grid_Beam_Building_Syste
> The Hexayurt, at http://www.p2pfoundation.net/Hexayurt
> Movisi Open Design Furniture, at http://www.p2pfoundation.net/Movisi_Open_Design_Furniture
> Open Cores, at http://www.p2pfoundation.net/Open_Cores and other Open Computing Hardware, at http://www.p2pfoundation.net/Open_Hardware
> Open Source Green Vehicle, at http://www.p2pfoundation.net/Open_Source_Green_Vehicle
> Open Source Scooter http://www.p2pfoundation.net/Open_Source_Scooter
> The Ronja Wireless Device at http://www.p2pfoundation.net/Twibright_Ronja_Open_Wireless_Networking_Device
> Open Source Sewing patterns, at http://www.p2pfoundation.net/Open_Source_Sewing_Patterns
> Velomobiles http://www.p2pfoundation.net/Open_Source_Velomobile_Development_Project
> Open Energy http://www.p2pfoundation.net/SHPEGS_Open_Energy_Project[3]

One of the most ambitious attempts at such an open design project is Open Source Ecology, which is developing an open-source, virally reproducible, vernacular technology-based “Open Village Construction Set” in its experimental site at Factor E Farm.[4] (Of course OSE is also directly involved in the physical implementation of its own designs; it is a manufacturing as well as a design network.)

A more complex scenario involves the coordination of an open source design stage with the production process, with the separate stages of production distributed and coordinated by the same peer network that created the design. Dave Pollard provides one example:

> Suppose I want a chair that has the attributes of an Aeron without the $1800 price tag, or one with some additional attribute (e.g. a laptop holder) the brand name doesn't offer? I could go online to a Peer Production site and create an instant market, contributing the specifications..., and, perhaps a maximum price I would be willing to pay. People with some of the expertise needed to produce it could indicate their capabilities and self-organize into a consortium that would keep talking and refining until they could meet this price.... Other potential buyers could chime in, offering more or less than my suggested price. Based on the number of 'orders' at each price, the Peer Production group could then accept orders and start manufacturing....
>
> As [Erick] Schonfeld suggests, the intellectual capital associated with this instant market becomes part of the market archive, available for everyone to see, stripping this intellectual capital cost, and the executive salaries, dividends and corporate overhead out of the cost of this and other similar product requests and fulfillments, so that all that is left is the lowest possible cost of material, labour and delivery to fill the order. And the order is exactly what the customer wants, not the closest thing in the mass-producer's warehouse.[5]

In any case, the removal of proprietary control over the implementation of designs means that the production phase will be subject to competitive pressure to adopt the most efficient production methods

1 <http://www.p2pfoundation.net/Hexayurt>.
2 <http://hexayurt.com/>.
3 Michel Bauwens, "What kind of economy are we moving to? 3. A hierarchy of engagement between companies and communities," *P2P Foundation Blog*, October 5, 2007 <http://blog.p2pfoundation.net/what-kind-of-economy-are-we-moving-to-3-a-hierarchy-of-engagement-between-companies-and-communities/2007/10/05>.
4 Marcin Jakubowski, "Clarifying OSE Vision," *Factor E Farm Weblog*, September 8, 2008 <http://openfarmtech.org/weblog/?p=325>.
5 Dave Pollard, "Peer Production," *How to Save the World*, October 28, 2005 <http://blogs.salon.com/0002007/2005/10/28.html#a1322>.

—a marked departure from the present, where “intellectual property” enables privileged producers to set prices as a cost-plus markup based on whatever inefficient production methods they choose.

The most ambitious example of an open-source physical production project is the open source car, or “OScar.”

> Can open-source practices and approaches be applied to make hardware, to create tangible and physical objects, including complex ones? Say, to build a car?...
>
> Markus Merz believes they can. The young German is the founder and "maintainer" (that's the title on his business card) of the OScar project, whose goal is to develop and build a car according to open-source (OS) principles. Merz and his team aren't going for a super-accessorized SUV—they're aiming at designing a simple and functionally smart car. And, possibly, along the way, reinvent transportation.[1]

As of June 2009, the unveiling of a prototype—a two-seater vehicle powered by hydrogen fuel cells—was scheduled in London.[2]

Well, actually there's a fictional example of an open-source project even more ambitious than the OScar: the open-source moon project, a volunteer effort of a peer network of thousands, in Craig DeLancy's "Openshot." The project's ship (the *Stallman*), built largely with Russian space agency surplus, beats a corporate-funded proprietary project to the moon.[3]

A slightly less ambitious open-source manufacturing project, and probably more relevant to the needs of most people in the world, is Open Source Ecology's open-source tractor (LifeTrac). It's designed for inexpensive manufacture, with modularity and easy disassembly, for lifetime service and low cost repair. It includes, among other things, a well-drilling module, and is designed to serve as a prime mover for machinery like OSE's Compressed Earth Block Press and saw mill.[4]

When physical manufacturing is stripped of the cost of proprietary design and technology, and the consumer-driven, pull model of distribution strips away most of the immense marketing cost, we will find that the portion of price formerly made up of such intangibles will implode, and the remaining price based on actual production cost will be as much as an order of magnitude lower.

Just as importantly, open-source design reduces cost not only by removing proprietary rents from “intellectual property,” but by the substantive changes in design that it promotes. Eliminating patents removes legal barriers to the competitive pressure for interoperability and reparability. And interoperability and reparability promote the kind of modular design that is most conducive to networked production, with manufacture of components distributed among small shops producing a common design.

The advantages of modular design of physical goods are analogous to those in the immaterial realm.

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1 Bruno Giussani, "Open Source at 90 MPH," *Business Week*, December 8, 2006 <http://www.businessweek.com/innovate/content/dec2006/id20061208_509041.htm?>. See also the OS Car website, <http://www.theoscarproject.org/>.
2 Lisa Hoover, “Riversimple to Unveil Open Source Car in London This Month,” *Ostatic*, June 11, 2009 <http://ostatic.com/blog/riversimple-to-unveil-open-source-car-in-london-this-month>.
3 Craig DeLancey, "Openshot," *Analog*, December 2006, pp. 64-74.
4 "LifeTrac," Open Source Ecology wiki <http://openfarmtech.org/index.php?title=LifeTrac>.

> Current thinking says peer production is only suited to creating information-based goods—those made of bits, inexpensive to produce, and easily subdivided into small tasks and components. Software and online encyclopedias have this property. Each has small discrete tasks that participants can fulfill with very little hierarchical direction, and both can be created with little more than a networked computer.
>
> While it's true that peer production is naturally suited to bit products, it's also true that many of the attributes and advantages of peer production can be replicated for products made of atoms. If physical products are designed to be modular—i.e., they consist of many interchangeable parts that can be readily swapped in or out without hampering the performance of the overall product—then, theoretically at least, large numbers of lightly coordinated suppliers can engage in designing and building components for the product, much like thousands of Wikipedians add to and modify Wikipedia's entries.[1]

This is hardly mere theory, but is reflected in the real-world reality of China's motorcycle industry: "The Chinese approach emphasizes a modular motorcycle architecture that enables suppliers to attach component subsystems (like a braking system) to standard interfaces."[2] And in an open-source world, independent producers could make unauthorized modular components or accessories, as well.

Costs from outlays on physical capital are not a constant, and modular design is one factor that can cause those costs to fall significantly. It enables a peer network to break a physical manufacturing project down into discrete sub-projects, with many of the individual modules perhaps serving as components in more than one larger appliance. According to Christian Siefkes,

> Products that are modular, that can be broken down into smaller modules or components which can be produced independently before being assembled into a whole, fit better into the peer mode of production than complex, convoluted products, since they make the tasks to be handled by a peer project more manageable. Projects can build upon modules produced by others and they can set as their own (initial) goal the production of a specific module, especially if components can be used stand-alone as well as in combination. The Unix philosophy of providing lots of small specialized tools that can be combined in versatile ways is probably the oldest expression in software of this modular style. The stronger emphasis on modularity is another phenomenon that follows from the differences between market production and peer production. Market producers have to prevent their competitors from copying or integrating their products and methods of production so as not to lose their competitive advantage. In the peer mode, re-use by others is good and should be encouraged, since it increases your reputation and the likelihood of others giving something back to you....
>
> Modularity not only facilitates decentralized innovation, but should also help to increase the longevity of products and components. Capitalism has developed a throw-away culture where things are often discarded when they break (instead of being repaired), or when one aspect of them is no longer up-to-date or in fashion. In a peer economy, the tendency in such cases will be to replace just a single component instead of the whole product, since this will generally be the most labor-efficient option (compared to getting a new product, but also to manually repairing the old one).[3]

Siefkes is wrong only in referring to producers under the existing corporate system as "market producers," since absent "intellectual property" as a legal bulwark to proprietary design, the market incentive would be toward designing products that were interoperable with other platforms, and toward competition in the design of accessories and replacement parts tailored to other companies' platforms. And given the absence of legal barriers to the production of such interoperable accessories, the market

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1 Tapscott and Williams, pp. 219-220.
2 Ibid., p. 222.
3 Christian Siefkes, *From Exchange to Contributions: Generalizing Peer Production into the Physical World* Version 1.01 (Berlin, October 2007), pp. 104-105.

incentive would be to designing platforms as broadly interoperable as possible.

This process of modularization is already being promoted within corporate capitalism, although the present system is struggling mightily—and unsuccessfully—to keep itself from being torn apart by the resulting increase in productive forces. As Eric Hunting argues, the high costs of technical innovation, the difficulty of capturing value from it, and the mass customization or long tail market, taken together, create pressures for common platforms that can be easily customized between products, and for modularization of components that can be used for a wide variety of products. And Hunting points out, as we already saw in regard to flexible manufacturing networks in Chapters Four and Five, that the predominant "outsource everything" and "contract manufacturing" model increasingly renders corporate hubs obsolete, and makes it possible for contractees to circumvent the previous corporate principals and undertake independent production on their own account.

> Industrial ecologies are precipitated by situations where traditional industrial age product development models fail in the face of very high technology development overheads or very high demassification in design driven by desire for personalization/customization producing Long Tail market phenomenon [sic]. A solution to these dilemmas is modularization around common architectural platforms in order to compartmentalize and distribute development cost risks, the result being 'ecologies' of many small companies independently and competitively developing intercompatible parts for common product platforms—such as the IBM PC.
>
> The more vertical the market profile for a product the more this trend penetrates toward production on an individual level due [to] high product sophistication coupled to smaller volumes.... Competitive contracting regulations in the defense industry (when they're actually respected...) tend to, ironically, turn many kinds of military hardware into open platforms by default, offering small businesses a potential to compete with larger companies where production volumes aren't all that large to begin with. Consequently, today we have a situation where key components of some military vehicles and aircraft are produced on a garage-shop production level by companies with fewer than a dozen employees.
>
> All this represents an intermediate level of industrial demassification that is underway today and not necessarily dependent upon open source technology or peer-to-peer activity but which creates a fertile ground for that in the immediate future and drives the complementary trend in the miniaturization of machine tools.[1]

In other words, the further production cost falls relative to the costs of design, the greater the economic incentive to modular design as a way of defraying design costs over as many products as possible.

In an email to the Open Manufacturing list, Hunting summed up the process more succinctly. Industrial relocalization

> compels the modularization of product design, which results in the replacement of designs by platforms and the competitive commoditization of their components. Today, automobiles are produced as whole products made with large high-capital-cost machinery using materials—and a small portion of pre-made components—transported long distances to a central production site from which the end product is shipped with a very poor transportation efficiency to local sales/distribution points. In the future automobiles may be assembled on demand in the car dealership from modular components which ship with far greater energy efficiency than whole cars and can come from many locations. By modularizing the design of the car to allow for this, that design is changed from a product to a platform for which many competitors, using much smaller less

1 Hunting comment under Michel Bauwens, "Phases for implementing peer production: Towards a Manifesto for Mutually Assured Production," P2P Foundation *Forum*, August 30, 2008 <http://p2pfoundation.ning.com/forum/topics/2003008:Topic:6275>.

expensive means of production, can potentially produce parts to accommodate customers desire for personalization and to extend the capabilities of the automobile beyond what was originally anticipated. End-users are more easily able to experiment in customization and improvement and pursue entrepreneurship based on this innovation at much lower start-up costs. This makes it possible to implement technologies for the automobile—like alternative energy technology—earlier auto companies may not have been willing to implement because of a lack of competition and because their capital costs for their large expensive production tools and facilities take so long (20 years, typically) to amortize. THIS is the reason why computers, based on platforms for modular commodity components, have evolved so rapidly compared to every other kind of industrial product and why the single-most advanced device the human race has ever produced is now something most anyone can afford and which a child can assemble in minutes from parts sourced around the world.[1]

The beauty of modular design, Hunting writes elsewhere (in the specific case of modular prefab housing), is that the bulk of research and development man-hours are incorporated into the components themselves, which can be duplicated across many different products. The components are smart, but the combinations are dumbed-down and user friendly. A platform is a way to spread the development costs of a single component over as many products as possible.

> But underneath there are these open structural systems that are doing for house construction what the standardized architecture of the IBM PC did for personal computing, encoding a lot of engineering and pre-assembly labor into small light modular components created in an industrial ecology so that, at the high level of the end-user, it's like Lego and things go together intuitively with a couple of hand tools. In the case of the Jeriko and iT houses based on T-slot profiles, this is just about a de-facto public domain technology, which means a zillion companies around the globe could come in at any time and start making compatible hardware. We're tantalizingly close to factoring out the 'experts' in basic housing construction just like we did with the PC where the engineers are all down in the sub-components, companies don't actually manufacture computers they just do design and assemble-on-demand, and now kids can build computers in minutes with parts made all over the world. Within 20 years you'll be going to places like IKEA and Home Depot and designing your own home by picking parts out of catalogs or showrooms, having them delivered by truck, and then assembling most of them yourself with about the same ease you put in furniture and home appliances.[2]

More recently, Hunting wrote of the role of modularized development for common platforms in this history of the computer industry:

> We commonly attribute the rapid shrinking in scale of the computer to the advance of integrated circuit technology. But that’s just a small part of the story that doesn’t explain the economy and ubiquity of computers. The real force behind that was a radically different industrial paradigm that emerged more-or-less spontaneously in response to the struggle companies faced in managing the complexity of the new technology. Put simply, the computer was too complicated for any one corporation to actually develop independently—not even for multi-national behemoths like IBM that once prided itself on being able to do everything. A radically new way of doing things was needed to make the computer practical.
>
> The large size of early computers was a result not so much of the primitive nature of the technology of the time but on the fact that most of that early technology was not actually specific to the application of computers. It was repurposed from electronic components that were originally designed for other kinds of machines. Advancing the technology to where the vast diversity of components needed could be made and optimized specifically for the computer demanded an extremely high development investment -more than

1 Eric Hunting, "[Open Manufacturing] Re: Why automate? and opinions on Energy Descent?" *Open* Manufacturing, September 22, 2008 <http://groups.google.com/group/openmanufacturing/browse_thread/thread/1f40d031453b94eb>.
2 Hunting, “[Open Manufacturing] Re:Vivarium,” *Open Manufacturing*, March 28, 2009 <http://groups.google.com/group/openmanufacturing/browse_thread/thread/a891d6f72243436d/e58d837ac4022484?hl=en&q=vivarium+hunting#>.

any one company in the world could actually afford. There simply wasn't a big enough computer market to justify the cost of development of very sophisticated parts exclusively for computers. While performing select R&D on key components, early computer companies began to position themselves as systems integrators for components made by sub-contractracted suppliers rather than manufacturing everything themselves. While collectively the development of the full spectrum of components computers needed was astronomically expensive, individually they were quite within the means of small businesses and once the market for computers reached a certain minimum scale it became practical for such companies to develop parts for these other larger companies to use in their products. This was aided by progress in other areas of consumer, communications, and military digital electronics—a general shift to digital electronics—that helped create larger markets for parts also suited to computer applications. The more optimized for computer use subcomponents became, the smaller and cheaper the computer as a whole became and the smaller and cheaper the computer the larger the market for it, creating more impetus for more companies to get involved in computer-specific parts development. ICs were, of course, a very key breakthrough but the nature of their extremely advanced fabrication demanded extremely large product markets to justify. The idea of a microprocessor chip exclusive to any particular computer is actually a rather recent phenomenon even for the personal computer industry. Companies like Intel now host a larger family of concurrently manufactured and increasingly use-specialized microprocessors than was ever imaginable just a decade ago.

For this evolution to occur the nature of the computer as a designed product had to be very different from other products common to industrial production. Most industrial products are monolithic in the sense that they are designed to be manufactured whole from raw materials and very elemental parts in one central mass production facility. But the design of a computer isn't keyed to any one resulting product. It has an 'architecture' that is independent of any physical form. A set of component function and interface standards that define the electronics of a computer system but not necessarily any particular physical configuration. Unlike other technologies, electronics is very mutable. There are an infinite variety of potential physical configurations of the same electronic circuit. This is why electronics engineering can be based on iconographic systems akin to mathematics—something seen in few other industries to a comparable level of sophistication. (chemical engineering) So the computer is not a product but rather a *platform* that can assume an infinite variety of shapes and accommodate an infinite diversity of component topologies as long as their electronic functions conform to the architecture. But, of course, one has to draw the line somewhere and with computer parts this is usually derived from the topology of standardized component connections and the most common form factors for components. Working from this a computer designer develops configurations of components integrated through a common motherboard that largely defines the overall shape possible for the resulting computer product. Though companies like Apple still defy the trend, even motherboards and enclosures are now commonly standardized, which has ironically actually encouraged diversity in the variety of computer forms and enclosure designs even if their core topological features are more-or-less standardized and uniform.

Thus the computer industry evolved into a new kind of industrial entity; an Industrial Ecology formed of a food-chain of interdependencies between largely independent, competitive, and globally dispersed companies defined by component interfaces making up the basis of computer platform architectures. This food chain extends from discrete electronics components makers, through various tiers of sub-system makers, to the computer manufacturers at the top—though in fact they aren't manufacturing anything in the traditional sense. They just cultivate the platforms, perform systems integration, customer support, marketing, and—decreasingly as even this is outsourced to contract job shops—assemble the final products.

For an Industrial Ecology to exist, an unprecedented degree of information must flow across this food chain as no discrete product along this chain can hope to have a market unless it conforms to interface and function standards communicated downward from higher up the chain. This has made the computer industry more open than any other industry prior to it. Despite the obsessions with secrecy, propriety, and intellectual property among executives, this whole system depends on an open flow of information about architectures, platforms, interfaces standards, software, firmware, and so on—communicated through technical reference guides and marketing material. This information flow exists to an extent seen nowhere else in the Industrial

Age culture....

Progressive modularization and interoperability standardization tends to consolidate and simplify component topologies near the top of the food chain. This is why a personal computer is, today, so simple to assemble that a child can do it—or for that matter an end-user or any competitor to the manufacturers at the top. All that ultimately integrates a personal computer into a specific physical form is the motherboard and the only really exclusive aspect of that is its shape and dimensions and an arrangement of parts which, due to the nature of electronics, is topologically mutable independent of function. There are innumerable possible motherboard forms that will still work the same as far as software is concerned. This made the PC an incredibly easy architecture to clone for anyone who could come up with some minor variant of that motherboard to circumvent copyrights, a competitive operating system, a work-around the proprietary aspects of the BIOS, and could dip into that same food chain and buy parts in volume. Once an industrial ecology reaches a certain scale, even the folks at the top become expendable. The community across the ecology has the basic knowledge necessary to invent platforms of its own, establish its own standards bottom-up, and seek out new ways to reach the end-user customer. And this is what happened to IBM when it stupidly allowed itself to become a bottleneck to the progress of the personal computer in the eyes of everyone else in its ecology. That ecology, for sake of its own growth, simply took the architecture of the PC from IBM and established its own derivative standards independent of IBM—and there was nothing even that corporate giant could ultimately do about it....

...Again, this is all an astounding revolution in the way things are supposed to work in the Industrial Age. A great demassification of industrial power and control. Just imagine what the car industry would be like if things worked like this—as well one should as this is, in fact, coming. Increasingly, the model of the computer industry is finding application in a steadily growing number of other industries. Bit by bit, platforms are superceding products and Industrial Ecologies are emerging around them.[1]

The size limitations of fabrication in the small shop, and the lack of facilities for plastic injection molding or sheet metal stamping of very large objects, constitute a further impetus to modular design.

By virtue of the dimensional limits resulting from the miniaturization of fabrication systems, Post-Industrial design favors modularity following a strategy of maximum diversity of function from a minimum diversity of parts and materials—Min-A-Max....

Post-industrial artifacts tend to exhibit the characteristic of perpetual demountability, leading to ready adaptive reuse, repairability, upgradeability, and recyclability. By extension, they compartmentalize failure and obsolescence to discrete demountable components. A large Post-Industrial artifact can potentially live for as long as its platform can evolve -potentially forever.

A scary prospect for the conventional manufacturer banking on the practice of planned obsolescence....[2]

One specific example Hunting cites is the automobile. It was, more than anything, "the invention of pressed steel welded unibody construction in the 1930s," with its requirement for shaping sheet metal in enormous multi-story stamping presses, that ruled out modular production by a cooperative ecology of small manufacturers. Against that background, Hunting sets the abortive Africar project of the 1980s, with a modular design suitable for networked production in small shops.[3] The Africar had a

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1 Hunting, "On Defining a Post-Industrial Style (1): from Industrial blobjects to post-industrial spimes," *P2P Foundation Blog*, November 2, 2009 <http://blog.p2pfoundation.net/on-defining-a-post-industrial-style-1-from-industrial-blobjects-to-post-industrial-spimes/2009/11/02>.
2 "On Defining a Post-Industrial Style (2): some precepts for industrial design," *P2P Foundation Blog*, November 3, 2009 <http://blog.p2pfoundation.net/on-defining-a-post-industrial-style-2-some-precepts-for-industrial-design/2009/11/03>.
3 "On Defining a Post-Industrial Style (3): Emerging examples," *P2P Foundation Blog*, November 4, 2009 <http://blog.p2pfoundation.net/on-defining-a-post-industrial-style-3-emerging-examples/2009/11/04>.

jeeplike body design; but instead of pressed sheet metal, its surface was put together entirely from components capable of being cut from flat materials (sheet metal or plywood) using subtractive machinery like cutting tables, attached to a structural frame of cut or bent steel.

A more recent modular automobile design project is Local Motors. It's an open design community with all of its thousands of designs shared under Creative Commons licenses. All of them are designed around a common light-weight chassis, which is meant to be produced economically in runs of as little as two thousand. Engines, brakes, batteries and other components are modular, so as to be interchangeable between designs. Components are produced in networks of "microfactories." The total capital outlay required to produce a Local Motors design is a little over a million dollars (compared to hundreds of millions for a conventional auto plant), with minimal inventories and turnaround times a fifth those of conventional Detroit plants.[1]

Michel Bauwens, in commenting on Hunting's remarks, notes among the "underlying trends... supporting the emergence of peer production in the physical world,"

> the 'distribution' of production capacity, i.e. lower capital requirements and modularisation making possible more decentralized and localized production, which may eventually be realized through the free self-aggregation of producers.[2]

Modular design is an example of stigmergic coordination. Stigmergy was originally a concept developed in biology, to describe the coordination of actions between a number of individual organisms through the individual response to markers, without any common decision-making process. Far from the stereotype of the "hive mind," ants—the classic example of biological stigmergy—coordinate their behavior entirely through the individual's reading of and reaction to chemical markers left by other individuals.[3] As defined in the Wikipedia entry, stigmergy is

> a mechanism of spontaneous, indirect coordination between agents or actions, where the trace left in the environment by an action stimulates the performance of a subsequent action, by the same or a different agent. Stigmergy is a form of self-organization. It produces complex, apparently intelligent structures, without need for any planning, control, or even communication between the agents. As such it supports efficient collaboration between extremely simple agents, who lack any memory, intelligence or even awareness of each other.[4]

The development of the platform is a self-contained and entirely self-directed action by an individual or a peer design group. Subsequent modules are developed with reference to the platform, but the design of each module is likewise entirely independent and self-directed; no coordination with the platform developer or the developers of other modules takes place. The effect is to break design down into numerous manageable units.

2. Reduced Transaction Costs of Aggregating Capital. We will consider the cheapening of

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1 "Jay Rogers: I Challenge You to Make Cool Cars," Alphachimp Studio Inc., November 10, 2009 <http://www.alphachimp.com/poptech-art/2009/11/10/jay-rogers-i-challenge-you-to-make-cool-cars.html>; Local Motors website at <http://www.local-motors.com>.
2 Michel Bauwens, "Contract manufacturing as distributed manufacturing," *P2P Foundation Blog*, September 11, 2008 <http://blog.p2pfoundation.net/contract-manufacturing-as-distributed-manufacturing/2008/09/11>.
3 John Robb, "Stigmergic Leaning and Global Guerrillas," *Global Guerrillas*, July 14, 2004 <http://globalguerrillas.typepad.com/globalguerrillas/2004/07/stigmergic_syst.html>.
4 "Stigmergy," *Wikipedia* <http://en.wikipedia.org/wiki/Stigmergy> (accessed September 29, 2009).

actual physical tools in the next section. But even when the machinery required for physical production is still expensive, the reduction of transaction costs involved in aggregating funds is bringing on a rapid reduction in the cost of physical production. In addition, networked organization increases the efficiency of physical production by making it possible to pool more expensive capital equipment and make use of "spare cycles." This possibility was hinted at by proposals for pooling capital outlays through cooperative organization even back in the 1970s, as we saw in the first section. But the rise of network culture takes it to a new loevel (which, again, we will consider in the next section). As a result, Stallman's distinction between "free speech" and "free beer" is eroding even when tools themselves are costly. Michel Bauwens writes:

> • P2P can arise not only in the immaterial sphere of intellectual and software production, but wherever there is access to distributed technology: spare computing cycles, distributed telecommunications and any kind of viral communicator meshwork.
>
> • P2P can arise wherever other forms of distributed fixed capital is [sic] available: such is the case for carpooling, which is the second mode of transportation in the U.S.....
>
> • P2P can arise wherever financial capital can be distributed. Initiatives such as the ZOPA bank point in that direction. Cooperative purchase and use of large capital goods are a possibility....[1]

As the reference to "distributed financial capital" indicates, the availability of crowdsourced and distributed means of aggregating dispersed capital is as important as the implosion of outlay costs for actual physical capital. A good example of such a system is the Open Source Hardware Bank, a microcredit network organized by California hardware hackers to pool capital for funding new open source hardware projects.[2]

The availability (or unavailability) of capital to working class people will have a significant effect on the rate of self-employment and small business formation. The capitalist credit system, in particular, is biased toward large-scale, conventional, absentee-owned firms. David Blanchflower and Andrew Oswald[3] found that childhood personality traits and test scores had almost no value in predicting adult entrepreneurship. On the other hand, access to startup capital was the single biggest factor in predicting self-employment. There is a strong correlation between self-employment and having received an inheritance or a gift.[4] NSS data indicate that most small businesses were begun not with bank loans but with own or family money...."[5] The clear implication is that there are "undesirable impediments to the market supply of entrepreneurship."[6] In short, the bias of the capitalist credit system toward conventional capitalist enterprise means that the rate of wage employment is higher, and self-employment is lower, than their likely free market values. The lower the capital outlays required for self-employment, and the easier it is to aggregate such capital outside the capitalist credit system, the more self-employment will grow as a share of the total labor market.

Jed Harris, at *Anomalous Presumptions* blog, reiterates Bauwens' point that peer production makes

1 Bauwens, "The Political Economy of Peer Production," *CTheory*, December 2005 <http://www.ctheory.net/articles.aspx?id=499>.
2 Priya Ganapati, "Open Source Hardware Hackers Start P2P Bank," *Wired*, March 18, 2009 <http://www.wired.com/gadgetlab/2009/03/open-source-har/>.
3 David G. Blanchflower and Andrew J. Oswald, "What Makes an Entrepreneur?" <http://www2.warwick.ac.uk/fac/soc/economics/staff/faculty/oswald/entrepre.pdf>. Later appeared in Journal of Labor Economics, 16:1 (1998), pp. 26-60.
4 Ibid., p. 2.
5 Ibid., p. 28.
6 Ibid., p. 3.

it possible to produce without access to large amounts of capital. “The change that enables widespread peer production is that today, an entity can become self-sustaining, and even grow explosively, with very small amounts of capital. As a result it doesn’t need to trade ownership for capital, and so it doesn’t need to provide any return on investment.”[1]

Charles Johnson adds that, because of the new possibilities the Internet provides for lowering the transaction costs entailed in networked mobilization of capital, peer production can take place even when significant capital investments are required—without relying on finance by large-scale sources of venture capital:

> it’s not just a matter of projects being able to expand or sustain themselves with little capital.... It’s also a matter of the way in which both emerging distributed technologies in general, and peer production projects in particular, facilitate the aggregation of dispersed capital—without it having to pass through a single capitalist chokepoint, like a commercial bank or a venture capital fund.... Meanwhile, because of the way that peer production projects distribute their labor, peer-production entrepreneurs can also take advantage of spare cycles on existing, widely-distributed capital goods—tools like computers, facilities like offices and houses, software, etc. which contributors own, which they still would have owned personally or professionally whether or not they were contributing to the peer production project.... So it’s not just a matter of cutting total aggregate costs for capital goods...; it’s also, importantly, a matter of new models of aggregating the capital goods to meet whatever costs you may have, so that small bits of available capital can be rounded up without the intervention of money-men and other intermediaries.[2]

So network organization not only lowers the transaction costs of aggregating capital for the purchase of physical means of production, but also increases the utilization of the means of production when they are expensive.

3. Reduced Capital Outlays for Physical Production. As described so far, the open-source model only removes proprietary rents from the portion of the production process—the design stage—that has no material cost, and from the process of aggregating capital. As Richard Stallman put it, to repeat, it's about “free speech” rather than “free beer.” Simply removing proprietary rents from design, and removing all transaction costs from the free transfer of digital designs for automated production, will have a revolutionary effect by itself. Marcin Jakubowski, of Factor E Farm, writes:

> The unique contribution of the information age arises in the proposition that data at one point in space allows for fabrication at another, using computer numerical control (CNC) of fabrication. This sounds like an expensive proposition, but that is not so if open source fabrication equipment is made available. With low cost equipment and software, one is able to produce or acquire such equipment at approximately $5k for a fully-equipped lab with metal working, cutting, casting, and electronics fabrication, assisted by open source CNC.[3]

But as Jakubowski's reference to the declining cost of fabrication equipment suggests, the revolution in open-source manufacturing goes beyond the design stage, and promises to change the way physical production itself is organized. Chris Anderson is not the first, and probably won't be the last, to point to the parallels between what the desktop computer revolution did to the information and

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1 Jed Harris, "Capitalists vs. Entrepreneurs," *Anomalous Presumptions*, February 26, 2007 <http://jed.jive.com/?p=23>.
2 Charles Johnson, "Dump the rentiers off your back," *Rad Geek People's Daily*, May 29, 2008 <http://radgeek.com/gt/2008/05/29/dump_the/>.
3 Marcin Jakubowski, “OSE Proposal—Towards a World Class Open Source Research and Development Facility,” v0.12, January 16, 2008 <http://openfarmtech.org/OSE_Proposal.doc> (accessed August 25, 2009).

culture industries, and what the desktop manufacturing revolution will do in the physical realm:

> The tools of factory production, from electronics assembly to 3-D printing, are now available to individuals, in batches as small as a single unit. Anybody with an idea and a little expertise can set assembly lines in China into motion with nothing more than some keystrokes on their laptop. A few days later, a prototype will be at their door, and once it all checks out, they can push a few more buttons and be in full production, making hundreds, thousands, or more. They can become a virtual micro-factory, able to design and sell goods without any infrastructure or even inventory; products can be assembled and drop-shipped by contractors who serve hundreds of such customers simultaneously.
>
> Today, micro-factories make everything from cars to bike components to bespoke furniture in any design you can imagine. The collective potential of a million garage tinkerers is about to be unleashed on the global markets, as ideas go straight into production, no financing or tooling required. “Three guys with laptops” used to describe a Web startup. Now it describes a hardware company, too.
>
> “Hardware is becoming much more like software,” as MIT professor Eric von Hippel puts it. That’s not just because there’s so much software in hardware these days, with products becoming little more than intellectual property wrapped in commodity materials, whether it’s the code that drives the off-the-shelf chips in gadgets or the 3-D design files that drive manufacturing. It’s also because of the availability of common platforms, easy-to-use tools, Web-based collaboration, and Internet distribution.
>
> We’ve seen this picture before: It’s what happens just before monolithic industries fragment in the face of countless small entrants, from the music industry to newspapers. Lower the barriers to entry and the crowd pours in....
>
> A garage renaissance is spilling over into such phenomena as the booming Maker Faires and local “hackerspaces.” Peer production, open source, crowdsourcing, user-generated content—all these digital trends have begun to play out in the world of atoms, too. The Web was just the proof of concept. Now the revolution hits the real world.
>
> In short, atoms are the new bits.[1]

We already saw, in Chapter Three, what this meant from the standpoint of investors: they're suffering from the superfluity of most investment capital, resulting from the emerging possibility of small producers and entrepreneurs owning their own factories. From the perspective of the small producer and entrepreneur, the same trend is a good thing because it enables them to own their own factories without any dependency on finance capital. Innovations not only in small-scale manufacturing technology, but in networked communications technology for distribution and marketing, are increasingly freeing producers from the need for large amounts of capital. Charles Hugh Smith writes:

> What I find radically appealing is not so much the technical aspects of desktop/workbench production of parts which were once out of financial reach of small entrepreneurs—though that revolution is the enabling technology—it is the possibility that entrepreneurs *can own the means of production without resorting to vulture/bank investors/loans*.
>
> Anyone who has been involved in a tech startup knows the drill--in years past, a tech startup required millions of dollars to develop a new product or the IP (intellectual property). To raise the capital required, the entrepreneurs had to sell their souls (and company) to venture capital (vulture capital) "investors" who simply took ORPM (other rich people's money) and put it to work, taking much of the value of new

1 Chris Anderson, “In the Next Industrial Revolution, Atoms Are the New Bits,” *Wired*, January 25, 2010 <http://www.wired.com/magazine/2010/01/ff_newrevolution/all/1>.

promising companies in trade for their scarce and costly capital.

The only alternative were banks, who generally shunned "speculative investments" (unless they were in the billions and related to derivatives, heh).

So entrepreneurs came up with the ideas and did all the hard work, and then vulture capital swooped in to rake off the profits, all the while crying bitter tears about the great risks they were taking with other rich people's spare cash.

Now that these production tools are within reach of small entrepreneurs, the vulture capital machine will find less entrepreneural fodder to exploit. The entrepreneurs themselves can own/rent the *means of production*.

That is a fine old Marxist phrase for the tools and plant which create value and wealth. Own that and you create your own wealth.

In the post-industrial economies of the West and Asia, distribution channels acted as means of wealth creation as well: you want to make money selling books or music, for instance, well, you had to sell your product to the owners of the distribution channels: the record labels, film distributors, book publishers and retail cartels, all of whom sold product through reviews and adverts in the mainstream media (another cartel).

The barriers to entry were incredibly high. It took individuals of immense wealth (Spielberg, et al.) to create a new film studio from scratch (DreamWorks) a few years ago. Now any artist can sell their music/books via the Web, completely bypassing the gatekeepers and distribution channels.

I**n a great irony, publishers and labels are now turning to the Web to sell their product.** If all they have is the Web, then what value can they add? I fully expect filmakers to go directly to the audience via the Web in coming years and bypass the entire film distribution cartel entirely.

Why go to Wal-Mart to buy a DVD when you can download hundreds of new films off the Web?

Both the supply chain and distribution cartels are being blown apart by the Web. Not only can entrepreneurs own/rent the means of production and arrange their own supply/assembly chains, they can also own their own distribution channels.

The large-scale factory/distribution model is simply no longer needed for many products. As the barriers to owning the means of production and distribution fall, a Renaissance in small-scale production and wealth creation becomes not just possible but inevitable.[1]

Even without the latest generation of low-cost digital fabrication machinery, the kind of flexible manufacturing network that exists in Emilia-Romagna or Shenzen is ideally suited to the open manufacturing philosophy. Tom Igoe writes:

There are some obvious parallels here [in the shanzhai manufacturers of China—see Chapter Four] to the open hardware community. Businesses like Spark Fun, Adafruit, Evil Mad Scientist, Arduino, Seeed Studio, and others thrive by taking existing tools and products, re-combining them and repackaging them in more usable ways. We borrow from each other and from others, we publish our files for public use, we improve upon each others' work, and we police through licenses such as the General Public License, and continual discussion between competitors and partners. We also revise products constantly and make our

1 Charles Hugh Smith, "The Future of Manufacturing in the U.S." oftwominds, February 5, 2010 <http://charleshughsmith.blogspot.com/2010/02/future-of-manufacturing-in-us.html>.

businesses based on relatively small runs of products tailored to specific audiences.[1]

The intersection of the open hardware and open manufacturing philosophies with the current model of flexible manufacturing networks will be enabled, Igoe argues, by the availability of

> **Cheap tools.** Laser cutters, lathes, and milling machines that are affordable by an individual or a group. This is increasingly coming true. The number of colleagues I know who have laser cutters and mills in their living rooms is increasing (and their asthma is worsening, no doubt). There are some notable holes in the open hardware world that exist partially because the tools aren't there. Cheap injection molding doesn't exist yet, but injection molding services do, and they're accessible via the net. But when they're next door (as in Shenzen), you've got a competitive advantage: your neighbor.[2]

(Actually hand-powered, small-scale injection molding machines are now available for around $1500, and Kenner marketed a fully functional "toy" injection molding machine for making toy soldiers, tanks, and the like back in the 1960s.)[3]

And the flexible manufacturing network, unlike the transnational corporate environment, is actively conducive to the sharing of knowledge and designs.

> **Open manufacturing information.** Manufacturers in this scenario thrive on adapting existing products and services. Call them knockoffs or call them new hybrids, they both involve reverse engineering something and making it fit your market. Reverse engineering takes time and money. When you're a mom & pop shop, that matters a lot more to you. If you've got a friend or a vendor who's willing to do it for you as a service, that helps. But if the plans for the product you're adapting are freely available, that's even better. In a multinational world, open source manufacturing is anathema. Why would Nokia publish the plans for a phone when they could dominate the market by doing the localization themselves? But in a world of networked small businesses, it spurs business. You may not have the time or interest in adapting your product for another market, but someone else will, and if they've got access to your plans, they'll be grateful, and will return the favor, formally or informally.[4]

The availability of modestly priced desktop manufacturing technology (about which we will see more immediately below), coupled with the promise of crowdsourced means of aggregating capital, has led to a considerable shift in opinion in the peer-to-peer community, as evidenced by Michel Bauwens:

> I used to think that the model of peer production would essentially emerge in the immaterial sphere, and in those cases where the design phase could be split from the capital-intensive physical production sphere....
>
> However, as I become more familiar with the advances in Rapid Manucturing [sic]... and Desktop Manufacturing..., I'm becoming increasingly convinced of the strong trend towards the distribution of physical capital.
>
> If we couple this with the trend towards the direct social production of money (i.e. the distribution of financial capital...) and the distribution of energy...; and how the two latter trends are interrelated..., then I believe we have very strong grounds to see a strong expansion of p2p-based modalities in the physical sphere.[5]

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1 Tom Igoe, "Idle speculation on the shan zhai and open fabrication," *hello* blog, September 4, 2009 <http://www.tigoe.net/blog/category/environment/295/>.
2 Ibid.
3 Joseph Flaherty, "Desktop Injection Molding," *Replicator*, February 1, 2020 <http://replicatorinc.com/blog/2010/02/desktop-injection-molding>.
4 Igoe, op. Cit.
5 Michel Bauwens post to Institute for Distributed Creativity email list, May 7, 2007.

The conditions of physical production have, in fact, experienced a transformation almost as great as that which digital technology has brought about on immaterial production. The "physical production sphere" itself has become far less capital-intensive. If the digital revolution has caused an implosion in the physical capital outlays required for the information industries, the revolution in garage and desktop production tools promises an analogous effect almost as great on many kinds of manufacturing. The radical reduction in the cost of machinery required for many kinds of manufacturing has eroded Stallman's distinction between "free speech" and "free beer." Or as Chris Anderson put it, "Atoms would like to be free, too, but they're not so pushy about it."[1]

The same production model sweeping the information industries, networked organization of people who own their own production tools, is expanding into physical manufacturing. A revolution in cheap, general purpose machinery, and a revolution in the possibilities for networked design made possible by personal computers and network culture, according to Johann Soderberg, is leading to

> an extension of the dream that was pioneered by the members of the Homebrew Computer Club [i.e., a cheap computer able to run on the kitchen table]. It is the vision of a universal factory able to run on the kitchen table.... [T]he desire for a 'desktop factory' amounts to the same thing as the reappropriation of the means of production.[2]

Clearly, the emergence of cheap desktop technology for custom machining parts in small batches will greatly lower the overall capital outlays needed for networked physical production of light and medium consumer goods.

We've already seen the importance of the falling costs of small-scale production machinery made possible by the Japanese development of small CNC machines in the 1970s. That is the technological basis of the flexible manufacturing networks we examined in the last chapter.

When it comes to the "Homebrew" dream of an actual desktop factory, the most promising current development is the Fab Lab. The concept started with MIT's Center for Bits and Atoms. The original version of the Fab Lab included CNC laser cutters and milling machines, and a 3-D printer, for a total cost of around $50,000.[3]

Open-source versions of the machines in the Fab Lab have brought the cost down to around $2-5,000.

One important innovation is the multimachine, an open-source, multiple-purpose machine tool that includes drill press, lathe and milling machine; it can be modified for computerized numeric control. The multimachine was originally developed by Pat Delaney, whose YahooGroup has grown into a design community and support network of currently over five thousand people.[4]

As suggested by the size of Delaney's YahooGroup membership, the multimachine has been taken up independently by open-source developers all around the world. The Open Source Ecology design community, in particular, envisions a Fab Lab which includes a CNC multimachine as "the central tool

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<https://lists.thing.net/pipermail/idc/2007-May/002479.html>

1 Chris Anderson, *Free: The Future of a Radical Price* (New York: Hyperion, 2009), p. 241.

2 Soderberg, *Hacking Capitalism*, pp. 185-186.

3 MIT Center for Bits and Atoms, "Fab Lab FAQ" <http://fab.cba.mit.edu/about/faq/> (accessed August 31, 2009).

4 "Multimachine," *Wikipedia* <http://en.wikipedia.org/wiki/Multimachine> (accessed August 31, 2009>; <http://groups.yahoo.com/group/multimachine/>.

piece of a flexible workshop... eliminating thousands of dollars of expenditure requirement for similar abilities" and serving as "the centerpieces enabling the fabrication of electric motor, CEB, sawmill, OSCar, microcombine and all other items that require processes from milling to drilling to lathing."[1]

> It is a high precision mill-drill-lathe, with other possible functions, where the precision is obtained by virtue of building the machine with discarded engine blocks....
>
> The central feature of the Multimachine is the concept that either the tool or the workpiece rotates when any machining operation is performed. As such, a heavy-duty, precision spindle (rotor) is the heart of the Multimachine—for milling, drilling and lathing applications. The precision arises from the fact that the spindle is secured within the absolutely precise bore holes of an engine block, so precision is guaranteed simply by beginning with an engine block.
>
> If one combines the Multimachine with a CNC XY or XYZ movable working platform—similar to ones being developed by the Iceland Fab Lab team[2], RepRap[3], CandyFab 4000[4] team, and others—then a CNC mill-drill-lathe is the result. At least Factor 10 reduction in price is then available compared to the competition. The mill-drill-lathe capacity allows for the subtractive fabrication of any allowable shape, rotor, or cylindrically-symmetric object. Thus, the CNC Multimachine can be an effective cornerstone of high precision digital fabrication—down to 2 thousandths of an inch.
>
> Interesting features of the Multimachine are that the machines can be scaled from small ones weighing a total of ~1500 lb to large ones weighing several tons, to entire factories based on the Multimachine system. The CNC XY(Z) tables can also be scaled according to the need, if attention to this point is considered in development. The whole machine is designed for disassembly. Moreover, other rotating tool attachments can be added, such as circular saw blades and grinding wheels. The overarm included in the basic design is used for metal forming operations.
>
> Thus, the Multimachine is an example of appropriate technology, where the user is in full control of machine building, operation, and maintenance. Such appropriate technology is conducive to successful small enterprise for local community development, via its low capitalization requirement, ease of maintenance, scaleability and adaptability, and wide range of products that can be produced. This is relevant both in the developing world and in industrialized countries.[5]

The multimachine, according to Delaney, “can be built by a semi-skilled mechanic using just common hand tools,” from discarded engine blocks, and can be scaled from “a closet size version” to “one that would weigh 4 or 5 tons.”[6]

In developing countries, in particular, the kinds of products that can be built with a multimachine include:

> AGRICULTURE:
> Building and repairing irrigation pumps and farm implements.
>
> WATER SUPPLIES:
> Making and repairing water pumps and water-well drilling rigs.

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1 "Multimachine & Flex Fab--Open Source Ecology" <http://openfarmtech.org/index.php?title=Multimachine_%26_Flex_Fab>.
2 <http://smari.yaxic.org/blag/2007/11/14/the-routing-table/> (note in quoted text).
3 <http://reprap.org/bin/view/Main/RepRap>. (note in quoted text).
4 <http://www.makingthings.com/projects/CandyFab-4000> (note in quoted text).
5 Jakubowski, “OSE Proposal.”
6 <http://groups.yahoo.com/group/multimachine/?yguid=234361452>.

FOOD SUPPLIES:
Building steel-rolling-and-bending machines for making fuel efficient cook stoves and other cooking equipment.

TRANSPORTATION:
Anything from making cart axles to rebuilding vehicle clutch, brake, and other parts....

JOB CREATION:
A group of specialized but easily built MultiMachines can be combined to form a small, very low cost, metal working factory which could also serve as a trade school. Students could be taught a single skill on a specialized machine and be paid as a worker while learning other skills that they could take elsewhere.[1]

More generally, a Fab Lab (i.e. a digital flexible fabrication facility centered on the CNC multimachine along with a CNC cutting table and open-source 3-D printer like RepRap) can produce virtually anything—especially when coupled with the ability of such machinery to run open-source design files.

> Flexible fabrication refers to a production facility where a small set of non-specialized, general-function machines (the 5 items mentioned [see below]) is capable of producing a wide range of products if those machines are operated by skilled labor. It is the opposite of mass production, where unskilled labor and specialized machinery produce large quantities of the same item (see section *II, Economic Base*). When one adds *digital fabrication* to the flexible fabrication mix—then the skill level on part of the operator is reduced, and the rate of production is increased.
>
> Digital fabrication is the use of computer-controlled fabrication, as instructed by data files that generate tool motions for fabrication operations. Digital fabrication is an emerging byproduct of the computer age. It is becoming more accessible for small scale production, especially as the influence of open source philosophy is releasing much of the know-how into non-proprietary hands. For example, the Multimachine is an open source mill-drill-lathe by itself, but combined with computer numerical control (CNC) of the workpiece table, it becomes a digital fabrication device.
>
> It should be noted that open access to digital design—perhaps in the form a global repository of shared open source designs—introduces a unique contribution to human prosperity. This contribution is the possibility that data at one location in the world can be translated immediately to a product in any other location. This means anyone equipped with flexible fabrication capacity can be a producer of just about any manufactured object. The ramifications for localization of economies are profound, and leave the access to raw material feedstocks as the only natural constraint to human prosperity.[2]

Open Source Ecology, based on existing technology, estimates the cost of producing a CNC multimachine with their own labor at $1500.[3] The CNC multimachine is only one part of a projected "Fab Lab," whose total cost of construction will be a few thousand dollars.

1. CNC Multimachine—Mill, drill, lathe, metal forming, other grinding/cutting. This constitutes a robust machining environment that may be upgraded for open source computer numerical control by OS software, which is in development.[4]

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1 <http://opensourcemachine.org/node/2>.
2 Jakubowski, "OSE Proposal."
3 Marcin Jakubowski, "Rapid Prototyping for Industrial Swadeshi," Factor E Farm Weblog, August 10, 2008 <http://openfarmtech.org/weblog/?p=293>. "Open Source Fab Lab," Open Source Ecology wiki (accessed August 22, 2009) <http://openfarmtech.org/index.php?title=Open_Source_Fab_Lab>.
4 Open source CNC code is being developed by Smari McCarthy of the Iceland Fab Lab,

2. XYZ-controlled torch and router table—can accommodate an acetylene torch, plasma cutter, router, and possibly CO_2 laser cutter diodes
3. Metal casting equipment—all kinds of cast parts from various metals
4. Plastic extruder—extruded sheet for advanced glazing, and extruded plastic parts or tubing
5. Electronics fabrication—oscilloscope, circuit etching, others—for all types of electronics from power control to wireless communications.

> This equipment base is capable of producing just about anything—electronics, electromechanical devices, structures, and so forth. The OS Fab Lab is crucial in that it enables the self-replication of all the 16 technologies.[1]

(The "16 technologies" refers to Open Source Ecology's entire line of sixteen products, including not only construction and energy generating equipment, a tractor, and a greenhouse, but using the Fab Lab to replicate the five products in the Fab Lab itself. See the material on OSE in the Appendix.)

Another major component of the Fab Lab, the 3-D printer, sells at a price starting at over $20,000 for commercial versions. The RepRap, an open-source 3-D printer project, has reduced the cost to around $500.[2] MakerBot[3] is a closely related commercial 3-D printer project, an offshoot of RepRap that shares much of its staff in common.[4] Makerbot has a more streamlined, finished (i.e., commercial-looking) appearance. Unlike RepRap, it doesn't aim at total self-replicability; rather, most of its parts are designed to be built with a laser cutter.[5]

3-D printers are especially useful for making casting molds. Antique car enthusiast Jay Leno, in a recent issue of *Popular Mechanics*, described the use of a combination 3-D scanner/3-D printer to create molds for out-of-production parts for old cars like his 1907 White Steamer.

> The 3D printer makes an exact copy of a part in plastic, which we then send out to create a mold....
>
> The NextEngine scanner costs $2995. The Dimension uPrint Personal 3D printer is now under $15,000. That's not cheap. But this technology used to cost 10 times that amount. And I think the price will come down even more.[6]

Well, yeah—especially considering RepRap can *already* be built for around $500 in parts. Even the Desktop Factory, a commercial 3-D printer, sells for about $5,000.[7]

Automated production with CNC machinery, Jakubowski argues, holds out some very exciting possibilities for producing at rates competitive with conventional industry.

> It should be pointed out that a particularly exciting enterprise opportunity arises from automation of fabrication, such as arises from computer numerical control. For example, the sawmill and CEB discussed

<http://smari.yaxic.org/blag/2007/11/14/the-routing-table/>.
1 Jakubowski, "OSE Proposal."
2 RepRap site <http://reprap.org/bin/view/Main/WebHome>; "RepRap Project," Wikipedia <http://en.wikipedia.org/wiki/RepRap_Project> (accessed August 31, 2009).
3 <http://makerbot.com/>
4 Keith Kleiner, "3D Printing and Self-Replicating Machines in Your Living Room—Seriously," *Singularity Hub*, April 9, 2009 <http://singularityhub.com/2009/04/09/3d-printing-and-self-replicating-machines-in-your-living-room-seriously/>.
5 "What is the relationship between RepRap and Makerbot?" *Hacker News* <http://news.ycombinator.com/item?id=696785>.
6 Jay Leno, "Jay Leno's 3-D Printer Replaces Rusty Old Parts," *Popular Mechanics*, July 2009 <http://www.popularmechanics.com/automotive/jay_leno_garage/4320759.html?page=1>.
7 <http://www.desktopfactory.com/>.

above are made largely of DfD, bolt-together steel. This lends itself to a fabrication procedure where a CNC XYZ table could cut out all the metal, including bolt holes, for the entire device, in a fraction of the time that it would take by hand. As such, complete sawmill or CEB kits may be fabricated and collected, ready for assembly, on the turn-around time scale of days....

The digital fabrication production model may be equivalent in production rates to that of any large-scale, high-tech firms.[1]

The concept of a CNC XYZ table is powerful. It allows one to prepare all the metal, such as that for a CEB press or the boundary layer turbine, with the touch of a button if a design file for the toolpath is available. This indicates on-demand fabrication capacity, at production rates similar to that of the most highly-capitalized industries. With modern technology, this is doable at low cost. With access to low-cost computer power, electronics, and open source blueprints, the capital needed for producing a personal XYZ table is reduced merely to structural steel and a few other components: it's a project that requires perhaps $1000 to complete.[2]

(Someone's actually developed a CNC XYZ cutting table for $100 in materials, although the bugs are not yet completely worked out.)[3]

Small-scale fabrication facilities of the kind envisioned at Factor E Farm, based on CNC multimachines, cutting tables and 3D printers, can even produce motorized vehicles like passenger cars and tractors, when the heavy engine block is replaced with light electric motor. Such electric vehicles, in fact, are part of the total product package at Factor E Farm.

The central part of a car is its propulsion system. *Fig. 6* shows a *fuel* source feeding a *heat generator*, which heats a flash steam generator *heat exchanger*, which drives a *boundary layer turbine*, which drives a *wheel motor* operating as an electrical generator. The electricity that is generated may either be fed into *battery storage*, or controlled by *power electronics* to drive 4 separate wheel motors. This constitutes a hybrid electric vehicle, with 4 wheel drive in this particular implementation.

This hybrid electric vehicle is one of intermediate technology design that may be fabricated in a small-scale, flexible workshop. The point is that a complicated power delivery system (clutch-transmission-drive shaft-differential) has been replaced by four electrical wires going to the wheel electrical motors. This simplification results in high localization potential of car manufacturing.

The first step in the development of open source, Hypercar-like vehicles is the propulsion system, for which the boundary layer turbine hybrid system is a candidate. Our second step will be structural optimization for lightweight car design.[4]

The CubeSpawn project is also involved in developing a series of modular desktop machine tools. The first stage is a cubical 3-axis milling machine (or "milling cell"). The next step will be to build a toolchanger and head changer so the same cubical framework and movement controls can be used for a 3-D printer.[5]

It starts by offering a simple design for a 3 axis, computer controlled milling machine.

With this resource, you have the ability to make a significant subset of all the parts in existence! So,

1 Jakubowski, "OSE Proposal."
2 Ibid.
3 "CNC machine v2.0 - aka 'Valkyrie'," *Let's Make Robots*, July 14, 2009 <http://letsmakerobots.com/node/9006>.
4 Jakubowski, "OSE Proposal."
5 <http://www.cubespawn.com/>.

parts for additional machines can be made on the mill, allowing the system to add to itself, all based on standards to promote interoperability....

The practical consequence is a self expanding factory that will fit in a workshop or garage....

Cross pollenization with other open source projects is inevitable and beneficial although at first, commercial products will be used if no open source product exists. This has already begun, and CubeSpawn uses 5 other open source+ projects as building blocks in its designs These are electronics from the Sanguino / RepRap specific branch of the Arduino project, Makerbeam for cubes of small dimensions, and the EMC control software for an interface to individual cells. There is an anticipated use of SKDB for part version and cutting geometry file retrieval, with Debian Linux as a central host for the system DB....

By offering a standardized solution to the problems of structure, power connections, data connections, inter-cell transport, and control language, we can bring about an easier to use framework to collaborate on. The rapid adoption of open source hardware should let us build the “better world” industry has told us about for over 100 years.[1]

With still other heads, the same framework can be used as a cutting table.

If these examples are not enough, the P2P Foundation's “Product Hacking” page provides, under the heading of “Production/Machinery,” a long list of open-source CNC router, cutting table, 3-D printer, modular electronics, and other projects.[2]

One promising early attempt at distributed garage manufacturing is 100kGarages, which we will examine in some detail in the Appendix. 100kGarages is a joint effort of the ShopBot 3-axis router company and the Ponoko open design network (which itself linked a library of designs to local Makers with CNC laser cutters).

Besides Ponoko, a number of other commercial firms have appeared recently which offer production of custom parts to the customer's digital design specifications, at a modest price, using small-scale, multipurpose desktop machinery. Two of the most prominent are Big Blue Saw[3] and eMachineShop.[4] The way the latter works, in particular, is described in a *Wired* article:

> The concept is simple: Boot up your computer and design whatever object you can imagine, press a button to send the CAD file to Lewis' headquarters in New Jersey, and two or three weeks later he'll FedEx you the physical object. Lewis launched eMachineShop a year and a half ago, and customers are using his service to create engine-block parts for hot rods, gears for home-brew robots, telescope mounts—even special soles for tap dance shoes.[5]

Another project of the same general kind was just recently announced: CloudFab, which offers access to a network of job-shops with 3-D printers.[6] Also promising is mobile manufacturing (Factory in a Box).[7]

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1 “CubeSpawn, An open source, Flexible Manufacturing System (FMS)” <http://www.kickstarter.com/projects/1689465850/cubespawn-an-open-source-flexible-manufacturing>.
2 <http://p2pfoundation.net/Product_Hacking#Production.2FMachinery>.
3 <http://www.bigbluesaw.com/saw/>.
4 <http://www.emachineshop.com/> (see also <www.barebonespcb.com/!BB1.asp>).
5 Clive Thompson, "The Dream Factory," *Wired*, September 2005 <http://www.wired.com/wired/archive/13.09/fablab_pr.html>.
6 “The CloudFab Manifesto,” *Ponoko Blog*, September 28, 2009 <http://blog.ponoko.com/2009/09/28/the-cloudfab-manifesto/>.
7 Carin Stillstrom and Mats Jackson, "The Concept of Mobile Manufacturing," *Journal of Manufacturing Systems* 26:3-4

Building on our earlier speculation about networked small machine shops and hobbyist workshops, new desktop manufacturing technology offers an order of magnitude increase in the quality of work that can be done for the most modest expense.

Kevin Kelly argues that the actual costs of physical production are only a minor part of the cost of manufactured goods.

> ....material industries are finding that the costs of duplication near zero, so they too will behave like digital copies. Maps just crossed that threshold. Genetics is about to. Gadgets and small appliances (like cell phones) are sliding that way. Pharmaceuticals are already there, but they don't want anyone to know. It costs nothing to make a pill.[1]

If, as Kelley suggests, the cheapness of digital goods reflects the imploding cost of copying them, it follows that the falling cost of “copying” physical goods will follow the same pattern.

There is a common thread running through all the different theories of the interface between peer production and the material world: as technology for physical production becomes feasible on increasingly smaller scales and at less cost, and the transaction costs of aggregating small units of capital into large ones fall, there will be less and less disconnect between peer production and physical production.

It's worth repeating one last time: the distinction between Stallman's "free speech" and "free beer" is eroding. To the extent that embedded rents on "intellectual property" are a significant portion of commodity prices, "free speech" (in the sense of the free use of ideas) will make our "beer" (i.e., the price of manufactured commodities) at least a lot cheaper. And the smaller the capital outlays required for physical production, the lower the transaction costs for aggregating capital, and the lower the overhead, the cheaper the beer becomes as well.

If, as we saw Sabel and Piore say above, the computer is a textbook example of an artisan's tool—i.e., an extension of the user's creativity and intellect—then small-scale, computer-controlled production machinery is a textbook illustration of E. F. Schumacher's principles of appropriate technology:

- cheap enough that they are accessible to virtually everyone;
- suitable for small-scale application; and
- compatible with man's need for creativity.

D. The Microenterprise

We have already seen, in Chapter Four, the advantages of low overhead and small batch production that lean, flexible manufacturing offers over traditional mass-production industry. The household microenterprise offers these advantages, but increased by another order of magnitude. As we saw Charles Johnson suggest above, the use of “spare cycles” of capital goods people own anyway results

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(July 2007) <http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VJD-4TK3FG8-6&_user=108429&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_version=1&_urlVersion=0&_userid=108429&md5=bf6e603b5de29cdfd026d5d00379877c>.

1 Kevin Kelly, "Better Than Free," *The Technium*, January 31, 2008 <http://www.kk.org/thetechnium/archives/2008/01/better_than_fre.php>.

in enormous cost efficiencies.

Consider, for example, the process of running a small, informal brew pub or restaurant out of your home, under a genuine free market regime. Buying a brewing vat and a few small fermenters for your basement, using a few tables in a remodeled spare room as a public restaurant area, etc., would require a small bank loan for at most a few thousand dollars. And with that capital outlay, you could probably make payments on the debt with the margin from one customer a day. A few customers evenings and weekends, probably found mainly among your existing circle of acquaintances, would enable you to initially shift some of your working hours from wage labor to work in the restaurant, with the possibility of gradually phasing out wage labor altogether or scaling back to part time, as you built up a customer base. In this and many other lines of business (for example a part-time gypsy cab service using a car and cell phone you own anyway), the minimal entry costs and capital outlay mean that the minimum turnover required to pay the overhead and stay in business would be quite modest. In that case, a lot more people would be able to start small businesses for supplementary income and gradually shift some of their wage work to self employment, with minimal risk or sunk costs.

But that's *illegal*. You have to buy an extremely expensive liquor license, as well as having an industrial sized stove, dishwasher, etc. You have to pay rent on a separate, dedicated commercial building. And that level of capital outlay can only be paid off with a large dining room and a large kitchen/waiting staff, which means you have to keep the place filled or the overhead costs will eat you alive—in other words, Chapter Eleven. These high entry costs and the enormous overhead are the reason you can't afford to start out really small and cheap, and the reason restaurants have such a high failure rate. It's illegal to use the surplus capacity of the ordinary household items we have to own anyway but remain idle most of the time (including small-scale truck farming): e.g. RFID chip requirements and bans on unpasteurized milk, high fees for organic certification, etc., which make it prohibitively expensive to sell a few hundred dollars surplus a month from the household economy. As Roderick Long put it,

> In the absence of licensure, zoning, and other regulations, how many people would start a restaurant today if all they needed was their living room and their kitchen? How many people would start a beauty salon today if all they needed was a chair and some scissors, combs, gels, and so on? How many people would start a taxi service today if all they needed was a car and a cell phone? How many people would start a day care service today if a bunch of working parents could simply get together and pool their resources to pay a few of their number to take care of the children of the rest? These are not the sorts of small businesses that receive SBIR awards; they are the sorts of small businesses that get hammered down by the full strength of the state whenever they dare to make an appearance without threading the lengthy and costly maze of the state's permission process.[1]

Shawn Wilbur, an anarchist writer with half a lifetime in the bookselling business, describes the resilience of a low-overhead business model: "My little store was enormously efficient, in the sense that it could weather long periods of low sales, and still generally provide new special order books in the same amount of time as a Big Book Bookstore." The problem was that, with the state-imposed paperwork burden associated with hiring help, it was preferable—i.e. less complicated—to work sixty-hour weeks.[2] The state-imposed administrative costs involved in the cooperative organization of labor amount to an entry barrier that can only be hurdled by the big guy. After some time out of the business of independent bookselling and working a number of wage-labor gigs in chain bookstores, Wilbur has

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1 Roderick Long, "Free Market Firms: Smaller, Flatter, and More Crowded," *Cato Unbound*, November 25, 2008 <http://www.cato-unbound.org/2008/11/25/roderick-long/free-market-firms-smaller-flatter-and-more-crowded/>.

2 Comment under Shawn Wilbur, "Who benefits most economically from state centralization" *In the Libertarian Labyrinth*, December 9, 2008 <http://libertarian-labyrinth.blogspot.com/2008/12/who-benefits-most-economically-from.html>.

recently announced the formation of Corvus—a micropublishing operation that operates on a print-on-demand basis.[1] In response to my request for information on his business model, Wilbur wrote:

> In general..., Corvus Editions is a hand-me-down laptop and a computer that should probably have been retired five years ago, and which has more than paid for itself in my previous business, some software, all of which I previously owned and none of which is particularly new or spiffy, a $20 stapler, a $150 laser printer, a handful of external storage devices, an old flatbed scanner, the usual computer-related odds and ends, and the fruits of thousands of hours of archival research and sifting through digital sources (all of which fits on a single portable harddrive.) The online presence did not involve any additional expense, beyond the costs of the free archive, except for a new domain name. My hosting costs, including holding some domain registrations for friendly projects, total around $250/year, but the Corvus site and shop could be hosted for $130.
>
> Because Portland has excellent resources for computer recycling and the like, I suspect a similar operation, minus the archive, using free Linux software tools, could almost certainly be put together for less than $500, including a small starting stock of paper and toner—and perhaps more like $300.

The cost of materials is some 20% of Wilbur's retail price on average, with the rest of the price being compensation free and clear for his labor: "the service of printing, folding, stapling and shipping...." There are no proprietary rents because the pdf files are themselves free for download; Wilbur makes money entirely from the convenience-value of his doing those printing, etc., services for the reader.[2]

As an example of a more purely service-oriented microenterprise, Steve Herrick describes the translators' cooperative he's a part of:

> ...We effectively operate as a job shop. Work comes in from clients, and our coordinator posts the offer on email. People offer to take it as they're available. So far, the supply and demand have been roughly equal. When multiple people are available, members take priority over associates, and members who have taken less work recently take priority over those who have taken more.
>
> We have seven members, plus eight or ten associates, who have not paid a buy-in and who are not expected to attend meetings. They do, however, make the same pay for the same work.
>
> Interpreting and translating are commonly done alone. So, why have a co-op? First, we all hate doing the paperwork and accounting. We'd rather be doing our work. A co-op lets us do that. The other reason is branding/marketing/reputation. Clients can't keep track of the contact info for a dozen people, but they can remember the email and phone number for our coordinator, who can quickly contact us all. Also, with us, they get a known entity, even if it's a new person. (Unlike most other services an organization might contract for, clients don't usually know how well their interpreters are doing for their pay. With us, they worry about that a lot less.)
>
> We keep our options open by taking many kinds of work. We don't compete with the local medical and court interpreter systems (and some of us also work in them), but that leaves a lot of work to do: we work for schools and universities, non-profits, small businesses, individuals, unions, and so on. We've pondered whether there are clients we would refuse to work for, but so far, that hasn't been an issue.

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1 Shawn Wilbur, "Taking Wing: Corvus Editions," *In the Libertarian Labyrinth*, July 1, 2009 <http://libertarian-labyrinth.blogspot.com/2009/07/taking-wing-corvus-editions.html>; Corvus Distribution website <http://www.corvusdistribution.org/shop/>.

2 Shawn Wilbur, "Re: [Anarchy-List] Turnin' rebellion into money (or not... your choice)," email to *Anarchy List*, July 17, 2009 <http://lists.anarchylist.org/private.cgi/anarchy-list-anarchylist.org/2009-July/003406.html>.

> We have almost no overhead. We are working on getting an accountant, but we don't anticipate having to pay more than a few hours a month for that. Our books aren't that complicated. We also pay rent to the non-profit we spun off from, but that's set up as a percentage of our income, not a fixed amount, so it can't put us under water. It also serves as an incentive for them to send us work! Other than that, we really have no costs. As a co-op, taxes are "pass-through," meaning the co-op itself pays no taxes; we pay taxes on our income from the co-op. We will be doing some marketing soon, but we're investigating very low-cost ways to reach our target market, like in-kind work. And we have no capital costs, apart from our interpreting mic and earpieces, which we inherited from the non-profit. Occasionally, we have to buy batteries, but I'm going to propose we buy rechargables, so even that won't be a recurring cost. And finally, we're looking in to joining our local Time Bank.
>
> What this means is that we can operate at a very low volume. As a ballpark figure, I'd say we average an hour of work per member per week. That's not much more than a glorified hobby. Even so, 2009 brought in considerably more work than 2008, which saw twice as much work as 2007 (again, with essentially no marketing). We're not looking for it to increase too rapidly, because each of us has at least one other job, and six of the seven of us have kids (ranging from mine at three weeks to one member with school-age grandkids). A slow, steady increase would be great.[1]

More generally, this business model applies to a wide range of service industries where overhead requirements are minimal. An out of work plumber or electrician can work out of his van with parts from the hardware store, and cut his prices by the amount that formerly went to commercial rent, management salaries and office staff, and so forth—not to mention working for a "cash discount." Like Herrick's translator cooperative, one of the main functions of a nursing or other temporary staffing agency is branding—providing a common reference point for accountability to clients. But the actual physical capital requirements don't go much beyond a phone line and mail drop, and maybe a scanner/fax. The business consists, in essence, of a personnel list and a way of contacting them. The main entry barrier to cooperative self-employment in this field is non-competition agreements (when you work for a client of a commercial staffing agency, you agree not to work for that client either directly or through another agency for some period—usually three months—after your last assignment there). But with a large enough pool of workers in the cooperative agency, it should be possible to direct assignments to those who haven't worked for a particular client, until the non-competition period expires.

The lower capital outlays and fixed costs fall, the more meaningless the distinction between being "in business" and "out of business" becomes.

Another potential way to increase the utilization of capacity of capital goods in the informal and household economy is through sharing networks of various kinds. The sharing of tools through neighborhood workshops, discussed earlier, is one application of the general principle. Other examples include ride-sharing, time-sharing one another's homes during vacations, gift economies like FreeCycle, etc. Regarding ride-sharing in particular, *Dilbert* cartoonist Scott Adams speculates quite plausibly on the potential for network technologies like the iPhone to facilitate sharing in ways that previous technology could not, by reducing the transaction costs of connecting participants. The switch to network connections by mobile phone increases flexibility and capability for short-term changes and adjustments to plans by an order of magnitude over desktop computers. Adams describes how such a system might work:

> ...[T]he application should use GPS to draw a map of your location, with blips for the cars available for ridesharing. You select the nearest blip and a bio comes up telling you something about the driver, including

1 Steve Herrick, private email, December 10, 2009.

his primary profession, age, a photo, and a picture of the car. If you don't like something about that potential ride, move on to the next nearest blip. Again, you have a sense of control. Likewise, the driver could reject you as a passenger after seeing your bio.

After you select your driver, and he accepts, you can monitor his progress toward your location by the moving blip on your iPhone....

I also imagine that all drivers would have to pass some sort of "friend of a friend" test, in the Facebook sense. In other words, you can only be a registered rideshare driver if other registered drivers have recommended you. Drivers would be rated by passengers after each ride, again by iPhone, so every network of friends would carry a combined rating. That would keep the good drivers from recommending bad drivers because the bad rating would be included in their own network of friends average.... And the same system could be applied to potential passengers. As the system grew, you could often find a ride with a friend of a friend.[1]

Historically the prevalence of such enterprises has been associated with economic downturn and unemployment.

The shift to value production outside the cash nexus in the tech economy has become a common subject of discussion in recent years. We already discussed at length, in Chapter Three, how technological innovation has caused the floor to drop out from beneath capital outlay costs, and thereby rendered a great deal of venture capital superfluous. Although this was presented as a negative from the standpoint of capitalism's crisis of overaccumulation, we can also see it as a positive from the standpoint of opportunities for the growth of a new economy outside the cash nexus.

Michel Bauwens describes the way most innovation, since the collapse of the dotcom bubble, has shifted to the social realm and become independent of capital.

To understand the logic of this promise, we can look to a less severe, but nevertheless serious crisis: that of the internet bubble collapse in 2000-1. As an internet entrepreneur, I personally experienced both the manic phase, and the downturn, and the experience was life changing because of the important discovery I and others made at that time. All the pundits where [sic] predicting, then as now, that without capital, innovation would stop, and that the era of high internet growth was over for a foreseeable time. In actual fact, the reality was the very opposite, and something apparently very strange happened. In fact, almost everything we know, the Web 2.0, the emergence of social and participatory media, was born in the crucible of that downturn. In other words, innovation did not slow down, but actually increased during the downturn in investment. This showed the following new tendency at work: capitalism is increasingly being divorced from entrepreneurship, and entrepreneurship becomes a networked activity taking place through open platforms of collaboration.

The reason is that internet technology fundamentally changes the relationship between innovation and capital. Before the internet, in the Schumpeterian world, innovators need capital for their research, that research is then protected through copyright and patents, and further funds create the necessary factories. In the post-schumpeterian world, creative souls congregate through the internet, create new software, or any kind of knowledge, create collaboration platforms on the cheap, and paradoxically, only need capital when they are successful, and the servers risk crashing from overload. As an example, think about Bittorrent, the most important software for exchanging multimedia content over the internet, which was created by a single programmer, surviving through a creative use of some credit cards, with zero funding. But the internet is not just for creative individual souls, but enables large communities to cooperate over platforms. Very importantly, it is not limited to knowledge and software, but to everything that knowledge and software

1 Scott Adams, "Ridesharing in the Future," *Scott Adams Blog*, January 21, 2009 <http://dilbert.com/blog/entry/ridesharing_in_the_future/>.

> enables, which includes manufacturing. Anything that needs to be physically produced, needs to be 'virtually designed' in the first place.
>
> This phenomena [sic] is called social innovation or social production, and is increasingly responsible for most innovation....
>
> But what does this all mean for the Asian economic crisis and the plight of the young people that we touched upon at the beginning? The good news is this: first, the strong distinction between working productively for a wage, and idly waiting for one, is melting. All the technical and intellectual tools are available to allow young people, and older people for that matter, to continue being engage [sic] in value production, and hence also to continue to build their experience (knowledge capital), their social life (relationship capital) and reputation. All three of which will be crucial in keeping them not just employable, but will actually substantially increase their potential and capabilities. The role of business must be clear: it can, on top of the knowledge, software or design commons created by social production, create added value services that are needed and demanded by the market of users of such products (which includes other businesses), and can in turn sustain the commons from which it benefits, making the ecology sustainable. While the full community of developers create value for businesses to build upon, the businesses in term help sustain the infrastructure of cooperation which makes continued development possible.[1]

The shift of value-creation outside the cash nexus provoked an interesting blogospheric discussion between Tyler Cowen and John Quiggin. Cowen raised the possibility that much of the productivity growth in recent years has taken place "outside of the usual cash and revenue-generating nexus."[2] Quiggin, in an article appropriately titled "The end of the cash nexus," took the idea and ran with it:

> There has been a huge shift in the location of innovation, with much of it either deriving from, or dependent on, public goods produced outside the market and government sectors, which may be referred to as social production....
>
> If improvements in welfare are increasingly independent of the market, it would make sense to shift resources out of market production, for example by reducing working hours. The financial crisis seems certain to produce at least a temporary drop in average hours, but the experience of the Depression and the Japanese slowdown of the 1990s suggest that the effect may be permanent....[3]

If, as we saw in earlier chapters, economic downturns tend to accelerate the expansion of the custom industrial periphery at the expense of the mass-production core, such downturns also accelerate the shift from wage labor to self-employment or informal production outside the cash nexus. James O'Connor described the process in the economic stagnation of the 1970s and 1980s: "the accumulation of stocks of means and objects of reproduction within the household and community took the edge off the need for alienated labor."

> Labor-power was hoarded through absenteeism, sick leaves, early retirement, the struggle to reduce days worked per year, among other ways. Conserved labor-power was then expended in subsistence production.... The living economy based on non- and anti-capitalist concepts of time and space went underground: in the reconstituted household; the commune; cooperatives; the single-issue organization; the self-help clinic; the solidarity group. Hurrying along the development of the alternative and underground economies was the growth of underemployment... and mass unemployment associated with the crisis of the

1 Michel Bauwens, "Asia needs a Social Innovation Stimulus plan," *P2P Foundation Blog*, March 23, 2009 <http://blog.p2pfoundation.net/asia-needs-a-social-innovation-stimulus-plan/2009/03/23>.
2 Tyler Cowen, "Was recent productivity growth an illusion?" *Marginal Revolution*, March 3, 2009 <http://www.marginalrevolution.com/marginalrevolution/2009/03/was-recent-productivity-growth-an-illusion.html>.
3 John Quiggin, "The End of the Cash Nexus," *Crooked Timber*, March 5, 2009 <http://crookedtimber.org/2009/03/05/the-end-of-the-cash-nexus>.

1980s. "Regular" employment and union-scale work contracted, which became an incentive to develop alternative, localized modes of production....

> ...New social relationships of production and alternative employment, including the informal and underground economies, threatened not only labor discipline, but also capitalist markets.... Alternative technologies threatened capital's monopoly on technological development... Hoarding of labor-power threatened capital's domination of production. Withdrawal of labor-power undermined basic social disciplinary mechanisms....[1]

And back in the recession of the early eighties, Samuel Bowles and Herbert Gintis speculated that the "reserve army of the unemployed" was losing some of its power to depress wages. They attributed this to the "*partial deproletarianization of wage labor*" (i.e. the reduced profile of wage labor alone as the basis of household subsistence). Bowles and Gintis identified this reduced dependency largely on the welfare state, which seems rather quaint for anyone who since lived through the Reagan and Clinton years.[2] But the partial shift in value creation from paid employment to the household and social economies, which we have seen in the past decade, fully accords with the same principle.

Dante-Gabryell Monson speculated on the possibility that the open manufacturing movement was benefiting from the skills of corporate tech people underemployed in the current downturn, or even from their deliberate choice to hoard labor:

> *Is there a potential scenario for a brain drain from corporations to intentional peer producing networks ? *....
>
> Can part-time , non-paid (in mainstream money) "hobby" work in open, diy, collaborative convergence spaces become an *argument for long term material security of the participating peer* towards he's/her family ?
>
> Hacker spaces seem to be convergence spaces for open source programmers, and possibly more and more other artists, open manufacturing, diy permaculture, ... ?
>
> Can we expect a "Massive Corporate Dropout"... to drain into such diy convergence and interaction spaces ?
>
> *Can "Corporate Dropouts" help financing new open p2p infrastructures ?*
>
> Is there an increase of part-time "Corporates", working part time in open p2p ?
>
> Would such a transition , potentially part time "co-working / co-living " space be a convergence "model" and scenario some of us would consider working on ?...
>
> I personally observe some of my friends working for money as little as possible, sometimes on or two months a year, and spend the rest of their time working on their own projects.[3]

The main cause for the apparently stabilizing level of unemployment in the present recession, despite a decrease in the number of employed, is that so many "discouraged workers" have disappeared from the unemployment rolls altogether. At the same time, numbers for self-employment are

1 James O'Connor, *Accumulation Crisis* (New York: Basil Blackwell, 1984), pp. 184-186.
2 Samuel Bowles and Herbert Gintis, "The Crisis of Liberal Democratic Capitalism: The Case of the United States," *Politics and Society* 11:1 (1982), pp. 79-84.
3 Dante-Gabryell Monson, "[p2p-research] trends ? : "Corporate Dropouts" towards Open diy ? ..." *P2P Research*, October 13, 2009 <http://listcultures.org/pipermail/p2presearch_listcultures.org/2009-October/005128.html>.

continuing to rise.

> We [Canadians] lost another 45,000 jobs in July, but the picture is much worse on closer examination. There were 79,000 fewer workers in paid jobs compared to June, while self-employment rose by 35,000. This was on top of another big jump in self-employment of 37,000 last month.
>
> Put it all together and the picture is of large losses in paid jobs, with the impact on the headline unemployment rate cushioned by workers giving up the search for jobs or turning to self-employment.[1]

A recent article in the Christian Science Monitor discussed the rapid growth of the informal economy, even as the formal economy and employment within it shrink (Friedrich Schneider, a scholar who specializes in the shadow economy, expects it to grow at least five percent this year). Informal enterprise is mushrooming among the unemployed and underemployed of the American underclass: street vendors of all kinds (including clothing retail), unlicensed moving services consisting of a pickup truck and cell phone, people selling food out of their homes, etc.

And traditional small businesses in permanent buildings resent the hell out of it (if you ever saw that episode of *The Andy Griffith Show* where established retailer Ben Weaver tries to shut down Emmet's pushcart, you get the idea).

> "Competition is competition," says Gene Fairbrother, the lead small-business adviser in Dallas for the National Association for the Self-Employed. But competition from producers who don't pay taxes and licensing fees isn't fair to the many struggling small businesses who play by the rules.
>
> Mr. Fairbrother says he's seen an increase in the number of callers to his Shop Talk show who ask about starting a home-based business, and many say they're working in a salon and would rather work out of their homes or that they want to start selling food from their kitchens. Businesses facing this price pressure should promote the benefits of regulation, he advises, instead of trying to get out from under it.

Uh huh. Great "benefits" if you're one of the established businesses that uses the enormous capital outlays for rent on dedicated commercial real estate, industrial-sized ovens and dishwashers, licensing fees, etc., to crowd out competitors. Not so great if you're one of the would-be microentrepreneurs forced to pay artificially inflated overhead on such unnecessary costs, or one of the consumers who must pay a price with such overhead factored in. Parasitism generally has much better benefits for the tapeworm than for the owner of the colon.

Fortunately, in keeping with our themes of agility and resilience throughout this book, microentrepreneurs tend to operate on a small scale beneath the radar of the government's taxing, regulatory and licensing authorities. In most cases, the cost of catching a small operator with a small informal client network is simply more than it's worth.

> The Internal Revenue Service or local tax authorities would have to track down thousands of elusive small vendors and follow up for payment to equal, by one estimate, the $100 million a year that the US could gain by taxing several hundred holders of Swiss and other foreign bank accounts.[2]

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1 Andrew Jackson, "Recession Far From Over," *The Progressive Economics Forum*, August 7, 2009 <http://www.progressive-economics.ca/2009/08/07/recession-far-from-over/>.
2 Taylor Barnes, "America's 'shadow economy' is bigger than you think - and growing," *Christian Science Monitor*, November 12, 2009 <http://features.csmonitor.com/economyrebuild/2009/11/12/americas-shadow-economy-is-bigger-than-you-think-and-growing>.

So we can expect the long-term structural reduction in employment and the shortage of liquidity, in the current Great Recession or Great Malaise, to lead to rapid growth of an informal economy based on the kinds of household microenterprises we described above. Charles Hugh Smith, after considering the enormous fixed costs of conventional businesses and the inevitability of bankruptcy for businesses with such high overhead in a period of low sales, draws the conclusion that businesses with low fixed costs are the wave of the future. Here is his vision of the growing informal sector of the future:

> **The recession/Depression will cut down every business paying high rent and other fixed costs like a razor-sharp scythe hitting dry corn stalks....**
>
> **...[H]igh fixed costs will take down every business which can't remake itself into a low-fixed-cost firm....**
>
> **For the former employees, the landscape is bleak: there are no jobs anywhere, at any wage....**
>
> **So how can anyone earn a living in The End of Work? Look to Asia for the answer.** The MSM snapshot of Asia is always of glitzy office towers in Shanghai or a Japanese factory or the docks loaded with containers: the export machine.
>
> But if you actually wander around Shanghai (or any city in Japan, Korea, southeast Asia, etc.) then you find the number of people working in the glitzy office tower is dwarfed by the number of people making a living operating informal businesses.
>
> **Even in high-tech, wealthy Japan, tiny businesses abound.** Wander around a residential neighborhood and you'll find a small stall fronting a house staffed by a retired person selling cigarettes, candy and soft drinks. Maybe they only sell a few dollars' worth of goods a day, but it's something, and in the meantime the proprietor is reading a magazine or watching TV.
>
> **In old Shanghai, entire streets are lined with informal vendors.** Some are the essence of enterprise: a guy buys a melon for 40 cents, cuts it into 8 slices and then sells the slices for 10 cents each. Gross profit, 40 cents.
>
> **In Bangkok, such areas actually have two shifts of street vendors: one for the morning traffic, the other for the afternoon/evening trade.** The morning vendors are up early, selling coffee, breakfasts, rice soup, etc. to workers and school kids. By 10 o'clock or so, they've folded up and gone home.
>
> That clears the way for the lunch vendors, who have prepared their food at home and brought it to sell. In some avenues, a third shift comes in later to sell cold drinks, fruit and meat sticks as kids get out of school and workers head home.
>
> **Fixed costs of these thriving enterprises: a small fee to some authority, an old cart and umbrella--and maybe a battered wok or ice chest.**
>
> So this is what I envision happening as the Depression drives standard-issue high-fixed cost "formal" enterprises out of business in the U.S.:
>
> 1. The mechanic who used to tune your (used) vehicle for $300 at the dealership (now gone) tunes it up in his home garage for $120--parts included.
>
> 2. The gal who cut your hair for $40 at the salon now cuts it at your house for $10.
>
> 3. The chef who used to cook at the restaurant that charged $60 per meal now delivers a gourmet plate to your door for $10 each.

4. The neighbor kids' lemonade stand is now a permanent feature; you pay 50 cents for a lemonade or soft drink instead of $3 at Starbucks.

5. Used book sellers spread their wares on the sidewalk, or in fold-up booths; for reasons unknown, one street becomes the "place to go buy used books."

6. The neighborhood jazz guy/gal sets up and plays with his/her pals in the backyard; donations welcome.

7. The neighborhood chips in a few bucks each to make it worth a local Iraqi War vet's time to keep an eye on things.

8. When your piece-of-crap Ikea desk busts, you call a guy who can fix it for $10 (glue, clamps, a few ledger strips and screws) rather than go blow $50 on another particle board P.O.C. which will bust anyway. (oh, and you don't have the $50 anyway.)

9. The guy with a Dish runs cables to the other apartments in his building for a few bucks each.

10. One person has an "unlimited" Netflix account, and everyone pays him/her a buck a week to get as many movies as they want (he/she burns a copy of course).

11. The couple with the carefully tended peach or apple tree bakes 30 pies and trades them for vegtables, babysitting, etc.[1]

The crushing costs of formal business (State and local government taxes and junk fees rising to pay for unaffordable pensions, etc.) and the implosion of the debt-bubble economy will drive millions into the informal economy of barter, trade and "underground" (cash) work.

As small businesses close their doors and corporations lay off thousands, the unemployed will of necessity shift their focus from finding a new formal job (essentially impossible for most) to fashioning a livelihood in the informal economy.

One example of the informal economy is online businesses--people who make a living selling used items on eBay and other venues. Such businesses can be operated at home and do not require storefronts, rent to commercial landlords, employees, etc., and because they don't require a formal presence then they also fly beneath all the government junk fees imposed on formal businesses.

I have mentioned such informal businesses recently, and the easiest way to grasp the range of possibilities is this: whatever someone did formally, they can do informally.

Chef had a high fixed-cost restaurant which bankrupted him/her? Now he/she prepares meals at home and delivers them to neighbors/old customers for cash. No restaurant, no skyhigh rent, no employees, no payroll taxes, no business licenses, inspection fees, no sales tax, etc. Every dime beyond the cost of food and utilities to prepare the meals stays in Chef's pocket rather than going to the commercial landlords and local government via taxes and fees.

All the customers who couldn't afford $30 meals at the restaurant can afford $10. Everybody wins except commercial landlords (soon to be bankrupt) and local government (soon to be insolvent). How can you bankrupt all the businesses and not go bankrupt yourself?

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1 Charles Hugh Smith, “End of Work, End of Affluence III: The Rise of Informal Businesses,” *Of Two Minds*, December 10, 2009 <http://www.oftwominds.com/blogdec08/informal12-08.html>.

As long as Chef reports net income on Schedule C, he/she is good to go with Federal and State tax authorities. [And if Chef doesn't, fuck 'em.]

Now run the same scenario for mechanics, accountants, therapists, even auto sales—just rent a house with a big yard or an apartment with a big parking lot and away you go; the savvy entrepreneur who moves his/her inventory can stock a few vehicles at a time. No need for a huge lot, high overhead, employees or junk fees. It's cash and carry.

Lumber yard? Come to my backyard lot. Whatever I don't have I can order from a jobber and have delivered to your site.

This is the result of raising the fixed costs of starting and running a small business to such a backbreaking level that few formal businesses can survive.[1]

Appendix

Case Studies in the Coordination of Networked Fabrication and Open Design

1. Open Source Ecology/Factor e Farm. Open Source Ecology, with its experimental demo site at Factor e Farm, is focused on developing the technological building blocks for a resilient local economy.

We are actively involved in demonstrating the world's first replicable, post-industrial village. We take the word *replicable* very seriously—we do not mean a top-down funded showcase—but one that is based on ICT, open design, and digital fabrication—in harmony with its natural life support systems. As such, this community is designed to be self-reliant, highly productive, and sufficiently transparent so that it can truly be replicated in many contexts—whether it's parts of the package or the whole. Our next frontier will be education to train Village Builders—just as we're learning how to do it from the ground up.[2]

Open Source Ecology's latest core message is "Building the world's first replicable, open source, modern off-grid global village—to transcend survival and evolve to freedom."...

Replicable means that the entire operation can be copied and 'replicated' at another location at low cost.

Open source means that the knowledge of how it works and how to make it is documented to the point that others can "make it from scratch." It can also be changed and added to as needed....

Permafacture: A car is a temporarily useful consumer product—eventually it breaks down and is no longer useful as a car. The same is true for almost any consumer product—they are temporary, and when they break down they are no longer useful for their intended purpose. They come from factories that use resources from trashing ecosystems and using lots of oil. Even the "green" ones. Most consumer food is grown on factory farms using similar processes, and resulting in similar effects. When the resources or financing for those factories and factory farms dries up they stop producing, and all the products and food they made stop flowing into the consumer world. Consumers are dependent on these products and food for their very survival, and every product and food they buy from these factories contributes to the systems that are destroying the ecosystems that they will need to survive when finances or resources are interrupted. The

1 Smith, "Trends for 2009: The Rise of Informal Work," *Of Two Minds*, December 30, 2009 <http://www.oftwominds.com/blogdec08/rise-of-informal12-08.html>.
2 Marcin Jakubowski, "Clarifying OSE Vision," *Factor e Farm Weblog*, September 8, 2008 <http://openfarmtech.org/weblog/?p=325>.

more the consumers buy, the more dependent they are on the factories consuming and destroying the last of the resources left in order to maintain their current easy and dependent survival. These factories are distributed all over the world, and need large amounts of cheap fuel to move the products to market through the global supply and production chain, trashing ecosystems all along the way. The consumption of the products and food is completely disconnected from their production and so consumers do not actually see any of these connections or their interruptions as the factories and supply chains try hard to keep things flowing smoothly, until things reach their breaking point and the supply of products to consumers is suddenly interrupted. Open Source Ecology aims to create the means of production and reuse on a small local scale, so that we can produce the machines and resources that make survival trivial without being dependent on global supply and production chains, trashing ecosystems, and cheap oil.[1]

The focus of OSE is to secure "right livelihood," according to founder Marcin Jakubowski, who cites Vinay Gupta's "The Unplugged" as a model for achieving it:

> The focus of our *Global Village Construction program* is to deploy *communities* that live according to the intention of *right livelihood*. We are considering the *ab initio* creation of nominally 12 person communities, by networking and marketing this *Buy Out at the Bottom* (BOAB) package, at a fee of approximately $5k to participants. *Buying Out at the Bottom* is a term that I borrowed from Vinay Gupta in his article about The Unplugged—where *unplugging* means the creation of *an independent life-support infrastructure and financial architecture--a society within society—which allowed anybody who wanted to "buy out" to "buy out at the bottom" rather than "buying out at the top."*
>
> Our Global Village Construction program is an implementation of *The Unplugged* lifestyle. With 12 people *buying out* at $5k each, that is $60k seed infrastructure capital.
>
> We have an option to stop feeding invading colonials, from our own empire-building governments to slave goods from China. Structurally, the more self-sufficient we are, the less we have to pay for our own enslavement—through education that dumbs us down to producers in a global workforce—through taxation that funds rich peoples' wars of commercial expansion—through societal engineering and PR that makes the quest for an honest life dishonorable if we can't keep up with the Joneses. [2]

Several of the most important projects interlock to form an "OSE Product Ecology."[3] For example the LifeTrac Open Source Tractor acts as prime mover for Fabrication (i.e., the machine shop, in which the Multi-Machine features prominently), and the Compressed Earth Block Press and the Sawmill, which in turn are the basic tools for housing construction. The LifeTrac also functions, of course, as a tractor for hauling and powering farm machinery.

Like LifeTrac, the Power Cube—a modular power-transmission unit—is a multi-purpose mechanism designed to work with several of the other projects.

> Power Cube is our open source, self-contained, modular, interchangeable, hydraulic power unit for all kinds of power eguipment. It has an 18 hp gasoline engine coupled to a hydraulic pump, and it will later be be powered by a flexible-fuel steam engine. Power Cube will be used to power MicroTrac (under construction) and it is the power source for the forthcoming CEB Press Prototype 2 adventures. It is designed as a general power unit for all devices at Factor e Farm, from the CEB press, power take-off (PTO) generator, heavy-duty workshop tools, even to the LifeTrac tractor itself. Power Cube will have a quick

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1 Jeremy Mason, "What is Open Source Ecology?" *Factor e Farm Weblog*, March 20, 2009 <http://openfarmtech.org/weblog/?p=595>.

2 "Organizational Strategy," Open Source Ecology wiki, February 11, 2009 <http://openfarmtech.org/index.php?title=Organizational_Strategy> (accessed August 28, 2009).

3 Marcin Jakubowski, "CEB Proposal—Community Supported Manufacturing," *Factor e Farm* weblog, October 23, 2008 <http://openfarmtech.org/weblog/?p=379>.

attachment, so it can be mounted readily on the quick attach plate of LifeTrac. As such, it can serve as a backup power source if the LifeTrac engine goes out....

The noteworthy features are modularity, hydraulic quick-couplers, lifetime design, and design-for-disassembly. Any device can be plugged in readily through the quick couplers.

It can be maintained easily because of its transparency of design, ready access to parts, and design for disassembly. It is a major step towards realizing the true, life-size Erector Set or Lego Set of heavy-duty, industrial machinery in the style of Industrial Swadeshi.[1]

Among projects that have reached the prototype stage, the foremost is the Compressed Earth Block Press, which can be built for $5000—some 20% of the price of the cheapest commercial competitor.[2] In field testing, the CEB Press demonstrated the capability of producing a thousand blocks in eight-hours, on a day with bad weather (the expected norm in good weather is 1500 a day).[3] On August 20, 2009, Factor e Farm announced completion of a second model prototype, its most important new feature being an extendable hopper that can be fed directly by a tractor loader. Field testing is expected to begin shortly.[4]

The speed of the CEB Press was recently augmented by the prototyping of a complementary product, the Soil Pulverizer.

Initial testing achieved 5 ton per hour soil throughput, while The Liberator CEB press requires about 1.5 tons of soil per hour....

Stationary soil pulverizers comparable in throughput to ours cost over $20k. Ours cost $200 in materials—which is not bad in terms of 100-fold price reduction. The trick to this feat is modular design. We are using components that are already part of our LifeTrac infrastructure. The hydraulic motor is our power take-off (PTO) motor, the rotor is the same tiller that we made last year—with the tiller tines replaced by pulverizer tines. The bucket is the same standard loader bucket that we use for many other applications....

It is interesting to compare this development to our CEB work from last year—given our lesson that soil moving is the main bottleneck in earth building. It takes 16 people, 2 walk-behind rototillers, many shovels and buckets, plus backbreaking labor—to load our machine as fast as it can produce bricks. We can now replace this number of people with 1 person—by mechanizing the earth moving work with the tractor-mounted pulverizer. In a sample run, it took us about 2 minutes to load the pulverizer bucket—with soil sufficient for about 30 bricks. Our machine produces 5 bricks per minute—so we have succeeded in removing the soil-loading bottleneck from the equation.

This is a major milestone for our ability to do CEB construction. Our results indicate that we can press 2500 bricks in an 8 hour day—with 3 people.[5]

In October Jakubowski announced plans to release the CEB Beta Version 1.0 on November 1, 2009. The product as released will have a five block per minute capacity and include automatic controls (the

1 Jakubowski, "Power Cube Completed," *Factor e Farm* weblog, June 29, 2009 <http://openfarmtech.org/weblog/?p=814>.
2 Jakubowski, "CEB Phase 1 Done," Factor e Farm Weblog, December 26, 2007 <http://openfarmtech.org/weblog/?p=91>.
3 Jakubowski, "The Thousandth Brick: CEB Field Testing Report," *Factor e Farm Weblog*, Nov. 16, 2008 <http://openfarmtech.org/weblog/?p=422>.
4 Jakubowski, "CEB Prototype II Finished," *Factor e Farm Weblog*, August20, 2009 <http://openfarmtech.org/weblog/?p=1025>.
5 Jakubowski, "Soil Pulverizer Annihilates Soil Handling Limits," *Factor e Farm Weblog*, September 7, 2009 <http://openfarmtech.org/weblog/?p=1063>.

software for which is being released on an open-source basis).[1] The product was released, on schedule, on November 1.[2] Shortly thereafter, OSE was considering options for commercial production of the CEB Press as a source of revenue to fund new development projects.[3]

The MicroTrac, a walk-behind tractor, has also been prototyped. Its parts, including the Power Cube, wheel, quick-attach motor and cylinder are interchangeable with LifeTrac and other machines. "We can take off the wheel motor from MicroTrac, and use it to power shop tools."[4]

OSE's planned facilities for replication and machining are especially exciting, including a 3-D printer and a Multi-Machine with added CNC controls.

> There is a significant set of open source technologies available for rapid prototyping in small workshops. By combining 3D printing with low-cost metal casting, and following with machining using a computer controlled Multimachine, the capacity arises to make rapid prototypes and products from plastic and metal. This still does not address the feedstocks used, but it is a practical step towards the post-centralist, participatory, distributive economy with industrial swadeshi on a regional scale....
>
> The interesting part is that the budget is $500 for RepRap, $200 for the casting equipment, and $1500 for a Multimachine with CNC control added. Using available knowhow, this can be put together in a small workshop for a total of about $2200—for full, LinuxCNC computer controlled rapid fabrication in plastic and metal. Designs may be downloaded from the internet, and local production can take place based on global design.
>
> This rapid fabrication package is one of our near-term (one year) goals. The research project in this area involves the fabrication and integration of the individual components as described....
>
> Such a project is interesting from the standpoint of localized production in the context of the global economy—for creating significant wealth in local economies. This is what we call industrial swadeshi. For example, I see this as the key to casting and fabricating low-cost steam engines ($300 for 5 hp) for the Solar Turbine—as one example of Gandhi's mass production philosophy.[5]

The entire Fab Lab project aims to produce "the following equipment infrastructure, in order of priorities...":

* 300 lb/hour steel melting Foundry—$1000
* Multimachine-based Lathe, mill, and drill, with addition of CNC control—$1500
* CNC Torch Table (plasma and oxyacetylene), adaptable to a router table
* RepRap or similar 3D printer for printing casting molds—$400
* Circuit fabrication—precise xyz router table
* Open Source Wire Feed Welder[6]

In August 2009, Lawrence Kincheloe moved to Factor e Farm in August 2009 under contract to

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1 Jakubowski, "Exciting Times: Nearing Product Release," *Factor e Farm Weblog*, October 10, 2009 <http://openfarmtech.org/weblog/?p=1168>.
2 Jakubowski, "Product," *Factor e Farm Weblog*, November 4, 2009 <http://openfarmtech.org/weblog/?p=1224>.
3 Jakubowski, "CEB Sales: Rocket Fuel for Post-Scarcity Economic Development?" *Factor e Farm Weblog*, November 28 2009 <http://openfarmtech.org/weblog/?p=1331>.
4 Jakubowski, "MicroTrac Completed," *Factor e Farm Weblog*, July 7, 2009 <http://openfarmtech.org/weblog/?p=852>.
5 Jakubowski, "Rapid Prototyping for Industrial Swadeshi," *Factor e Farm Weblog*, August 10, 2008 <http://openfarmtech.org/weblog/?p=293>.
6 "Open Source Fab lab," Open Source Ecology wiki (accessed August 22, 2009) <http://openfarmtech.org/index.php?title=Open_Source_Fab_Lab>.

build the torch table in August and September.[1] He ended his visit in October with work on the table incomplete, owing to “a host of fine tuning and technical difficulties which all have solutions but were not addressable in the time left.”[2] Nevertheless, the table was featured in the January issue of *MAKE Magazine* as RepTab (the name reflects the fact that—aside from motors and microcontrollers—it can replicate itself):

> One of the interesting features of RepTab is that the cutting head is interchangeable (router, plasma, oxyacetylene, laser, water jet, etc.), making it versatile and extremely useful.
>
> “Other machines make that difficult without major modifications,” says Marcin Jakubowski, the group's founder and director. “We can make up to 10-foot-long windmill blades if we modify the table as a router table. That's pretty useful.”[3]

Since then, Factor e Farm has undertaken to develop an open-source lathe, as well as a 100-ton ironworker punching/shearing/bending machine; Jakubowski estimates an open-source version can be built for a few hundred dollars in materials, compared to $10,000 for a commercial version.[4]

In December 2009 Jakubowski announced that a donor had committed $5,000 to a project for developing an open-source induction furnace for smelting, and solicited bids for the design contract.

> You may have heard us talk about recasting civilization from scrap metal. Metal is the basis of advanced civilization. Scrap metal in refined form can be mined in abundance from heaps of industrial detritus in junkyards and fence rows. This can help us produce new metal in case of any unanticipated global supply chain disruptions. This will have to do until we can take mineral resources directly and smelt them to pure metal.
>
> I look forward to the day when our induction furnace chews up our broken tractors and cars – and spits them out in fluid form. This leads to casting useful parts, using molds printed by open source ceramic printers – these exist. This also leads to hot metal processing, the simplest of which is bashing upon an anvil – and the more refined of which is rolling. Can we do this to generate metal bar and sheet in a 4000 square foot workshop planned for Factor e Farm? We better. Technology makes that practical, though this is undeard-of outside of centralized steel mills. We see the induction furnace, hot rolling, forging, casting, and other processes critical to the fabrication component of the Global Village Construction Set.
>
> We just got a $5k commitment to open-source this technology.[5]

In January, Jacubowski reported initial efforts to build a lathe-drill-mill multimachine (not CNC, apparently) powered by the LifeTrac motor.[6]

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1 Marcin Jakubowski, “Moving Forward,” Factor e Farm Weblog, August 20, 2009<http://openfarmtech.org/weblog/?p=1020>; “Lawrence Kincheloe Contract,” OSE Wiki <http://openfarmtech.org/index.php?title=Lawrence_Kincheloe_Contract>; “Torch Table Build,” *Open Source Ecology* wiki (accessed August 22, 2009 <http://openfarmtech.org/index.php?title=Torch_Table_Build>.

2 Lawrence Kincheloe, “First Dedicated Project Visit Comes to a Close,” *Factor e Farm Weblog*, October 25, 2009 <http://openfarmtech.org/weblog/?p=1187> (see especially comment no. 5 under the post).

3 Abe Connally, “Open Source Self-Replicator,” *MAKE Magazine*, No. 21 <http://www.make-digital.com/make/vol21/?pg=69>.

4 Jakubowski, “CEB Sales”; “Ironworkers,” Open Source Ecology Wiki <http://openfarmtech.org/index.php?title=Ironworkers>. Accessed December 10, 2009.

5 Jakubowski, “Open Source Induction Furnace,” *Factor e Farm Weblog*, December 15, 2009 <http://openfarmtech.org/weblog/?p=1373>.

6 Jakubowski, “Initial Steps to the Open Source Multimachine,” *Factor e Farm Weblog*, January 26, 2010 <http://openfarmtech.org/weblog/?p=1408>.

In addition to the steel casting functions of the Foundry, Jakubowski ultimately envisions the production of aluminum from clay as a key source of feedstock for relocalized production. As an alternative to "high-temperature, energy-intensive smelting processes" involving aluminum oxide (bauxite), he proposes "extracting aluminum from clays using baking followed by an acid process."[1]

OSE's flexible and digital fabrication facility is intended to produce a basic set of sixteen products, five of which are the basic set of means of fabrication themselves:

1. *Boundary layer turbine*—simpler and more efficient alternative to most external and internal combustion engines and turbines, such as gasoline and diesel engines, Stirling engines, and air engines. The only more efficient energy conversion devices are bladed turbines and fuel cells.
2. *Solar concentrators* – alternative heat collector to various types of heat generators, such as petrochemical fuel combustion, nuclear power, and geothermal sources
3. *Babington[2] and other fluid burners*–alternative heat source to solar energy, internal combustion engines, or nuclear power
4. *Flash steam generators* – basis of steam power
5. *Wheel motors* - low-speed, high-torque electric motors
6. *Electric generators* – for generating the highest grade of usable energy: electricity
7. *Fuel alcohol* production systems – proven biofuel of choice for temperate climates
8. *Compressed wood gas* – proven technology; cooking fuel; usable in cars if compressed
9. *Compressed Earth Block* (CEB) press – high performance building material
10. *Sawmill* – production of dimensional lumber
11. *Aluminum from clay* – production of aluminum from subsoil clays

Means of fabrication:

12. *CNC Multimachine[3]* – mill, drill, lathe, metal forming, other grinding/cutting
13. *XYZ*-controlled torch and router table – can accommodate an acetylene torch, plasma cutter, router, and possibly CO_2 laser cutter diodes
14. *Metal casting* equipment – various metal parts
15. *Plastic extruder[4]* – plastic glazing and other applications
16. *Electronics fabrication* – oscilloscope, multimeter, circuit fabrication; specific power electronics products include battery chargers, inverters, converters, transformers, solar charge controllers, PWM DC motor controllers, multipole motor controllers.[5]

The Solar Turbine, as it was initially called, uses the sun's heat to power a steam-driven generator, as an alternative to photovoltaic electricity.[6] It has since been renamed the Solar Power Generator, because of the choice to use a simple steam engine as the heat engine instead of a Tesla turbine.[7]

The Steam Engine, still in the design stage, is based on a simple and efficient design for a 3kw

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1 Jakubowski, "OSE Proposal—Towards a World Class Open Source Research and Development Facility" v0.12, January 16, 2008 <http://openfarmtech.org/OSE_Proposal.doc> (accessed August 25, 2009).
2 http://www.aipengineering.com/babington/Babington_Oil_Burner_HOWTO.html
3 <http://opensourcemachine.org/>.
4 See Extruder_doc.pdf at <http://www.fastonline.org/CD3WD_40/CD3WD/INDEX.HTM>.
5 Jakubowski, "OSE Proposal" [Note—OSE later decided to replace the boundary layer turbine with a simple steam engine as their primary heat engine. Also "Babington oil burner, compressed fuel gas production, and fuel alcohol production have now been superseded by pelletized biomass-fueled steam engines." (Marcin Jakubowski, private email, January 22, 2010)]
6 "Solar Turbine—Open Source Ecology" <http://openfarmtech.org/index.php?title=Solar_Turbine>.
7 Marcin Jakubowski, "Factor e Live Distillations—Part 8—Solar Power Generator," *Factor e Farm Weblog*, February 3, 2009 <http://openfarmtech.org/weblog/?p=507>.

engine, with an estimated bill of parts of $250.[1]

The Sawmill, which can be built with under $2000 in parts (a "Factor 10 cost reduction"), has "the highest production rate of any small, portable sawmills."[2]

OSE's strategy is to use the commercial potential of the first products developed to finance further development. As we saw earlier, Jakubowski speculates that a fully equipped digital fabrication facility could turn out CEB presses or sawmills with production rates comparable to those of commercial manufacturing firms, cutting out all the metal parts for the entire product with a turn-around time of days. The CEBs and sawmills could be sold commercially, in that case, to finance development of other products.[3]

And in fact, Jakubowski has made a strategic decision to give priority to developing the CEB Press as rapidly as possible, in order to leverage the publicity and commercial potential as a source of future funding for the entire project.[4]

OSE's goal of replicability, once the first site is completed with a full range of production machinery and full product line, involves hosting interns who wish to replicate the original experiment at other sites, and using fabrication facilities to produce duplicate machinery for the new sites.[5] Jakubowski recently outlined a more detailed timeline:

> Based on our track record, the schedule may be off by up to twenty years. Thus, the proposed timeline can be taken as either entertainment or a statement of intent—depending on how much one believes in the project.
>
> 2008 - modularity and low cost features of open source products have been demonstrated with LifeTrac and CEB Press projects
>
> 2009 - First product release
>
> 2010 - TED Fellows or equivalent public-relations fellowship to propel OSE to high visibility
>
> 2011 - $10k/month funding levels achieved for scaling product development effort
>
> 2012 - Global Village Construction Set finished
>
> 2013 - First true post-scarcity community built
>
> 2014 - OSE University (immersion training) established, to be competitive with higher education but with an applied focus
>
> 2015 - OSE Fellows program started (the equivalent of TED Fellows, but with explicit focus of solving pressing world issues)
>
> 2016 - First productive recursion completed (components can be produced locally anywhere)

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1 Nick Raaum, "Steam Dreams," *Factor e Farm* weblog, January 22, 2009 <http://openfarmtech.org/weblog/?p=499>.
2 Jeremy Mason, "Sawmill Development," *Factor e Farm* weblog, January 22, 2009 <http://openfarmtech.org/weblog/?p=498>.
3 Jakubowski, "OSE Proposal."
4 Ibid.
5 "Organizational Strategy."

2017 - Full meterial [sic] recursion demostrated (all materials become producible locally anywhere)

2018 - Ready self-replicability of resilient, post-scarcity communities demonstrated

2019 - First autonomous republic created, along the governance principles of Leashless

2020 - Ready replicability of autonomous republics demonstrated[1]

In August 2009, some serious longtime tensions came to a head at OSE, as the result of personality conflicts beyond the scope of this work, and the subsequent departure of members Ben De Vries and Jeremy Mason.

Since then, the project has given continuing signs of being functional and on track. As of early October 2009, Lawrence Kincheloe had completed torch table Prototype 1 (pursuant to his contract described above), and was preparing to produce a debugged Prototype 2 (with the major portion of its components produced with Prototype 1).[2] As recounted above, OSE also went into serial production of the CEB Press and has undertaken new projects to build the open-source lathe and ironworker.

2. 100kGarages. Another very promising open manufacturing project, besides OSE's, is 100kGarages—a joint effort of ShopBot and Ponoko. ShopBot is a maker of CNC routers.[3] Ponoko is both a network of designers and a custom machining service, that produces items as specified in customer designs uploaded via Internet, and ships them by mail, and also has a large preexisting library of member product designs available for production.[4] 100kGarages is a nationwide American network of fabbers aimed at "distributed production in garages and small workshops"[5]: linking separate shops with partial tool sets together for the division of labor needed for networked manufacturing, enabling shops to contract for the production of specific components, or putting customers in contact with fabbers who can produce their designs. Ponoko and ShopBot, in a joint announcement, described it as helping 20,000 creators meet 6,000 fabricators, and specifically putting them in touch with fabricators in their own communities.[6] As described at the 100kGarages site:

> 100kGarages.com is a place for anyone who wants to get something made ("Makers") to link up with those having tools for digital fabrication ("Fabbers") used to make parts or projects.... At the moment, the structure is in place to for [sic] Makers to find Fabbers and to post jobs to the Fabber community.... We're working hard to provide software and training resources to help those who want to design for Fabbers, whether doing their own one-off projects or to use the network of Fabbers for distributed manufacturing of products (as done by the current gallery of designers on the Ponoko site).
>
> In the first few weeks there have been about 40 Fabbers who've joined up. In the beginning, we are sticking to Fabbers who are ShopBotters. This makes it possible to have some confidence in the credibilty

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1 Jakubowski, ""TED Fellows," *Factor e Farm Weblog*, September 22, 2009 <http://openfarmtech.org/weblog/?p=1121>.
2 Lawrence Kincheloe, "One Month Project Visit: Take Two," *Factor e Farm Weblog*, October 4, 2009 <http://openfarmtech.org/weblog/?p=1146>.
3 <http://www.shopbottools.com/>.
4 <http://www.ponoko.com/>.
5 "What's Digital Fabrication?" 100kGarages website <http://100kgarages.com/digital_fabrication.html>.
6 Ted Hall (ShopBot) and Derek Kelley (Ponoko), "Ponoko and ShopBot announce partnership: More than 20,000 online creators meet over 6,000 digital fabricators," joint press release, September 16, 2009. Posted on Open Manufacturing email list, September 16, 2009 <http://groups.google.com/group/openmanufacturing/browse_thread/thread/fdb7b4d562f5e59d?hl=en>.

and capability of the Fabber, without wasting enormous efforts on certification.... But before long, we expect to open up 100kGarages.com to all digital fabrication tools, whether additive or subtractive. We're hoping to grow to a couple of hundred Fabbers over the next few months, and this should provide a geographical distribution that brings fabrication capabilities pretty close to everyone and helps get the system energized.[1]

> As we all are becoming environmentally aware, we realize that our environment just can't handle transporting all our raw materials across the country or around the world, just to ship them back as finished products. These new technologies make practical and possible doing more of our production and manufacturing in small distributed facilities, as small as our garages, and close to where the product is needed. Most importantly our new methods for collaboration and sharing means that we don't have to do it all by ourselves ... that designers with creative ideas but without the capability to see their designs become real can work with fabricators that might not have the design skills that they need but do have the equipment and the skills and orientation that's needed to turn ideas into reality … that those who just want to get stuff made or get their ideas realized can work with the Makers/designers who can help them create the plans and the local fabricators who fulfill them.
>
> To get this started ShopBot Tools, Makers of popular tools for digital fabrication and Ponoko, who are reinventing how goods are designed, made and distributed, are teaming-up to create a network of workshops and designers, with resources and infrastructure to help facilitate "rolling up our sleeves and getting to work." Using grass roots enterprise and ingenuity this community can help get us back in action, whether it's to modernize school buildings and infrastructure, develop energy-saving alternatives, or simply produce great new products for our homes and businesses.
>
> There are thousands of ShopBot digital-fabrication (CNC) tools in garages and small shops across the country, ready to locally fabricate the components needed to address our energy and environmental challenges and to locally produce items needed to enhance daily living, work, and business. Ponoko's web methodologies offer people who want to get things made an environment that integrates designers and inventors with ShopBot fabricators. Multiple paths for getting from idea to object, part, component, or product are possible in a dynamic network like this, where ideas can be realized in immediate distributed production and where production activities can provide feedback to improve designs.[2]

Although all ShopBot CNC router models are quite expensive compared to the reverse-engineered stuff produced by hardware hackers (most models are in the $10-20,000 range, and the two cheapest are around $8,000), ShopBot's recent open-sourcing of its CNC control code received much fanfare in the open manufacturing community.[3]

And as the 100kGarages site says, they plan to open up the network to machines other than routers, and to "home-brew routers" other than ShopBot, as the project develops. Ponoko already had a similar networking project among owners of CNC laser cutters.[4] As a first step toward its intention to "expand to all kinds of digital fabrication tools," in October ShopBot ordered a MakerBot kit with a view to investigating the potential for incorporating additive fabrication into the mix.[5] 100kGarages announced in January 2010 it had signed up 150 Fabbers, and was still developing plans to add other digital tools

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1 100KGarages founder Ted Hall, "100kGarages is Open: A Place to Get Stuff Made," *Open Manufacturing* email list, September 15, 2009 <http://groups.google.com/group/openmanufacturing/browse_thread/thread/ae45b45de1d055a7?hl=en#>.
2 "Our Big Idea!" 100kGarages site <http://100kgarages.com/our_big_idea.html>.
3 Gareth Branwyn, "ShopBot Open-Sources Their Code," *Makezine*, April 13, 2009 <http://blog.makezine.com/archive/2009/04/shopbot_open-sources_their_code.html>.
4 "What's Digital Fabrication?"
5 "100kGarages is Building a MakerBot," *100kGarages*, October 17, 2009 <http://blog.100kgarages.com/2009/10/17/100kgarages-is-building-a-makerbot/>.

like cutting tables and 3-D printers to its network.[1] In February they elaborated on their plans, specifying that 100kGarages would add the owners of other digitally controlled tools, with the same certification mechanism for reliability they already used for the ShopBot:

> The plan we've come up with is to work with other Digital Fabrication Equipment manufacturers and let them do the same sort of ownership verification steps that ShopBot has done with the original Fabbers. If a person with a Thermwood (or an EZRouter, Universal Laser, etc) wants to join 100kGarages they can have the manufacturer of their tool verify that they are an owner. We'll work out a simple process for this verification and will work to develop relationships with other manufacturers over time to make the process as painless as possible and to let them get involved if they would like.

Plans to incorporate homebrew tools are also in the works, although much less far along than plans for commercially manufactured tools.

> It also leaves a question of the home-made and home-brew Fabbers. We appreciate that some of these tools can be pretty good. There may be other kinds of user organizations for some types of tools that could help with certification, but we've got to admit that we don't know exactly how we'll deal with it yet. It may be as simple as "send us a picture of yourself, your machine, and a portfolio of work", or we may have to develop some sort of certification method involving cutting a sample. We'll let you know when we come up with something, but we'll try to make it as painless for you (and for us) as possible.[2]

Interestingly, this was almost identical to the relocalized manufacturing model described by John Robb:

> It is likely that by 2025, the majority of the "consumer" goods you purchase/acquire, will be manufactured locally. However, this doesn't likely mean what you think it means. The process will look like this:
>
> 1. You will purchase/trade for/build a design for the product you desire through online trading/sharing systems. That design will be in a standard file format and the volume of available designs for sale, trade, or shared openly will be counted in the billions.
>
> 2. You or someone you trust/hire will modify the design of the product to ensure it meets your specific needs (or customize it so it is uniquely yours). Many products will be smart (in that they include hardware/software that makes them responsive), and programmed to your profile.
>
> 3. The refined product design will be downloaded to a small local manufacturing company, co-operative, or equipped home for production. Basic feedstock materials will be used in its construction (from metal to plastic powders derived from generic sources, recycling, etc.). Delivery is local and nearly costless.

The relocalization of manufacturing will be promoted among other things, Robb says, by the fact that

> [l]ocal fabrication will get cheap and easy. The cost of machines that can print, lathe, etch, cut materials to produce three dimensional products will drop to affordable levels (including consumer level versions). This sector is about to pass out of its "home brew computer club phase" and rocket to global acceptance.[3]

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1 "What are we working on?" *100kGarages*, January 8, 2010 <http://blog.100kgarages.com/2010/01/08/what-are-we-working-on/>.
2 "What's Next for 100kGarages?" *100kGarages News*, February10, 2010 <http://blog.100kgarages.com/2010/02/10/whats-next-for-100kgarages/>.
3 John Robb, "The Switch to Local Manufacturing," *Global Guerrillas*, July 8, 2009 <http://globalguerrillas.typepad.com/globalguerrillas/2009/07/journal-the-switch-to-local-manufacturing.html>.

It's impossible to underestimate the revolutionary significance of this development. As Lloyd Alter put it, “This really does change everything.”[1]

Back in January, Eric Hunting considered the slow takeoff in the open manufacturing/Making movement on the Open Manufacturing email list.

> There seem to be a number of re-occurring questions that come up—openly or in the back of peoples minds- seeming to represent key obstacles or stumbling blocks in the progress of open manufacturing or Maker culture....
>
> Why are Makers still fooling around with toys and mash-ups and not making serious things? (short answer; like early computer hackers lacking off-the-shelf media to study, they're still stuck reverse-engineering the off-the-shelf products of existing industry to learn how the technology works and hacking is easier than making something from scratch)
>
> Why are Makers rarely employing many of the modular building systems that have been around since the start of the 20th century? Why do so few tech-savvy people seem to know what T-slot is when it's ubiquitous in industrial automation? Why little use of Box Beam/Grid Beam when its cheap, easy, and has been around since the 1960s? Why does no one in the world seem to know the origin and name of the rod and clamp framing system used in the RepRap? (short answer: no definitive sources of information)
>
> Why are 'recipes' in places like Make and Instructibles most [sic] about artifacts and rarely about tools and techniques? (short answer; knowledge of these are being disseminated ad hoc)
>
> Why is it so hard to collectivize support and interest for open source artifact projects and why are forums like Open Manufacture spending more time in discussion of theory rather than nuts & bolts making? (short answer; no equivalent of Source Forge for a formal definition of hardware projects—though this is tentatively being developed—and no generally acknowledged definitive channel of communication about open manufacturing activity)
>
> Why are Fab Labs not self-replicating their own tools? (short answer; no comprehensive body of open source designs for those tools and no organized effort to reverse-engineer off-the-shelf tools to create those open source versions)
>
> Why is there no definitive 'users manual' for the Fab Lab, its tools, and common techniques? (short answer; no one has bothered to write it yet)
>
> Why is there no Fab Lab in my neighborhood? Why so few university Fab Labs so far? Why is it so hard to find support for Fab Lab in certain places even in the western world? (short answer; 99% of even the educated population still doesn't know what the hell a Fab Lab is or what the tools it's based on are)
>
> Why do key Post-Industrial cultural concepts remain nascent in the contemporary culture, failing to coalesce into a cultural critical mass? Why are entrepreneurship, cooperative entrepreneurship, and community support networks still left largely out of the popular discussion on recovery from the current economic crash? Why do advocates of Post-Industrial culture and economics still often hang their hopes on nanotechnology when so much could be done with the technology at-hand? (short answer; no complete or documented working models to demonstrate potential with)
>
> Are you, as I am, starting to see a pattern here? It seems like there's a Missing Link in the form of a kind

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1 Lloyd Alter, “Ponoko + ShopBot = 100kGarages: This Changes Everything in Downloadable Design,” *Treehugger*, September 16, 2009 <http://www.treehugger.com/files/2009/09/ponoko-shopbot..php>.

> of communications or media gap. There is Maker media—thanks largely to the cultural phenomenon triggered by Make magazine. But it's dominated by ad hoc individual media produced and published on-line to communicate the designs for individual artifacts while largely ignoring the tools. People are learning by making, but they never seem to get the whole picture of what they potentially could make because they aren't getting the complete picture of what the tools are and what they're capable of.
>
> We seem to basically be in the MITS Altair, Computer Shack, Computer Faire, Creative Computing, 2600 era of independent industry. A Hacker era. Remember the early days of the personal computer? You had these fairs, users groups, and computer stores like Computer Shack basically acting like ad hoc ashrams of the new technology because there were no other definitive sources of knowledge. This is exactly what Maker fairs, Fab Labs, and forums like this one are doing....
>
> There are a lot of parallels here to the early personal computer era, except for a couple of things; there's no equivalent of Apple (yet..), no equivalent of the O'Reily Nutshell book series, no "##### For Dummies" books.[1]

100kGarages is a major step toward the critical mass Hunting wrote about. Although there's as yet no Apple of CNC tools (in the sense of the CAD file equivalent of a user-friendly graphic user interface), there is now an organized network of entrepreneurs with a large repository of open designs. As Michel Bauwens puts it, “Suddenly, anyone can pick one of 20,000 Ponoko Designs (or build one themselves) and get it cut out and built just about anywhere.”[2] This is essentially what Marcin Jakubowski referred to above, when he speculated on distributed open source manufacturing shops linked to a “global repository of shared open source designs.” To get back to Lloyd Alter's theme (“This changes everything”):

> Ponoko is the grand idea of digital design and manufacture; they make it possible for designers to meet customers, "where creators, digital fabricators, materials suppliers and buyers meet to make (almost) anything." It is a green idea, producing only when something is wanted, transporting ideas instead of physical objects.
>
> Except there wasn't a computerized router or CNC machine on every block, no 3D Kinko's where you could go and print out your object like a couple of photocopies. Until now, with the introduction of 100K Garages, a joint venture between Ponoko and ShopBot, a community of over six thousand fabricators.
>
> Suddenly, anyone can pick one of 20,000 Ponoko Designs (or build one themselves) and get it cut out and built just about anywhere.[3]

The answer to Hunting's question about cooperative entrepreneurship seems to have come to a large extent from outside the open manufacturing movement, as such. And ShopBot and Ponoko, if not strictly speaking part of the committed open manufacturing movement, have grafted it onto their business model. This is an extension to the physical realm of a phenomenon Bauwens remarked on in the realm of open-source software:

> ...[M]ost peer production allies itself with an ecology of businesses. It is not difficult to understand why this is the case. Even at very low cost, communities need a basic infrastructure that needs to be funded. Second, though such communities are sustainable as long as they gain new members to compensate the loss of existing contributors; freely contributing to a common project is not sustainable in the long term. In

1 Eric Hunting, “Toolbook and the Missing Link,” *Open Manufacturing*, January 30, 2009 <http://groups.google.com/group/openmanufacturing/msg/2fccdde02f402a5b>.
2 Michel Bauwens, “A milestone for distributed manufacturing: 100kGarages,” *P2P Foundation Blog*, September 19, 2009 <http://blog.p2pfoundation.net/a-milestone-for-distributed-manufacturing-100k-garages/2009/09/19>.
3 Alter, op. Cit.

> practice, most peer projects follow a 1-10-99 rule, with a one percent consisting of very committed core individuals. If such a core cannot get funded for its work, the project may not survive. At the very least, such individuals must be able to move back and forth from the commons to the market and back again, if their engagement is to be sustainable.
>
> Peer participating individuals can be paid for their work on developing the first iteration of knowledge or software, to respond to a private corporate need, even though their resulting work will be added to the common pool. Finally, even on the basis of a freely available commons, many added value services can be added, that can be sold in the market. On this basis, cooperative ecologies are created. Typical in the open source field for example, is that such companies use a dual licensing strategy. Apart from providing derivative services such as training, consulting, integration etc., they usually offer an improved professional version with certain extra features, that are not available to non-paying customers. The rule here is that one percent of the customers pay for the availability of 99% of the common pool. Such model also consists of what is called benefit sharing practices, in which open source companies contribute to the general infrastructure of cooperation of the respective peer communities.
>
> Now we know that the world of free software has created a viable economy of open source software companies, and the next important question becomes: Can this model be exported, wholesale or with adaptations, to the production of physical goods?[1]

I think it's in process of being done right now.

Jeff Vail expressed some misgivings about Ponoko, wondering whether it could go beyond the production of trinkets and produce primary goods essential to daily living. 100kGarages' partnership with PhysicalDesignCo[2] (a group of MIT architects who design digitally prefabricated houses), announced in early October, may go a considerable way toward addressing that concern. PhysicalDesignCo will henceforth contract the manufacture of all its designs to 100kGarages.[3]

3. Assessment. Franz Nahrada, of the Global Village movement, has criticized Factor e Farm in terms of its relationship to a larger, surrounding networked economy. However, he downplayed the importance of autarky compared to that of cross-linking between OSE and the rest of the resilient community movement.

> I really think we enter a period of densification and intensive cross-linking between various projects. I would like to consider Factor_E_Farm the flagship project for the Global Village community even though I am not blind to some shortcomings. I talked to many people and they find and constantly bring up some points that are easy to critisize [sic]. But I want to make clear: I also see these points and they all can be dealt with and are IMHO of minor importance.
>
> * the site itself seems not really being locally embedded in regional development initiatives, but rather a “spaceship from Mars” for the surrounding population. The same occured to me in Tamera 10 years ago when I stayed at a neighboring farmhouse with a very benevolent Portuguese lady who spoke perfect German (because she was the widow of a German diplomat). She was helpful im [sic] mediating, but still I saw the community through the “lenses of outsiders” and I saw how much damage too much cultural isolation can do to a village building effort and how many opportunities are missed that way. We must consider the local and the regional as equally important as the global, in fact the global activates the local

1 Bauwens, “The Emergence of Open Design and Open Manufacturing,” *We Magazine*, vol. 2 <http://www.we-magazine.net/we-volume-02/the-emergence-of-open-design-and-open-manufacturing/>.
2 <http://www.physicaldesignco.com/>.
3 “PhysicalDesignCo teams up with 100kGarages,” *100kGarages News*, October 4, 2009 <http://blog.100kgarages.com/2009/10/04/physicaldesignco-teams-up-with-100kgarages/>.

and regional potential. It makes us refocus on our neighbors because we bring in a lot of interesting stuff for them - and they might do the same for us....

> * the overall OSE project is radically geared towards local autonomy—something which sometimes seemingly cuts deeply into efficiency and especially life quality. I think that in many respects the Factor e Farm zeal, the backbreaking heroism of labor, the choice of the hard bottom-up approach, is more a symbolic statement—and the end result will differ a lot. In the end, we might have regional cooperatives, sophisticated regional division of labor and a size of operations that might still be comparable to small factories; especially when it comes to metal parts, standard parts of all kinds, modules of the toolkit etc. But the statement "we can do it ourselves" is an important antidote to todays absolutely distorted system of technology and competences.

> We cannot really figure out what is the threshold where this demonstration effort becomes unmanageable; I think that it is important to start with certain aspects of autarky, with the idea of partial autarky and self-reliance, but not with the idea of total self-sufficiency. This demonstration of aspectual autarky is important in itself and gives a strong message: we can build our own tractor. we can produce our own buidling materials. we can even build most of our own houses.[1]

So OSE is performing a valuable service in showing the outer boundaries of what can be done within a resilient, self-sufficient community. In a total systemic collapse, without (for example) any microchip foundries, the CNC tools in the Fab Lab will—obviously—be unsustainable on a long-term basis. But assuming that such resilient communities are part of a larger network with some of Nahrada's "regional division of labor" and "small factories" (including, perhaps, a decentralized, recycling-based rubber industry), OSE's toolkit will result in drastic increases in the *degree* of local independence and the length of periods a resilient local economy can weather on its own resources.

100kGarages and OSE may be converging toward a common goal from radically different starting points. That is, 100kGarages may be complementary to OSE in terms of Nahrada's criticism. If 100kGarages' networked distributed manufacturing infrastructure is combined with OSE's open-source design ecology, with designs aimed specifically at bootstrapping technologies for maximum local resilience and economy autonomy, the synergies are potentially enormous. Imagine if OSE products like the LifeTrac tractor/prime mover, sawmill, CEB, etc., were part of the library of readily available designs that could be produced through 100kGarages.

1 Quoted in Michel Bauwens, "Strategic Support for Factor e Farm and Open Source Ecology," *P2P Foundation Blog*, June 19, 2009 <http://blog.p2pfoundation.net/strategic-support-for-factor-e-farm-and-open-source-ecology/2009/06/19>.