Eight Economic Truths

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Preface

Discussing issues related to limits to economic growth (an activity in which I have engaged on various Internet discussion forums) is often an extremely frustrating experience. Frequently bringing up limits to growth causes one to be dismissed as either a fanatical socialist *comrade* and/or as a tree hugging hippie sentimentalist who has no understanding of the practical realities of human nature. My perception is that the people who make such accusations are resisting (for very understandable reasons) the prospect of a major discontinuity in our prevailing social institutions, but they are not responding to the actual substance of limits to growth arguments and the implied serious problems which need to be addressed. The reality of the economic and environmental crises which we face can be understood independently of political ideology. The fact that once that understanding is achieved very uncomfortable conclusions about the fate of our current social institutions immediately follows does not in any way tend to falsify the underlying fundamental truths.

While thinking along these lines I decided to write down a series of statements about economic production which, within the limits of my understanding, are objectively true. The list given below is the result of this effort. In the chapters in the first part of this book I shall expand on each of the each of these truths.

1. Human beings are dependent upon each other.

2. Human beings are dependent upon the resource base provided by the earth's mineral resources and by the transformations of those resources provided by the interactions of the biosphere with solar energy.

3. The resource base which supports the human economy is finite.

4. Growth of the economy at a constant percentage implies constant acceleration of growth in absolute in absolute terms in a pattern known as exponential growth.

5. Dematerialization of economic output (e.g. the service economy, the information economy etc.) cannot support exponential expansion of economic output indefinitely.

6. Private finance of economic infrastructure requires growth for effective functioning.

7. Private savings are investments in economic infrastructure. The desire to store up lots of economic value in order to gain future security is really a desire to continuously build up economic infrastructure and increase total resource use.

8. All investment in infrastructure are community investments.

Part I

The Truths

Chapter 1

Truth 1: Human beings are dependent upon each other

This truth can be regarded as self-evident, but there is a surprisingly large group of people who want to deny it, or at least regard such dependence as onerous and wish to do everything they can to minimize it. Unfortunately for the people possessed by this idea, the reality is that ever since the beginning of the industrial revolution and the increasingly diverse specialization of labor which accompanied it, the circle of human beings upon whom we are dependent for the economic artifacts of our everyday lives has continually increased in both numbers and in geographical area. This increasing human interdependence is a physically necessary consequence of the scope and methods of modern economic production. To fail to understand this physical necessity is to live in a dream world.

Nevertheless many people experience a very real longing to be independent, self-sufficient, masters of their own fate. However, the most elementary knowledge of natural and human history should make it clear that no one is master of his or her own fate. Not Alexander the Great, not Isaac Newton, not Michelangelo obtained such mastery. No amount of talent, creative energy, and will power can protect anyone from the actions of chance and mutability. In the final analysis the desire to be /textitmaster of one's own fate is the desire to be lucky. Such a wish is perfectly natural, but basing public policy decisions upon people's desire to be lucky does not seem to be an intelligent basis for creating a stable society.

A casual examination of the facts of physical existence make it clear that society as a collective organism can greatly reduce the probability that bad luck will limit the individual's chances to realize his or her full potential as a human being. If you lived alone on an island utterly isolated from other intelligent beings, then a broken leg, an attack of the flu, a bad back, a bad storm, or a summer drought could end your life. In society the support of other human beings reduces the chances that comparatively minor accidents will be fatal or crippling with respect to your future prospects for finding life satisfaction.

Many people will accept some degree of dependence on other human beings but want to limit it to a small group: To their families and to a select group of friends. But in a complex economy with a great deal of specialization of labor and elaborate large scale infrastructure this limitation is not possible. What is really meant by independence in this case is that the necessary dependence should operate smoothly and reliably without any need to explicitly ask for or to give help to one's larger circle of co-dependents. The key question is what form of social organization is likely to give the greatest stability to the complex network of social and physical interdependencies which enable us to live and interact with the world in the manner to which we have become accustomed. Very few people have given any serious thought to this question, but simply wish for a continuation of whatever they are used to, or long for a return to some supposed ideal condition of the past, the fundamental basis of which has not been carefully examined.

Let us examine a classic example of supposed *independent* nuclear families: That of American pioneer farmers. It cannot be denied that ownership of high quality agricultural land conveys a sort of economic power to the proprietor. However, *ownership* is a social phenomenon which (unless you are living alone on an isolated planet) can be maintained only by some form of agreement among the various aspirants to such a form of economic power. For example, the Native Americans whose hunting grounds and garden land were being taken over by European settlers were eager to deny ownership to the pioneers, but the American military, backed initially by the industrial might of England, and eventually by the growing industry of the eastern United States made sure that the rights of the new owners were enforced.

For a long time a large percentage of the U.S. population was able to attain to such land ownership because of the "underpopulated" state of North America by the standards of European agricultural technology. However, this ability of anyone with willingness to take a risk, to pull up stakes, move west, and take possession of substantial quantities of high quality land for a relative pittance was a form of historical good luck (from the point of view of the European settlers, at least) which could not last forever. Again being lucky is not the same thing as being independent in an absolute sense.

But even within the historical context of cheap and plentiful land, American pioneer farmers were hardly independent. Yes, they were business owners and could direct their time as they saw fit within certain limits, but without the ability to trade their produce for the output of centers of industrial manufacturing they would have been dirt poor subsistence farmers. The whole infrastructure of industrial civilization, including mining, manufacturing, transportation, education, law, government, and so forth was an essential contributor to the wealth of such *independent* farmers. The failure to understand this fact is a failure to understand the essential nature of the modern human social organism.

And, in fact, even the independence of the individual farmer to run his or her business in the best way he or she sees fit is limited by considerations of general social agreements. Suppose for example that some far sighted individual foresaw that the trend of modern mechanized/chemicalized agriculture was not sustainable in the long term because it could not preserve soil and soil fertility. If such a person wished to experiment with more sustainable methods of food production, emphasizing tree crops and other perennial plants, the immediate pressure of economic competition with well established, high yielding (at least in the short term) agricultural methods would put tremendous pressure on this farsighted individual to go along with accepted methods of agricultural production. If you depend upon trade for your livelihood then you are not independent of the general social will concerning the *right* way to create human welfare.

Perhaps the most absurd conception associated with false ideas of independence (of true ideas of independence I will speak shortly) is that of financial independence. In many traditional societies people are supported in their declining years by their children or by the tribe in tribal societies. This dependence of the old on the young is perfectly natural, and the support given is viewed as being a deserved return for the support and protection provided by the parents to their children or to the tribe during the early part of their life. The physical underpinnings of modern financial independence (so-called) are not really any different than the traditional methods of supporting the aged. If retired people continue to consume food, clothing, fuel, medical care, etc. they do so because men and women who have not retired get out of their beds every morning and do the work which provides these outputs. Financial independence is really dependence with the human element of mutual obligation moved out of immediate sight.

So-called savings are often viewed as simply deferral of consumption, and as such are regarded as a form of virtue and discipline which deserves future recompense. However, one can easily show that except in relatively small amounts intended to cover large consumer purchases or to serve as a crisis fund in periods of temporary unemployment this view of financial holdings as deferred consumption is functionally incorrect. The essentially unbounded desire to accumulate financial markers as the primary means of gaining ongoing and future support from our economic fellow travelers has destructive consequences in the long run, as I will explain more fully under Truth 7.

Many people will think that I am being overly negative about the idea of independence. Surely the word has some positive meaning? Certainly it does, even though economic independence is nonsense. Let us consider two common uses of the word independent. Many people profess to admire *independent* thinkers. An independent thinker is someone whose ideas are not completely constrained by social conventions in some particular area of knowledge, and who can therefore sometimes achieve insights about the workings of reality that cannot be achieved by people who *know* what *everyone* knows without really understanding the fundamental basis of the belief which they mistake for knowledge. Note that in this instance we do not really love independence for independence sake. An independent inventor who ended up poisoning his or her neighbors or burning them alive in the pursuit of some invention that no one else thought was of any value would be sent to prison rather than given a reward. Insofar as we admire independent thought we do so because we believe it can help to bring into existence new kinds of social utility.

In fact the admiration expressed for independent thought is often more conventional that real. We admire independent thinkers after the fact when the social benefit of their originality is manifest, but before the fact they are often regarded with fear and distrust by the conventional *everyone* of *everyone* knows. This distrust of originality exists even in the supposedly objective hard sciences, but even more so in the field of social and political organization where it generally believed that all of the fundamental issues of fact were settled long ago, and only fanatics or delusionary idiots could possibly doubt the fundamental rightness of our current social institutions.

The question of how to encourage independent thinking is a delicate one. The tenure system used by many institutions of higher learning is an attempt to do so. By granting a creative individual economic security the intention is to give him or her the freedom to pursue interesting research projects independently of currently popular ideas about the most important subjects of such research. However, economic security granted by the judicious judgment of one's colleagues (and of the taxpaying public) is not the same thing as absolute economic independence.

Another form of independence which is much desired is independence from arbitrary authority. I distinguish arbitrary authority from natural authority. Natural authority comes into existence when a group of people recognize that some person has superior knowledge or ability that should be deferred to in order to better accomplish some common goal toward which the group is working. Such natural authority is spontaneous and voluntary. On the other hand arbitrary authority is the imposition of the will of one person or of a small group of persons over other people by means of fear and threats, in most cases hiding behind a mask of social necessity. The absolute monarch or the absolute dictator who can have you beheaded or sent to the gulag simply because they dislike you are archetypal examples of arbitrary authority. Of course, far less extreme examples of arbitrary authority exist: Petty bureaucrats and corporate tyrants of various types exist in our current socioeconomic system who enjoy tormenting people who must submit to their dictates in order to achieve a desired end.

Whether or not it is possible to create a social and political system in which almost all authority is natural and almost none is arbitrary is question on which I will express no opinion. However, my inclination is to strive to maximize natural authority and minimize arbitrary authority as much as possible. However, I think that the idea that capitalism, as it now exists or as it existed fifty or a hundred years ago, has provided an optimum stable final solution to this problem is a mistaken notion, as I hope to show in the remainder of this book.

Chapter 2

Truth 2: Human beings are dependent upon the resource base provided by the earth's mineral resources and by the transformations of those resources provided by the interactions of the biosphere with solar energy

The first part of this truth concerning our economic dependence on the earth's mineral resources is, I believe, universally acknowledged, although many people regard it as having no real relevance to any limitation on human economic activity, since they regard this resource base as being effectively infinite, *effectively infinite* meaning *of no practical concern until long after I am dead and gone.* Some people are hoping that asteroid mining will eventually extend our mineral resource base beyond the earth's atmosphere thus postponing concerns about the limits of this resource base to an even more distant future. I do not pretend to have a crystal ball which allows me to see into the far distant future, but I am not expecting any economic help from asteroid mining within my lifetime or, indeed, within this century.

Truth 2: Human beings are dependent upon the resource base provided by the earth's mineral resources and by the transformations of those resources provided by the interactions of the biosphere with solar energy

It is true, that for the most part, human mining and manufacturing activity is dispersing the earth's elemental resources rather than destroying them. However, since such dispersed supplies of the elements may require much more energy and labor to gather together and purify than was required to gather and purify them originally from concentrated ores in the earth's crust, such dispersal may ultimately have negative economic consequences. Therefore the supply lifetime of key elements relative to some definition of economic health depends on the distribution of these elements in the earth's upper crust and not just on the total amount present.

The second part of this truth concerning our dependence on the transformations of the earth's material matrix brought about by the biosphere is acknowledged in some degree by a fairly large group of people, and it finds its typical modern expression in the movement called *environmentalism*. However, many people regard environmental issues as related more to quality of life than to fundamental human welfare, and are willing to trade off long term environmental health against short term economic "health" as that term is defined in the dominant cultural paradigm.

Of course, no one can deny our dependence on plants and animals for food, but our agricultural system has come to depend on a relatively small number of species raised in artificially managed ecosystems (e.g. farms, orchards, ranches, etc) which have been rising in productivity for several hundred years. The success of this system of food production can be interpreted to mean that we have freed ourselves from dependence on so called *wild* nature.

However, continued progress in the productivity of agricultural food systems or even the maintenance of current levels of production is not guaranteed. These simplified ecosystems require constant human intervention to maintain production of the desired species at high yields. Plant monocultures are highly susceptible to pests so that heavy use of chemical pesticides is required to prevent serious crop damage. Over time the targeted pests become resistant to particular chemical killers and new varieties of pesticide have to be developed. Whether or not this cycle of stronger pests and stronger pest killers can be maintained in the long term is questionable. Dependence on a small number of crop species cultivated in huge monocultural plantings also carries a certain amount of risk because the emergence of a super-pest for which we have no adequate defense could seriously effect food supplies. The Irish potato famine is a well knows historical example of this danger.

Shallow rooted annual plants cannot reach deep sources of water. Furthermore regular plowing tends to lower the water retention capacity of the tilled soil. Therefore the need for irrigation water during dry spells is increased. In a number of important agricultural regions water tables are being pumped down faster than the natural replacement rate with an obvious threat to future productivity when the wells eventually run dry. Natural ecosystems with undisturbed soil and deep-rooted perennial plants make much better use of available water.

Modern agriculture also requires heavy applications of chemical fertilizer (the primary required nutrients being nitrogen, phosphorus, and potassium). Phosphorus fertilizer, which is derived from rock phosphates, is a particular concern because global phosphate resources are much lower than potash resources (the source of potassium fertilizer) or nitrogen supplies (Nitrogen constitutes 78% of the earth's atmosphere.). To some extent this need for heavy chemical nutrient feeding may be inextricably tied to high crop yields, but some aspects of agricultural ecosystems may exacerbate the need for nutrient feeding compared to natural ecosystems. Shallow rooted annual plants cannot access nutrients in the deeper soil. Much of the nutrient load absorbed by crop plants is removed from the land permanently in the form of grain, fruit, roots, vegetable stalks, etc. since we do not complete the nutrient cycle and return our manure, urine, and decomposing bodies to the land in the same way that animals do in natural ecosystems. However, a significant portion of the applied nutrients remain behind in the form of organic matter from plant roots, and from plant shoots as well if these are left on the land. In natural ecosystems the nutrients from this organic matter are consumed by soil organisms which eventually make the nutrients available again in a form that plants can use. Nutrients leach out of tilled soil with a reduced population of soil organisms or disappear directly via soil erosion at a much higher rate than they do from the untilled soil of natural ecosystems, again increasing the need for externally applied nutrients.

Many important food plants are dependent upon insects for pollination and thus for the development of fruit. Certain plants are adapted to be pollinated by specific insects, and in particular the honey bee is a vitally important pollinator for a variety of important food crops (e.g. apples, cranberries, almonds, melons, broccoli, blueberries, cherries, tomatoes, beans etc.). Honey bee populations are currently shrinking due to unknown causes (chemical pesticides are suspected). There is not the remotest prospect of any human technology substituting for the role played by honey bees, so that a collapse of the bee population could have very serious effects on the human food supply.

Another possible threat to the productivity of our food production system is climate change (human induced or otherwise). Natural ecosystems adapt to changing conditions by utilizing the store of genetic information that has been produced over vast periods of time. When environmental conditions change the mix of species and the relative population density of different species change in response to the new conditions. Human food production systems have become dependent on a relatively small variety of plants with high productivity under existing conditions. Whether or not such artificial ecosystems can adapt to rapidly changing climactic conditions with sufficient speed to maintain current levels of productivity is questionable.

Our dependence upon the material transformations brought about by plants and animals does not end with food. Wood is still an important construction material and its fibers are the primary source of paper products. Plant fiber and animal fur (e.g., cotton and wool) are still widely used in manufacture of clothing. Animal hides in the form of leather are still widely used for shoes and clothing. A variety of medicinal and chemical products are derived from plants and animals.

Biologist Edmund O. Wilson, among many others, has argued for the importance of preserving biodiversity both as a source for the development of useful products for human use, and as a source of adaptability to environmental changes. The genetic heritage of the biosphere is a source of information developed over vast periods of time in response to changing environmental conditions. Wilson estimates a lower limit on current species extinction rates at one thousand times the prehuman rate [1].

It is not possible to put any immediate economic value on the genetic information that is being lost, but in the long term these losses could have significant impacts on our ability to adapt to environmental changes.

Another important aspect of our dependence on the transformations of matter brought about by the biosphere with the aid of solar energy is our dependence upon the fossil fuels coal, natural gas, and oil. Plants use energy from the sun to combine hydrogen from water and carbon from atmospheric carbon dioxide into carbohydrate compounds. The carbohydrate compounds thus produced are the basic chemical energy source which support the life functions of most living organisms on earth (there are a few microscopic life forms which obtain their energy from geothermal sources). Animals (including humans) get their bodily energy by eating plants or by eating other animals which have eaten plants.

When human beings first mastered fire they began using the stored chem-

[1] Wilson, Edmund O. (2002), *The Future of Life*, Chapter 4, p. 99, Vintage Books, New York

ical energy of plants for other purposes than the direct support of their bodily functions through the consumption of food. With the invention of metallurgy an important extension of this external dependence of human economic activity on plant chemical energy came into existence. Important metals such as copper, zinc, iron, and lead exist in nature primarily in combination with other elements, the most important being oxygen. For example the classic iron ores are magnetite (Fe3O4) and hematite (Fe2O3). In order to get pure iron the oxygen must be removed from the ore. The primary method of this reduction (i.e. removal of oxygen) is to heat the ore to a high temperature in the presence of pure carbon and oxygen. The carbon combines with the oxygen to form carbon monoxide (CO) and then the carbon monoxide reacts with the iron oxide to produce pure iron and carbon dioxide. In the Iron Age charcoal (which is wood reduced to a state of nearly pure carbon) was used as both the energy source to produce the necessary high temperature and as the source of carbon required to draw oxygen out of the iron ore.

However, charcoal derived from trees or other woody plants is not the only source of biological carbon. Typically when plants or animals die their bodies (and the chemical energy contained therein) are consumed by scavengers and microscopic decomposers. However, in some circumstance large amounts of biological material have been geologically buried in oxygen free conditions where their chemical energy cannot be consumed by other living organisms. Heat and pressure eventually drive out most of the oxygen from this buried organic material leaving behind energy rich hydrocarbon compounds. These remaining hydrocarbon compounds in the form of coal, oil, and natural gas are collectively called fossil fuels.

Eventually coal took over from charcoal as the preferred source of carbon for smelting metal ores, although this development took a surprisingly long time. The reason for this long delay is that coal in its natural state when it is dug out of the ground has inferior properties for the reduction of metals compared to charcoal. In order for coal to be useful for smelting iron it must be converted to a substance called coke by driving out impurities at high temperature, and only certain grades of coal are capable of producing high quality coke. The Chinese discovered how to make coke as early as the ninth century, but in Europe the discovery was delayed until the beginning of the eighteenth century. It was the rising cost of charcoal and of timber generally in the seventeenth century that lead smelters to experiment with alternate fuels. These experiments lead to the invention of the blast furnace powered by coke derived from special grades of coal.

Just a few years after Adam Darby introduced coking coal into the iron industry in 1709, Thomas Newcomen invented the first practical coal powered steam engine in 1712. This engine was primarily used for pumping water out of mines. A new era in the relation of the human economy to solar energy transformed by plants into chemical potential energy had begun. For the last three hundred years human consumption of so-called fossil fuels has steadily increased and is still increasing even at the present time in spite of all the hoopla surrounding renewable energy from the wind and the sun.

Obviously the total amount of such transformed biological material available in the earth's crust is quite large or it would not have been able to support three centuries of economic expansion. However the supply is not infinite, and in particular, the run-up in oil prices in the first decade of this century which drove large volumes of shale oil and tar sands production, highlighted the limited supplies of conventional petroleum, discoveries of which peaked in 1960s.

Many people have interpreted the recent drop in oil prices as clear evidence that any economic constraints due to the direct expenses of fossil fuel production are still comfortably distant. Whether or not this sense of comfort is well founded is questionable, but the geological/economic issues involved are so complex that a definitive pronouncement on this subject is nearly impossible to come by. Indeed concerns about climate change caused by the emission of CO2 into the atmosphere have given rise to a serious worry that the supplies of economically extractable fossil fuel are too large rather than too small. In these scenarios the indirect environmental costs of continued large scale extraction of fossil fuels will hit humanity sooner and harder than will the rising labor and capital costs of that extraction. I will have make more comments about both of these concerns in the next chapter.

Chapter 3

Truth 3: The resource base which supports the human economy is finite

3.1 An obvious truth. But does it really matter any time soon?

The finite nature of the earth's resource base is self-evident. However it is possible to doubt the relevance of this fact to any short term limitation on the business as usual operation of global capitalism on two different grounds:

1. The earth is a very large place and provides a very large pool of resources. Even if the finite nature of this pool will eventually limit human economic expansion the hour of this dismal event is still far distant. Gentlepersons, keep your engines running.

2. The relationship between resource input and economic output is not fixed. Advances in science and manufacturing technology are enabling us to produce more economic output with a given amount of resources. Therefore even as physical constraints start to raise the costs of increasing resource extraction, human technological cleverness will compensate for the increasing cost of raw materials and keep the growth engine running.

Both of these arguments are attempts to help the current generation of human beings escape from any necessity of achieving economic maturity. We can chase more dollars and increase the variety and sophistication of our toys and recreational amusements and let some future generation worry about limits to growth. The second argument about the triumph of human technological sophistication over physical and biological limits I will cover in truth five. In this chapter I will only address argument 1 concerning the size of the available resource base.

3.2 Mineral resources

The earth is a very large place and the use of a wide variety of resources has steadily increased in the three hundred years since the beginning of the industrial revolution. Furthermore the earth's elemental resources are, for the most part, not destroyed by human activity; they are merely redistributed. Nevertheless this redistribution may eventually have economic consequences. If more energy and labor are required to gather together and purify the metals which have entered the waste streams of the human economy than it did to gather and purify them from concentrated deposits in the earth's crust in the first place, then this redistribution of material will eventually impact our economic productivity if we exhaust the easily available, high quality deposits of critical minerals.

The declining grade of copper ores being mined is an often cited example of the finite nature of the earth's mineral resources. Hall et al[1] in their book Energy and Resource Quality present a graph which they created from data in the U.S. Bureau of Mines Minerals Yearbook which shows the trend in the average copper ore grade (% of copper by weight) and the total amount of ore produced between 1905 and 1980. During this time period the ore grade (the % by weight of copper present in the ore) declined by a factor of four from an average of 2% to an average of 0.5%. At the same time the total tons of ore produced increased by a factor of 14. If we account for the lower grade of ore the total increase in the mined amount of elemental copper was 3.5. During the same time period the population of the United States increased by a factor of 2.8 so that the total copper mined per capita increased by 23%. One can point to increasing total copper extraction in the face of declining ore grades as evidence of increased efficiency in mining technology.

In the USGS 2015 mineral year book (the most recent one I could find on line) U.S. ore grades for the years 2011 to 2015 are published[2]. The average

[1]Hall, Charles A. S.; Cleveland, Cutler J.; Kaufmann, Robert; 1912, *Energy & Resource Quality, Chapter 4: Resource Quality*, p. 99, University Press of Colorado, Niwot Colorado

[2]Edelstein, Daniel L.; 2013, *2015 Minerals Yearbook Copper*, U.S. Department

value is 0.41%, indicating a possible further degradation in ore grade since 1985.

Whether or not the decline of copper ore grades will lead an actual decline of copper production in medium term (i.e. the next two to three decades) depends on several factors. First it depends on the actual distribution of copper ore within the earth's upper crust. If the total amount of ore between say 0.4% and 0.2% is very large compared to current production rates then ore availability may not limit production for a long time, as long as other input costs of copper production stay relatively constant.

One important production cost of mining and smelting is the cost of energy. A lot of energy is required to mine and smelt a metric ton (1000kg) of pure copper. The lower the ore grade the more energy is required both for mining and for post processing of the ore after it has been removed from the ground. Most of this energy is at present provided by fossil fuels. I will come to a discussion of fossil fuels as a finite resource shortly, but here the combination of declining ore grades and rising energy cost is a more likely source of resource extraction limits in the medium term than simple exhaustion of key elemental resources.

3.3 Rock phosphates

One particularly important mineral resource which deserves special mention is rock phosphates which contain the important agricultural nutrient phosphorous. Phosphorous is one of the important NPK (nitrogen, phosphorous, and potassium) triumvirate of nutrients which are used to enhance the yield of agricultural crops. Concentrated sources of phosphorous are rarer than for the other two members of the triumvirate. Phosphorous in the earth's crust appears primarily combined with oxygen in the compound $P2O_5$. $P2O_5$ constitutes about 0.27% by weight of the earth's crust[3] . Most commercially mined phosphorus comes from beds of sedimentary rock called phosphorite which has a $P2O_5$ content of nearly 30%. The beds of this extremely rich source of phosphorous are concentrated in a relatively small number of locations around the globe. Morocco, which has been called the Saudi Arabia of rock phosphates, contains approximate 40% of the known global deposits of phosphorite. Just five countries (Morocco, Jordan, South

of the Interior, U.S. Geological Survey (https://s3-us-west-2.amazonaws.com/prd-wret/assets/palladium/production/mineral-pubs/copper/myb1-2015-coppe.pdf, Viewed 04/05/2020)

[3] McKelvey, V. E.; 1967, *Phosphate Deposits*, Geological Survey Bulletin 1252-D, (http://pubs.usgs.gov/bul/1252d/report.pdf, Viewed 04/05/2020)

Africa, the United States and China) contain 90% of the known high grade phosphorous deposits. Scientific American published an article in November 2009 claiming that, at current usage rates, known deposits of high grade rock phosphate could be substantially depleted by the end of the century [4].

As with copper I would emphasize the fact that we will not completely run out of rock phosphate in an absolute sense any time soon, but we may be forced to exploit lower grade deposits with substantially increased production costs.

Current agricultural ecosystems do not make very efficient use of applied phosphorus fertilizer. Only about 20% of the applied fertilizer is taken up by the target crops. The rest is rapidly mineralized into forms that plants cannot utilize. Natural ecosystems make better use of phosphorus than do agricultural ecosystems by recycling (e.g. animal manure, animal carcasses, dead roots and shoots from plants), and by preserving soil with a large component of organic matter and a rich soil biota which helps to transform mineralized phosphorus into forms which can be utilized by plants. If supplies of rock phosphates start to limit the current system of food production we will need to develop systems which better imitate natural ecosystems. Waiting to start this development until short term market signals tell us we have problem with phosphate supply is probably not a good plan of action.

3.4 Fresh water

Another important finite resource is fresh water. Of course the supply of fresh water is continually renewed by the process of evaporation from the surface of the ocean and precipitation as rain or snow. However, the amount of yearly precipitation is finite, and human demands on fresh water have been steadily growing with the human population of the earth and with our standard of living. The fact that supplies of fresh water are a potentially limiting factor in future economic expansion is not particularly controversial[5]. In many parts of the world underground water tables are being pumped down faster than the natural refreshment rate from the hydrologic cycle. Competition between industrial/urban and agricultural uses of water is putting strains on existing supplies of water as industrialization/urbanization continue to advance in the economically underdeveloped parts of the world.

[4] Vaccari, David A. (2009) *Phosphorous: A Looming Crisis*, Scientific American, June 2009, p54

[5] Brown, Lester R, 2004, *Outgrowing the Earth*, Chapter 6, Stabilizing Water Tables, W.W. Norton and Company

It is possible to produce fresh water from seawater by the process of desalinization, but the cost in terms energy and other resources (not to mention the negative externalities of dumping concentrated brines into the environment) make it unlikely that the water produced from this source will ever be more than a small fraction of total human water consumption.

3.5 Soil

Another finite resource is soil. Soil is produced is produced by the weathering of rocks into small mineral particles and by the decay of dead organisms into a long lived organic substance called humus. In most of the agricultural land currently being cultivated soil is being lost by wind and water erosion faster than the natural formation rate. According to Cornell Ecologist David W. Wolfe the rate of soil loss on agricultural land in Europe and the United States average between 9 and 15 metric tons per Hectare per year, which is about ten time the natural formation rate of new soil[6]l . Of course this loss rate is small compared to the overall volume of soil or agricultural productivity would have severely declined a long time ago. Nevertheless in the long run we must develop methods of agricultural production which preserve soil if we are going to continue to use this resource for the production of human food. Some people claim that hydroponic farming (i.e. growing crops indoors with the roots immersed in a mixture of water and chemical nutrients) will eventually make soil an obsolete agricultural resource, or at least greatly reduce the demand for this resource compared to current systems of food production. I am fairly skeptical of this claim although hydroponic farming does have some significant advantage over soil based agriculture:

1. Much lower water use (up to 10 times less)

2. Lower nutrient inputs due to more efficient uptake by plants

3. Higher yields because less energy and nutrients are used in growing an extensive root system.

4. Fewer pest and disease problems

5. Year round crop production because of mild indoor temperatures

[6]Wolfe, David W. (2001), *Tales From The Underground: A Natural History of Subterranean Life*, Chapter 9, p 19, Perseus Publishing, Cambridge Massachusetts

3.6 Fossil fuels

That the reservoir of fossil hydrocarbons available in the earth's crust is finite in size is an obvious fact. Even in the early days of the industrial revolution there were people who questioned the wisdom of building a large infrastructure based on a finite resource like coal. In H.G. Wells' science fiction novel *When the Sleeper Wakes* he depicts a future high tech society powered by wind. He did so because it was just as obvious to him as to any other thinking human being that an economic system based on mining fossil hydrocarbons from the earth's crust must eventually pass away.

In 1866 the English economist William Stanley Jevons published a book called *The Coal Question* in which he predicted that British coal production would peak in a comparatively short time period and thus bring an end to Britain's economic growth because coal based energy was the primary fuel source of the industrial revolution. Vaclav Smil in his book *Energy at the Crossroads* cites this book as early and spectacularly wrong prediction of resource exhaustion leading to limits to growth. Before joining Smil in smiling at the wrongheadedness of Jevon's book let us examine what aspect of his prediction was wrong and try to understand the mistake that he made. British coal production peaked in 1913 at 292 million tons and by 2012 had descended all the way to 18 million tons. This amount of production is extremely small change compared to major producers such as China (4025 million tons), the United States (1016 million tons), India (650 million tons), Indonesia (488 million tons), Australia (464 million tons), and Russia (390 million tons). This aspect of his prediction was completely correct although the precise timing was not.

On the other hand one hundred years have passed since British peak coal and clearly British economic output has not stagnated and declined along with coal production. The most important reason why British economic production and British energy production are not closely correlated is that energy can be purchased from foreign producers without disastrous economic consequences. Fossil fuels are energy dense and transportable, and in a world of economic specialization and economic integration far beyond the borders of individual nation states, large energy reservoirs within the borders of a particular state are not necessary for economic success, as countries like Japan, Korea, and the Netherlands have amply proved.

Of course, it is also true that Jevons did not appreciate the significance of oil and natural gas which would increase the total global reservoir of economically useful fossil hydrocarbons by a large amount. Nevertheless the total reservoir is finite, and the idea that an economic system based on mining constantly increasing amounts of these fossil hydrocarbons will eventually face serious problems caused by rising fuel costs is valid. Of course if such problems are decades distant at the earliest then a natural tendency exists to treat them as a purely academic subject with no practical immediate impact on the quest for ever increasing flows of money to which we have grown accustomed as a deeply entrenched cultural norm. The run up of oil prices which began in 2004 is an indication that supplies of this fossil fuel which still dominates transportation markets are very tight, and with China and India developing urban automobile cultures the potential increase in demand over the coming decades is quite large.

Of course oil prices began a previous run up in 1974 when prices (in 2014 dollars) increased from $25/barrel in the previous year to 45$/barrel. Prices climbed all the way to $107/barrel in 1980 and did not drop back below $40/barrel until 1986. After 1986 the run of low oil prices continued until 2004. Oil from the north slope of Alaska and from the North Sea contributed greatly to this easing of oil prices. Oil prices dropped from slightly over $100/barrel to about $50/barrel in 2014 with the increase in shale oil production in the United States being pointed to by many people as the primary cause. Some people are claiming shale oil supplies are sufficient to keep prices well below $100/barrel for another couple of decades at minimum. The U.S. Energy Information Administration (EIA) estimates that global resources of technically recoverable shale oil represent a 10% increase in total recoverable oil resources when lumped together with non-shale sources of oil[7]. Natural gas from shale is a larger resource and the EIA estimates a 48% increase in total recoverable resources when shale gas is added to conventional reserves.

A 10% rise in total oil reserves is not that large particularly compared to the potential rise in energy use by the developing world over the next several decades. Sooner or later oil production from the large oil fields of the Middle East will start to decline and it is far from clear that production from shale will be able to compensate for this decline.

A number of analysts are claiming that possible future declines in oil supply are economically irrelevant because the electric transportation revolution will lower the demand for oil fast enough to prevent any huge oil price shocks. I regard this optimistic evaluation of the long term evolution the oil supply/demand situation as being highly uncertain. Electric cars are still

[7]U.S. Energy Information Administration, *Today in Energy, Table 1. Technically Recoverable shale oil and shale gas in the context of total world resources*, http://www.eia.gov/todayinenergy/detail.cfm?id=14431, Viewed 04/04/2020

range limited and very expensive compared to internal combustion engine cars. The biggest increase in automobile use in a business as usual global growth scenario will be in the developing world where consumers will be a lot more likely to choose low costs over low environmental impact. Furthermore if the electric transportation sector grows to be a major consumer of energy then issues associated with a major increase in electricity demand will become important. The supply of renewable energy varies on long time scales including the six month Summer/Winter variation. Current lithium ion battery installations for the storage of grid electricity are designed to provide four to six hour of storage. Six months' worth of storage implies a two order of magnitude increase in capital costs as well as the loss of the ability to amortize these costs over several thousand battery cycles in a reasonable period of time. A massive buildup of nuclear power would avoid the variability issues of renewable energy, but a buildup massive enough to substantially replace fossil fuels seem unlikely to materialize any time soon. Conceivably fuel cell hybrid cars could deal with long term variation in energy supply by using long term hydrogen storage to compensate for these variations. However, building up an economical renewable energy based hydrogen infrastructure faces a number of significant technical barriers.

The question is how far away are we from significant declines in oil production from some of the established large oil fields of the Middle East? The oil and energy news site oilprice.com published an article in July of 2017 documenting technical problems with Saudi Arabia's Manifa oil field (900,000 barrels per day) and with Quatar's Al Shaheen oil field (300,000 barrels per day)[8]. Both of these fields will eventually need major infrastructure investments to maintain current output levels. If these fields have to close down temporarily while infrastructure upgrades are constructed the article claims that it would take just a few weeks to clear the oil glut from the market and send prices shooting up.

However, I want to emphasize that I am not trying to follow in Jevon's footsteps and predict severe economic problems by a specific date. I am just pointing out the obvious fact of the finite nature of the earth hydro carbon resources and the truth that an economic system whose normal operation requires constantly increasing total extraction of these resources will sooner or later face difficult problems.

It is obvious that fossil fuels cannot power the global economy forever, and that humanity must ultimately develop an economic system based on

[8]http://oilprice.com/Energy/Crude-Oil/The-Technical-Failure-That-Could-Clear-The-Oil-Glut-In-A-Matter-Of-Weeks.html, viewed 9/14/2017

other energy sources. The two energy sources most often discussed as fossil fuel alternatives are nuclear energy and so-called renewable energy which is largely solar energy (wind and waves are indirect forms of solar energy resulting from the unequal heating of the earth's surface by solar radiation.). A brief discussion of the economic potential of these energy sources is appropriate at this point.

Fossil fuels are the energy rich remains of ancient flows of solar energy captured by plants in the process of photosynthesis. Clearly the flow of solar energy has not stopped and earth is continually receiving fresh supplies of energy from the sun. The average rate at which solar energy strikes the earth's surface is approximately ten thousand times the average rate at which the global human economy is currently consuming energy. Many people are encouraged by this large ratio to believe that substituting current solar energy flows for fossil preservations of ancient solar energy flows will be a relatively easy matter. Of course it would be impractical to harness 100% of the solar energy flow for human economic purposes, but if we could harness 10% of it that is still a factor of one thousand times current energy consumption rates.

However, it is not just the absolute size of an energy reservoir which matters in economic terms. One must also account for the resource opportunity cost of delivering a given amount of energy in a useful form for economic production. If the resource costs in terms of human labor, agricultural land years, fresh water, etc. of delivering a given amount of energy from current solar flows to useful economic production are significantly higher than the resource costs of delivering energy from fossil hydrocarbon reservoirs, then negative economic consequences will follow if we are forced to extract our energy supplies from these more expensive sources. That is even if the flow of solar energy is large compared to current human consumption levels, the costs in terms of other finite production resources (such as labor or agricultural land) may limit how much energy we can afford to harvest from that flow.

At this point I think that it is advisable to discuss one aspect of the cost of converting solar energy to an economically usable form that is not sufficiently emphasized by renewable energy enthusiasts. Fossil fuels have two properties which make them very desirable energy sources: High energy density and long term stability. The gravimetric energy density of gasoline is approximately fifty time higher than the energy density of the lithium ion batteries which power the Tesla Model S electric sedan. Furthermore fossil fuels are very stable and can be stored for very long periods of time without degradation. I recently went on camping trip during which I used the last of the white gas in a gallon container which has been sitting in my garage for over a decade and its combustion properties had undergone no observable degradation. Furthermore the petroleum from which that white gas was refined had probably been sitting around in rock formations for millions years before human beings extracted it.

Fossil fuel powered human societies have been using the earth's crust as a highly stable storage system for energy dense fuels, and even after the fuel is removed from geological reservoirs and further processed in refineries, it can be transported over the surface of the earth at relatively low cost, sit around in storage depots for months or years, and be used at any time we find convenient.

Current solar energy flows (in which wind energy is indirectly included), on the other hand, must be harvested when they are available and can be converted to stable stored forms only at substantial extra cost and usually with some significant loss of energy in the conversion process.

Costs of renewable energy are usually quoted under the assumption that every kilowatt hour which comes out of a renewable generator can be used at the moment it is produced. To some extent this assumption is true as long as we have other sources of electricity that can be turned up and down at will such as fossil fuel or hydroelectric plants, although even in this case there are excess costs (and carbon emissions) associated with using fossil fuel powered spinning reserves to compensate for variation in renewable energy flows. However, once fossil fuels go away (as they eventually will) then some other form of energy storage must be substituted if we want the grid to operate with the same availability and reliability as it does at present. Such energy storage costs represent an additional economic barrier to replacing fossil fuels with an energy system based on current solar energy flows.

The recent upsurge of lithium ion battery installations for grid energy storage is giving many people the impression that an economic solution to the problem of variable solar energy flows is relatively close at hand. However, the battery systems being installed typically have discharge times of a few hours, while solar energy flows change on a variety of time scales some of which are much longer than a few hours (e.g. weeks or months). Battery energy storage systems which can accommodate these long scale time variations will have to be much larger and will have much longer economic payback times. If a battery with a cycle life of 5000 can charge and discharge once per day then the full value of its service is obtained in less than 14 years. A battery system which cycles once per week will require 96 years to provide its full value, and once per year cycle would require 5000 years.

Of course various schemes exist to compensate these long time scale variations which are technically feasible but which will substantially increase the cost of delivering energy when fossil fuels are phased out. One such scheme is a global super grid capable of distributing electrical energy over very wide geographical area (possibly over the whole habitable globe.). The solar influx over the whole of the earth's surface is fairly constant. It varies locally with weather and with variation of the angle of the sun above the horizon as the seasons change. Connecting the global South with the global North by an electrical grid would allow excess solar electricity in the northern summer to be sent south and excess summer energy in the southern summer to be sent north. Also shorter timescale variations due to cloud cover could also be compensated by a widespread electrical grid. The most mature technology for long distance electrical energy transmission is high voltage DC transmission which has energy losses of 5%/2000km. Therefore transmission over a quarter to the earth's circumference (10,000km) would involve a 25% loss of electrical energy. This loss is quite significant, but not so high as to make such a project unthinkable. Nevertheless the construction of such a super grid would be a very expensive infrastructure project requiring a degree of global economic planning, cooperation and integration well beyond anything that has been previously achieved.

The replacement of the chemical potential energy of fossil carbohydrates by hydrogen produced from the decomposition of water has also often been proposed as a means of dealing with long term energy storage requirements. The catalytic electrodes or photo electrodes required to produce hydrogen are fairly complex and expensive devices, but because they are catalytic electrodes (that is they promote the chemical decomposition of water without themselves being consumed) rather than energy storage electrodes, the quantity of material and thus capital cost per unit of stored energy for very long storage times is potentially much less than for batteries. Potentially hydrogen could be produced locally where solar and/or wind energy resources are high and then transported to end users thus avoiding the need for building an international super grid.

However, significant economic and technical barriers exists to the use of hydrogen as an energy storage medium. The round trip efficiency for the electrolytic conversion of electricity to hydrogen and then hydrogen to electricity in a fuel cell or hydrogen gas turbine is unlikely to much greater than 50%. At this level of efficiency the cost of electricity delivery is multiplied by a factor 2 just from efficiency considerations alone. On top of this one has to add the capital cost of electrolysis. Furthermore hydrogen is a much more difficult gas to transport than is natural gas. At present the only practical means for long distance road transport of hydrogen is cryogenic (temperature = -253°C) liquid tankers. The energy losses from liquefaction plus boil off during transportation can approach 40% which would lower the round trip efficiency for electricity storage to a very low level. Other schemes for the long distance transport of hydrogen such as chemical combination with metals in the form of hydrides or chemical combination with liquid organic compounds (liquid organic hydrogen carriers or LOHC) have been proposed but have not been demonstrated in an economically practical form.

A group of people exists who think that the cost of energy derived from current solar flows will be too high support the current life styles of the most highly developed human economies, and who are promoting energy from nuclear fission as an alternative energy source with lower costs.

Nuclear energy resides in the potential energy arising from the interaction of the protons and neutrons which make up the nucleus of the atom rather than in the interaction of the electrons clouds surrounding the nucleus which is the source of the chemical potential energy in hydrocarbon fuels. The fuel used for most of the current global fleet of approximately 430 commercial reactors is uranium oxide (UO_2). Uranium in the earth's crust occurs in two main isotopes (Isotopes of an element have the same number of protons in the nucleus but different numbers of neutrons.): U238 (99.3%) and U-235 (0.7%). Nuclear fuel is enriched to contain approximate 4% of U-235. U-238 cannot not be used a nuclear fuel by itself because it does not undergo the fission reaction (i.e. the breaking up of the atomic nucleus) which is the source of energy. Nevertheless U-238 contributes about one third of the total energy produced by a nuclear reactor. The way this energy contribution comes about is that neutrons released by the fissioning U-235 are captured by the U-238 which then becomes U-239. U-239 then undergoes a process called beta decay in which the nucleus emits electrons and neutrons are converted into protons. After two such decays the U-239 nuclear becomes Plutonium 239 which is a fissionable nucleus that contributes to the reactor energy supply.

The ultimate source of nuclear energy is the gravitational energy of collapsing massive stars in which the fusion of lighter elements produces Uranium 235 and Uranium 238. Of course Uranium is a finite resource just like fossil fuels, and unlike other elements which we "consume" U-235 truly disappears inside the nuclear reactor. The nucleus breaks up (or fissions) into smaller fragments and thus disappears for good.

Production of fuel rods for nuclear reactors requires producing uranium with an enriched U-235 content of about 4%. The energy density of these fuel rods is 3 million times higher than that of coal. This incredibly high energy density is the reason why a single nuclear explosive device was able to destroy a whole city when the United States used them against Japan in the closing days of World War II.

One might think that if uranium has such huge energy density compared to coal then the cost of electricity produced from this source might be much cheaper than electricity produced from coal. Clearly this is not the case. Nuclear electricity cannot be outrageously costly since France gets 80% of its electricity from nuclear generators and its average price of 0.19 $US/kWh is well within the European norm. On the other hand nuclear energy is not dirt cheap, since the Chinese, whose government has even more authority than that of France in determining national energy policy, has chosen to power the spectacular economic expansion of the last several decades primarily with coal.

So why is it that fission energy cannot beat the cost of coal? One important reason is that in spite of their incredibly high energy density the production of Uranium fuel rods requires costly post processing even after uranium ore has been mined and the uranium has been separated from the other constituents of the ore. Since the chemical properties of an atom are determined by its electron shells and not by its nucleus the two isotopes of uranium which have nearly the same electronic structure cannot be separated by chemical methods. Instead very expensive methods (e.g. gas centrifuge separation, atomic vapor laser isotope separation, etc.) which rely on the small difference in the nuclear mass are required. Nuclear fuel rods are cheaper per kWh than coal but only by a factor of four or five[9] and not by orders of magnitude. On the other hand the up-front capital costs and the operation and maintenance costs of nuclear power plants are higher than coal powered plants because of the greater technical complexity of a nuclear power plant compared to a coal powered steam turbine.

The issue of whether or not nuclear energy can be substituted for fossil fuel energy at a low enough cost to maintain the standard economic model of private credit markets and continuous growth "healthy" for many decades into the future is a complex one. The first question to be asked is how much Uranium fuel is available for the current once through fuel cycle using UO_2 with enriched U-235 content. There is only a finite amount of Uranium available in the earth's upper crust where the costs of mining are reasonably low. A joint report[10] of the OECD Nuclear Energy Agency (NEA) and the

[9] Energy Information Administration, *Table 8.4. Average Power Plant Operating Expenses for Major U.S. Investor-Owned Electric Utilities, 2008 through 2018 (Mills per Kilowatthour)*, https://www.eia.gov/electricity/annual/html/epa_08_04.html, viewed 04/05/2020

[10] *A Joint Report by the OECD Nuclear Energy Agency and the International Atomic*

International Atomic Energy Agency (IAEA) makes a detailed assessment of potential global supplies of economically recoverable uranium from rock deposits. The report concludes that identified Uranium resources are sufficient to last for more than 100 years at 2011 yearly usage rates of 63,875 metric tons (1 metric ton=1000kg). If prognosticated and speculative Uranium resources are included the projected supplies at 2011 usage rates goes up to 300 years.

Of course if one is hoping to largely replace fossil fuel consumption with Uranium consumption then the potential upside in uranium demand is quite large. In 2011 nuclear energy provided 13% of the global electricity supply. Most attempts to project future electricity consumption predict that global electricity consumption will more than double my mid-century. Taking a factor of two as a conservative estimate, assuming 80% of the electricity will come from nuclear energy and assuming a linear rise in nuclear power generation from where we are now to 2050 as simple calculation shows that in the next 30 years we will have consume 239 years' worth of the 300 years of supply. Since our Uranium consumption will have risen by a factor of 12.3 the remaining 61 years of supply will last for 5 years.

I should mention the fact that I do not take the above cited report on future uranium supplies from minerals as an unquestioned gospel. Doubt has been cast on this report from both sides. Some people claim that it is too optimistic and that therefore a ten-fold increase in nuclear generation is not in the cards. Other people claim that the report is too pessimistic and that further exploration will turn up supplies of Uranium that cannot be predicted by current geological knowledge. I do not have any expert knowledge that allows me emit a definitive option on this matter, but I think that the NEA/IAEA report casts some significant doubt on the current nuclear fuel cycle as a long term replacement for fossil fuels.

However, another aspect of the supply of nuclear fuel exists. I have already mentioned that approximately 2% of the U-238 in uranium fuel rod assemblies contributes to the energy supply by conversion to Pu-239 via neutron capture and beta decay. If we could convert 40% or more of the U-238 into fissionable plutonium then we could increase our supply of nuclear fuel by more than a factor of 10.

A so-called fast breeder reactor is designed to accomplish this purpose. In a breeder reactor a blanket of U-238 surrounds a core of fissile material.

Energy Agency, ISBN 978-92-64-17803-8, 2012, Uranium 2011: Resources, Production and Demand, https://www.oecd-nea.org/ndd/pubs/2012/7059-uranium-2011.pdf, viewed 04/06/2020

Excess neutrons from the core are captured by the U-238 atoms in the blanket which are then converted to Pu-239 by beta decay. As long as the density of Pu-239 is low enough a fission chain reaction will not start in the blanket material. Eventually the blanket is removed and the material is processed to separate out the Pu-239 for the production of core fuel rods.

In addition the element thorium can also be used in the blanket of a breeder reactor. The predominant isotope of thorium (Th-232) is not fissile but it can capture a neutron and undergo a double beta-decay to become U-233 which is fissile. Thorium is more abundant in the earth's crust than is Uranium so that thorium breeder reactors would represent another substantial increase in the supply of nuclear fuel.

A number of people have done calculations which suggest that breeder reactors could maintain the world's current total energy use for centuries into the future and possible for several millennia into the future. Of course if the world's population remains at above 7 billion people all of whom naturally feel that they have an equal right to enjoy the abundance of the earth's resources there is still a potential huge upside to current energy demand. Furthermore it is far from clear that with an abundant low cost substitute for fossil fuels and no other major resource constraints that a standard model economy based on private credit markets and unbounded competitive accumulation of consumption rights will reach a natural asymptote of energy use corresponding to the current living standards of the world most economically advanced countries. The potential for advanced microprocessors and robotics to lower the labor cost of production has by no means been exhausted if sufficient supplies of energy and other resources are available to support further development.

The approach of the most advanced economies to an asymptotic level of per capita energy use was highly questionable, given the movement of manufacturing to Asia where energy consumption is rapidly rising. The only thing preventing everyone in the world from living in a 3000 square foot home, from driving an expensive sports car and SUV, and from jetting off to exotic vacation locales multiple times per year is productivity limitations. In a world without any resource or productivity limits other than energy we could burn through an *effectively infinite supply of energy* (i.e. lasting much longer than the lifetime the person trying to free himself or herself from any concern about intelligent resource planning) much faster than calculations based on current human energy use would suggest.

However, apart from the issue of the total supply of nuclear fuel available another concerns exist about an easy transition from a fossil fuel based economy to a nuclear fuel based economy. Electric motors are the dominant providers of mechanical work in situations where mobility is not required. Machine shop tools, assembly line tools and robots, washing machines, dishwashers, tables saws, fans, refrigerator and air conditioning compressors, kitchen blenders and mixers, etc. all use grid based electricity wherever it is available. However, in applications which require mobility, such as rail transport, trucking, shipping, air freight and travel, construction machinery, farm machinery, and the personal automobile, internal combustion engines and petroleum based fuel still dominates the global economy because of its low cost and high energy density relative to electrical storage batteries. As the cost of oil rises natural gas is finding increased use in the transportation section of the economy. It is not quite as convenient a fuel as liquid petroleum products, but it still economically far superior to batteries.

Therefore even if nuclear power can replace coal and natural gas as an energy source for electrical generation at a low enough cost to avoid a major economic disturbance, it is far from clear that it can replace gasoline and diesel fuel at a similarly low cost. Electric rail transportation is a well-established technology, but the continued dominance of diesel fuel in the long distance, heavy rail sector indicates that electric rail has cost disadvantages. Electrifying automobile transportation, truck freight construction and repair equipment, farm machinery, ocean shipping, and air traffic all present major economic challenges. We may be able to find technically workable alternatives for all of these applications of mobile energy supplies, but still not be able to afford the same level of economic activity that we can in the presence of cheap oil and natural gas.

Of course, as a practical matter, a significant buildup of new nuclear power plants in the OECD countries is being strongly inhibited by anti-nuclear sentiment in the aftermath of the Fukushima Nuclear power plant failures. Furthermore the fast breeder reactor scenario would produce large amounts of bomb grade plutonium which raises concerns about nuclear weapons proliferation. The issue of nuclear power safety is complex and controversial, and I am not going to attempt to address these complex issues in this book. The point I am trying to make is that even if you take an optimistic view about nuclear power safety (and therefore an optimistic view about the economic externalities of this means of energy production) the view that nuclear power represents an easy path to many more decades (and possibly centuries) more of business as usual economic growth is questionable even under the questionable assumption that energy is the only limiting resource of any concern.

3.7 Pollutable reservoirs

I take the term /textitpollutable reservoirs from economist Kenneth Boulding's essay /textitEconomics and the Future of Man1. Two of the largest pollutable reservoirs employed by the human economy are the earth's atmosphere and the earth's oceans. These reservoirs are very large indeed, but so large has the earth's human population grown and so large has our per capita resource consumption grown that human economic activity is beginning to have a significant impact on both of these reservoirs. The most significant pollutant in both of these reservoirs is carbon dioxide (CO_2) released from the burning of fossil fuels and from changes in land use which have destroyed a large percentage of the earth's old growth forests. Some people object to calling CO_2 a pollutant since it is naturally present in both the atmosphere and the ocean and its presence is necessary for land and ocean plants to convert sunlight into forms of chemical potential energy that can be utilized by living organisms as an energy source for their internal metabolism. However, in this case as in many others, it is possible to have too much of a good thing. Sunlight striking the earth's surface is absorbed and reradiated as infrared light. Carbon dioxide in the atmosphere absorbs some portion of this infrared radiation from the earth's surface and reradiates part of this energy back down towards the surface of the earth. This so-called greenhouse effect mean that the temperature of the earth's surface required to balance incoming and outgoing solar energy becomes higher as the concentration of CO_2 become higher. This increase in temperature has already significantly impacted the earth's ecosystems, and further rises in temperature will probably have further and even greater impacts than those already observed. In the long term the rich diversity of genetic information stored in the various lifeforms of the earth's biota will almost certainly adapt to these changes, but the time scale of this adaptation may be very long in terms of the time scale of human history so that the period of adaptation may seriously disrupt the human socioeconomic system. I have already pointed out how the artificial ecosystems of human agriculture with a heavy dependence on a limited number crops are probably even less adaptable to rapid changes in climate than natural ecosystems so the impact of global warming on human food production could be quite severe.

About 25% of the emitted CO_2 is absorbed by the earth's oceans. This reduces the greenhouse effect but has negative effects on ocean ecosystems because CO_2 combines with water to form carbonic acid (H_2CO_3). Carbonic acid is very weak compared to the better knows hydrochloric and sulfuric acids, but sufficient amounts are present to have increased the ocean acidity by 30% in the last 200 years. Substantial further increases in acidity are expected if CO_2 emissions are not rapidly reduced. Increasing acidity has various effects on the ocean ecosystem, the most prominent being interference with the formation of shells composed of calcium carbonate ($CaCO_3$). Considering that marine copepods (tiny planktonic crustaceans) constitute the largest stock on animal protein on the planet this interference could have a very significant impact on marine ecosystems.

The intermediate to long term effects of increasing ocean acidity on marine food chains are incalculable, but could potentially have serious impacts on the human food supply harvested from this reservoir. A natural buffering effect of the minerals washed into the ocean by streams and rivers will eventually return the ocean acidity to normal levels, but the timescale of this buffering will be long compared to the timescale of human history so that major disturbances in human socioeconomic systems are very possible.

Other pollutable reservoirs of concern are fresh water reservoirs on and beneath the surface of the earth and the living biome itself. Agricultural and industrial pollution enters the water supply with potential adverse effects on human health on the health of river, lake, and wetland biomes. Pollutants enter natural food chains with potentially adverse effects on various living species. The potential collapse of honey bee populations which are vital pollinators for many important crop plants has already been cited as one possible effect of such pollution.

3.8 Biological diversity

I have already discussed some aspects of the dependence of human beings on the rest of the biosphere in Truth 2. Here I merely want to re-emphasize that the expanding scale of the human population of the earth and the expanding ecological foot print per capita that is involved in increasing standards of consumption are making significant inroads into the important resource of biological diversity (i.e. Species extinction rate have risen to more than one thousand times the pre human rate and are still increasing.). Of course biological diversity is renewable on long time scales. In the distant past the Earth has undergone several major episodes of mass extinction where the number of animal species was reduced by 50% or more. The biosphere has always recovered from these extinction episodes and produced a vast array of new species. However, the recovery times are long compared to the time scale of human history so that the implications of loss of biodiversity could be felt for many generations of human existence (Assuming, that is, that we are not one of the species which goes extinct).

Chapter 4

Truth 4: Growth of the economy at a constant percentage implies exponential increase of economic output in absolute terms

Growth in total economic output has come to be regarded as the universal norm of human economic activity. And indeed, although there have been a number of temporary setbacks to human economic activity in the form of wars and trade depressions, substantial growth (i.e. producing obvious changes in standards of consumption within the life time of a single human being) in global economic output has been the norm for nearly two hundred years. However, using the principle of induction to conclude that what has happened for the last two hundred years must inevitably go on happening for the next two hundred years is not a logically sound procedure.

Economic growth is generally quoted as a percentage of current economic output measured by dollar exchanges of goods. Thus we talk of 2% annual growth, 3% growth, or 4% growth. Growth by a constant percentage implies that absolute growth rates are constantly accelerating. For example at a growth rate of 4% per year the time required for economic output to double is approximately 17.7 years. If after 17.7 years the 4% growth rate continues the absolute growth rate will be twice what is today. After another 17.7 years the absolute growth rate will have doubled again and be four times what it is today. After another 17.7 years the absolute growth rate will be 8 times what it is today and so forth as long as growth at this annual percentage rate continues. This kind of accelerating growth pattern is called exponential growth.

Insofar as economic growth implies increased consumption of resources this pattern of acceleration means that most of the resource consumption which has occurred is of comparatively recent date. For example, consider human caused carbon dioxide emissions which are a result of fossil fuel consumption. Of all the emissions from these sources that have occurred since coke powered blast furnaces came to dominate the European production of iron in 1750, 58% have occurred since 1980 [1] . In order for the exponential growth pattern to continue for a period of time that is long compared to human history truly miraculous improvements in human productivity would be required. For example a growth rate of 2% continued from the present moment for ten thousand years into the future would result in an economic output that is approximately $10^{8}6$ times larger than our current global economic output. Or, to be somewhat more precise, by a factor of $1.00391 \times 10^{8}6$. The difference between these two numbers which represents an error of less than 0.4% is equal to an economic output which is 391 billion billion billion billion billion billion billion billion billion times the current annual economic output of the entire earth. Clearly this pattern of growth cannot continue forever.

[1] Boden, T.A., G. Marland, and R.J. Andres. 2016. *Global CO_2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2014*,https://cdiac.ess-dive.lbl.gov/ftp/ndp030/global.1751_2014.ems, viewed 08/19/2020

Chapter 5

Truth 5: Dematerialization of economic output (e.g. the service economy, the information economy etc.) cannot support exponential growth indefinitely

Relatively few people spend time thinking about the future development of human civilization on a time scale of centuries or millennia. The next few decades or, in some cases, the rest of the century is about as far as most people are willing to go in envisioning the practical future. The total expansion of human economic activity required to maintain "healthy" growth on this time scale may therefore appear manageable depending on what assumptions are made. A popular assumption among those who are eager to assure themselves that the economic way of life to which they have grown accustomed is not under any immediate threat is the assumption of dematerialization of economic output. "Yes", such people say, "economic transactions measured in dollars need to go on increasing exponentially in order to keep our financial system healthy, but the flows of material resources which accompany those transactions can potentially increase at a much lower rate than the flow of dollars.".

This process of decreasing the amount of energy and other physical resources required to produce a given amount of dollar exchanges of economic goods I call dematerialization of economic output. Buckminster Fuller in his 1981 book *Critical Path* referred to this phenomenon as ephemeralization of economic output. Of course for dematerialization to support exponential economic growth for indefinite periods of time dematerialization must improve exponentially for indefinite periods of time. For example suppose that we wished to keep resource consumption rates at their current level and to maintain a long term growth rate of 2% via the process of dematerialization. Global energy consumption in 2017 was approximate 5.65×1020 Joules (I used the average value of the quoted numbers from the *BP Statistical Review of World Energy*[1] and the *Enerdata Global Energy Statistical Yearbook*[2]. The two estimates differed by 3%.) A joule is the amount of energy consumed by 1 watt of power expended for 1 second. I found an advertisement on line for a 4 watt LED light bulb which provides equivalent illumination to an old fashioned 40 watt incandescent light bulb (an example of dematerialization of economic output). The energy consumed by this light bulb in 1 second is 141 billion billion times smaller than the total global energy consumption in 2017. If economic growth continues at a rate of 2% per year in a completely dematerialized fashion with respect to energy consumption (That is energy consumption remains constant at 2017 levels and all improvements are made by increasing the efficiency of energy use.) then after 2343 years the energy output of that light bulb for one second will be producing an economic output equivalent to the entire global economic output in 2017, and the total global economic output will have increased by a factor of 141 billion billion times. Clearly dematerialization has long term limits. However, if one is concerned with only a few decades, or maybe a century, then perhaps there is hope that dematerialization may put off the day of reckoning with respect to limits to growth. For example a 2% growth rate continued for 80 years would result in 487% expansion of economic output. Given the current state of environmental degradation I think that real reasons exist for being concerned about this near factor of five increase in economic activity over the rest of the century, but because no certain boundary can be given to the technological prowess of the human race there is imaginative room for techno-optimists to hope that such

[1] BP, 2019, *BP Statistical Review of World Energy 2019*, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/downloads.html, viewed online 04/06/2020

[2] Enerdata.net, 2018, *Global Energy Statistical Yearbook*, https://yearbook.enerdata.net/total-energy/world-consumption-statistics.html, viewed online 04/06/2020

an expansion can be successfully carried out. In case anyone is surprised by the 20 orders of magnitude difference between 80 years of growth and 2343 years of growth just get out your calculator or open a spreadsheet and verify for yourself that to three digits of accuracy: $1.02^{80} = 4.87$ and $1.02^{2342} = 141,000,000,000,000,000,000$. Not forever, my friends.

The most often cited example of dematerialized growth is in the consumer electronics industry, where increasing miniaturization of printed circuitry has rapidly increased the functionality that can be packed into a given area of electronics grade silicon. Although this example is well chosen, we must recognize that electronics information technology is a unique economic product. Digital information technology is driven by bits of information and by logic gates which are based on small pieces of matter which can exist in distinct physical states. One of the two states is arbitrarily assigned the value 0 and the other state is assigned the value 1. Any form of information (e.g. words, images, sound sequences) can be packaged into a complex pattern of 0s and 1s. The physical size of a bit is unimportant as long as its physical state can be determined. In principle a single atom could serve as bit as long as it was constrained to flip back and forth between two recognizable physical states.

I should point out, however, that although it would be possible to use the physical properties of information technology to provide a given level of service with steadily decreasing resource inputs, this course of action is not being pursued. Instead a constant effort is made to increase the variety and sophistication of services provided in order to extract large profits from people who are eager to stay at the forefront of the information technology revolution. These profits come from selling new physical devices with more sophisticated, higher performing hardware, and from selling access to ever larger stores of data accessible at ever faster data rates which people are willing to pay premium prices for in order to satisfy the increasing data requirements of leading edge hardware and software. Under these conditions it is not an inevitable law that growth of the information economy will be completely dematerialized (i.e. that it will proceed without increasing resource inputs). All that can be said is that under resource constraints such as rising energy costs (direct and/or indirect) the information industry has a better chance than other sectors of the economy to keep growing in the presence of such constraints.

However, most economic products and services are not subject to this kind of dematerialization. You cannot make a coat, a pair of shoes, a chair, a refrigerator, a table saw, an electric drill, a house, a sky scraper, an automobile, a train, or a jet airplane out of a single atom. With a global human population of seven billion people and rising, a lot of very material growth has to occur before everyone has achieved the standards of living realized by the most economically developed parts of the world. Furthermore, prior to the great recession of 2008 it was hardly true that all growth in the developed world was focused on information technology. In the United States house sizes, automobile sizes, the frequency of jet airplane travel were all still increasing. The economic downturn and the stubbornly high price of oil moderated these tendencies temporarily by cold, hard necessity, but the recent recovery has lead the business as usual optimists to hope for a return to vigorous growth across all economic sectors. If resource limitations or the externalities of human economic activities begin to bite hard, the ability of growth in information technology alone to hold up the financial system for many decades into the future is questionable.

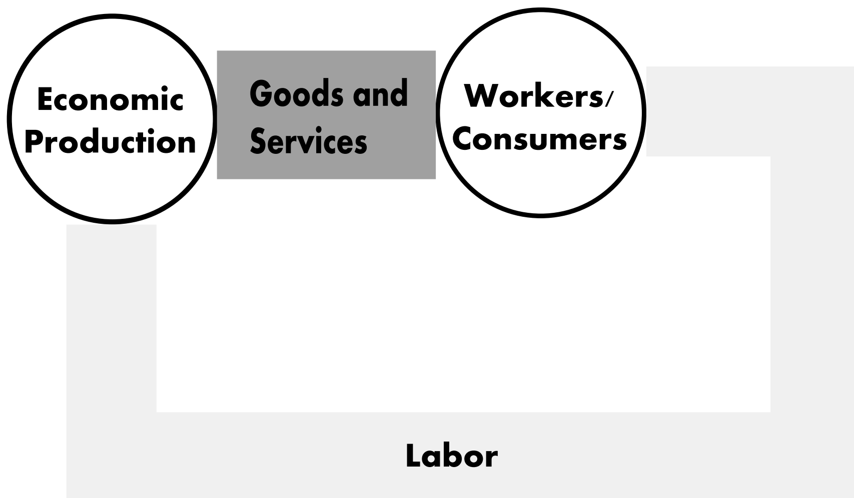
Chapter 6

Truth 6: Private finance of economic infrastructure requires growth for effective functioning

Figure 1 depicts the flow of labor in the process of economic production. This flow is circular. Labor flows into the process of economic production. Goods and services flow out of production where they are consumed, and in the process sustain and renew labor power which then flows back into the production of goods and services. Of course other thing besides labor (e.g. energy and raw materials) are required for economic production. However, these things are obtained with the aid of labor, and in the diagram the procurement of such things is viewed as being contained within the process labeled economic production. The nature of the resource environment within which labor is expended determines how productive that labor will be. The efficiency of labor may defined as the quantitative output of consumer good (assuming for the moment that this output can be measured on some objective quantitative scale) divided by the total labor hours. With the aid of energy and machinery fashioned from the earth's biological and mineral resources the efficiency of labor can be greatly multiplied. The intricacies of this process are hidden in the diagram within the circle labeled *economic production*.

One can question whether consumption has as its only goal the renewal of labor power, but from a narrow economic (as that word is typically understood) point of view, only that consumption which sustains our physical

Figure 6.1: Flow of labor in economic production



and psychological health and renders us fit for further productive activity is truly useful. Of course once psychological health is included in the economic equation a wide variety of subjective interpretations can be given about what constitutes useful consumption.

Finance, in its most general sense, is the expenditure of production resources (e.g. labor, energy, fresh water, etc.) in the present in the expectation of getting a future return of economic output in goods and services. Finance in this generalized sense is unavoidable in any large scale enterprise with pay back times that are long in relation to short intense episodes of resource expenditure. Any time that such expenditures are made someone must pass judgment on the degree of risk that the required expenditure will not be adequately compensated by the long term returns. If the risk of poor returns is judged to be sufficiently low and the expected return is judged to be sufficiently high, then *credit* is given to the idea that the proposed investment of resources is worthwhile. This process of judging investment risk and granting credit to specific proposals for investment of resources cannot be avoided. Even a private company spending its own cash reserves on its own plant must engage in this process.

Investments in manufacturing infrastructure are of two types. The first type are maintenance investments which are required keep current infrastructure in working order at current levels of efficiency. Such investments can still take the form of episodic intense expenditures, rather like putting a new roof on your house. The roofing industry has well established materials and techniques, but the expense of a new roof is high enough that you want to take time and care in choosing materials and installers in order to ensure that you get a good long term return on your investment. In addition you need to take care that in your effort to find a good price that you do not take too high a risk by employing materials that have questionable long term quality.

The other type of infrastructure investments are those which create new infrastructure directed at producing new products or which upgrade old infrastructure in a way which increases its productivity. With this type of investment we run into the phenomenon of interest. The first type of investment merely maintains current levels of production. The second type actually increases total production. The increase in total production I call physical interest (in contradistinction to financial interest, to which idea we will come shortly).

The need for these periodic intense expenditures of resources creates problems for individual enterprises since their flow of income typically does not match the pattern of their expenditures. Before considering the methods which are used to help match the flows of income to expenditures by individual enterprises let us consider this problem from the point of view of the complete economic community. Consider a situation of steady state economic production in which the variety and quantity of economic goods and services produced is nearly constant. Individual enterprises will occasionally need major upgrades to equipment and plant. As long as the average yearly expenditure of the whole economic community on such capital maintenance is constant there is no problem of lumpiness in expenditure. A certain percentage of our manufacturing resources are dedicated each year to capital maintenance rather than to the direct production of goods and services, but the income from previous investments which are made at constant rate (averaged over the whole economic system) year after year, make up for this year's capital expenditures, and thus these expenditures have no effect on our current income of consumer goods and services. It is only the individual enterprise making a large expenditure in the current year which will produce income for twenty years into the future which has a problem matching expenditure and income.

In the current economic system there are two methods of attempting to match income to expenditure for individual enterprises. One method is saving which I will cover in truth 7. The other method is private finance. In this process the evaluation of risk and the granting of credit, is accomplished by private investors external to the specific enterprise in which the expenditure of resources will occur. The private financiers grant present purchasing power to the enterprise in question and allow them to pay back this purchasing power out of their future earnings. However, private financiers do not evaluate risk and grant credit merely to maintain the productivity of the larger economic community. They are out to "make money" as the saying goes rather than to make infrastructure, although in many cases these two goals coincide. In order to make money the private financiers require that the receivers of credit should eventually return a larger amount of purchasing power than they received in the first place. This excess purchasing power I call financial interest.

Clearly the demand for financial interest will direct the attention of private financiers towards investments of the second type: those which tend to increase total economic production. The excess purchasing power returned to private investors has to come from somewhere. If real physical production does not increase as a result of the investment of resources, then either the investment must fail and the enterprise in question must declare bankruptcy, or someone else must lose purchasing power in order for the investor to receive his or her interest. In the absence of overall economic growth private finance becomes a zero sum game. For one financier to increase the purchasing power of his or her financial capital someone else must lose purchasing power.

For the past several centuries growth in overall economic output has been the norm in European and North American society so that interest producing investments have been widely available. Of courses, the element of speculation about increases in future production and consumption involved in private finance has its disadvantages even when relatively vigorous growth is possible, and spectacular financial collapses resulting from over investment have been a serious recurring problem in the history of capitalism. However, if real physical problems start to limit the opportunities for productivity increases then our ability to recover from a serious financial collapse to a state of "healthy" economic growth may become extremely difficult or impossible.

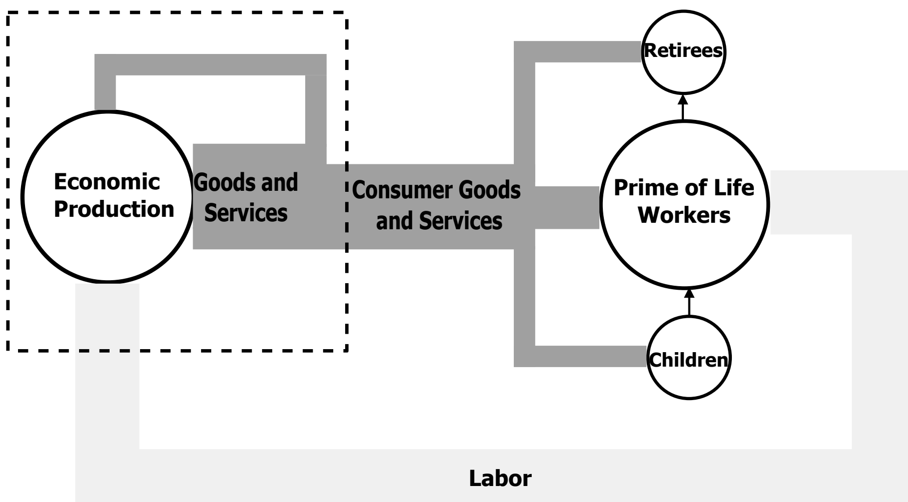
Chapter 7

Truth 7: Private savings are investments in economic infrastructure. The desire to store up lots of economic value in order to gain future security is really a desire to continuously build up economic infrastructure.

Savings are usually viewed as a prudent, conservative, common sense, economic activity. Instead of consuming all of the goods and services that you are entitled to today, you put aside something for the future. Before you put this something aside it was your property in an absolute, unconditional sense. You have the right to dispose of this something in any way you choose, and having chosen to put it aside, you have an unconditional right to bring it back into the realm of your personal use whenever you decide to do so.

Before accepting this point of view we need to ask exactly what this something is that is being put aside. Let us consider this question from the point of view of the overall economic machine of society which consists of a large variety of specialized production enterprises which are necessary because every individual consumes a wide variety of products and not just the few specialized products of the production enterprise to which he or she directly contributes. The diagram below depicts the flow of labor and economic goods and services of the overall economic system. Labor flows into the process of economic production. Goods and services flow out and are consumed by the laborers, thus renewing their physical and psychical energy so that the process of labor can be continued. I have depicted children and retirees as separate populations which consume economic output but do not contribute labor to economic production (This assumption is not really correct since many people not in the labor force indirectly contribute to economic production by voluntary community services of various types). Over time children enter the work force and take the place of people who die or retire.

Figure 7.1: Income and labor flow in a steady state economy



A part of the output of goods and services is used to support industry rather than going directly into the hands of consumers. So machines or machine parts which are destined for the factory floor are not consumer goods. Construction materials which are used to build or maintain factories are not consumer goods. And so forth. In the diagram I depict these kind of outputs as coming out of the process of economic production and being fed back in again to help maintain that process. In some sense these goods might be thought of as internal to the process of economic production so that the dotted box might be regarded as the real boundary of the process of economic production and the consumer goods which come out of it are the real final output.

Now obviously this diagram is a greatly simplified picture of economic production. There are many other required inputs besides labor, such as energy, raw materials, agricultural land, fresh water, etc. Such inputs are part of the resource environment within which economic production takes place. In a highly favorable resource environment with plentiful supplies of cheap energy, high quality mineral resources, plentiful agricultural land, plentiful fresh water supplies, etc. a much larger output will be obtained for a given input of labor than in a less favorable resource environment. However, for the purposes of this illustration I am assuming a more or less unchanging resource environment which is being exploited in a way which can be maintained for a long period of time. I assume that the human population is constant and that the variety and quantity of goods and services being produced is constant. The work load of producing these goods is shared in such a way that nearly full employment is maintained. Such a system of production is called a steady state economy.

Under these assumptions, where is the opportunity for savings in this system of production? That is what sort of output exists that we can put aside for the future or consume in the present according to our personal choice? The output of goods and services provides full employment, so we certainly do not wish to reduce it. The goods and services directed towards maintaining industry is a necessary ongoing expense. The minute we reduce this expenditure our system of production starts to decay and we become poorer. We could of course adjust the relative consumption between the active work force, children, and retirees. We could also change the proportion of the population who are retired by raising or lowering the retirement age. However, such an adjustment would be a one-time event, and when the new system of consumption was in place there would be no opportunity to put anything aside. From a systems point of view no opportunity for savings exists in a steady state economy. An individual can defer consumption, but society as a whole cannot do so. The group of consumers who are currently saving money for relatively expensive purchases of goods and/or services some time in the future must be balanced by a group who are using their savings in the present to buy relatively expensive goods and/or services.

It is true, of course, that in order to receive support in your old age you should have built up some kind of social credit during your productive middle life by helping to maintain and run the system of economic production. But this social credit does not consist in putting aside personal property to which you have some absolute unconditional right. The goods and services

Truth 7: Private savings are investments in economic infrastructure. The desire to store up lots of economic value in order to gain future security is really a desire to continuously build up economic infrastructure.

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dedicated to maintaining industrial infrastructure are a necessary expense, not a voluntary "savings". The goods and services consumed by the elderly are a necessary cost of a humane society. If you have any hope of decent treatment in your old age this is not a cost that you can accept or forgo as the fancy takes you. Make no mistake about it; The people who have left active employment are supported by the people who are still working. Bill Gates has retired from running Microsoft Corporation and the food, clothing, and fuel which he continues to consume are supplied by the men and women who get out of bed every morning and go their jobs to produce these things. No other physical possibility exists.

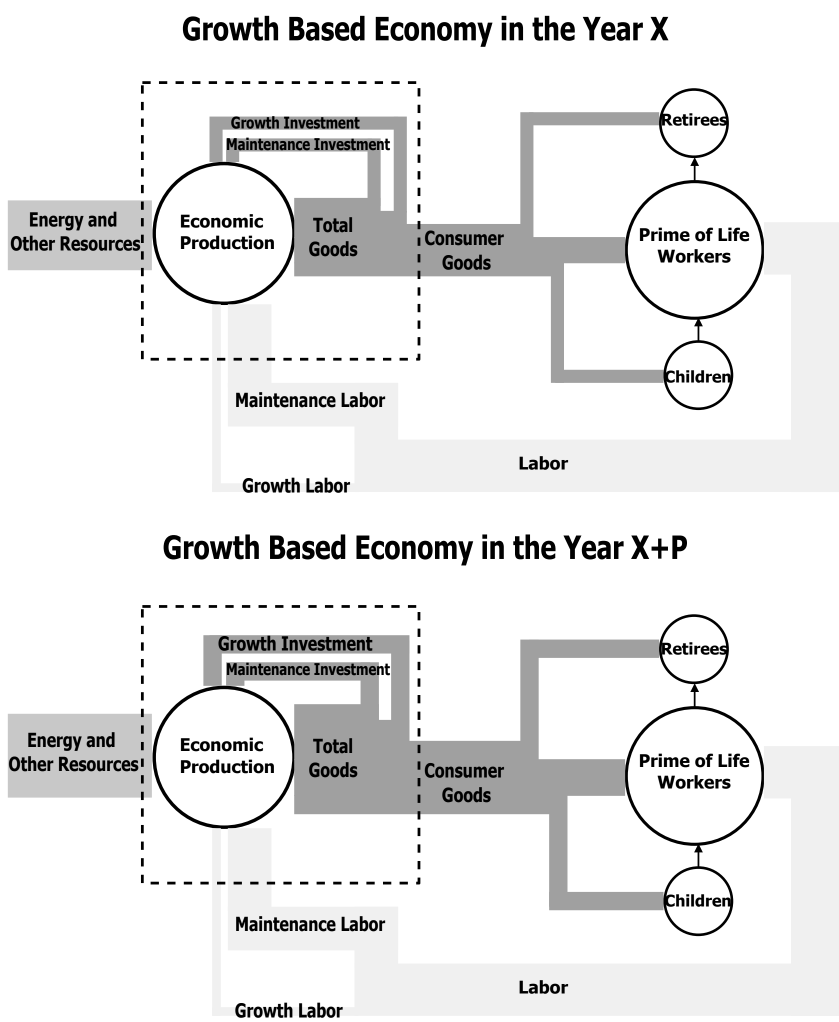
So far I have discussed the possibility of savings in a steady state economy in which the quantity and variety of goods and services produced is constant. The situation is somewhat different in an economy in which the variety and quantity of production goods and services in growing, such as we have experienced over the last several centuries. Figure 3 illustrates the flow of goods and labor in a growing economy.

In a growing economy a certain portion of our yearly labor and a certain portion of our yearly output of goods and services is directed toward bringing about future increases in economic production rather than toward producing goods for immediate household consumption. These growth directed flows have been separately labeled in the figure. The payoffs for these investments are in the future. The figure shows snapshots of the economy taken p years apart during which time the output of consumer goods and services has grown by 40%. At a 4% annual growth rate it would take a little less than nine years to produce such an increase in output. At a 2% growth rate it would take and approximately 17 years to produce such an increase. I show this growth in consumer goods being equally shared by active workers, retirees, and children, a distribution which may not apply in actual practice.

In the figure I also assume that after p years of growth that the investment of labor and economic goods in growth producing investments is still ongoing. I have depicted the fraction of labor and the fraction of total economic output directed to this end as being the same at the end of the p years as at the beginning.

In this figure I have also shown the input of energy and other resources from the environment. As the total economy grows these inputs from the environment also grow. I have chosen to show a case where the growth in resource inputs is smaller than the growth in the output of goods and services. That is I assume that there has been some improvement in the efficiency with which natural resources are converted into consumer goods and services. The degree to which such dematerialization of economic output

Figure 7.2: Labor, production resources, and income flows in a growing economy



is possible has been a subject of a fair amount of debate. However, the idea that such dematerialization can become indefinitely exponential so that the resource efficiency of economic can grow exponentially with constant resource input is not a reasonable assumption as was previously discussed.

The investment of labor and economic goods in growth producing activities resembles the traditional idea of savings in one respect: It represents an expense which we could choose not to incur. If we are content with the mix of goods and services that we are currently producing then all we need to do is to maintain and operate our current system of production, and we can avoid expenses associated with producing future growth. Nevertheless it is a strange use of language to call investments in growth producing infrastructure savings, since the tendency of such expenditure is to constantly expand total resource consumption. Eating extra food to supply the calories you need to support a rigorous athletic training regimen might result in future competitive success, but no one in his or her right mind would dream of calling such excess consumption “savings”.

In populist politics economic growth is promoted as being good for the whole of society. Everyone is supposed to get a higher quality of life from the increase in the variety and quantity of goods and services produced. However, very few people labor under the delusion that economic growth is a uniformly rising tide which raises all boats equally. There is obviously a tremendous ongoing competition to claim as large a piece of the growth pie as possible. Let us consider some of the specialized skills that are used in bringing about growth and which, therefore, have the most legitimate claim to a larger than average piece of the growth pie.

First there are technical innovators who develop new technology, new products, new kinds of manufacturing machinery and processes. Secondly there are industrial organizers or entrepreneurs, who view the creation of new products and new industries from a systems point of view. Such people are involved in the creation of new industrial products/processes in a variety of ways, including cost analysis, market analysis, and general organizational decision making which insure that the right resources are made available at the right time. Thirdly are the people who make decisions about debt and risk. That is for new products and processes substantial amounts of resources have to be consumed in the present in order to produce new products and services in the future. Someone has to evaluate the likelihood of adequate future payback for present investment and authorize the necessary expenditures. Now to some extent this skill is exhibited by the entrepreneurs themselves. However, it frequently happens that entrepreneurs have to persuade outside investors to authorize the necessary expenditure of resources.

Insofar as these outside investors are talented evaluators of systems risk with respect to industrial enterprises they are providing a valuable service (assuming, that is, that growth in total economic output is considered desirable) to the overall economic enterprise of society.

These are the three classes of people who contribute specialized skills to the creation of economic growth. However, it would be mistake to claim that they produce such wealth independent of the rest of society. If every last citizen decided that they wanted to be a scientist, engineer, entrepreneur, or venture capitalist and to spend 100% of their time creating new products and services, society would immediately fall apart. We need people to raise children, build and repair streets, do plumbing, pound nails, haul garbage, pick fruit, etc. Industrial innovation cannot take place unless basic systems of production are in place to provide established products and services. From a systems point of view the maintenance of current systems of production is a part of the growth process.

However, a significant part of the new wealth created through the growth process is claimed not on the basis of skill used in the creation of that wealth, but simply on the basis of the possession of money. People who have present consumption rights in the form of money surrender it to various manufacturing enterprises and expect to get back a larger amount of consumption rights in the future as new products and services become profitable. This attempt to gain future security of consumption rights through competitive "frugality" in the present is the normal process of "savings" in our modern economic system. The use of the word *frugality* in this context was introduced by Adam Smith in *Wealth of Nations*. The use of the word frugality in this context is strange and comes about from taking a narrow point of view. If you consider two people who have similar current incomes then the one who is saving and investing the most is being more frugal but in the long run she or he (or his or her heirs) will consume more than the present spendthrift. Furthermore if one considers income groups rather than individuals within the same income group, one finds that the groups with the largest absolute savings rates are also the largest consumers of economic goods in an absolute sense. I do not intend this comment as a criticism of the upper middle class. It is absolutely essential that people should spend in proportion to their incomes in order to keep the current financial system from collapsing.

The process of private savings has unfortunate consequences. In the first place nothing is actually being saved as I have pointed out before. Our "savings" stimulate constantly increasing economic production and therefore constantly increasing consumption of resources. Furthermore this program

Truth 7: Private savings are investments in economic infrastructure. The desire to store up lots of economic value in order to gain future security is really a desire to continuously build up economic infrastructure.

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of individualized, “independent” savings creates great personal insecurity. Very few people have saved enough money that they are completely confident of their future. No one can predict how long they might live and how much money they might need if their physical condition eventually degenerates. On top of these consideration of physical need the built in monetary inflation of the financial system creates an additional anxiety about having stored up a sufficient amount of consumption rights. Therefore the desire for savings has no boundary for the vast majority of workers. Consider two men who are planning to retire at 65. One dies of a heart attack when he is 64.5 years old and the other lives to be 98 years old. Both feel that they need to have very large amounts of money saved up, just in case they live to a very old age. Therefore the natural human desire for security and comfort leads to a constant stimulation of the economic system to greater and greater levels of economic production.

If, indeed, physical limits to growth are reached, then the pursuit of personal security of consumption via so-called competitive frugality will lead to great social difficulties. If today’s round of savings does not result in the required future growth then the people who are counting on that growth for their retirement security will be in serious trouble. If on the other hand retirement security is provided by a system of social credit in which it is recognized that those people who put their shoulder to the wheel and did their part to support the economic machinery of society during their productive prime, deserve to be supported by that machinery in their declining years, then no problem exists with respect to shifting from an economic growth mode to an economic maintenance mode; We simply eliminate investments in growth when they no longer make sense and give an appropriate proportion of our remaining economic output to the aged as the due reward of their life’s labors.

Chapter 8

Truth 8: All investments in infrastructure are community investments.

This truth may perhaps be regarded as the least obvious of the whole group of eight. Nevertheless, it does not require a very sophisticated analysis to understand the underlying meaning of this statement. In discussing the issue of limits to growth and a possible credit crisis in which in which industrial finance by private lenders is no longer possible, some people have suggested the alternative of a cash economy, in which businesses would set aside cash for anticipated investments in plant and machinery. Suppose for example that a successful steel manufacturing company exists. If you wish you can imagine that the CEO is an Ayn Randian hero of industry who is an engineer and scientist as well as an entrepreneur. He and his employees work long hard hours and make their factory one of the most productive in the industry. The company has made substantial profits over a number of years, but their machinery and plant are getting old and a major refurbishment of their plant is required. They have saved up the necessary money from their profits and they now decide to renovate their manufacturing plant. This is an example of a private company spending their own hard earned cash. How can it be claimed that this is a community investment?

Consider for a moment where this company's cash came from. It came from other members of the economic community who needed steel for their own economic projects. It is impossible to make a living running a specialized large scale enterprise like a steel plant without the existence of an extensive economic community of other specialized enterprises (see truth number 1). Part of the price paid by the community for steel is intended to help maintain steel manufacturing capability for the long term. If these funds are misinvested the whole community will suffer.

Suppose now that the hero CEO dies of a heart attack before the refurbishment takes place, and his son, who is an incompetent playboy nincompoop, takes over the reins of the company. The son thinks he can cut corners on the plant refurbishment in order to pay for his personal mansion, his sports cars, his ski condo, etc. If the investment in manufacturing infrastructure fails through incompetence then the whole economic community will suffer the consequences. The community will either have to put up with a smaller supply of steel (and consequently higher prices) or they will have to cough up the resources to correct the mistakes of the incompetent/greedy playboy nincompoop.

The best thing that can be said about such "private" investments in economic infrastructure is what Adam Smith said about them in his famous passage about the invisible hand [1]:

> *As every individual, therefore, endeavors as much as he can both to employ his capital in the support of domestic industry, and so to direct that industry that its produce may be of the greatest value; every individual necessarily labours to render the annual revenue of the society as great as he can. He generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it. By preferring the support of domestic to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention.*

It may be true to a limited extent that public welfare can be promoted by private greed while abundant low cost resource reservoirs are available and while the biosphere has abundant capacity to absorb our wastes without damaging essential ecosystem services. However, it seems unlikely that in the long run we can live within the natural limits of the terrestrial environment without consciously intending to do so.

[1] Smith, Adam, 1994, *The Wealth of Nations*, Book IV, Chapter II, p. 484, Modern Library, New York

Part II

Alternatives to the growth oriented features of the economic standard model

Chapter 9

Belief in the end of growth as a social nightmare

As we have seen in the first part of this book, our current economic system is strongly oriented towards growth in total economic output. Unless increases in economic output can be completely decoupled from increasing resource inputs and increasing negative externalities (e.g. pollution, soil loss, species destruction, etc.) this growth orientation cannot be continued indefinitely. In this part of the book I will discuss some possible alternative methods of organizing economic production which do not require a growth orientation.

For better or for worse human society tends to be permeated by a natural conservatism which strongly resists changes to familiar social institutions. This natural conservatism or desire for social continuity was given perhaps its most intelligent expression by the sixteenth century French essayist Michel de Montaigne. Montaigne was opposed to innovation in established social forms not because he believed that he had achieved a definitive understanding of the best principles by which society could be organized or because he understood definitively what are the ultimate limitations of human nature in terms of social cooperation. Montaigne did not believe that his intelligence had penetrated to the final term of either of these complex questions. However, he did not believe that anyone else's intelligence had penetrated these mysteries either, and he therefore distrusted social innovation. Once the door to social innovation is opened who knows what kind of monster might walk through it? The cure might end up being much worse than the disease. He felt that it was better to "bear those ills we have than fly to others that we know not of".

Most people's resistance to social change is more instinctive and less rational than Montaigne's, but it is nevertheless permeated with a great deal of practical intelligence. However, if external circumstances are changing in a way that makes existing social institutions more and more dysfunctional, then the painful necessity of social transformation may be forced upon us whether we wish for it or not. This part of the book will discuss possible adaptive transformations which industrial society might adopt in response to constraints on economic productivity.

Before proceeding with this discussion, however, I would like to briefly discuss a serious psychological problem which often arises in any attempt to discuss alternative modes of economic organization. In many people's minds the following two equations concerning economic growth are valid descriptions of reality:

Economic Growth = Life and Progress

Lack of Economic Growth = Stagnation and Death

If one accepts these equations as true, then there is no point in thinking about alternative methods of economic organization. We should grow as long as we possibly can, and when we cannot grow any more then society will descend into chaos and misery. Voluntarily embracing chaos and misery before external necessity forces us to do so is obviously an act of insanity. Clearly I do not agree that the above equations represent eternal and unchanging truths or I would not have bothered to write this book. However, like many false formulas these two contain elements of truth. Suppose we rewrite them thusly:

Aesthetic and Intellectual Growth = Life and Progress

Lack of Aesthetic and Intellectual Growth = End of Modernity

In this form I think that the equations can potentially be used to approach a post growth society without horror and fear. I have substituted *the end of modernity* for the more extreme claim of *stagnation and death*. The available evidence does not indicate that primitive peoples who held no conception of progress in the modern sense regarded their lives as a form of miserable monotonous slavery, and the idea that their overall psychological health was superior to that of civilized humanity has been promoted by a number of observers including Thomas Jefferson. However, the possibility of completely turning our backs on modernity as a response to the ecological and resource crises that we are facing does not seem like a practical option.

The question of how our sense of psychological well-being has become tied to the notion of an ever increasing (in both variety and total quantity) flow of consumer goods is a complex one. The ancient Greeks are widely viewed as the source of one of the most vital and creative cultures that ever existed. Their innovations in philosophy, political organization, mathematics, physics, literature, drama, sculpture, painting, and architecture are among the most important foundations of modern civilization. Nevertheless their purely economic productivity was negligible compared to the output of modern industrial civilization. I do not mean to imply by these comments that the ancient Greeks were not preoccupied by material wealth, because they undoubtedly were. However, this example makes clear that psychological vitality is not directly proportional to the amount and variety of consumer goods available.

A key question to be dealt with in facing limits to growth issues is whether or not we can transition to a quasi steady state economy without turning our backs on modernity, that is without losing our sense of being on a quest for increased knowledge and understanding of the world in which we live. The example of the ancient Greeks gives some hope that psychological modernity and increasing flows of consumer goods are not inevitably tied together. Of course no definitive pronouncements can be made concerning this complex questions of human values, but a purely technical discussion of the means of organizing economic production without some reference to these wider psychological issues is not really possible. The practical question of how intellectual and economic productivity are to be efficiently encouraged without the constant stimulus of greater personal consumption in the present and in the future is complex one. I do not pretend to be able to give a definitive answer, but in the following chapters I will outline some speculations on this subject which I have made over a number of years.

Chapter 10

On socialism

Since I have little doubt that some of the ideas I have already expressed in the earlier parts of this book, and even more some of the ideas I will express in this section of the book will bring on accusations that I am a socialist, I think that a preliminary discussion of the word "socialism" is in order before proceeding further.

Notice that I say the word "socialism" and not the economic or governmental theory of socialism. Many people seem to think that a single well defined theory called "socialism" exists and either one believes in it or one does not. I think that this claim is false. In the first place I think that over a long period of time in the nineteenth and early twentieth centuries a complex of ideas grew up out of the perceived defects of the existing economic and political system. The natural human tendency to attach a kind of mystic significance to verbal formulas made many of the people who participated in this intellectual and social ferment willing to accept the label of "socialist", but to claim that this ferment converged to a single uniform theory of economic organization and governance is, as far as I can tell, not true. I personally found Marx's *Capital* to be almost unreadable and I have never attempted to read Lenin, but nevertheless I think that it is clear that the Marxist-Leninist claim to have reduced to movement of human social development to an objectively established scientific discipline is one of the great intellectual absurdities of history.

Secondly people who are searching for truth in a complex and evolving world do not "believe in" theories. At best a theory is accepted as a tentative hypothesis and is then tested against data to see to what extent it is verified or falsified by experience. In the case of human social theories, for better or for worse, it is impossible to do controlled repeatable experiments changing one variable at a time as is done the natural sciences. Reading history can shed some amount of light on the relative merits of various types of social organization, but real innovations in social organization proceeds via thought experiments and then by risky changes in the real organization of currently existing human associations. Of course, a natural conservatism exists which resists such innovations in existing social conventions, but the pressure of changing circumstances sometimes triumphs over such conservatism and established human associations change their forms and/or new human associations with new rights and privileges come into existence.

The problem of social theory is further complicated by the fact that no fixed universal agreement exists about what goals human associations should be designed to achieve. Not merely do opinions about what constitutes the good life vary within the existing population, but our views of the best mode of living are evolving over time. Therefore social thinkers must explicitly state what goals are to be aimed at by the human associations they wish to create or reform. Only if they can persuade a substantial group of people that their goals are worth pursuing will they be able to get anyone to pay attention the technical details of their proposals.

I do not intend in this chapter to attempt to outline the history of so-called socialist thought, a task for which I am woefully ill equipped. Instead I will discuss a number of popular conceptions of the nature of socialism which currently exist.

One loosely stated idea of socialism is that it means government control of industry. Now in actual fact substantial government control of industry does exist, and no sane person would suggest that that control should be entirely eliminated. If your next door neighbor sold his or her property to a business which tore down the house and put up a factory which made loud noises day and night and continually belched forth clouds of foul smelling poisonous smoke, I assume that all of the people who would react to this event by falling down on their knees and praising God that government control of industry had finally been eliminated are either currently residing in insane asylums or will be heading there shortly. Therefore we cannot use belief or disbelief in government control of industry to separate the socialist goats from the free market sheep.

Since *control of industry* is a very broad concept which can cover a variety of community standards concerning the proper operation of industrial enterprises, let us consider a much narrower conception of industrial control: Government as an industrial employer. In this conception of socialism socialists believe that government or the state is the sole legitimate employer: Everyone should work for the government and any attempt to pursue purely private enterprise should punishable by law. As far as I can tell (and I am not scholar of communist history) this extreme position was indeed held by the Soviet Bolsheviks and by the Chinese communist leadership under Mao, although they were never completely successful in suppressing independent enterprise. If such a doctrine is “socialism” then I am not a socialist. However, I know for a fact that not all of the people who were willing to accept the label of socialist believed in this extreme doctrine. For example the novelist H. G. Wells (e.g. *A Modern Utopia* [1]), the British political and economics writer J. A. Hobson (e.g. *The Social Problem* [2]), and Greek scholar and historian John Mavrogordato (e.g. *The World in Chains* [3]) all identified themselves to some degree with the socialist movement, but none of them believed in the extreme doctrine of the state as the only legitimate employer.

In fact the state does act as an employer even in areas that are not directly involved in government: e.g. the post office, the fire department, public libraries, public schools, land grant universities, the National Park service, the National Forest service, etc. Would the extension of government employment into manufacturing in any imaginable conditions automatically become a disaster of bureaucratic incompetence? I regard the answer to this question as uncertain, and if this lack of absolute certainty about this issue makes me a socialist then I fear I will have to accept the label. However, I hasten to add that I do not think that public employment vs private employment is the central issue with respect to the long term stability of our current economic system. In my view it is possible to imagine a system of economic production in which employment is largely private which manages its resources wisely from a long term point of view, and it is also possible to imagine a system of economic production in which public employment is dominant but which is still rapidly undermining the resource base which supports its own existence.

The issue of public employment vs private employment is often stated in terms of ownership of capital. In this version of the socialist/free market duality socialists believe that the community or the government should own capital while free marketers believe that capital should be owned by private individuals or groups of private individuals. Whoever owns the capital pays the salaries so that this definition of the capitalist/socialist duality is

[1] Wells, H.G.; 1905, *A Modern Utopia*, Charles Scribner’s Sons, New York

[2] Hobson, J.A., 1902, *The Social Problem: Life and Work*, James Nisbet & Co., Limited, London

[3] Mavrogordato, John, 1917, *The World in Chains: Some Aspect of War and Trade*, Martin Secker, London

essentially the same as the previous one.

In my mind, however, the most important question is not: *Who owns the capital?, but rather: For what purpose shall this capital be called into existence?* The free marketer says that capital is called into existence to make money and discussion of any other purposes is idealistic nonsense. Another group of people, who are not necessarily socialists in the classical sense, say that capital is called into existence to serve human needs. It is true that the people who utilize the capital to produce useful products and services should be able to earn a decent living by so doing, and in this sense, in an economy based on monetary exchange, capital is an aid to the earning of money. However, if there is absolutely no limit to people's desire to earn present consumption rights and to lay claim to future consumption rights via "savings" (i.e. investment in infrastructure) then the process of earning a living becomes a game of constantly urging people to raise their standard of consumption so that there will be an adequate market for the continuously emerging stream of new products and improved versions of old products.

Capital is not the only resource that has to be accumulated to make large scale modern machine production possible. One also needs an accumulation of engineering, and scientific skill as wells as a supply of skilled labor. To some extent physical capital represents embedded engineering and scientific, and manufacturing skill, and in a resource rich environment such skill can rapidly replace the capital destroyed by natural disaster or by war. Witness the relatively rapid return to prosperity of Europe and Japan after the widespread destruction of World War II.

The key question surrounding the long term stability of modern methods of economic production is the following: *What is the logical basis for calling into existence large collections of physical and human resources dedicated to producing highly specialized products and services?* This is not really the same question as "Who should own capital?" as will be seen in the subsequent discussion.

A concern with the long term consequences of the unbounded competitive accumulation of consumption rights is not in and of itself socialism, but if one takes the potential threats of the continuation of this form of competition seriously, then it is an easy matter to reach conclusions about the functioning of so called free markets which will make supporters of the social status quo very uncomfortable.

Another common conception of socialism is that it means that the government will directly guarantee the economic welfare of all of its citizens. Food, clothing, medical care, and education will be provided for everyone regardless of ability or productive performance. These items of consumption may be tied to a job, but a job will be provided for everyone and nothing short of criminal activity will result in a layoff.

I call this conception of socialism the Free Ride version of socialism. It is then supposed that the availability of the free ride will discourage application and hard work, and society will decay into a state of general miserable poverty. In terms of the metaphor of the household economy, which I will develop in detail in the next chapter, this claim is equivalent to saying that either the members of a household must engage in a constant competition to increase the size and number of rooms of their house, the total quantity of furniture and appointments, and the quantity and variety of household services available, or they must live in a miserable hovel barely sufficient to prevent death from exposure because no one will be willing to do more than the minimum amount of work required to prevent this eventuality.

At the household level of a few people it is fairly obvious that some intelligent cooperative agreement about what constitutes sufficient domestic comfort can be reached so that a constant expansion of the total household economy is a not a requirement for domestic comfort. Whether or not it is possible to reach such an intelligent cooperative agreement on the much larger scale of organization required by modern methods of economic production can certainly be doubted, but I can see no a priori logical reason why such an agreement must, of necessity, disconnect the right to consume goods and services from an obligation to do productive work.

The final conception of socialism that I will consider is philosophical. According to this idea socialists believe that human activity should be organized to promote the good of an abstract entity called Society. An organic metaphor is sometimes employed comparing Society as a whole to a highly evolved multi-celled organism such as a plant or an animal. The health of the whole organism is of supreme importance since, if the organism dies all of the individual cells will die along with it since they cannot exist independent of the interconnected systems of the whole organism which provide energy and nutrients to all of the constituent cells.

This organic analogy to human society has some limited degree of validity. An individual human being cannot live at a certain level of physical and psychological comfort without a variety of interconnected social systems operating in a stable, predictable way. However, the social agreements and rules of conduct which govern the life of an individual do not really constitute a Great Society with the tightly integrated structure and the relatively well defined survival needs of a plant or an animal. A major disruption of social systems may indeed result in increased death rates and in increased general physical and psychological suffering for certain groups of people (e.g. as in the breakup of the Soviet Union), but they rarely result in the universal death of a well-defined Society. And, in fact, social disruptions which have negative consequences for large numbers of people may have beneficial effects for certain smaller groups of people who can effectively exploit the new social environment for their own benefit.

The associated ideas of Society and The Social Contract are hardly inventions of the socialists. The English philosopher Thomas Hobbes made extensive use of the term The Social Contract in his famous philosophical treatise *The Leviathan* published in 1651. Hobbes is about as far from being a socialist as it is possible to imagine anyone being. But the idea of Society as being a voluntary association of human beings based on coherent logical principles which is created for the mutual benefit of its members has continued to attract many people.

Of course all human associations have an element of voluntary cooperation in their makeup. Even a gang leader or an absolute monarch could not rule for a week if they did not have supporters who agree that they ought to wield power, and who act in a supporting role to make that power effective. Al-Assad is still in power in Syria because a large group of people want him to be in power and are willing to carry out effective actions to maintain him in that role. However, the notion that a modern nation-state consists of a single coherent human association created on the basis of well-defined and universally agreed upon philosophical principles is a fiction.

The American *Declaration of Independence* or the *French Declaration des Droits de l'Homme et du Citoyen* should be thought of as poetical summations of certain historical currents of human thought and feeling rather than as statements of completely self-consistent principles for the organization of society.

Certainly we all desire life, liberty, and happiness, but the proper definitions of liberty and happiness are very complicated matters. I by no means wish to demean the importance of the creative individual who brings something new into the world which no existing social formula could have anticipated, but the fact is that almost all kinds of creativity require association with other human beings. Isaac Newton, whose book *Mathematical Principles of Natural Philosophy* is widely regarded as the greatest contribution ever made to human knowledge within the pages of a single book, could not have achieved his great advances in mathematics and physics if society had not been organized in a way that gave him the resources which allowed him to spend long periods of time engaged in the very specialized mental labor required for these kinds of achievements. Michelangelo could not have created his great works of art if he had not lived in a society that appreciated his genius and gave him the time and the resources which made the Sistine Chapel and other great public works of art possible.

Almost all forms of seeking personal satisfaction require association with other human beings. Two of my greatest personal pleasures are reading and hiking both of which can be done alone. However, in order to hike one must have a place to hike in, and if every hectare of land was privately owned and fenced in with signs reading *Posted. No Trespassing. Violators will be prosecuted.* then my so-called private pleasure would no longer be possible. Either there must be public land or there must be public right of way through otherwise privately owned land, or the pleasure of hiking would vanish from the world. Reading is an apparently solitary pleasure, but in order for there to be readers there must be writers. There must be education. There must be printing and means of publication and distribution. All of these things require human association and cooperation.

Furthermore even though hiking and reading can be solitary pleasures they are nevertheless enhanced by association with other human beings. Of course one can join books clubs and hike with other people, but even apart from such direct association, the fact that other people like to read and hike and like to share their pleasure about these activities enhances the pleasure of the apparently solitary practitioners of these activities. One can discover good places to hike by reading the opinions and experiences of other hikers in books or on the internet. The wide community of readers who likes to share their opinions about what they have read gives the so-called solitary reader a means of discovering worthwhile books which merely reading the advertising blurbs of publishers could not accomplish.

No sensible person can deny the practical importance of the widespread net of human associations which make modern civilization possible. The question is whether the modern State represents a master association based on widely understood coherent philosophical principles? In my view the answer to this question is undoubtedly: *No.*

The United States government and modern European governments originated in opposition to certain historical systems of hierarchical privilege, but to maintain that any of these modern governments represents a system of pure meritocracy based upon universal agreement about the relative value of various kinds of human activity and upon a clear vision of the long term health of the society governed by these agreements is nonsense.

Instead of government motivated primarily by zeal for protecting the rights and welfare of the isolated individual, we have government motivated by the rights and welfare of various associations (both formal and informal) of individuals who have common interests. The industrial revolution and the political revolutions which followed it have brought new interest groups to the forefront of power, but the idea that the abstract ideal interest group known as The People are the primary power holders is not true. Instead we have a complex and continuously evolving interplay of various associations (often called interest groups) vying for political influence.

The word interest group as opposed to association is often used in a pejorative sense as implying a narrow minded pursuit of selfish goals without a proper regard for the wider social consequences of a proposed course of action. But the fact is that we are all members of various formal or informal interest groups, and the evolving interplay of these various associations is the essence of human political development.

The creative individual may be of central importance in an aesthetic and/or spiritual sense, but in a practical organizational sense such individuals always exist within the context of various cooperative human associations. Therefore the key question I am trying to address is not whether or not one believes that the rights and welfare of an abstract ideal entity known as *Society* should take precedence over the rights and welfare of the individual, but rather whether or not the rights and short term welfare of certain powerful existing interest groups is undermining the long term welfare of the collection of human associations which constitutes society (with a small s). If the answer to this question is yes, then the existing system of rights and privileges needs to be adjusted to mitigate these destructive tendencies.

Chapter 11

A metaphor for the economic standard model

Before entering on a discussion of new economic thinking in terms of the larger national and global society, let me offer a metaphor for the economic standard model of the modern world, which though imperfect (as all metaphors must be) will nevertheless help to make concrete certain issues which remain somewhat remote and abstract when discussed in terms of large scale systems of economic production.

Consider then a household as an economic system. A household has physical plant (e.g. the house itself with its roof, walls, windows, basement, etc.), auxiliary supply systems (e.g. hot and cold water, natural gas, electricity), machinery and tools (e.g. Refrigerator, stove, dishwasher, clothes washer, clothes dryer, lawnmower, kitchen ware, power tools, hand tools, etc.), and laborers (i.e. the household residents). How would a household be organized if it followed the economic standard model outlined in the first part of this book?

First of all individual householders would be assigned primary responsibility for the production of particular goods and/or services (e.g. food service, washing, plumbing and water provision, exterior repairs and weather proofing, interior repairs, provision of furniture, entertainment and communication systems, etc.). The individual producers of a certain type of goods/services would trade their output with other individual producers in order to get the mix of goods and services that they desire.

Each individual producer is responsible for all of the costs associated with maintaining the physical plant/machinery required for the production of his or her output. When a water heater breaks the plumber/water producer must bear the cost of replacement. If the water heater unexpectedly fails at a much earlier time than its anticipated end of life, and the plumber does not have the cash required to purchase a replacement, then he or she must borrow money from another householder, who will expect repayment of the loan with interest.

In order to pay the interest the plumber will have to somehow increase sales. She will either have to persuade people that they need to take more showers, or wash their cars more often, or perhaps she can borrow even more money to install some luxury service such as a hot tub for which she can charge premium prices.

But in fact the drive to produce and sell luxury services is much more powerful than that provided by an occasional shortfall of cash and a consequent loan. Not only is present consumption dependent on trading your output for the output of others, but your future consumption in your years of declining productivity is also dependent on the current sales volume of your product or service. You must save for the future since your support at that time will depend on your investments in the household plant rather than on the record of your past service to the household.

In this household metaphor it is quite obvious that there are no physical savings. In order to save you have to produce and sell, and everything that is sold is consumed. There are two possible outlets for so called under consumption (i.e. that portion of current income which is not spent on consumer goods) by currently active producers. One is older householders who have passed their years of maximum production and are now partially or wholly living off of the social credit earned by their productivity in the past. The problem with this outlet for under consumption is that it is difficult to balance the essentially unbounded desire for savings of the active work force with the numerical consumption rights stored up by the people who are past their working prime. Therefore a second outlet for under consumption is required to ride to the rescue. This savior is investment in new plant and machinery destined to increase the variety and quantity of household goods and services in the future. When this new bounty of economic output appears the investors who bore the costs of the new infrastructure can reclaim their sacrificed consumption rights with interest.

Therefore every individual householder wants to invest in new infrastructure to increase their future security. The plumber wants to persuade people that they each need their own private bathroom. The furniture dealer wants to persuade people that they each need a private suite of richly furnished rooms. The entertainment provider tries to convince each householder that they need their own personal theater/sound system. The food provider tries to encourage a variety of specialized tastes in food requiring specialized equipment and preparation techniques for which he or she can charge premium prices. In the course of constantly trying to increase the total productive capacity of the household the inmates with temporary cash shortages will resort to borrowing money from inmates with a cash excess in return for a share of the profits when the stream of new and improved products comes into existence as a result of investment. Under this scheme of procedure it may turn out that certain householders will be able to make a living by financing new production schemes without having to do any of the substantive physical work involved in maintaining the household.

Of course if the number of householders is fixed then a potential problem arises with this constant increase in plant (i.e. the size of the house), equipment, and complexity of output; Unless labor efficiency constantly increases the burden of work required to maintain the constantly increasing outputs will convert household life into a form of slavery. Therefore it is essential that technology advances should be utilized to make possible the maintenance of the system of household production with higher and higher labor efficiency.

Of course a household is not an isolated system. It exists within larger economic/social/political/biological/physical systems and is vitally dependent on inputs from these other systems. If external conditions change in a way that makes it no long practical to constantly increase the size of the house and the total complexity of household goods and services, then a system of personal security based on the assumption of such a continual increase will run into severe problems.

At the household level, the alternative to this crazy system of unending increase in the quantity and variety of goods and services is obvious. The householders need to reach an agreement on the size, form, equipment, and furnishings of a house that will allow them to have a decent quality of life. They then need to divide up the work of maintaining this household in an equitable manner. Although specialization of labor may occur, ongoing investment in plant and equipment should be made out of a common budget to which each householder is expected to contribute. If for reasons of bad luck the contribution to the budget of some individual falls short he or she does not contract a debt of interest, although the individual in question may be expected in the future to make up for the present shortfall. If some individual is consistently derelict in their household duties or their contribution to the household budget they can potentially be exiled as unworthy members of the community.

Continuing access to household services during one's years of declining productivity is based on perceived adequate levels of service during the most productive years of one's life. If an individual lives to an exceptionally old age this eventuality will be considered a matter of luck and their right to continue to enjoy household services will not be restricted for this reason. Of course it also reasonable to expect them to contribute some amount of household labor for as long as they are capable of it.

This latter form of household management represents a steady state economy and will bear some further examination. Therefore consider the case of a group of people living in a house and maintaining it as their present and future dwelling, but not seeking to expand or upgrade the household plant and equipment. Even in such a steady state ongoing investment in plant and equipment is required. Every several decades the roof must be replaced. Plumbing must be repaired or replaced. Household appliances wear out and must be replaced. In a steady state situation such investments are necessary expenses. They are not opportunities to make money. Suppose the householders are partners who are expected to contribute approximately equally to the ongoing upkeep of the house. If, when the time comes to put a new roof on the house, one partner is short of cash and the other bears all the expense of the new roof, then it is reasonable that the bearer of this expense should expect some future compensation, the most obvious being that the other partner should contribute more to future household investments.

However, if one tries to make competitive investment in infrastructure a source of retirement income a problem immediately arises. Suppose that you and I are partners in a household. If the roof needs to be replaced, and I end up bearing all the expense, then it is reasonable that I should expect some kind of compensation from you in the future. However, trying to make my excess investment in household infrastructure my primary source of retirement income is a strategy than cannot work. Once we are both retired I cannot receive consumption rights from you unless you have saved up some consumption rights from another source. In a steady state economy competition to see who invests the most in infrastructure can redistribute retirement income, but it cannot be the primary source of such income.

The primary source of retirement income is people who are still working since there is no other physical possibility. This income was earned during your prime working years when you were supporting the people who were in their declining years of productivity. This cross generational support is directly evident in the U.S. Social Security system in which payroll taxes taken from the current generation of workers is transferred to retirees, and their right to this transfer is established by the record of the payroll taxes they paid during their working years. In private retirement funds such as pensions and 401K plans this cross generational support is hidden, but still present; Dividends and interest paid to stock holders and bond holders is money which is not available to be paid to currently active workers.

This metaphor of investment in household infrastructure has still more information to give us. It is clear that in a steady state situation replacing an aging structure such as a roof with an exactly equivalent new structure is not an opportunity to increase your wealth. Anyone was who has gone through the expense and inconvenience of having a new roof put on their house would laugh at this idea. In order for a household investment to increase wealth, it must increase household productivity. So if you replace your furnace with a new more fuel efficient model, then your lower monthly fuel bill will increase your effective real income (after a payback period which defrays the cost of the initial investment). A more efficient refrigerator or washing machine will lower your electricity bill. And so forth. However, in a steady state situation where you are just maintaining a house of given size with a given set of services, such efficiency improvements cannot be a source of exponential increases in wealth; The volume of major appliances being purchased is not going to increase over time.

It is also interesting to consider household efficiency improvements from a larger social perspective. Suppose that all of the householders in a large geographical area replace their old furnaces with new more efficient models. Fuel bills go down and effective real income goes up. We have gotten richer and reduced our carbon footprint at the same time. What could be better than that? However, assuming that the population of this geographical region is not growing, a secondary consequence of this goodness is that a certain number of people who make their living by pulling fossil carbon out of the ground will lose their jobs. Of course if you believe that putting fossil carbon into the earth's atmosphere is a bad thing, then in the long run you would like to everyone who pulls fossil carbon out of the ground to lose their jobs. The people who are newly unemployed may, of course, take a different view of the situation.

However, not all is black for the people who have lost their jobs. In an economic system such as ours extra income always results in new demand. Even if this extra income is initially saved such savings are really investments in infrastructure which creates new jobs, and ultimately new production. This new production consumes energy and partially (or possibly wholly) offsets the fuel savings achieved by the new more efficient furnaces.

In order for the fuel and carbon emission savings of the new furnaces to be fully realized a completely different economic paradigm is required. Suppose that after the new furnaces have been installed and paid for in fuel savings the people whose effective real incomes have risen say to themselves: "Wait a second. My real income has risen, but in fact I already have enough income and do not need any more" (Yes, I am being serious.). "Therefore I am going to work less hard at my regular job and spend more time on my avocations". The people who have lost their jobs pulling fossil carbon out of the ground can do the work that the owners of the more efficient furnaces have abandoned. In this situation new jobs are created without new consumption of energy and other resources. Such a system of social organization may seem utterly fantastic at the present time, but any hope of bringing human economic activity within ecological limits for long periods of time requires that a substantial majority of the population should feel that the current rate at which they are accumulating consumption rights is sufficient, and are happy about gaining time to pursue other interests than *making money*.

Of course, human beings are never going to be content with their current psychic income, and will always be seeking a further development of personal satisfaction. But unless this quest for personal development can be decoupled from a quest for the unbounded accumulation of consumption rights then the destructive tendencies of our current economic system cannot be brought under control.

Chapter 12

Elements of an alternative economic model

12.1 A summary of the elements

In this chapter I will present elements of an alternative economic model in a generalized form. A more explicit discussion of possible implementation of these ideas will be given in later chapters. Here then are the proposed elements of a new economic paradigm:

1. A constantly rising uncontrolled standard of consumption should be replaced by a socially agreed upon standard of consumption.

2. Retirement security should be based on the explicit accumulation of social credit for supporting the elderly.

3. Private, for profit, credit markets should be replaced by non-profit community credit markets.

12.2 The first element of economic reform: A constantly rising uncontrolled standard of consumption should be replace by a socially agreed upon standard of consumption.

The first of the elements, the replacement of a constantly rising uncontrolled standard of consumption by a socially agreed upon standard of consumption, is conceptually simple, but complex and difficult in any attempt to imagine a real implementation. An often used argument in favor of the current economic paradigm is that it is in accord with human nature: We are selfish, greedy, competitive wealth accumulators by nature, and no conceivable future innovation in human social relations can change this fact. In Wealth of Nations Adam Smith says the following about the human inclination to acquire and display valuable possessions [1]:

> *The rich man consumes no more food than his poor neighbour. In quality it may be very different, and to select and prepare it may require more labour and art; but in quantity it is very nearly the same. But compare the spacious palace and great wardrobe of the one, with the hovel and the few rags of the other, and you will be sensible that the difference between their cloathing, lodging, and household furniture, is almost as great in quantity as it is in quality. The desire of food is limited in every man by the narrow capacity of the human stomach; but the desire of the conveniencies and ornaments of building, dress, equipage, and household furniture, seems to have no limit or certain boundary.*

As usual, Smith is far less dogmatic than his acolytes. He makes no absolutist claim about what human nature is or is not capable of. He merely says that within the social context with which he is familiar the human desire for conspicuous consumption (i.e. consumption that is greater than that of your less well-off neighbors) has no definite limit. Of course in a social milieu in which the point of conspicuous consumption is a display of status, and an open-ended competition for status of this type is the norm, then there is nothing surprising about an open-ended desire for consumption. The question of whether or not this state of affairs is unavoidable in any conceivable form of social organization is another issue.

Other people have categorically denied this need for the primacy of private acquisitiveness in human economic affairs, though in the popular perception the people who issue these denials have an *idealistic* and *utopian* turn of character. For example John Cowper Powys writes in *The Complex Vision* [2]:

> *The individual bringing forward this argument of the "initiative of greed" will invariably be found to be a member of what might*

[1] Smith, Adam, 1994, *The Wealth of Nations*, *Chapter 11 Of the Rent of Land*, p. 188, The Modern Library, New York

[2] Powys, John Cowper, 1920, *The Complex Vision*, p334, Dodd Mead and Company, New York

> *be called the "parasitic class". He will either be an intellectually second-rate minister or politician or lawyer or professor, or he will be a commercial and financial "middleman", whose activities are entirely absorbed in the art of exploitation and who has never experienced the sensation of creative work.*
>
> *If he does not himself belong to the unproductive and parasitic class it will be easy to detect in him the unmistakable presence of the emotion of malice. Nowhere is the emotion of malice more entirely in harmony with itself than when it is engaged in attributing base and sordid motives to the energy of human nature.*
>
> *This monstrous doctrine that human beings require "the incentive of greed" and that without that incentive or "initiative" no one would engage in any kind of creative work, is a doctrine springing directly from the aboriginal malice of the soul; and a doctrine which is refuted every day by every honest, healthy and honorable man and woman.*

George Eliot in her novel *Middlemarch* gives the following portrait of an *honest, healthy, and honorable man* [3]:

> *The first part of this speech comprised his whole store of maledictory expression, and was uttered with a slight snarl easy to imagine. But it would be difficult to convey to those who never heard him utter the word "business", the peculiar tone of fervid veneration, of religious regard, in which he wrapped it, as a consecrated symbol is wrapped in its gold-fringed linen.*
>
> *Caleb Garth often shook his head in meditation on the value, the indispensable might of that myriad-headed, myriad-handed labor by which the social body is fed, clothed, and housed. It had laid hold of his imagination in boyhood. The echoes of the great hammer where roof or keel were a-making, the signal-shouts of the workmen, the roar of the furnace, the thunder and plash of the engine, were a sublime music to him; the felling and lading of timber, and the huge trunk vibrating star-like in the distance along the highway, the crane at work on the wharf, the piled-up produce in warehouses, the precision and variety of muscular effort wherever exact work had to be turned out, all these sights of his youth had acted on him as poetry without the aid of the poets,*

[3]Elliot, George, 1985, *Middlemarch*, Chapter 24, p227, Bantam Books, New York

had made a philosophy for him without the aid of philosophers, a religion without the aid of theology. His early ambition had been to have as effective a share as possible in this sublime labor, which was peculiarly dignified by him with the name of "business"; and though he had only been a short time under a surveyor, and had been chiefly his own teacher, he knew more of land, building, and mining than most of the special men in the county.

His classification of human employments was rather crude, and, like the categories of more celebrated men, would not be acceptable in these advanced times. He divided them into "business, politics, preaching, learning, and amusement". He had nothing to say against the last four; but he regarded them as a reverential pagan regarded other gods than his own. In the same way, he thought very well of all ranks, but he would not himself have liked to be of any rank in which he had not such close contact with "business" as to get often honorably decorated with marks of dust and mortar, the damp of the engine, or the sweet soil of the woods and fields. Though he had never regarded himself as other than an orthodox Christian, and would argue on prevenient grace if the subject were proposed to him, I think his virtual divinities were good practical schemes, accurate work, and the faithful completion of undertakings: his prince of darkness was a slack workman. But there was no spirit of denial in Caleb, and the world seemed so wondrous to him that he was ready to accept any number of systems, like any number of firmaments, if they did not obviously interfere with the best land-drainage, solid building, correct measuring, and judicious boring (for coal). In fact, he had a reverential soul with a strong practical intelligence. But he could not manage finance: he knew values well, but he had no keenness of imagination for monetary results in the shape of profit and loss: and having ascertained this to his cost, he determined to give up all forms of his beloved "business" which required that talent. He gave himself up entirely to the many kinds of work which he could do without handling capital, and was one of those precious men within his own district whom everybody would choose to work for them, because he did his work well, charged very little, and often declined to charge at all. It is no wonder, then, that the Garths were poor, and "lived in a small way". However, they did not mind it.

Of course one can argue that Caleb Garth is merely a figment of George Eliot's imagination, or that, even if he is based on some real person that she actually knew, he is nevertheless an extreme case: A saint or a genetic freak depending upon your point of view. Surely no practical scheme of human social interaction can be based on the assumption of a world populated by Caleb Garths? However, even if it is impossible to imagine a world in which such virtues have become universal, it is perhaps less difficult to imagine a world in which people possessing such virtues are held in higher social honor than bank presidents, stock traders, corporate raiders, or millionaire producers of electronic toys. Such a vision of human social organization may indeed be a form of idealism, but still one worth striving for. After all widespread agreement exists that universal liberty and justice are worthy goals, even though no practical person expects the perfect attainment of these ideals in this highly imperfect world.

However, it is not my purpose in this book to make definitive pronouncements about the capabilities and limitation of human nature. I am merely trying to understand to the best of my ability what forms of social organization are theoretically capable of changing the destructive tendencies of the current social order. Whether or not these imagined forms can find a practical implementation will be determined by the unfolding of the world process, which may well prove me to be just as impractical and mistaken as many previous thinkers on this subject.

If we chose not to despair about the possibility of rationally limiting the consumption of economic goods and services, what are the basic methods of such limitation? It can be argued that the consumption of economic goods and services has a back end and a front end, both of which must be controlled in an effort to create bounded forms of consumption. The back end of economic consumption is production. We consume today a wide variety of goods and services that our grandparents in their youth did not consume or even desire to consume because such goods and services did not yet exist even as a twinkle in their inventor's eyes. Therefore a back end solution to the problem of over consumption would involve reaching a widespread agreement about the mix of goods and services that it is desirable to produce and an agreement to prevent the production of goods which are judged to be a wasteful use of available resources.

The prospect of such back end control of consumption seems dauntingly difficult and bureaucratic. Furthermore if we attempt to control both the quantity and variety of goods produced by this method then we would face the prospect of shortages relative to demand which might necessitate rationing and/or queuing. Of course we would not necessarily need to control both variety and quantity of consumption at the back end of the economic process. We could simply control variety (e.g. no jet skis, SUVs, jet airplane tourism, etc.) in an attempt to control certain kinds of destructive economic production. However it is not clear that a simple control on variety of goods produced is sufficient to create a reasonable standard of consumption. For example housing and furniture are obviously necessary goods, but if everyone aspires to live in a six thousand square foot mansion stuffed full of furniture made out of topical hardwood then our standard of consumption has an obvious problem.

Of course controls on economic production already exist in the form of regulations concerning pollution, toxic substances, product safety, and so forth. Indeed a school of thought exists which maintains that we can fix the destructive tendencies of our current economic system not by making direct decisions about production and consumption, but rather by putting taxes on destructive economic activity. Lester Brown of the Earth Policy Institute argues in favor of this strategy in his book *Plan B* [4]. He wants to shift taxes from income to environmentally destructive activity and thereby "make the market tell the ecological truth". Unfortunately if the ecological truth is that the OECD nations need to lower their total consumption, then tax shifting without any changes in our financial institutions will be incapable of bringing about the necessary result or will result in a global financial collapse.

While attempting to regulate certain destructive aspects of our economic activity at the production end of things has some merit, it does not seem likely to me that such regulation can be the primary mechanism for creating a reasonable standard of consumption. Therefore let us turn to the front end of economic production: consumer demand.

At first sight controlling consumer demand might seem even more daunting than directly controlling economic production. How can we hope to control human desire? Fortunately controlling consumer demand does not require direct control of human desire. Although one does not see fast food workers driving around in Ferraris or living in thirty room mansions, there is no reason to believe that, as a class, they desire these things any less than do CEOs with seven figure salaries. If goods are priced high enough relative to income then demand is automatically controlled. This fact suggests progressive consumption taxes as means controlling consumer demand.

I would suggest that a progressive consumption tax should be based on a social agreement about what constitutes normal consumption. This normal

[4]Brown, Lester R., 2006, *Plan B 2.0*, W. W. Norton & Company, New York

consumption should not be based on a monetary standard but on a physical standard of goods and services consumed. Obviously not every individual will consume the exact same mix of goods and services, but nevertheless a fictitious basket of specific goods and services supposed to represent a substantial fraction of the average yearly consumption for one person will be used to determine the normal yearly consumption (NYC). If the fraction of yearly consumption represented by the basket of goods and services is y then the monetary value of the normal consumption NYC will then be then the price of this basket of goods divided by y:

$$NYC = \frac{PriceofBasket}{y} \tag{12.1}$$

I imagine the fraction y being a number somewhere between 0.5 and 1. Letting y be less than 1 allows for the fact that a complete specification of normal consumption is not practical. Not every person will consume exactly this basket of goods and services but basing the NYC on an actual quantitative set of goods ties desirable consumption levels to our physical production abilities. I should mention here one practical complication concerning specifying the basket of goods which determines the NYC. A yearly consumption rate of things like food, clothing, fuel, etc. can relatively easily be defined, but for durable goods that are useful for many years it would be necessary to define the yearly consumption rate as some fraction of the expected life time of the good in question. So if the average life time of a dining table is 30 years then the yearly consumption of such tables would be defined as 1/30 of a table.

The resource costs of this basket of goods should be such that, in principle, a society composed of an ideal mix of work skills could sustainably support every single person at this level of consumption. Note than an ideal skill mix does not consist only of scientific and engineering geniuses and high level entrepreneurs. A society composed solely of people with this skill set would not attain to maximum productivity. Society needs people to pound nails, to haul garbage, to repair plumbing, to do nursing, to provide child care, to act as sales clerks, etc. In an ideal skill mix we would have maximally skilled, hardworking people in the exact proportion needed for each niche in the productive process. In this ideal case society should be able to sustainably supply the normal consumption income to every single worker. There should be no other resource limitation beside the labor skill mix which prevents everyone from obtaining the NYC. Note that saying that we should be physically capable of provide everyone with the NYC is not the same thing as saying that everyone will receive such income. I am merely talking about a principle which can be used as a basis for determining the NYC.

Rather than trying to directly limit the consumption of every individual to the NYC I propose to impose highly progressive taxes on consumption which exceeds this level. Note that controlling consumer demand through consumption taxes automatically controls the back end of consumption which is economic production. The market mechanism guarantees that manufacturers cannot sell what people cannot afford to buy. One can strive to produce goods that are superior to one's competitors, or one can try to bring to market some new good that is more desirable than some existing good, but high taxes placed on excess consumption will act as a brake on expansion of the variety and quantity of toys and luxury services. I will consider the question of how to go about collecting such progressive consumption taxes in the next chapter. Clearly sales taxes in their current form will not work since taxes would depend on total consumer spending by an individual and not just on the price of an item being purchased.

12.3 The 2nd element of economic reform: Retirement security should be based on the explicit accumulation of social credit for supporting the elderly.

The proposed second element of economic reform is not really separate from the first, since retirement security is obviously part of the general problem of the accumulation of consumption rights. Nevertheless this issue is so widely misunderstood, private personal savings are so widely regarded as a conservative, prudent, normal part of economic activity, that I thought it was worthwhile to give this subject a separate and special treatment.

People who work support the people who don't work. This is a cold, hard, objective fact. The sooner our economic system explicitly acknowledges this truth the better off we will be. Note the word "explicit" in the phrase "explicit accumulation of social credit". All long term security of consumption is based on social credit. Denial of this fact represents a failure to understand the real workings of our economic system. Suppose a hardworking entrepreneur has labored eighty hours a week for decades and has accumulated many millions of dollars which he or she has converted into gold bars and has placed underground in a locked and guarded vault. If global society holds a debate and decides that the mining of gold is environmentally destructive, and thus decides to ban all future trade in gold, then the entrepreneur's fortune vanishes in a puff of smoke. The value of gold is the result of widespread social agreement and would not survive the dissolution of that agreement. Even ownership of high quality agricultural land, a resource with the greatest possible stability of real value, can disappear in a social revolution which seizes the current owner's rights in the name of a supposed larger social good. Nothing in this world can be *owned* by an individual unless the right of such *ownership* is recognized and respected by the larger society of which the individual is a part.

Of course people whose accumulation of social credit is high in the current scheme of things naturally tend to oppose any proposed reform which would threaten that credit. Furthermore there in a real concern that in a centrally controlled scheme of social credit, bureaucrats might seize a large portion of that credit for themselves and thus impoverish the general public. The vital question is: What form of social credit is likely to be equitable and stable in a resource limited world? My proposal is to institute a form of retirement credit that is based explicitly on support for the elderly and which has an insurance like quality so that people who contribute a similar amount to the support of the elderly do not have to be anxious about how long they might live; The person who lives be 100 is compensated for by the person who dies of heart attack six months after they retire. I will discuss this proposal in more detail in a later chapter.

12.4 The third element of economic reform: Private, for profit, credit markets should be replaced by non-profit community credit markets.

The wording of this particular item in my proposed program of economic reform is likely to be rejected by people on both ends of the political spectrum. The true believers in private credit markets as the final arbiters of freedom, liberty, economic efficiency, and human welfare will of course reject this idea as *communism.* After all I did use the word “community”. At the other end of the political spectrum the anti-market activists will be saying, “What the heck do you mean by a non-profit market? There is no such thing. You are trying to appease the political center by some form of pseudo-intellectual trickery. What game are you playing?”. It is possible that my use of the word *market* in this context is unfortunate, but I have not been able to come up with a better one. Let me try to explain more clearly what I am thinking about.

I begin this explanation by returning to the analogy of the household economy. In a household, when we need to invest in infrastructure (i.e. put a new roof on the house, replace the windows, buy a major appliance, etc.) we generally seek to get a good return for our investment though generally we do not base our decision on strict numerical calculations. We weigh the upfront costs and the ongoing service costs (e.g. a cheap appliance which frequently breaks down may not prove to be much of a bargain) against benefits and try to find the best deal we can. We shop around among various producers of the goods/services we wish to purchase and try to find a good deal.

Naturally the larger economic community also has to keep investing in infrastructure as well, and the return on many of these investments will be spread out over long periods of time. Therefore weighing the upfront costs against the long term benefits of ongoing infrastructure expense is a never ending process. In any conceivable method of infrastructure decision making some degree of competition between various possible investment choices would take place. Even if such decisions were made by a central committee on behalf of the state there would be various competing proposals for the available funding. Something of this nature occurs now for publicly funded scientific research. Public funds taken from taxes are directed into scientific research with the hope of producing long term public benefits from the development of new technological abilities. Individual scientists, or groups of scientists and particular research institution put together proposals for research funding, and judgments are made about which kinds of spending are likely to prove fruitful.

I hasten to point out that I am not suggesting that a central committee at the level of the nation state is the best means of making such infrastructure spending decisions. I am merely pointing out that any decision making group short of an all-wise, all-knowing divinity, will be forced to engage in an ongoing process of weighing the costs and benefits of various possible investments in infrastructure. Therefore in some sense an infrastructure market would continue to exist even in forms of economic organization that look quite different from our current private, monetary profit driven, credit markets.

By the expression “community credit market” I mean that a source of funds provided by the community would be used to direct resources into the creation and maintenance of valuable infrastructure. This infrastructure maintenance/creation procedure would have the aspect of a market because various production enterprises who have temporary mismatches between current income and capital expenses would compete for the available credit. When I prefix the adjective non-profit to this expression I do not mean to imply a lack of concern with return on investment, but rather that the desired return should be the goods and services actually produced rather than personal private gain in consumption rights for the people granting the credit. Whether such a community credit market could be made to operate with a reasonable level of efficiency can of course be doubted. I will have more to say about the possible structure of such a market and will consider some of the arguments alleging its inevitable gross inefficiency in a later chapter.

Chapter 13

A socially agreed upon standard of consumption: the central element of economic intelligence

If you do not believe in endless exponential dematerialization of economic output then economic consumption must sooner or later stop expanding. This cessation in the growth of physical wealth, does not necessarily mean that the variety of goods and services produced will be absolutely fixed and unchanging. Insofar as economic production has sufficient excess to produce products and services which are directed towards aesthetic and recreational pursuits tastes may change over time and the variety of goods will coevolve with these changing tastes. In addition the practical techniques of producing food, clothing, shelter, etc. may continue to undergo a slow evolution, and the output of goods serving these ends may undergo a similar evolution. However, the extreme emphasis on rapidly changing variety and sheer increase in quantity (e.g. more powerful cars, larger houses, more frequent jet airplane tourism) must come to an end.

The eventual necessity of bounded physical consumption has been recognized by some thinkers for quite a long time. The English economic and political writer John A. Hobson in his 1894 book *The Evolution of Modern Capitalism* wrote [1]:

[1] Hobson, John A., 1894, *The Evolution of Modern Capitalism, Chapter 14 Civilization and Industrial Development*, p 373, Walter Scott Ltd., London

> *It is hardly too much to say that the whole of social progress depends upon the substitution of qualitative for quantitative methods of consumption. In so far as individuals apply their growing ability to consume in order to demand increased quantities of the same articles they consumed before, or flash variety of fashionable goods in no wise adjusted to individual need or taste, they extend the dominion of machinery. In so far as they develop individual taste, delicacy rather than quantity of satisfaction, they give wider scope to work which embodies conscious human skill and deserves the name of art.*
>
> *But there is another bearing of this point of equal significance. Political economists have a dismal formula called the Law of Diminishing Returns, which casts a dark shadow upon industrial progress as it is commonly conceived. The more food and clothing, fuel, and other material goods we require, the further we have to go for the material, and the harder it is to get: we must plough inferior lands yielding smaller crops, we must sink deeper shafts for our coal and iron. As our population grows ever larger, and this larger number wants more and more pieces of the earth to feed its machines and to turn out the increased quantity of goods, the drain upon natural resources is constantly increasing. The material world is limited; in time Nature will become exhausted, and, long before this happens, the quantity of human labour required to raise the increased supply of raw material in the teeth of the Law of Diminishing Returns will far exceed the economies attending large-scale machine-production...*
>
> *The case is a simple one. A mere increase in the variety of our material consumption relieves the strain imposed upon man by the limits of the material universe, for such variety enables him to utilize a larger proportion of the aggregate of matter. But in proportion as we add to mere variety a higher appreciation of those adaptations of matter which are due to human skill, and which we call Art, we pass outside the limits of matter and are no longer the slaves of roods and acres and a law of diminishing returns. So long as we continue to raise more men who demand more food and clothes and fuel, we are subject to the limitations of the material universe, and what we get ever costs us more and benefits us less. But when we cease to demand more, and begin to demand better, commodities, more delicate, highly finished and*

> *harmonious, we can increase the enjoyment without adding to the cost or exhausting the store. What artist would not laugh at the suggestion that the materials of his art, his colours, clay, marble, or what else he wrought in, might fail and his art come to an end? When we are dealing with qualitative, i.e. artistic, goods, we see at once how an infinite expenditure of labour may be given, an infinite satisfaction taken, from the meagrest quantity of matter and space. In proportion as a community comes to substitute a qualitative for a quantitative standard of living, it escapes the limitations imposed by matter upon man. Art knows no restrictions of space or size, and in proportion as we attain the art of living we shall be likewise free.*

I have already suggested the idea of creating a standard of physical consumption which I call the normal yearly consumption (NYC) as a means of controlling consumer demand. The NYC would represent a basket of goods and services which would be used to define a normal level of acceptable consumption by an individual over the course of a year. Of course not every individual will consume exactly the same mix of goods and services and I have already discussed ways of allowing for this fact in determining the value of NYC. This consumption level should be set so that for a population with an ideal mix of work skills every individual should physically be able consume at this level. That is, there should be no other environmental limitation besides human knowledge and skill that should prevent everyone from enjoying this standard of consumption. I do not propose to strictly limit the consumption of all individuals to this level, but rather propose to impose progressive consumption taxes which will discourage higher levels of consumption.

Obviously families with children should have their taxes adjusted to allow for the naturally higher consumption that their family size implies. Whether this tax adjustment would be made by simply multiplying the various tax levels by the number of people in the household or whether some more complex formula would be used is a level of detail which I will not discuss in this proposal.

One question which might be asked about this proposal is: "How in the heck are we going to determine allowable levels of consumption in practice? Such a determination is a very complicated task. The earth is a huge place and all its resources have not been cataloged and are not likely to be so any time soon. Science and technology are still advancing so that we do not know what the economic cost of resources will be in the future. How can we ever reach a conclusion about allowable levels of consumption that is truly objective and that everyone will agree ought to be the basis of practical decisions about economic consumption?"

First of all, in a democratic society we do not need everyone to agree on the definition of the NYC, only a majority. Furthermore it is not necessary that our goal should be to make the NYC as large as we possibly can. Rather, the NYC should provide that "necessary minimum of food, shelter, clothing, leisure, comfort, freedom, solitude, and happiness, which is certainly real, essential and indispensable" [2]. Now comfort is without a doubt a subjective quality and substantial debate could arise about what level of consumption will provide the necessary minimum. Nevertheless reaching agreement about an adequate standard of consumption is a necessary requirement of any practical attempt to deal with limits to growth.

Since adequate standards of comfort will be conditioned to some extent by subjective cultural factors, we will also need the inputs of scientists and engineers about what levels of resource consumption are practical from a physical point of view. We do not need a definitive model of economic production which tells us exactly how much consumption is allowable, but rather general guidelines from knowledgeable experts in geology, mineralogy, mining, biology, agricultural science, etc.. If we aim too low with NYC (not a particularly likely event in the current cultural milieu) no harm is done and the standard of consumption can be revised upward at a later date. If we aim too high then over time we will have to ratchet down the standard of consumption, assuming that is, that we are truly committed to maintaining a humane civilization in the face of planetary resource limits.

In order for this process to work, we do not need a definitive model of economic production which tells us that we can consume some exact maximum level of resources and no more. Rather we need a flexible mechanism for actually limiting resource consumption and the generation of waste and an ongoing evaluation of where the limits should be set that makes use of both scientific analysis and of practical economic experience.

In order to calculate the NYC over a widespread geographical area like the United States one would have to use average costs of the defined basket of goods and services. In reality these costs would vary considerably from location to location thus effectively varying the tax rate in terms of true physical consumption. Of course a similar phenomenon occurs with federal income taxes at present. For example in the United States current federal

[2] Powys, John Cowper; (1920) *The Complex Vision*, Dodd Mead and Company, Inc., chapter XIV, p333

incomes taxes follow a universal schedule in spite of the fact that the cost of living varies considerably from place to place within the country. This potential variation of the effective tax burden is compensated in some degree by the correlation of the cost of living and income levels. That is places with low cost of living tend to have low incomes so that even though in a low cost of living area the purchasing power of after tax income is greater for a given income, the overall depression of income works against this relative advantage. In the same way if progressive consumption taxes were based on average costs of a specified basket of goods and services over a wide geographic area, the correlation of cost of living with income would work against the tax advantage of living in areas with low cost of living. If local taxes also become progressive consumption taxes then conceivably such taxes could be indexed to local prices of the specified basket of goods and services.

An important issue about progressive consumption taxes which needs to be addressed is the method of collection. How can we keep track of total consumption? This task seems more complex than keeping track of income. My proposal for keeping track of consumption is to keep track of income and savings and to set consumption equal to the difference between these two amounts. Income is already monitored, not perfectly to be sure, but well enough to allow the tax system to function effectively. In the tax scheme I am proposing we would additionally need to keep track of inflows and outflows to savings. Although such tracking would undoubtedly present certain practical difficulties, it appears to me to be a more manageable accounting problem than keeping track of every individual purchase of goods and services. Note that such a system of taxation would tend to discourage unreported flows of money into offshore tax havens. Any money that disappears from known income flows or known savings depositories without appearing in some other known savings depository will be assumed to have been used for consumption and will be taxed accordingly. If the amount of money disappearing is high then the marginal tax rate could be quite high.

At this point I want to discuss some special problems concerning the calculation consumption rates for durable goods. Items like food and fuel are typically consumed at a relatively steady rate from year to year, but durable items have a lumpiness of expenditure that could lead to burdensome taxes in some cases. The current tax code allows for income averaging if big variations in income happen over periods of just a few years. In a system based on consumption taxes we could potentially allow consumption averaging as well. That is if an individual or a family consumed below average rates for a period of years while they were saving for some fairly large expenditures on durable goods, then in the year when they nominally consumed far above average by large expenditures on durable goods, then they could offset some of the tax consequences by averaging their consumption of over a period of several years.

Another issue is the economic consequence of replacing durable goods before the end of their useful life. When you buy a new durable product the tax system I am proposing taxes you for the whole use value of the production over its life time. If you sell the product before the end of its useful life time then you have not received the full consumption value for which you were taxed. When you buy a new product you will be taxed for the full use value again, and the person who bought it is taxed again for its remaining use value. While this double taxation may seem unfair to some people we should remember that the purpose of consumption taxes is to encourage thoughtful consumption. That is purchases of durable goods should be comparatively infrequent, and in the majority of cases we should be planning to keep these items until the end of their useful life time.

However, there may be some cases which require special treatment. The most obvious of such cases is housing. Building a new house represent a large consumption of resources which is reflected in the price of the house. However the consumption of the use value produced will take place over a very long period of time (possibly more than a century of the house is well built). Asking an individual or a family to pay the full consumption tax on such an item at the time of purchase might be such a burdensome tax that very few people would be able to afford it. Furthermore if the full consumption taxes are collected every time the house changes hands then the level of multiple taxation would be egregiously high.

The obvious way to deal with this problem is not to include the purchase price of a house in the consumption tax of the year in which the purchase occurred, but to add a consumption tax to the yearly property tax. In this way the household will be taxed for that part of the use value of the house that they consume during their sojourn there, thus avoiding multiple taxation. Note also that required periodic repair or replacement of major housing components such as the plumbing or the roofing should also be tax exempt. Such repairs are part of the necessary upkeep of the house and in the long run such consumption is taxed via the yearly property tax bill. If you put a new forty year roof on the house and then move out after five years, you are only taxed for the one eighth of the use value which you consumed during your stay there. On the other hand if expand your house and add rooms or increase the size of existing rooms then this expenditure will be subject to consumption taxes. However, instead of paying all of the tax up front at the time of construction they payment would take place over an extended period of time via an increase in property tax.

One might wonder whether other expensive durable goods such as automobiles might also require special tax treatment. Personally I am not convinced that the current personal automobile paradigm as it exists in the United States and Europe is consistent with a resource resilient society, so I am not going to spend any intellectual energy figuring out how to preserve it. However I am sure that for expensive infrequently purchased goods it would be possible to devise special tax treatments.

Progressive consumption taxes will not prevent consumption beyond the NYC. They will merely discourage such excess consumption. How much they will discourage it depends upon how severely progressive they are. If the progression is sufficiently mild then they would not really affect the consumer society paradigm any more than the current progressive income tax does. On the other hand if severely progressive consumption taxes were implemented within the context of the current economic system with no other corresponding changes, an economic recession caused by a drop in consumer spending would be the immediate result.

I want to emphasize that progressive consumption taxes are not in and of themselves a sufficient mechanism for effectively incorporating long term resource planning into our economic system. However, they do represent a flexible mechanism for introducing a public discussion about reasonable levels of resource consumption. Furthermore if they are properly implemented in conjunction with other changes they can act as a reminder of and an incentive for ecologically reasonable limits to human economic activity.

One might ask if consumption is to be taxed rather than income, does this mean that savings will not be taxed? The answer to this question that yes, the long term goal of this tax system is to make savings tax free. Note that in a properly operating steady state economy such a tax exemption does not imply any loss of revenue. Society as a whole does not save. Economic infrastructure is maintained and goods and services are produced at a steady rate. Physical savings do not exist. Savings are an accounting device which help to compensate for temporal imbalances in earnings and expenditures. If overall consumption levels are steady then the tax flow will also be steady.

Chapter 14

The economic security of the aged should be based on the social credit they have built up during their productive prime by supporting a previous generation of the elderly

The people who work support the people who do not work. I know that I am repeating myself, but this fact is so widely misunderstood that it bears repeating. Economic goods and services come from the hands and minds of the people who are currently active in the system of economic production. If the people who produce these goods and services own them unconditionally and therefore have a right to dispose of them in any way they see fit, then retirees could continue to live only at the whim of the active workforce. Instead of depending on the whims of the following generation, active workers build up social credit during their productive years which they use to lay claim to economic output during the less productive years of their old age.

The commonly conceived notion of this social credit as deferred consumption is incorrect. In a healthily functioning economic system the rate of consumption equals the rate of production. Of course some amount of inventory of goods and materials is required, but we cannot build up or draw down inventory steadily over long periods at time. If we consume less than we produce over any significant period of time then the economic malady known as a recession occurs. Thus in a healthily functioning steady state economy there is no virtue in consuming less goods and services than you are entitled to.

On the other hand the goods and services which are given to the elderly are not something that we can pay out or withhold according to our mood, at least not if we wish to maintain a humane society. Of course it is appropriate to demand than the elderly should have done something during their productive prime to entitle them to receive these goods and services. The obvious form which this social credit should take is the record of the goods and services which the current generation of retirees provided to the previous generation of retirees. In a steady state economy with a stationary human population it is clear that the resources used by one generation to support the elderly should be approximately equal to the resources that the next generation will need to use for the same purpose. This record of support could take the form of payroll taxes as in the US Social Security system.

I think it might be a good idea if the social retirement credit built up was expressed on a specific numerical scale, say 0 to 10,000. Each year people who earned income would receive a statement with their numerical retirement credit (e.g. 2840, 5433, etc.) and a table of retirement ages and retirement credits which would indicate how much income they would be entitled to if they retired at a specific age with a specific amount of credits. Such a system would have some of the psychological force of traditional savings even though it does not represent a liquid reserve of purchasing power which the possessor can cash in at any time.

If the overall economic health of society changed for the worse or for the better because of changing circumstances, then the actual payout to a person with given level of retirement credit who retired at a given age might move the benefit up or down. However, as long as the overall productive machinery of society was still active this form of savings could not vanish into a black hole as can happen in the contraction of private credit markets with too high a burden of debt.

When a certain specified amount of retirement credits is reached (i.e. 10,000 points or some other arbitrarily chosen number) the possessor should be entitled to a yearly income starting at a specified age which would allow them to consume at the level of the NYC for the rest of their life. Earning further retirement credits might bring down the minimum retirement age but should not increase the yearly income.

This social security income could of course be supplemented by savings. However, if a large segment of the population has savings which allow them to consume far above the NYC during an extended retirement, then the purpose of the NYC is defeated. I have already mentioned that in a quasi steady state economy savings are an accounting device which help to compensate imbalances in the flow of income and expenditure for individuals and businesses. A key problem which needs to be solved in creating an economic system with intelligent long term resource management is how to maintain savings at a level which allows smooth functioning of the economic system while avoiding the desire for boundless accumulation of consumption rights which inevitably drives economic growth. I believe that a strong system of retirement credit which is based on the wage system and not on private savings is an important component of the solution to this problem.

The economic security of the aged should be based on the social credit they have built up during their productive prime by supporting a previous generation of the elderly

Chapter 15

Community credit markets

15.1 Private credit markets and a growth orientation of the economy are strongly linked

Private credit markets require economic growth for healthy functioning. This truth is widely acknowledged in the mainstream media in which metaphors of disease and death (e.g. *anemic*, *moribund* etc.) are regularly used describe an economy in which the inflation adjusted growth rate is significantly less than 2%. Many ideological supporters of private credit markets acknowledge the need for growth which this method of creating and supporting economic infrastructure requires. However, I have also heard some believers in the eternal fitness of private credit markets as arbiters of human welfare claim that, while economic growth is doubtless a desirable and pleasant thing, it is not really necessary for the healthy functioning of such markets. They claim that as long as some fraction of existing businesses are profitable (i.e. The income of such businesses are sufficiently large that money is left over after paying salaries, ordinary operating expenses, insurance, taxes, and debt principle) then private credit markets which compete to gain some portion of this excess income are a perfectly adequate economic institution for creating and maintaining manufacturing infrastructure, and no alternative means of supplying credit needs to be considered.

I could cite the authority of Adam Smith who said the following about an economy which had reached a maximum level of productivity [1]:

> *In a country which had acquired its full complement of riches,*

[1] Smith, Adam, 1776, *Wealth of Nations, Chapter XI: Of the Profits of Stock*, p. 111, The Modern Library, New York, 1994

> *where, in every particular branch of business, there was the greatest quantity of stock that could be employed in it, as the ordinary rate of clear profit would be very small, so the usual market rate of interest which could be afforded out of it would be so low as to render it impossible for any but the very wealthiest people to live upon the interest of their money. All people of small or middling fortunes would be obliged to superintend themselves the employment of their own stocks. It would be necessary that almost every man should be a man of business, or engage in some sort of trade.*

Smith is actually describing a situation of very low growth rather than zero growth so that a small percentage of very rich people will still be able to live off of the low interest rate earned by their very large stores of money. I believe that Smith describes this case because he correctly perceives the need for credit even in a quasi steady state economy, and he can conceive of no other method of providing such credit other than that of private markets. Therefore he posits the low rates of profit/interest which would keep the economic machinery functioning.

In addition to citing the authority of Adam Smith a few comments are in order about the possibility of the continued operation of private credit markets in the absence of economic growth. In the first place the claim that growth is necessary for the health functioning of private credit markets does not mean that private credit markets will collapse the minute real economic growth comes to an end. A strong cultural inertia with respect to the institution of private financial "savings" exists. People who are used to thinking of their future security in terms of such savings will continue to save money and invest even in the face of great financial uncertainty and danger simply because they do not know what else to do with their excess income. The general trend of markets for a couple of centuries (apart from some unpleasant troughs due to recessions and depressions) has been generally upwards, so surely we will return to a happy and healthy upward path after the current unpleasantness has been passed through. As long as belief in an eventual recovery persists financial markets can continue to function even in the face of unpleasant economic constraints. However, if belief in an eventual recovery wanes, then financial collapse can result as people rush to sell their stocks and bonds before they lose value.

In the current state of global financial markets in which the total formal value of all the holdings in stock and bonds is many times larger than the yearly production of economic goods and services, the risk of such a collapse is quite high. Suppose, however, that as we teeter on the brink of such a financial collapse we find a means to avoid it by a controlled cooperative destruction of debt, by inflation, or some other means. Furthermore suppose that the investment community is now chastened and wiser and understands that slow or even zero growth (I am thinking more of the OECD nations than of the underdeveloped parts of the world) is all that can reasonably be expected over the next several decades. I have discussed in a previous chapter why I think that private credit markets will not function well in such an economic environment. Nevertheless it might be worthwhile to discuss here the idea that since some businesses will still be profitable in the sense of having a total income exceeding ordinary expenses, competition by private financial investors to get their hands on this excess income is perfectly acceptable.

Salaries, operating expenses, taxes, and repayment of capital debt are the ordinary expenses of operating a business. In a steady state economy the net result of all such expenses for all business enterprises is a steady flow of goods and services. If some investor increases his or her right to claim a portion of this flow, then someone else must suffer a decrease in his or her rights to claim a portion of the same flow. Either some other investor(s) must lose value or some employee(s) must lose salary. If this constraint does not apply, then growth is occurring and the supposition with which this discussion began is invalid. The probability that such a zero sum game for the preservation of wealth can be made to work efficiently and with a reasonable amount of social harmony appears to me to be low. Furthermore, if real possibilities of short term economic growth in some sector of the economy present themselves then private credit markets will automatically and reflexively seek them out. In an environment in which such growth opportunities are few and far between this tendency provides a perfect formula for the creation and collapse of speculative bubbles.

“But wait a second!” you say. “Do you want to cut off all possibility of innovation forever, and never change or improve our techniques of economic production for as long as human beings exist on earth?” The answer to this question is that, of course, I do not want to suppress all innovation and change in the economic sphere. However, when productivity improvements become available we need to make intelligent decisions about how to leverage such changes to insure the long term stability of the economic community rather than leveraging them to produce more toys and luxuries in the short term as private credit markets inevitably and reflexively choose to do.

15.2 The idea of a system of community credit is not new

I should point out that the idea of community credit is not really a new one. The Italian political organizer and thinker Joseph Mazzini who was active in the movement to unite Italy under a republican form of government in the nineteenth century wrote the following in his famous essay *The Duties of Man* [2] :

> *...Suppose that with all this immense accumulation of wealth a NATIONAL FUND was formed, to be consecrated to the intellectual and economic progress of the whole country. Why should not a considerable portion of this fund be transformed, with the necessary precautions to prevent it being squandered into a fund of credit, to be distributed at a rate of one and a half or of two per cent. to the voluntary working-mens's associations, formed according to the principles indicated above and offering the security of morality and capacity? That capital ought to be sacred to the work of the future and not of a single generation only. But the vast scale of the operations would ensure compensation for inevitable losses from time to time.*
>
> *The distribution of this credit ought to be carried out, not by the Government nor by a Central National Bank, but by local Banks administered by elective communal councils and with the supervision of the Central Government. Without lessening the actual wealth of the various classes, and without allowing one class alone to monopolize the revenue from the taxation which is levied on all the citizens, and ought therefore to be devoted to the benefit of all, the series of measures suggested here, by difusing credit, increasing and improving production, compelling a graduated dimunition in the rate of interest and trusting to the zeal and interest of all the producers to insure the progress and continuity of work, would replace the limited sum of wealth now concentrated in a few hands and ill-directed, by the rich nation, manager of its own production and consumption.*

In the nineteenth century the industrial revolution was in full flower, and resource limits to economic production seemed far away, so that it

[2]Mazzini, Joseph; 1907, *The Duties of Man and Other Essays*, p. 130 J. M. Dent & Sons LTD, London

was reasonable to assume continuing growth for a long period of time into the future. This is why Mazzini assumed small but positive interest rates were a reasonable operating procedure for his proposed local community banks. Nevertheless he is clearly promulgating the idea of credit as a tool of the community for creating and maintaining useful infrastructure rather than credit as part of a game of unbounded competitive accumulation of consumption rights by private financiers.

I now attempt to follow in the footsteps of Mazzini, but I will try to describe an alternative to private credit markets which does not require the payment of interest at all. As I have already pointed out, the end of economic growth does not imply an end to the need for credit. Whenever the time period over which economic goods and services will be provided is long compared to the time period for a significant expenditure of resources required to produce that flow of goods and services, then a process of granting credit is involved. Someone must evaluate the probability that the present investment of resources will result in a sufficient future flow of goods and services to justify the expense. It is true, of course, that in a quasi steady state economy the risks associated with such extensions of credit may be relatively low. If a well-established business using well established production methods, needs to refurbish their plant because of aging equipment the risk involved may be relatively low. Nevertheless the chances that all such risks will be so near to zero so that the work of extending credit becomes completely trivial seems unlikely.

15.3 Financiers as community servants

I am proposing that in a wealth preserving economy the control of credit and debt creation should lie in the hands of the community. Any large expenditure of resources in the present which is expected to result in a flow of goods and services over an extended period time in the future is a form of debt. Allowing such debt to come into existence is the process of granting credit to productive enterprises on behalf of whom the debt is created. The intelligent creation of debt is a specialized skill, and the people who possess it should be rewarded for its exercise. However, the existence of a class of people who gain wealth in proportion to the amount of debt they create is fatal to any attempt to create an economic system with long term stability. Truly intelligent community financiers will be rewarded just as much for the debts they refuse to create as for those they allow to come into existence. These financiers should receive salaries, not interest on debt.

Two key questions are how should these financiers be chosen? And how should their performance be evaluated? Adam Smith in Wealth of Nations has the following to say about the possible involvement of government in making decisions about the employment of capital [3]:

> *What is the species of domestic industry which his capital can employ, and of which the produce is likely to be of the greatest value, every individual, it is evident, can in his local situation judge much better than any statesman or lawgiver can do for him. The statesman, who should attempt to direct private people in what manner they ought to employ their capitals, would not only load himself with a most unnecessary attention, but assume an authority which could safely be trusted, not only to no single person, but to no council or senate whatever, and which would nowhere be so dangerous as in the hands of a man who had folly and presumption enough to fancy himself fit to exercise it.*

This passage is worth thinking about in some detail. The first point to be noted is that Smith's emphasis on the individual owner of capital is outdated. Most of the capital currently employed in economic production is in the hands of large corporations which do not have individual owners. And, in fact, the collective owners of the company stock have very little role in deciding what capital is purchased or deployed with the purchasing power that they have provided. Of course the CEO plays an important role in making these decisions, but his or her direct ownership of company shares is generally a small percentage. As I have noted before the CEOs of large companies do not bear capital risk. Their egos may be bruised by failure, but they do not risk personal impoverishment if the company they run performs poorly under their watch. And, of course, the CEO is not truly an independent decision maker. He or she is the formal head of a community of people with specialized knowledge and talent who do the technical analysis, market analysis, and planning which form the basis of decisions about capital expenditure. John Kenneth Galbraith in his book /The New Industrial State/ called this community of people the technostructure [4].

In Galbraith's chapter on socialism he maintains that since the specialized technostructure of a particular enterprise are the only people competent

[3]Smith, Adam, 1994, *The Wealth of Nations*, Book IV, Chapter 2, p. 485, The Modern Library, New York

[4]Galbraith, John Kenneth, 1967, *The New Industrial State*, Princeton University Press, Princeton

to make decisions about the acquisition and deployment of capital for their business, socialism (defined as the ownership and control of capital by the state), must inevitably be bureaucratic and inefficient. Galbraith is making the same plea for independence on behalf of the technostructure of a large modern technology company that Adam Smith made on behalf of the small business owner of the eighteen century.

Of course it would be an absurdity to suggest that a committee of a national legislature should make detailed decisions about what kind of equipment an independent plumber needed to buy to run his or her business properly. But in point of fact it is probably even less likely that a legislative committee could give good advice about capital expenditure to the technostructure of a multibillion dollar manufacturer of computer chips. However, this insight closely approaches a tautology. A world filled with specialized production processes is bound to be filled with specialists who understand how to run these processes better than people who lack the particular knowledge and skill acquired by the expert.

However, the function of credit markets, private or otherwise is not to make detailed decisions about capital expenditure. A venture capitalist in Silicon Valley does not review in detail and pass judgment on the capital expenditures of the startup companies to which he or she provides funds. The function of the venture capitalist is to judge two things: 1. Whether or not a real demand exists or is likely to come into existence for the products/services which the startup intends to deliver. 2. Whether or not the technostructure of the startup has the knowledge and talent to deliver the proposed goods/services at a reasonable cost. To some extent the process of making such judgments is a kind of inspired guesswork, and it is impossible for any single person or for any group of people pooling their knowledge to always make correct judgments.

In a system of community credit markets the people making these judgments would be doing so on behalf of the community, and they would receive salaries for exercising their skill in this kind of evaluation. I am imagining a system of community banks, a significant fraction of whose reserves belong to the community collectively and not to individual depositors. Once the reserve is established it will be largely self-propagating. That is as new loans are made and money thereby flows out of the reserve, repayments from old loans flow in and replenishes the reserve. In the long run the price paid for various goods and services should, on average, pay for the full cost of producing them, including occasional large infrastructure investments. The system of banking credit is a source of liquidity which prevents occasional mismatches between current expenses and current income from causing a productive enterprise to have to choose between collapsing or attempting to live on starvation wages.

If the community banks do not charge interest then their reserves can never grow unless the community deliberately chooses to increase them, presumably using tax money. An occasional bankruptcy will decrease reserves since the loan in question will not be fully repaid. In this case the community will have to replenish the reserves with taxes if they do not want to diminish the available pool of credit. This need to top up the banking reserves with taxes from time to time emphasizes the important point that the community banks will not be money making institutions. Instead they will be infrastructure maintenance institutions.

15.4 A community bond market

In this section I will discuss one possible form for a community credit market. The idea that I have is that, at least for companies above a certain level of capitalization, credit will be granted in way that resembles today's market for industrial bonds. That is when a company has need of credit they will offer bonds for sale with a specific repayment time (e.g. five years, ten years etc.). If a bank buys some of these bonds then the enterprise in question gains a source of funds which they can use to meet short term expenses which their current income and savings are inadequate cover. The bond will then be repaid in equal installments over the specified time period. The community banks will not charge interest and therefore, at best, they will get back the face value of the bond. Occasional defaults will occur, necessitating that the banks reserves be topped up by public funds. If the only measure of a bank's success is the size of its reserves then a bank could achieve the best possible performance by doing nothing at all. However, if we devise quantitative performance measures which require that the bank should demonstrate evidence of having supported the economic activity of the community, then the bank will be on the lookout for bonds which it believes will help it to get a high rating according to the specified performance measures. I will discuss some possible forms of these performance measures in the next section.

The enterprises which receive credit will be under a legal obligation to pay back the value of the bonds in equal payments on the agreed upon schedule. Since they do not owe interest the burden of making these repayments will be far less than it would under the currently existing financial system. Nevertheless situations may arise where paying off the bond becomes difficult or impossible. Clearly what level of bond payments can be afforded depends on the salary payouts of the company. A company which is struggling to repay its debts could attempt to service them by cutting employee salaries. However, this strategy may not be successful. If salaries cuts are too large, good workers may leave the company leading to a reduction of income and a cascading collapse of the company in question.

In the event that a company is faced with such a potential collapse they can enter into legal proceedings for debt relief. Such debt relief could take the form of a traditional bankruptcy in which the company is disbanded and their assets sold to pay off as much of the debt as possible. It is also possible that current company head(s) could step down and new leaders can be found who think they can outperform the dunderheads who are leaving. In this case the company continues to exist in a new incarnation. The newly incarnated company may possible accept some part of the existing debt of the old company. This continuation of debt would be negotiated as part of the takeover by the new management. If the debt accepted is less than 100% of the outstanding debt then the bond holders must accept a partial default. If inability to pay back the full amount of the bond is judged to be due to bad luck rather than to incompetence then the company may be allowed to keep running under current management with a reduced debt payment. Again in this case the bond holders would have to accept a partial default.

I do not have any detailed knowledge of existing corporate debt law, but I do not believe that the menu of choices for dealing with debt that I have just described is a lot different than menu of choices in the existing financial system.

15.5 Sources of banking reserves

Even though this imagined system of banks is a community system in that the bankers are public employees whose salaries are paid for by taxes, there is no reason why a substantial portion of the of the reserves (possibly a majority) could not be private savings by individuals and businesses. Of course as with any system of credit a key issue is how to ensure proper sizing of the pool of available credit. If the pool of savings becomes too large it will either stimulate economic growth or lead to a financial contraction in the form of a recession or depression. If the pool of savings becomes too small then it will restrict valuable economic activity because businesses who have temporary mismatches between income flow and expenses will not get the credit they need to continue operating at full productivity.

In the current economic system a combination of interest rates and tax policy are used in an effort to control the size of the pool of available credit. These same tools could potentially also be used even in a quasi steady-state economy. If the pool of available credit is deemed to be too low the reserves can be topped up from public funds, thus requiring a temporary increase in taxes. If private savings threaten to become too large then the interest rate could be made negative to discourage saving. However, uniform negative interest rates on all savings would tend to encourage hoarding of money. Why should I put my money in a bank and see it lose value when I could stuff it under my mattress or keep it in a home safe? A better plan would be to make the interest paid depend on the amount of savings held by an individual or business. Below a certain savings level no interest would be charged, while at higher levels of savings progressively higher interest rates would be charged. I will discuss this proposal which in some ways resembles the idea of a progressive tax on capital as has been proposed by the French economist Thomas Picketty [5] in somewhat greater detail in a later section of this chapter.

Here I would like to propose another alternative for controlling the size of the pool of credit. Some fraction of the total pool of credit could be provided directly by the community in the form of tax money. This percentage need not be large (e.g. 10 or 20 percent), but this portion of the reserves could be increased or decreased simply as a matter of public policy rather than by playing financial and tax games to induce a higher or a lower amount of private savings. If the economy is overheated then the reserves can be reduced. If economic activity is being restricted in an undesirable manner then more reserves can be provided. I do not insist that such a policy of partial community ownership of banking reserves is a necessity. However, this idea appeals to me because it emphasizes the fact that credit is a tool whose purpose is to create and maintain useful infrastructure for the community and not merely a game for turning money into more money. Make no mistake about it, the securitization of mortgages or trading in derivatives can be justified only if such activities help to create useful long term infrastructure. Making money for investors is only a secondary purpose of such activities, and a purpose, moreover, that can be justified only in a situation where composite economic growth is still a reasonable goal.

[5] Piketty, Thomas, 2014, *Capital in the Twenty-First Century*, The Belknap Press of Havard University Press, Cambridge

15.6 Measuring the performance of community financiers

A key question is how the success or failure of such community bankers is to be measured? As I pointed out in the previous section of this chapter if the banks cannot make money by charging interest then suitable performance measures must be devised which will encourage the banks to make good use of their reserves in supporting the economic life of the community. If the bank's primary activity is to buy industrial bonds as I have described in the previous section of this chapter then a possible bank performance index for a given period of time is the total payments it has received from all active bonds divided by the reserves:

$$A_I = \frac{P_1 + P_2 + \cdots + P_n}{R} \tag{15.1}$$

This is an economic activity index. I have assumed that there are n active bond issues during the time period in question and Pi is total payment made on the i'th such issue during that time period. R is the total reserves of the bank. The index proposed above would undoubtedly give some indication of the level of economic activity being supported by the bank. Nevertheless the index in this form has certain obvious weaknesses. Consider four bond issues of the same size and same repayment length. One of the bond issuers undergoes a partial default and ends up paying off only 70% of the bond. The other three bond issuers successfully pay off their bonds, but each enterprise performs differently during the time period in which the bond is active. One company pays its employees well below average wages and builds up its reserve of savings by a very small amount. Another company is a normally performing company which pays its employees typical wages and builds up its savings by typical amount. The final company has high performance any pays its employees relatively high wages and builds up its savings by a large amount. The company that defaults on part of it bond payments will obviously contribute less to the activity index than the other three companies. However, the remaining three company will all contribute equally to the economic activity index in spite of their different overall performance. In current stock markets investing in high performing companies gives high returns which can be offset against the low returns or even losses of poorer performing investments. If we want to retain an ability to measure the overall performance of a company and not just its ability to pay off its debts the activity index proposed above could be altered my multiplying the bond payments P_i by a performance factor F_i:

$$A_I = \frac{P_1F_1 + P_2F_2 + \cdots + P_nF_n}{R} \tag{15.2}$$

I imagine the performance factors F_i as being approximately equal to 1 for a normally performing company, less than 1 for a company which performs below average and greater than 1 for a company which performs above average. For example a possible form of the performance factor F might be:

$$F = \frac{G - C}{f \times L \times \bar{E} \times NYC} \tag{15.3}$$

where G is the gross income, C is non labor related costs, L is length of time in years over which performance is being measure, $\bar{E}$ is the average number of employees over the time period in question, and NYC is the normal yearly consumption previously discussed. The parameter f is a fudge factor might be set equal to 1 in which case it has no effect of the performance factor F_i. $G - C$ is the money left over after non-labor related costs have been paid. If this money is sufficient to pay all employees the NYC then $F = \frac{1}{f}$. In reality $G - C$ has to be larger than $L \times E \times NYC$ since the people who work must earn more than the NYC in order to consume at this level since they have to pay taxes. The fudge factor f could be set to some number greater than one to account for this reality.

Note that this performance factor encourages labor efficiency since getting the same work done with a smaller number of employees (i.e. reducing the size of $\bar{E}$) will increase the performance factor. On the other hand the performance factor does not encourage minimizing salaries. A company which pays its employees good salaries and which has a relatively small cash reserve could have the same performance rating as a company which pays poor salaries and has a much higher cash reserve.

I do not want to lay too much emphasis on this particular performance index or another index which I describe below. I do not want to give the impression that I think I have discovered definitive formulas which need to be followed in order to make community finance a success. In the event that a serious effort to institute a system of community finance were undertaken in the real world, people with more financial smarts than I have might be able to devise substantially superior performance measures to those I am proposing. Nevertheless I wanted to propose concrete formulas rather than leaving the idea of the performance of a system of community finance as a purely nebulous qualitative concept.

One other aspect of this performance index is a potential cause of concern. If bond defaults occur the activity index will of course be lowered, both because the bond repayment P_i will be lowered and also because a company which is forced to default on it bonds will have a lower performance factor F_i. Nevertheless this index does not directly measure the banking costs of which bond defaults could conceivably form a major component. Therefore let me propose a second index which would directly measure banking costs. If C is ordinary banking costs (e.g. bankers salaries, office equipment and supplies, real estate costs, etc.) and D the total bond payment defaults during a given time period then a possible cost efficiency index is given by:

$$E_1 = \frac{P_1 F_1 + P_2 F_2 + \cdots + P_n F_n}{D + C} \tag{15.4}$$

The numerator of this efficiency index is the same as the numerator of the activity index given earlier. It is the sum of bond payments times a performance factor for each issuer of bonds. However, the numerator is now the total banking cost that was required to produce the economic activity which is measured by the numerator. This index tells us what the average economic result is for each dollar spent in the operation of the bank.

For people raised in the culture of the *bottom line* the idea of measuring financial performance by two different indices may seem strange. But in point of fact a system of community finance would have two goals which are to some extent in conflict with each other. We want the financiers to be efficient, that is to get good return per dollar invested. But we also want them to support a large enough amount of economic activity so that we have high employment levels and high general welfare. That these two goals are not necessarily identical can be seen by considering an analogy from education. Suppose that a school exists which accepts only students with genius level intelligence. The efficiency of this school as measured by citizen productivity produced per teacher hour might be extremely high. But if the overall welfare of society requires that a high percentage of its citizens should be educated, then the high performance school might not be serving the community's needs effectively.

Ultimately the performance of the community banks will be judged by the people who pay the banker's salaries: That is to say by the community itself, by its elected representatives, or by specially appointed experts who have special training and knowledge which aids them in the making of such judgements. Practical judgment and experience will be required to determine how much emphasis to place on each performance index.

One can ask whether these proposed indices of banking performance will tend to discourage or encourage economic growth. The answer to this question is that if no other constraints within the economic system prevent it, these indices will encourage growth. The activity index A_I will encourage banks to make lots of loans to businesses with high performance factors. In an economy which is growing in scale and productivity this index will be higher than in a static economy. The efficiency index E_I which is the ratio stimulated economic activity to banking costs will also tend to be higher in a growing economy than in a static one. A banking system such as I have been describing could potentially function effectively in a zero growth environment, but it will not in and of itself create such an environment.

The structure of a community banking system

As Mazzini mentions in his extended essay *The Duties of Man*, it is by no means necessary that the community bankers should all be concentrated in a single national bank. Perhaps some of you may have been thinking of such a possibility as a fatal weakness in my proposal for a system of community credit. Even if we devise good methods for measuring the performance of the providers of credit, if they are all concentrated in a single organization it may be difficult to discipline poor performance since we cannot afford to shut down our only source of credit. This is not to say that there would be no means of discipline whatsoever in such a case. Top management could be fired and have their retirement benefits curtailed if gross incompetence were demonstrated. However, decentralizing the provision of credit and having multiple centers of intelligence making decisions about the extension of credit is also a possibility.

Credit reserves could be dispersed widely among a comparatively large group of medium sized and/or small banks if experience showed that such an arrangement produced better results than large banks. If relatively large groups of people with specialized knowledge of different areas of infrastructure investment can cooperate to invest more efficiently, then banks organized in this way will outperform smaller banks and will become the preferred banking form. If smaller banks with less bureaucratic overhead are more successful then they will become the preferred banking form.

Providers of community credit could also exist at various levels of social organization (e.g. city, state or province, geographical region, nation, etc.). Bonds offered by a business could be purchased by any bank whatsoever. However banks representing smaller geographical regions might be given special incentives to invest in businesses providing local jobs.

One possible way to manage the flow of public funds to banks is to pay a given bank a negotiated yearly sum based on the bank's total reserves. The banks can then distribute money to its employees as it chooses. These payments could be made on a periodic (e.g. monthly) basis rather than as a single annual payment. The final payment at the end of the year (calendar or fiscal) could be a variable payment which depends on how the bank performed relative to certain target indices. Such an arrangement would allow banks to directly reward themselves for efficient performance. A bank which performs at a given level using fewer employees can pay higher salaries than a bank which requires more people to achieve the same level of performance.

I will now turn to the question of underperforming banks and how they could be disciplined or disbanded. A bank with certain reserves contracts to receive certain payments from public sources in return for supporting infrastructure maintenance through the provision of credit. A year end variable bonus payment is made based on the quantitative performance of the bank against certain defined indices. Two kinds of underperformance are possible. One is that than bank does not support a sufficient amount of economic activity relative to the size of its reserves. This fact would be revealed in the bank's activity performance index and would result in the reduction or elimination of its year-end bonus payment. A contract between a public body and a bank might be for only a specified period of time after which a review of the bank performance would be undertaken before renewing the contract. If the performance was sufficiently low the contract could be canceled or the bank could be required to reorganize under new management.

A second kind of underperformance would be high banking costs associated with bond defaults. Some low level of defaults or partial defaults should be considered as normal and acceptable. This fact would be allowed for in determining the level of payments required by the bank to carry out its operations. However, if the level of default is unusually high the bank may face a situation where it cannot meet its operating expenses (including salaries) and still maintain its reserves. Deposit insurance can be used to prevent depositors from losing their money. However, just as with automobile insurance if the required payouts results from carelessness or incompetence on the part of the insuree then the insurance rate paid by the bank will go up. If the level of default is sufficiently serious and investigation shows that the fault lies with the bankers then such an event could also be the basis for cancellation of the banking contract.

Note that a bank could conceivably have contracts with more than one community entity representing different levels of social organization (i.e. city, state, country, geographical region, and even international global interests). Losing one of these contracts might requiring some restructuring but would not necessarily cause the bank to fail.

The purpose of the system of community credit which I have outlined above is to make sure that the people who make daily decisions about whether or not to grant credit are specialists who have the knowledge and the experience to judge the risks involved. The fact that the bank's income comes from the community who they are serving rather than from charging interest means that economic growth is not required in order for than bank to effectively carry out its function. However, any reasonable performance index which measures the bank's success in creating and supporting useful infrastructure will tend to encourage growth producing investments unless other system constraints prevent such an outcome.

My purpose in this chapter is to describe an economic system in which such constraints actually exist. One of these constraints which I have already described is the steeply progressive tax on consumption above the NYC. If progressive consumption taxes are tied to the cost of a basket of goods and services they should help to control the demand for consumer goods and services and should therefore help to control what kinds of manufacturing infrastructure investment will perform well.

A second constraint on the bank's ability to stimulate economic growth is the size of the banking reserves. If we institute a system of full reserve banking the banks cannot loan money which they do not possess. Furthermore, if banks cannot grow their reserves by charging interest then the size of the reserves becomes a matter of public policy. The reserves will have to be topped up from time to time to make up for occasional loan defaults, but the overall size if the reserves could also be increased or decreased in accordance with perceived community needs. If the reserves are insufficient to maintain an adequate level of infrastructure then they can be increased. If increased economic efficiency allows a lower level of reserves to maintain an adequate infrastructure then the reserves can be decreased.

The banking performance indices will motivate the banks to support as much economic infrastructure as they can at a reasonable cost within the constraints provided by progressive consumption taxes and the size of their reserves. In the current financial system which is focused on turning money into more money and in which banks are always seeking to increase their total reserves, there is an automatic motivation for expanding the scale of investment as much as possible. In fact one of the great historical problems of the capitalist system has been that the volume of "savings" seeking profitable investments tended to become larger than the economy could find a good use for, leading to financial collapses and immiserating trade depressions.

In this chapter have been describing a financial system which would be capable of serving the credit needs of an economy in which rapid changes in standards of consumption are no longer the norm. However, even if abandon such change as our primary economic goal a need may still exist for a period of time for a high level of technical innovation and charge in infrastructure related to mitigating the ecological impacts of our economic activity. Electricity generation, heating and cooling, transportation systems, the production of manufacturing material, etc. need to be transformed to less environmentally damaging forms. This replacement of currently existing processes with new processes will in all probability have direct costs (as opposed to the indirect costs of the negative externalities of the old processes) which make them economically uncompetitive with more normal infrastructure investments when measure by the normal financial standards. One can attempt to deal with this reality by artificially adjusting relative costs through subsidies, pollution taxes, etc. However, and alternative method for dealing with these transformational investments would be to have a separate set of financial institutions whose mission is ecological footprint reductions. The performance indices of these institutions could then be adjusted to reflect their specialized mission. Again only time and practical experience will show the effectiveness of such specialized financial institutions.

15.7 Methods of controlling private savings in a wealth preserving economy

Since society as a whole cannot really save (that is set aside a large amount of consumer goods for future use) a too large pool of "savings" must either stimulate economic growth by increasing investments in infrastructure or it must lead to an economic contraction in the form of a recession or depression. Making sure that the pool of available credit is the right size is a critical function of the financial system. Interest rate policy has historically been one of the chief tools used for this purpose in capitalist economies. Even in a quasi steady state economy with very slow changes in the standard of consumption interest rates could be utilized to control the size of the credit pool. Conceivably one could try to accomplish this control by rocking the interest back and forth about zero. A negative interest rate is really the same as a tax on financial capital. The problem with such a control scheme is that if zero percent interest is insufficient to stimulate the required level of private saving then the goal of long term average interest rates of zero cannot be achieved. Therefore I suggest using negative interest rates if required in order to insure that private saving do not rise to an unacceptable level, but if savings levels are too low then reserves can be topped public monies derived from taxes.

Of course a uniform negative interest rate on all savings would be a form flat tax on financial capital. The French economist Thomas Picketty in his book *Capital in the Twenty-first Century* has proposed the idea of a progressive tax on capital as a tool for controlling the distribution of wealth in an economy with low, but still positive, economic growth. Inspired by this existing proposal I here propose the idea of a progressive tax on financial capital as a tool for controlling the size of the available pool of credit. Up to a certain limit savings would be tax free somewhat in the same fashion as the tax free retirement savings plans currently employed by the middle class. However, the limit would be on total savings and not on yearly savings. Once this limit is exceeded negative interest rates would apply if they are needed to control total private savings. A progressive interest schedule would exist which would collect interest from successively larger pools of savings. Obviously such a scheme would encourage people to spend their excess saving rather than allowing them to diminish in value over time. Whether you call this withdrawal from savings negative interest or taxes is irrelevant, but I think it is somewhat more honest to call it a capital tax, and I will refer to by this name in the discussion which follows.

The tax free savings limit and the progressive schedule of taxes on financial capital above that limit would be determined by practical experience. I imagine that savings levels for various degrees of taxation would be expressed in terms of the NYC. Suppose that an individual's total saving are $S \times NYC$. A series of tax levels $R_0, R_1, R_2, \cdots R_n$ will be determined by a set of savings levels $S_0, S_1, S_2, \cdots S_n$. So, for example if $S_2 < S < S_3$ then the yearly taxes are given by:

$$T_Y = [R_0 S_0 + R_1(S_1 - S_0) + R_3(S - S_2)] \times NYC \tag{15.5}$$

I am proposing that R_0 should be zero so that for savings less than or equal to $S_0 \times NYC$ no taxes would be collected.

One might ask whether or not such a system of negative interest rates would encourage hoarding. Why should I put my money in a bank and see it diminish in value when I could stuff it under my mattress or put it in a safe and not lose any of it? A partial answer to this question is that a system of consumption taxes such as I have described will tend to discourage hoarding. Remember that at tax time any income which cannot be documented as having been saved will be assumed to have been used for consumption and will be taxed as such. My assumption is that capital taxes will be low compared to consumption taxes so that hoarding would be a disadvantageous behavior except on very long time scales. For example if the normal consumption tax rate were 20 percent and the marginal capital tax were 2% it would take 22 years before the hoarder caught up with the bank saver (see the appendix A for the details of the calculation). I should point out here that as a collective strategy hoarding will not work. Society as a whole cannot hoard. If the group of people who are saving (i.e. consuming less than their current income allows) is not offset by another group who are drawing down savings (i.e. consuming more than their current income allows) then an economic contraction immediately results. Nevertheless an individual consumer looking out for their own isolated interest might be tempted to hoard.

One might ask whether savings that are taxed every year will not eventually disappear and so become entirely irrelevant to long term financial security. The answer to this question depends to some extent on how high the marginal tax level is. Since taxes are collected as a percentage of whatever savings are left the savings would never disappear completely, but after a long time the size of the remaining savings would be substantially diminished. One can characterize the tendency of savings to diminish by the half-life of the savings which is the period of time over which half of the savings would disappear. Table 15.1 gives the savings half-life for a series of marginal tax rates (See the appendix for details of the calculation):

Clearly a high marginal tax rate on financial capital would discourage long term savings. However if the marginal tax rates are low enough then savings could still be relevant to consumption rights during retirement. The goal of such a system of taxation of financial capital would be to discourage an unbounded desire for the accumulation of savings while still allowing individuals and families to accumulate and hold an effective strategic reserve of financial resources. The primary source of retirement income should be social security which is not liquid savings in the traditional sense. Liquid savings could be used to modestly enhance retirement income and as a strategic reserve for dealing with periods of unemployment or with occasional large domestic expenses.

Clearly people with different career paths might desire different sizes for their strategic financial reserves. People who have relatively short careers at high earnings levels and who want to use their savings to bridge to the age when they can collect social security might find taxes on financial capital more onerous than people with long careers and more steady income. One way to deal with these kind of differences in income profile would be to

Table 15.1: Saving Half Life

Marginal Tax Rate	Savings Half Life
0.00%	infinite life
1.00%	69 years
2.00%	34 years
3.00%	23 years
4.00%	17 years

give people tax relief on consumption taxes in the present if they have paid relatively high levels of capital taxes in the past. Such a policy would allow people who are bridging to social security to make more effective use of relatively short periods of high income levels.

Another important point to be discussed in understanding how to control the size of the credit pool is business savings. I would propose that business savings should also be subject to a schedule of progressive taxes on financial capital. However, unlike private savings by individuals taxes on business savings could not be made according to a universal schedule. A large business obviously needs a larger strategic operating fund than a small business. Capital taxes would have to be adjusted to compensate for this reality. The tax schedule could be based on some formula involving the total capitalization and the total yearly salary payout of the business (possibly averaged over some time period). As long as the total savings are below a certain level allowed for strategic operating purposes no tax would be collected. Above this level progressive yearly taxes would be leveled on business savings.

Of course under such a system a business which is growing by acquiring more capital and/or more employees could also grow its savings. My idea is that system of progressive taxation on financial capital would allow a healthy business to deal with short term mismatches in income and expenses on a purely internal basis, but for major capital expenses and/or a major expansion of its employee pool in anticipation of new revenues it would be forced to go to the community banking system for credit. This necessity is in accord with truth 8 that all investments in infrastructure are community investments. In the long run we want to create and maintain infrastructure which creates resilient long term wealth for the community rather than simply maximizing short term growth.

Even in a quasi steady-state economy it will not be true that all business will have an absolutely static size. Superior products which perform a given function may be developed, and then it will be appropriate that businesses supporting the new product line should grow while business supporting the old product line should shrink and finally disappear. Products that are manufactured with a smaller ecological foot print may grow at the expense of older less environmentally friendly products. That part of the economy which supports our aesthetic and recreational interests may evolve over time even if the absolute size this economic sector is not growing, leading to the shrinking production of certain products and services and the growth of others.

I am not suggesting that the bankers should directly exercise qualitative judgment over which investments lend themselves to long term resilience of community wealth. Their job is to meet their quantitative performance requirements within the limits allowed by the size of their total reserves. Limiting credit reserves does limit overall infrastructure growth, but judgments about long the term environmental impacts of human economic activity should be made legislatively via regulation and tax policy rather than being put directly into the hands of the financiers.

In some discussions of post growth economics I have encountered people of a libertarian leaning who want to reduce the amount of credit to zero, thus keeping the evil hand of government out of private enterprise. If private credit markets will not work in a post growth environment, say the libertarians, then let businesses finance major capital expenses through their own savings. If they have insufficient savings to meet the requirements of a major capital investment then let them go down in ruins as they so richly deserve to do.

There are two problems with such a proposal. In the first place it is doubtful that forcing any business that temporarily runs short of funds for a required major expense to immediately close its doors is an efficient way of running an economy. Capitalism, as it currently exists certainly does not operate in this manner, and it is not clear to me why such a procedure would become more desirable in a steady state economy.

The second problem with a savings only economy is more serious. From the point of view of the overall economic system savings are a fiction. The individual person or enterprise who saves money regards this savings as deferred consumption rights which they can decide to use at any time they choose. But society as a whole cannot defer consumption. Apart from some necessary amount of inventory which is required for the smooth functioning of the system of production and distribution we must consume everything we produce or we have recession and people lose their jobs. If someone saves (i.e. defers consumption) then someone else must spend. Once future security is based on savings only, the problem of balancing those who desire to defer consumption with those who are consuming above the average level becomes very difficult. People and enterprises whose future security depends on savings have an essentially unbounded desire for savings. Who can know for sure what contingencies the future will brings? If businesses attempt to save too much then these savings will either stimulate economic growth or they will produce a financial collapse if good investments cannot be found for all of the money which people desire to save.

My idea is that a substantial fraction of the yearly investment in infrastructure should come from private savings, but not 100%. The remaining reserves should come from the community itself. In this way we provide the necessary liquidity to ensure that the inevitable short term inequalities of income and expenditure in enterprises with a large level of capitalization can be smoothed over on a timely basis without encouraging the unbounded growth of savings, and thus the unbounded growth of manufacturing infrastructure.

15.8 Ownership of the means of production (i.e. physical capital) and whole enterprise ownership

One might ask whether the buying of industrial bond issues by community banks implies the end of private ownership of capital and is thus a form of communism. Obviously the answer to this question depends on how one defines the word *communism*. Personally I am not a believer in any sort of *ism*, and in my view it would be a complete waste of intellectual energy to spend my time crafting a definition of communism and attempting to explain why my proposal for community credit markets does or does not conform to this definition. On the other hand the idea of ownership as it relates to large scale industrial enterprises is an important one and merits a significant discussion.

It is important to distinguish between whole enterprise ownership and ownership of capital. The latter is only a subset of the former. The elements of each kind of ownership are listed below:

1. **Capital:** Plant, machinery, tools, inventory of materials and parts, inventory of finished goods not yet sold, financial capital

2. **Whole enterprise ownership:** Capital, intellectual property, company culture

Company culture is a difficult phenomenon to define, and yet it is very real and is often an important consideration in the sale of whole enterprises.

All of these elements of ownership can be present even in very small enterprises. For example consider an individual guitar maker. He or she will need physical plant in the form of work rooms and possibly a retail shop. He or she will need guitar making tools and an inventory of construction materials. If he or she runs a retail shop then a certain amount of inventory in finished guitars will be sitting in the shop at any given time. All of these items are part of the physical capital of the business. I should point out here that more technical definitions of capital include the cash reserves of a business along with the physical elements of capital. These cash reserves which can be converted to physical capital as needed are often an important part of the practical operation of a business enterprise. Obviously such business savings are owned by the individual enterprise in question and not by the community even in my proposed system of community credit.

If the guitar maker has specialized skill and knowledge which gives his or her guitars a unique sound and playing feel, then that skill and knowledge constitutes a kind of intellectual property. If the guitar maker hires other luthiers and teaches them to make guitars with the sound and feel that he or she has developed then a kind of company culture can come into existence which has a reputation for producing guitars of a certain quality and style.

Now I will discuss briefly the nature of the rights of ownership both of physical capital and of whole enterprise ownership.

Aspects of the ownership capital:

1. Right to decide how capital shall be employed
2. Right to decide when subsets of capital shall be replaced, sold, or scrapped

Aspects of whole enterprise ownership:

1. Right to claim a share of the business profits independent of any direct contribution to the output of goods and services
2. Right to obtain profits from selling the whole enterprise

The set of rights associated with ownership of physical capital is essentially the same as the rights of property ownership by an individual. The tools sitting around in my garage are my personal property. I decide which tools to buy, and I decide how those tools will be used. If decide to sell an old tool I do not have to consult the inclinations of my neighbors, and I can use the money received from the sale for any purpose I have a mind to.

On the other hand the set of rights associated with whole enterprise ownership is something quite different than the ownership of personal property. If I am sufficiently rich I can purchase any set of capital equipment I have a mind to simply by laying down my cash, but my ability to make money as a result of that expenditure depends upon the existence of a working enterprise which comprises many elements (not all of which are physically tangible) in addition to physical capital.

The price obtained for the sale of a whole enterprise often contains a strongly speculative component depending on projected future profits. These projected profits are often strongly dependent on intellectual property and on company culture, and not merely on physical capital. This kind of speculation in the future profitability of various production enterprises has come to dominate private credit markets as they currently exist and the majority of such ownership profits do not go to the people who do the work which makes such profits possible and who should be viewed as the owners of physical capital in a practical sense. Insofar as a company depended on a community bond market for credit it could afford to reward its employees more for real increases in productivity than if it obtained its credit in a stock market where owners of shares have a right to claim a major share of the profits.

My proposal for the creation of nonprofit community credit markets will not interfere with an enterprise's practical ownership of its physical manufacturing capital. In the current system of private credit markets the providers of credit do not own physical capital in any practical sense. A group of bank managers or a stockholder group cannot walk into a private business and arbitrarily take away pieces of equipment which they "own" because they have provided the credit with which that equipment was purchased. Nor do the external providers of credit get any say in day to day decisions about how that equipment shall be used, including whether it shall eventually be sold or scrapped when the enterprise in question thinks that the equipment is no longer necessary for its manufacturing process.

Nonprofit community banks would gain the rights to participate in practical decisions about how manufacturing capital is deployed and used only if we grant them such rights. I can see no reason for such a transfer of rights. Therefore in the system of community credit markets which I am proposing the ownership of capital at the manufacturing process level will remain with the individual enterprise which deploys such capital.

Suppose that a large part of the economy has come to depend on the community bond market and the general level of economic activity and the structure of capital taxes makes the possession of huge amounts of cash (relative to the size of the company) a rare thing. Do these facts imply that mergers of two companies will no longer occur since no one will have the required resources to buy up other companies? In my view the answer to this question is that acquisitions will disappear but mergers will not.

Recall that the practical owners of physical capital (i.e. the group of people who make decisions about its acquisition, use, and eventual retirement) are the group of engineers, managers, and planners who constitute the technostructure of the enterprise in question. The technostructure of a company is continuously changing. Managers, engineers, and market analysts come and go. But such changes are gradual and do not necessarily change the overall style of decision making. But in some cases a major reorganization of the decision making structure of an enterprise is required. One such form of change is the highly negative one of bankruptcy. In this case the assets of the company fall into the hands of its creditors who seek to dispose of them in the most profitable manner that they can. In the system of capital creation that I am proposing this aspect of the use of capital use will not change, except that the creditors will in most cases be community banks. If bankruptcy is declared then the assets of the failing company can be sold or provided as a form of credit to other enterprises who think that they can put them to good use. In some cases a new group of core managers may be found who think that can outperform the nincompoops who are on their way out, so that the whole company can be reconstituted under a new technostructure.

In other cases two companies who are not on the verge of bankruptcy may nevertheless believe that they could perform more efficiently if they merged operations. Such a merging of companies represents a major change in the technostructure as the two formerly separate operating groups must learn to work together. There are potentially a variety of forms of that such a merger could take, but I will consider only the simple case of two independent companies merging operations. In the current economic system such a merger usually takes the form of a sale of one company to the other. Of course in this case more than physical capital is being sold. Intellectual property, company culture and the technostructure itself is sold. Of course the members of the technostructure are not serfs and they can choose to resign if they do not wish to work for the new company. However, employment inertia will generally cause the majority of employees to stay with the new merged company if they are given the opportunity to do so. In many cases the knowledge and skill of the acquired employees is an important factor in the acquisition decision.

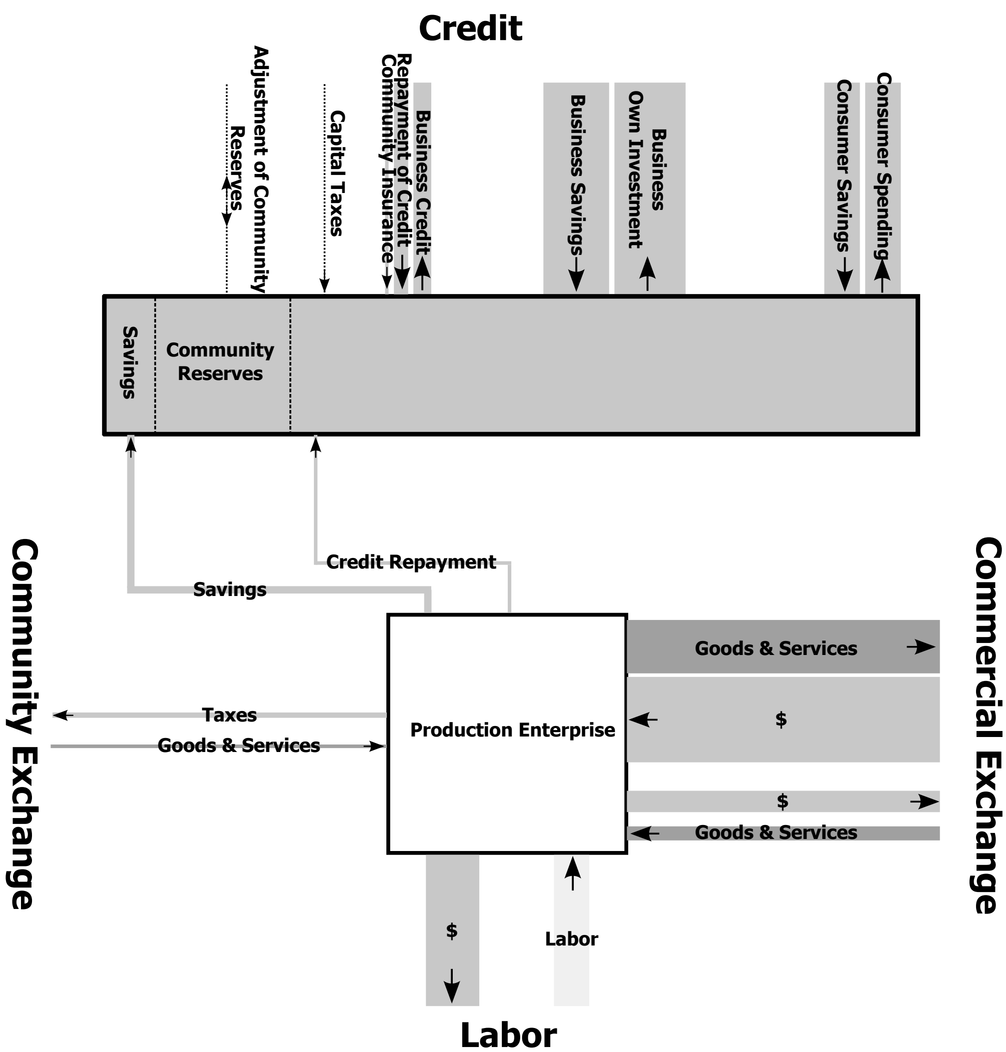
However, there is no need for a sale of capital and other company resources in order for such a merger to occur. Such a merger would be more like two people moving into a house together. One member of the couple does not pay the other and acquire his or her goods. They each bring their own property and a large part of it will now be shared between the householders. There is no issue of "owners" who need to be paid for giving up their property. If one of the two merging companies has outstanding debts that fact will be reflected in the credit situation of the merged company. Of course in a quasi steady state economy in which standards of consumption are changing very slowly and the opportunities to make enormous short term profits from the speculative future income of a given enterprise are relatively rare, then such mergers may happen much less often than do in the current economic system. Only true economies of scale or true technological synergies will drive such mergers.

15.9 Community credit diagrams

I will now present the same ideas about a system of community credit in graphical form. The diagram below shows the relation of a particular business to the system of credit during a time when it is building up its pool of savings. The diagram shows the enterprise in question connected to four different societal systems by means of monetary exchanges. These four systems are commercial exchange, labor, community exchange with the public sector, and the system of savings and credit. [here]

Monetary flows within the system of commercial exchange are bidirectional since the business sells its own goods and buys materials and parts from other businesses. The monetary flow to labor and to the public sector is unidirectional as money is used to purchase labor and to purchase community services (e.g. sewage systems, fire protection, roads for transportation and so forth). The monetary flow to the system of credit and savings can go either direction, but at the particular time shown in the diagram all of the flow is into the system of credit. Of course the flow of savings can be reversed at any time if the company has need of this money. That a business could be saving and paying off old debts at the same time should not be particularly surprising, particularly in a situation where no interest is owed on the debt. Even in current growth driven financial markets the decision

Figure 15.1: Income flow during buildup of savings



to pay down debts at less than the maximum possible rate are frequently made.

The width of the bars depicting the flow of money into and out of the business enterprise in question are proportional to the size of the flows (on a per year basis). The sum of all of the outflows is equal to the inflow obtained from selling goods and/or services. The outflow labeled "savings" can be reversed at any time if the enterprise has a need to meet higher than ordinary operating expenses. The width of the bars representing the flow of goods and services do not have any definite quantitative meaning. If the ratio of the width of the monetary flow to the width of the corresponding flow of goods and services received in exchange for it had been kept constant, this constancy could have been interpreted as implying that any basket of goods and services has some definite quantitative value attached to it which is always proportional to money price of the basket. Such a contention touches on so-called economic theories of value which I have no intention of exploring in this book.

Notice that I have depicted the taxes paid by the enterprise in question as the price of services obtained from the public sector (e.g. public roads, sewer systems, fire fighters, police, education for a new generation of workers, etc.). These taxes are not necessarily income taxes, but could be property taxes. I have depicted the pool of credit as a single object, although as I have explained previously, credit need not be concentrated in a single centralized institution. However, in attempting to understand how the overall economic system can exist in a state of approximate equilibrium it is useful think about credit as a unitary system. I have depicted a situation in which the sum of all the inflows to the system of credit are equal to the sum of all the outflows so that the banking reserves are constant.

Three groups of inflows/outflows exist which should logically be nearly balanced in a quasi steady state economy. Consumer savings should be equal to consumer withdrawals. Obviously the people withdrawing their savings are not the same people who are building up their savings. The second group is business savings and business own investment. I have separated one particular business out from the total group of enterprises participating in the economy, so that the savings of this particular business must be added to the savings of the other enterprises in order to make the inflow and outflow balance. Finally credit is flowing out to enterprises whose savings are insufficient to meet some present need of relatively intense expenditure. This flow needs to be matched by the inflow of repayment of old advancements of credit from other businesses. If any defaults (partial or whole) on these debts occur then the deficit is made up by payments from community funds.

Again the debt repayment from the particular enterprise singled out in this diagram must be added to the inflows to make the credit system balance.

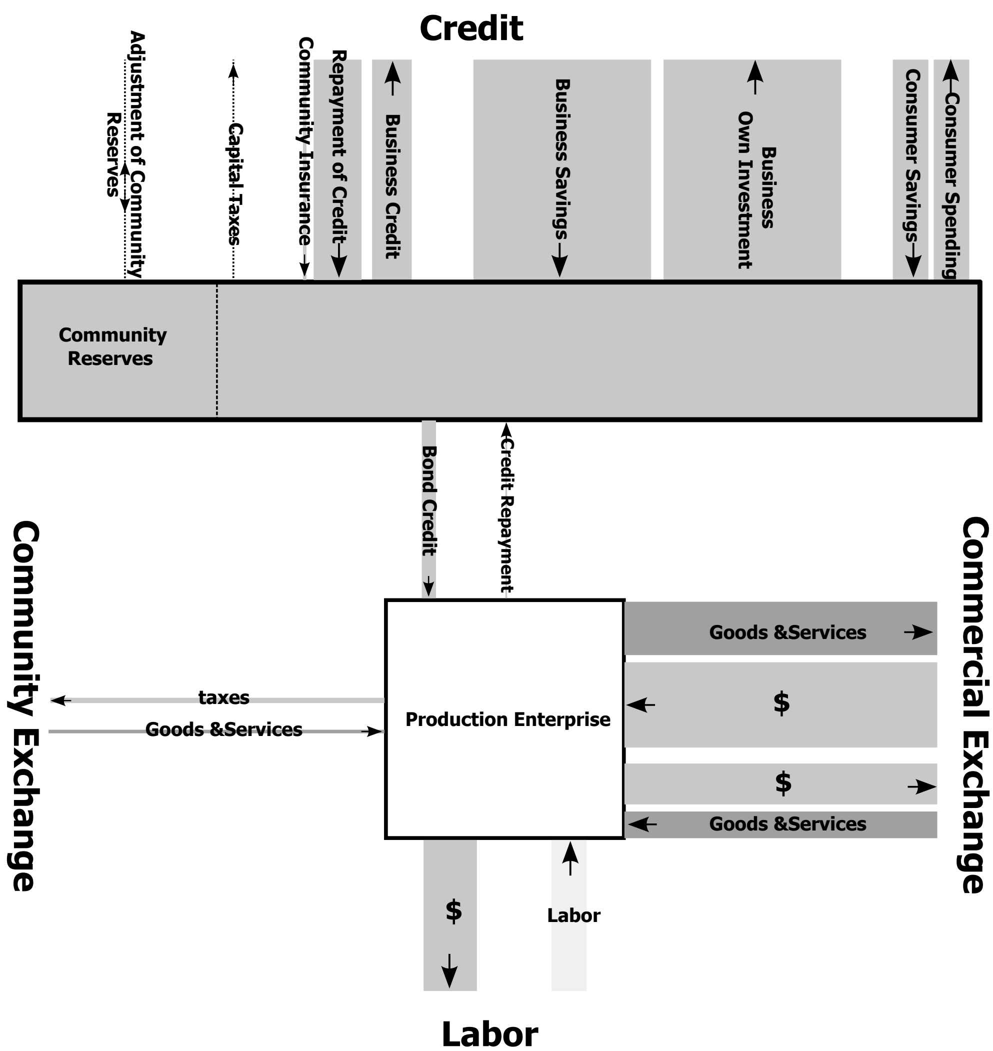
As I have pointed out previously business own investment and bank credit are not really functionally different. Credit, debt, and risk are present in both types of investment. Business own investments which produce a smaller return than anticipated still represent a default on debt and can have the same kind of negative consequences as misinvestment of bank credit. It is desirable that the decision making power about credit should lie with the individual enterprise utilizing the credit as much as is practically possible. I have quite arbitrarily shown the flow of bank credit to be 25% of the flow of business own investment. The actual percentages that would occur in a real implementation of a quasi steady state economy would be determined by a combination of practical experience and arbitrary choice.

The diagram depicts a situation in which the inflows and outflows are perfectly balanced and under which, presumably, the overall level of economic activity is acceptable. However, I have also shown by dotted lines one other inflow and one other outflow which could be used as tools of public policy in the event of disturbances to this equilibrium situation. One of these tools is available only on the supposition that some significant fraction of the total banking reserves belongs to the community as a whole and not to private individuals or to private businesses. This portion of the reserves can then be drawn down or increased (using tax money) in an effort to repress or to stimulate economic activity as circumstances require. Drawing down the community portion of public reserves to maintain economic activity on an even keel cannot continue indefinitely if private savings exhibit a long term growth trend. Therefore I have depicted an additional tool for controlling the size of banking reserves: taxes on financial capital. These two tools complement each other. Drawing down community reserves could be done relatively quickly by some public organization granted the proper decision making power, while raising capital taxes would require public consent via legislative action which would take a considerably longer time to implement.

The next diagram shows the flow of labor, goods and services, and money for the same production enterprise as in the previous figure during a time of relatively intense infrastructure investment in which the flow of current income is insufficient to cover current costs. The enterprise in question has already drawn down its savings and is now employing credit obtained from a bond issue.

The enterprise's income obtained from selling goods and/or services is the same as in the previous figure. Because the enterprise is not currently saving it can direct the money that was previously flowing in this channel

Figure 15.2: Income flow while employing bond credit



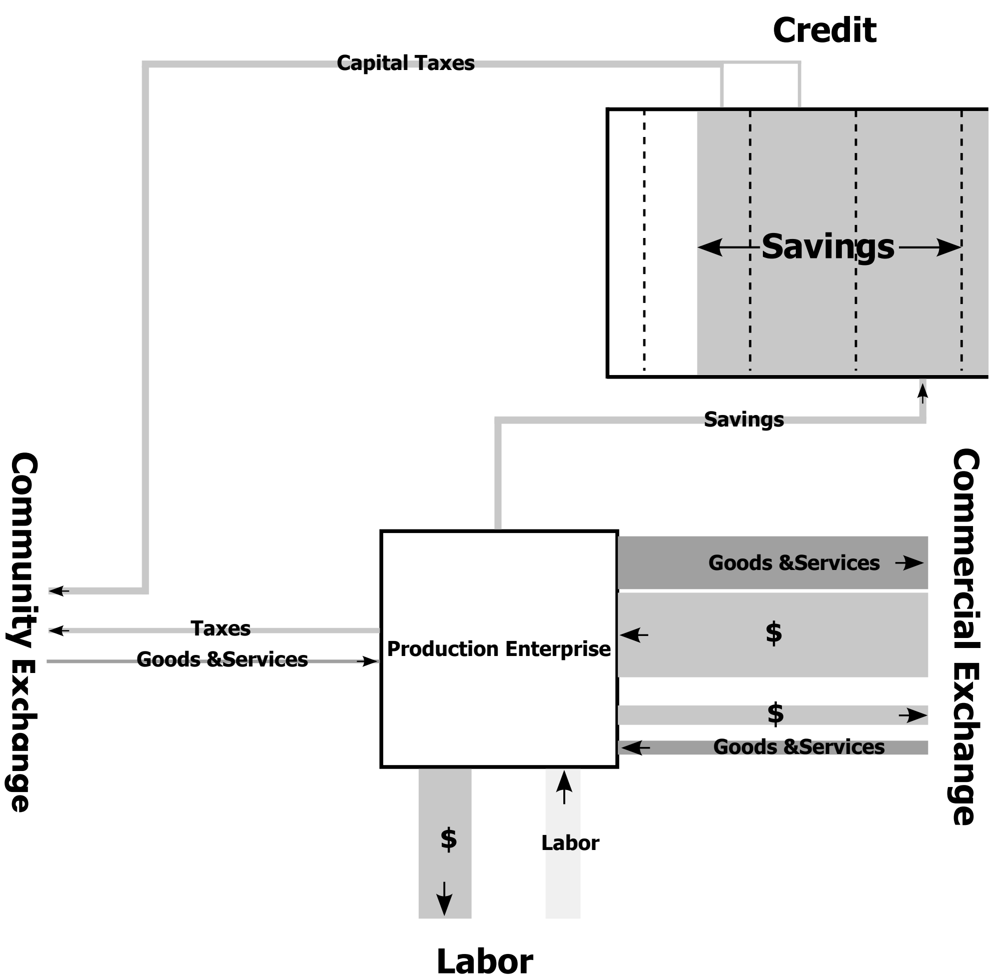
to meeting its current excess expenses. However, since this money is insufficient to meet these expenses a bond issue has been floated to obtain the necessary money. The enterprise is currently utilizing money from its available pool of credit and will continue to do so for a period of time that is short compared to the bond payback time. The enterprise has already begun its bond repayment, but because the length of the repayment period is long compared to period of heightened expenditure this payment is small compared to the flow of credit. The total extra rate of expenditure by the enterprise is equal to the difference between the flow of credit and the bond repayment plus the flow of money that was previously being sent to savings. Again the sum of all monetary flows into the enterprise (in this case the income from sales plus flow of credit) is equal to the sum of all of the monetary flows out of the company. Also the sum of all the inflows into the system of credit has been set equal the sum of all the outflows.

This situation applies to a relatively short time period during which intense infrastructure expenditure is required. When this time period is over the situation will return to that of the previous figure except that the pool of company savings will have disappeared. However, since the period of excess expenditure is over the enterprise can start saving again and thus re-establish its strategic financial reserve.

The next figure shows the savings of a very successful enterprise which has no debt and whose savings have exceeded the tax free limit. In this figure I do not show the whole system of credit but only part of it. That part of the pool of credit reserves which starts at the first dotted line on the right is the savings of the enterprise in question. The other dotted line represent various levels of savings which are taxed at different rates. Below the lowest level no taxes are collected whatsoever. Therefore a company which manages its financial reserves so that they do not exceed this level can avoid capital taxes altogether. The two savings levels which are being taxed are shown having the same amount of money flowing out. Because the upper level is only half full this implies a doubled the tax rate for this portion of the savings. I have arbitrarily depicted the savings levels as being evenly spaced. Imagining the details of how a real capital tax would be constructed is far beyond the level of detail that I want to examine in this exploration of the idea of a community credit market. This diagram is merely illustrative and is not a concrete proposal for real world taxes. In the diagram the rate of savings and the rate of taxation are depicted as equal. In a quasi steady state economy such a situation would prevent the further growth of savings. I have depicted this situation in order to show how taxes on financial capital could be used as a tool to control the available pool of credit. However, in practice companies would be very unlikely to operate in this fashion. It is not quite true that a company in this situation is getting nothing in return for its savings. The performance rating of such a company would be very high, so that if in the future it had need of credit, public financiers would be eager to accept its bond issues. However, the performance factors that I defined earlier would be equally good if the company used its excess cash to pay employees higher salaries, so that it seems likely that most companies would choose higher salary payouts rather than seeing its money disappear in the form of capital taxes. Furthermore if the savings limits depend on some formula involving total capitalization and total salary payouts then a higher salary structure would increase the savings limits. One point to be noted here is that a saving limits based on the salary payouts should have some provisions to encourage egalitarian salary structures. If such provisions are not included then a company with a large cash flow could avoid paying capital taxes by awarding large bonuses to its executives and doing nothing for its rank and file employees. Of course, if savings of private individuals are also subjected to capital taxes then the employees of a very successful company with high salary payout could be subjected to taxes on financial capital in addition to consumption taxes.

It is also possible that a company with a large cash flow could avoid capital taxes by expanding, that is by purchasing more capital and hiring more workers. Such action would siphon off their excess cash and increase their saving limits for the future. Of course in a quasi steady state economy where a substantial majority of the population are consuming at levels near the NYC the chances of a company being so successful that it will have large amounts of excess cash that it needs to dispose of will be comparatively small. In such a situation the majority of companies will operate with strategic reserves that never significantly exceed the tax free limit so that capital taxes will play a relatively small role in overall government income.

Figure 15.3: Income flow when savings have exceeded the tax free limit



Chapter 16

Land ownership in a wealth maintaining economy

In the previous chapter I did not talk specifically about land ownership. Of course a factory has to be located on a piece of land and the cost of land ownership (i.e. mortgage payments, rent, property taxes) are part of total business costs and therefore affect the overall credit situation of an enterprise, but do not necessarily require a separate economic discussion. However, I think that two specific kinds of land use require a special discussion. One type of use is for businesses in which land itself is a major factor of production, such as farming, forestry, and stock raising. The other type of use is land for domestic housing.

In a growing economy with "healthy" stock and bond markets which allow people with excess money to grow their wealth by investing, interest must be paid on loans for the purchase of housing and land in order to attract money away from other potential investments. In a quasi steady state economy this justification for charging interest on housing and land purchases no longer exists. Community banks could conceivably make interest free loans for these kinds of purchases as well as on other kinds of loans, but a potential problem arises with respect to measuring the performance of the banks with respect to this kind of economic activity. Land and housing changing hands is a fundamentally different kind of activity than businesses acquiring and/or upgrading capital or hiring new employees to support expanded production. If a bank's *raison d'être* is to turn money into more money, then housing loans are just another investment and incorporating the returns into the bottom line is a comparatively easy matter. If, however, a bank's mission is to maintain and create useful infrastructure rather than to make money then matters become more complicated. It is not immediately clear how flow of money associated with the changing proprietorship of housing and land can be combined with the flows of money associated with capital acquisition and maintenance to create a meaningful performance index for community financiers. Although the changing ownership of land is often a necessary condition of economic activity it does not seem obvious that the monetary volume of such exchanges is good measure of the resources required to create and maintain infrastructure.

Conceivably one could have separate lending institutions associated with housing and land which would be evaluated by a different set of performance measures. However, in this context I would like to introduce a model for the ownership of land and housing which completely separates it from the banking industry. After all if a business acquires a million dollar piece of machinery then the fundamental idea of physical credit (i.e. the future return of goods and services for the present expenditure of production resources) clearly applies, but the changing proprietorship of land or housing does not involve any expenditure of production resources. Therefore the idea that these two kinds of activities should be given different economic treatment should not be regarded as particularly bizarre. I do not insist that the model below is a necessity for the creation of a society with long term resource and ecological stability, but I nevertheless present if for consideration.

I call this model community ownership / private proprietorship. To some extent this model of land ownership was practiced in ancient China under the name Tsing Tien as described in Mabel Ping-Hua Lee's book *The Economic History of China With Special Reference to Agriculture* [1]. In this system the individual peasant farmers and their families worked an area of land to which they had an unconditional right during their lifetime. However, they had no right to sell the land to an arbitrary third party. When the proprietor died without heirs or voluntarily chose to leave, the land reverted to the community who then sought a new proprietor who again received lifetime rights to the use of the land.

This system was intended to insure a fair distribution of land and to prevent the formation of latifundia, huge private holdings of land worked by tenant farmers. However, for much of Chinese history this practice was abandoned and unlimited private ownership of land was allowed, with the result being the formation of latifundia. The peasant farmer was subject to the vagaries of weather and agricultural pests, and after a year or two of bad

[1] Lee, Mabel Ping-Hua; 1921, *The Economic History of China With Special Reference to Agriculture*, Longmans, Green & Co., New York

crops he would be forced to borrow money from some large land owner at ruinous interest rates (often greater than 100%). When the farmer defaulted on this debt his land passed into the hands of the provider of the loan. This process is referred many times in the source documents from which Lee drew her historical account as *the rich eating up the poor*.

Of course believers in the unrestricted accumulation of private property as the only true foundation of human liberty will maintain that Tsing Tien was abandoned because it was bureaucratic and inefficient, and it is better to be eaten up by your rich neighbor than to be eaten up by the government. My own point of view is that because creating a human society with long term stability requires that both the public and the private sectors be primarily occupied by other interests than eating up ones neighbors, we might as well assume that such alternative interests are possible or else abandon the discussion as pointless.

Therefore in the case of land (and in some cases capital improvements to land as I shall shortly explain) I propose a system of community ownership and private proprietorship. If proprietorship for life or until voluntary retirement proves to be the best way to motivate effort then there is no reason that such a practice should not be adopted. In some cases allowing inheritance of proprietorship within a family might also be acceptable. Such inheritance is not the same thing as unconditional ownership since the inheritor cannot act as a landlord or sell the property to an arbitrary third party. They would merely have the right to continue living on the land or utilizing it to earn a living. If the inheritor declines the inheritance or if they decide to leave the land after a certain period of time then the land passes back to the community and a new proprietor is sought.

In the case of private homes the private proprietorship/community ownership model should apply to both the land and the house which sits on it. The proprietor pays via property taxes or land rent (to use Henry George's term [2]) for that part of the value of the house which he or she uses up during their residence in the house. The proprietors would never be on the hook for the full value of the house, and therefore would not need to pay interest. However, real physical debt associated with building a new house cannot be avoided. Building a house requires a large expenditure of resources in the present which will provide services for a very long period time into the future (At least this will be the case if the house is well built.). Therefore someone has to make the evaluation whether the required expenditure of resources is justified. The best judge of whether credit should be extended

[2] George, Henry, 1886, *Progress and Poverty*, D. Appleton and Company, New York

to allow this expenditure of resources is the immediate community in which the house will be built. I am not attempting to specify here the exact political mechanism by which this judgment will be rendered, but assuming that it is rendered and a new house is judged to be a valuable long term resource for the community, the community will pay for its construction.

To some people the idea of community involvement in the building of private homes is horrifying and conjures up images of bland homogenized *government housing*. In point of fact there are plenty of homogenized monstrosities of housing tracts being built by private developers in the United States today, and many people are not wealthy enough to afford anything better. It cannot be denied that if you happen to be rich enough and/or able to convince a private lender that your career path will provide you with sufficient income in the future, then you can build any sort of house you take a fancy to (within the zoning and building code restrictions of your locality). There is no denying that high levels of private wealth confers certain kinds of freedom on its possessor. However, if resource constraints make economic growth impossible then the freedom for people to build privately financed dream homes may largely vanish, and community based finance may offer a superior alternative.

First of all we should understand that in a community with an approximately constant human population containing well build houses designed to last for long periods of time, there will not be a high rate of new building going on. There is no more reason to regret this fact than for a middle aged man to regret the fact that he is not forty feet tall and constantly getting bigger. Our urban infrastructure is the setting for the intellectual, spiritual, and aesthetic existence of city dwellers. The vitality of our inner life should be the measure of human welfare health and not the number of square feet of new interior space that we construct every year.

However, some level of new construction will be required as houses are destroyed by fire or storm, or simply become so old and decrepit that they are not worth repairing any more. Cases may also exist where individual towns are shrinking or growing even though at a macro scale the overall population of a large geographic region is stable. When the community determines that new houses needs to be built, community finance need not result in cookie cutter houses. Proprietors can be identified prior to construction and they can be allowed to exercise personal choice in the design of the new house. The proprietors could be given general guidelines about acceptable and unacceptable design features, after which they would proceed much as they would in the current system of house building. That is that could design the house alone or in conjunction with advice from building experts. They could solicits bids from builders. If the prospective proprietors have building skills they can plan on doing some of the work themselves and therefore get a lower bid than they would otherwise be able to obtain. Once a design and bids are obtained then a consultation with the community financiers will be required to get a final approval. A certain amount of back and forth negotiation may be required to reach a final contract.

Once a design is finalized and the contract signed the house gets built and the community pays for it. The proprietors pay nothing until the house is finished and they start living in it. They then pay for that portion of value of the house which they use up during their term of residence. They are not on the hook for the full value of the house, and they do not have to pay interest. Proprietorship is for life as long as you can make your monthly payments. The mayor cannot throw you out and give the house to his daughter or to one of his friends. Because the proprietors do not pay interest the overall cost of owning a home would be lower than is the case in the current system of private finance, and so they are less likely to lose their house because of inability to pay these costs.

Naturally under this system of building the proprietors do not build up equity. They can live in the house as long as they like, but if they choose to leave they do not sell the house; It merely passes back to the community who will then seek new proprietors. If a mistake is made and new houses are built which are not really needed (i.e. because population flows out of the community) then the community bears the loss of value and not the individual proprietor.

A question arises of who will bear the expense of ongoing maintenance. If the proprietors do not build up equity in the house then they may not be motivated to accept the expense associated with certain kinds of major repairs such as re-plumbing the house or putting on a new roof. This situation can be dealt with by having the community bear these expenses. The process of deciding to initiate major repairs could be initiated either by the proprietors themselves or by the community. Since the community owns the immovable parts of the physical structure of the house, they will want to inspect the physical state of the property on a periodic basis (perhaps every five years or so). Such inspection will allow the planning of expenses since major systems such as the roof or the plumbing degrade slowly and one can anticipate when repairs will be needed. If proprietors themselves discover a major problem developing they can request a special inspection.

Some people will find the idea of periodic inspections to be bureaucratic and intrusive, but home inspections are already a part of modern home owner's life. When you sell your house, it will be thoroughly inspected and you will have to pay the price (either by repairs or by a lowering of the price of the house) for a major degradation or faults in any of the physical subsystems of the building.

Once agreement is reached that major repairs are needed then two procedures are possible. The community itself can handle the repairs using preferred contractors, or the proprietors can seek their own contractors. The bid from the private contractor will have to be submitted for approval to the appropriate community authorities, and if price is too high the proprietors will then have to either bear part of the cost themselves or allow the community to carry out the repairs.

One advantage of community finance of housing is that might lead to more intelligent decisions about long term costs. In some cases trade-offs exist between up front construction costs and long term maintenance costs. The community will be able to make better decisions about choosing the lower long term costs than an individual home owner who is not sure that they will live in the house for more than a few years. For example suppose that there are two or three major roofing systems being used in a given community. If the community is paying for the cost of building new houses and for re-roofing old houses when required, it will be any easy matter to inspect its records to determine which roofing system has the lowest long term yearly costs. Up-front costs can be balanced against the long term repair/replacement costs.

At this point I would like to briefly discuss the issue of rental property. One might ask whether in a community ownership/private proprietorship model of property rights the state would become the sole landlord of rental properties? Before attempting to answer this question we should think about the general housing situation in a quasi steady-state economy such as I have been describing. In a situation of relatively slowly changing methods of economic production, a stable population, and a relatively equitable distribution of income, there is no reason why the vast majority of the population should not be the proprietors of their own housing rather than tenants. Of course not everyone may want the full practical responsibility of maintaining the exterior of a house and yard. Even in the current model of private ownership the condominium represents an intermediate case between the tenant and the house holder. The proprietors of condominiums own the interiors of their homes and are responsible for the upkeep, while the homeowners association (HOA) is responsible for the exterior wall, the roof, and a large portion of the landscaping. In the property ownership scheme that I am proposing there would be no reason to eliminate private HOAs although they would now have to interact with the local government in making decisions about new roofing.

Although in a properly organized quasi steady state economy the need for temporary housing would be less than in the current economic system some level of rental units might still be needed, but it would not be necessary for the government to directly manage such units. Indeed the proposal to build a group of such units could come from a private group, but they need to persuade community financiers rather than private financiers that the demand for such units will justify the required expenditure of resources. If their persuasion is successful then the rental units are built with community funds and the private management group runs the housing/apartment development and pays themselves salaries out of the rent money. Because there is no need to pay interest to private investors the rents could be substantially lower than in the current economic system.

So far I have discussed only the case of domestic land proprietorship. Other considerations apply when the land is being used for commercial purposes, such as agriculture, stock raising, or forestry. In this case I would make a distinction between small holdings and large holdings. Exactly how small holding are to be defined would be a matter of community policy in the same way as zoning laws. For small holdings proprietorship would be for life and potentially proprietorship could be handed down within a family if the younger generation decided they wished to continue the family business. The land would be taxed in proportion to its commercial value so that failure to pay taxes could result in repossession of the land. However, as long as the proprietors run a successful business and pay their yearly taxes or land rent their right to practical possession of the land cannot be legally challenged. If we succeed in eliminating interest based debt as part of the normal operation of land based systems of economic production then the probability of people being forced off their land would be lower than in the current system.

If large scale commercial exploitation of land still proves to have value in the stable economy of the future then such operations would be called large holdings and would be subject to different rules than small holdings. My idea is that proprietorship of large holdings of land should be for specified periods of time only, after which the lease would be subject to review. Furthermore the lessee would have to sign a charter which would put limits on the kinds of uses which would be made of the land in question. So, for example, if the land in question has traditionally been used for sustainable forestry and the community wishes this use to continue, then the charter would explicitly specify this intention. If a proprietor is found to violate the terms of her charter then her proprietorship can be legally revoked.

The proprietor of a large holding cannot automatically pass on proprietorship to his children any more than the CEO of large joint stock company can pass on his job to his children. If a child of a proprietor has worked in the family business and has demonstrated competence then he or she can present themselves as a candidate for the proprietorship when their parent dies or decides to retire, but they would have no absolute legal right to take over management of the large holding.

In many instances there would be no debt associated with passing on the management of a large holding from an old proprietor to a new proprietor. Of course current large scale farming and forestry also have large associated capital expenditures, and if an outstanding bond issue existed then a new proprietor might be obliged to continue make bond payments as a condition of taking over operation of the enterprise. Nevertheless interest based debt would be eliminated from the credit transactions just as it would from industrial enterprises in a system of community credit.

Chapter 17

How do we get there from here?

17.1 Introduction

In the previous three chapters covering the elements of a new post-growth economic paradigm I have touched at various places on the issue of unemployment but made no attempt at a full discussion of this issue. I have already pointed out that an ecologically sane system of economic production would be focused on creating resilient forms of wealth rather than on creating work. However, our current socioeconomic system has a long established tradition of tying the right to consume economic output to holding a paying job. If we hold to this tradition, then a system of production which has the technical capability to produce sufficient wealth to support the entire human population at a decent standard of consumption, but which condemns a large fraction of that population to live in poverty because of a maldistribution of decent paying work clearly has an organizational problem which needs to be solved.

17.2 A scenario for the evolutionary movement of the system of economic production from a consumption growth orientation to a resilient long term wealth orientation

In the previous chapter I have described how a system of community finance could potentially function effectively even in the absence of economic growth. But in fact such a system could also function in a growing economy if the community financiers had the right training and skills. The fact that the banks do not charge interest would mean that more of the benefits of increased productivity would go to the people who actually did the work that produced those productivity increases rather than to the providers of financial capital. I have tried to outline a system of performance measures which would help to drive efficient financial decision making.

The ability of such a system of community credit to adapt to different levels of economic growth (including zero growth) suggests a possible evolutionary approach towards a quasi steady state economy. Clearly a sudden implementation of very high rates of progressive taxes on consumption above a relatively modest NYC (normal yearly consumption) combined with steep progressive rates of taxation on financial capital would wreck economic havoc. A consumer spending/unemployment death spiral into a major recession or depression would almost certainly follow such a course of action.

Also a sudden complete conversion of the banking system from private to public ownership would meet with strong resistance and would carry considerable risk. Only the threat of a complete financial collapse could drive such a risky rapid change. A change of this sort occurred in Iceland during the 2008 financial crisis. Iceland's banking system was dominated by three large banks all of which had been indulging in highly risky investment practices. Without some kind of drastic government action Iceland's banking sector was facing a complete collapse. Instead of bailing out the banks, Iceland's government took control of them and ultimately put them into receivership and liquidated them. New banks were founded to take over the domestic operations and guaranteeing deposits was made a priority. A substantial group of bankers was put on trial and many were convicted and sent to prison. Iceland also chose to forgive any mortgage debt which was over 110% of the value of a home in order to prevent people from losing their homes. In the aftermath of this crisis Iceland's stock market dropped by 90% while its GDP dropped by 10%. Insofar as the stock market is the economy this event was a cataclysmic disaster, but insofar as the economy is the ability of people to obtain the food, fuel, and clothing they need for immediate daily living this event was not a total disaster. The fact that a working system of credit was preserved by government action meant that the economic system was not frozen, and, although unemployment rose in the aftermath of the financial crisis, Iceland did not enter a consumer spending/unemployment death spiral. In 2011, three years after the banking crisis Iceland's economy began to grow again.

Iceland's actions could serve as a model for a response to the next crisis in the larger global system of credit. Some portion of the banking system (presumably the banks with largest proportion of bad debt) could be taken into government administration. A controlled progressive destruction of debt could take place. By progressive debt destruction I mean that those people who have the largest amount of financial holdings at risk would lose proportionally more than people with lower financial holdings. I conceived of this idea of progressive debt destruction before I read Thomas Picketty's book /Capital in the Twenty-First Century/, but I believe that my conception of progressive debt destruction is essentially equivalent to Picketty's idea of a one-time progressive tax on capital as a means of dealing with a severe debt crisis. Such a progressive tax on capital preserves the spending power of the middle class and thus avoids a consumer spending/unemployment death spiral into severe recession or depression.

How further economic development will take place in the aftermath of such a severe financial crisis is unpredictable, but I would like to discuss a possible scenario as a means of clarifying the kinds of issues which need to be dealt with.

1. As the economic and human costs of climate change start to become severe a widespread popular movement demands serious action.

2. Income taxes are replaced by consumption taxes which are progressive for a consumption level above an NYC based on the price of a defined basket of goods and services time as multiplication factor. Initially the consumption taxes are set so they do not significantly alter current consumption patterns, since a rapid reduction in consumption would result in an economic recession.

3. A certain fraction of the financial system which is threatening to collapse under the strains of the negative externalities of human economic activity is placed under the stewardship of non-profit community banks. Such banks would be able to charge zero or even negative interest if circumstances required. Whether or not they would do so initially is doubtful since the political will to commit to zero growth policies might still take a substantial period of time to develop.

4. The community banks should be assigned the mission of financing resilient infrastructure projects. These projects could be undertaken by private firms but some kind government incentives (e.g. tax breaks or subsidies) will be probably be required to drive the necessary investment.

5. The NYC and/or the progressive consumption tax would be dynamically adjusted over time. Initially adjustments to allow a slowly increasing standard of consumption might be necessary as the old growth orientation of the financial system has continuing influence for a period of time. However, the long term goal would be very slowly changing standard of consumption with the change being focused on qualitative aspects of consumption as suggested by J. A. Hobson

6. As we come to better grips with the requirements of a human economy with long term resilience the NYC might have to be lowered in order to allow more resources to be dedicated to infrastructure transformation. Increases in manufacturing efficiency due to advances in robotics and artificial intelligence might allow a higher level of consumption than would otherwise be the case, but the economic emphasis should be on providing *that necessary minimum of food, shelter, clothing, leisure, comfort, freedom, solitude, and happiness, which is certainly real, essential and indispensable*[1] rather than on setting the level of consumption as high as we possibly can based on short-term resource constraints.

7. If the community banks perform in a satisfactory manner, then over time a larger portion of the total financial system can be taken over by this system of banks.

8. In the long term when infrastructure transformation nears completion policies could be devised to avoid an increase in unemployment. Among the possible actions to combat unemployment in this situation are:

    (a) Limiting the length of the work week. Being able to produce /that necessary minimum of food, shelter, clothing, leisure, comfort, freedom, solitude, and happiness, which is certainly real, essential and indispensable/ without having to work long hard hours might be considered one of the vital elements of true wealth by people with a certain cast of mind.

    (b) Standards of consumption could be raised in some degree as work on infrastructure transformation winds down thus taking up the employment slack.

[1] Powys, John Cowper, 1920, *The Complex Vision*, Chapter XIV, p. 333,Dodd, Mead and Company, New York

(c) Non-profit public of ecological restoration, art, architecture, parks, gardens, etc. could become a focus of human endeavor in a post growth world.

The above outline of social transformation is not intended either as a prediction nor as a definitive prescription. Nevertheless I think that a concrete imaginative scenario helps to focus attention on the relevant issues involved in a major transformation of our current socioeconomic organization. A more detailed discussion of the issues involved in a possible evolutionary change in the economic system from a focus on consumption growth to wealth maintenance is given below.

17.3 Further discussion of a possible evolutionary change in economic outlook

In the scenario outlined, what fraction of the banking system would initially go into government administration would depend on the details of the financial crisis. What fraction of the banking system would remain under community control after the worst phase of the crisis has passed would be a matter public policy. A certain fraction of the banking system could be left under community control for an indefinite period of time as an experiment. The reserves of these banks might come entirely from public funds with no private depositors at all. I am imagining such banks initially being specifically charged with financing a new infrastructure with long term resilience. With operating expenses paid by the community and without the need to pay interest to depositors these banks could charge very low or zero interest. Indeed in very dire circumstances (say in the presence of very high negative externalities due to the effects of climate change) community banks could even operate at negative interest rates. That is they could loan money and expect only a partial repayment of the loan. Obviously the reserves would have to be shored up by tax money in order to continue such a situation for any extended period of time. Such negative interest rates would be a form of subsidy, but unlike traditional subsides all of the benefit would go directly to the companies creating new infrastructure and none would go to private investors.

If the community banks proved themselves to be an effective instrument for the creation and maintenance of valuable infrastructure then over time a larger percentage of the total financial resources could be moved into community based institutions of this type. Eventually private deposits could be included in the community banks reserves as they grow to become a larger fraction of the total financial system.

An important issue in the attempt to move away from growth oriented economics is unemployment. A major preoccupation of the current economic system is "job creation" which is to say work creation. However, the central preoccupation any truly intelligent system of economic production should be the creation of an adequate level of goods and services, not the creation of work. To create *that necessary minimum of food, shelter, clothing, leisure, comfort, freedom, solitude, and happiness, which is certainly real, essential and indispensable*, without the need for extremely long stressful hours of work should be considered as a fundamental aid to the creation of true wealth and not as some negative destructive development because the total amount of work has been reduced. If the total effort required to maintain a certain quality of life is reduced, and if the right to consume goods and services is still largely tied to employment then some effort must be expended to make sure that the required work is properly shared among the population.

However, in making the transition from the current economic system to one which is not ecologically destructive and which is more resource resilient other factors than the present standard of consumption will affect the employment situation. Many aspects of our current infrastructure and methods of production will have to be changed in the long run. These changes may affect employment in two ways. Firstly they may temporarily ("Temporarily" in this case could imply a period of several decades.) create more work as the current infrastructure is replaced with a more resource resilient infrastructure. Secondly, resource resilient economic methods may, in some cases, require permanently adopting more labor intensive methods of production.

Of course, in the long term if we emerge from the current crisis into an ecologically sane society the possibility arises of laying a major emphasis on activities which are not primarily concerned with making money. Consider the great gothic cathedrals of Europe. The enormous labor required to create these public spaces did not have the slightest economic justification, but results of these efforts remain among the great monuments of the human spirit and continue to give deep satisfaction to people who have the privilege of entering their precincts. Of course such works of artistic genius cannot be created by fiat. A spirit must be abroad among the people that is in harmony with such things or they cannot come into existence. What works of this nature might lie hidden in the bosom of the future cannot be predicted. Nevertheless I cannot forbear pointing out that public spirit of the future might conceivably produce more valuable and interesting outputs than *consumer confidence*.

The consumption side of the economic equation is perhaps even more critical than credit in understanding the mechanics of an economic transition. Reasonable standards of consumption are the foundation of an ecologically sane society. One could initially set progressive consumption taxes at levels that would be revenue neutral and which would not significantly disturb current patterns of consumption. But once this initial change in the method of taxation has been made how can we proceed to evolve towards reasonable and relatively slowly changing standards of consumption without creating problems of economic unemployment?

How the NYC and the progressive consumption tax would evolve over time is a complex issue. Once the NYC and the progressive consumption taxes are established then they must be actively managed to adapt to changing circumstances. Of course adopting the NYC and progressive consumption taxes in the first place implies a public recognition that infrastructure transformation is more important than increasing the total volume of short-term economic transactions as rapidly as possible. The way in which these tools are used will depend upon the urgency with which this transformation is regarded by the general public and the degree to which the machinery of new infrastructure creation has been developed. A high development of this machinery implies a high degree of job creation in this sector. Note that manufacturing efficiency improvements via increased use of automation could be leveraged to dedicate more resources to infrastructure transformation and thus speed up the transition to a resilient infrastructure while maintaining the standard of consumption at an acceptable level.

In my mind any amount of yearly consumption equal to or less than the NYC should be taxed at a flat rate, with the next level of consumption being taxed at substantially higher rate. Such a policy would give a very strong emphasis to the idea that excess consumption carries a cost penalty. If the level of income inequality for people consuming at or below the NYC is high enough to require some amount of progressiveness in tax policy I would prefer to implement such progressiveness by income adjustments (e.g. deductions) rather than by variable tax rates.

Remember that consumption taxes will be based on a normal yearly consumption (NYC) which will be equal to the average price of a chosen basket of goods and services times a multiplication factor which is somewhat greater than 1. How the price of this basket will evolve over time depends on the overall economic situation of society. If constraints imposed by resource limitations and/or by negative externalities of changing environmental conditions are sufficiently weak then innovation may still be capable of improving the overall productivity of the economic system. In this case if the NYC is not adjusted its purchasing power will increase and new products and services will appear to take up the consumer slack. The idea of the NYC is that the price of the specified basket of goods and services will be monitored as they evolve over time and the NYC will be adjusted accordingly. If we take seriously the idea of using consumption taxes to lower our ecological footprint then the NYC would have to be revised downward if the price of the basket dropped significantly because of increased economic productivity.

Within the context of the current operation of the economic system such a choice creates two problems. First the people who are rushing to get rich by developing hot new "must have" toys will be much less likely to succeed, so that the flow of capital into such ventures will be slowed. Note that it will necessarily be impossible for such ventures to succeed. The NYC and the system of progressive consumption taxes do not attempt to completely specify the allowed consumption. If a certain part of our income is spent on goods and services having aesthetic or entertainment value, tastes could change and new goods and services could take market share from established goods and services. The fact that appearance of new toys would be slowed is really a major point of the proposed changes.

The second problem that would be created by these changes within the current economic context is unemployment. If we can produce a given basket of goods and services more efficiently (i.e. with less labor), and if we restrict the growth of new goods and services then the total workload of society will decrease. Now a decreasing workload is not in and of itself a problem. A problem arises only if the right to consume is tied to taking a share of the workload, and a substantial fraction of the working age population is unable to obtain a reasonable share of the work. If we return to the metaphor of the household economy which I have used previously it is obvious that at this level of economic organization that being able to maintain your house and your appliances with less work is an advantage and not a disadvantage. At this level of social organization responding to increased household efficiency by demanding that more house work should be created in order to prevent some fraction of the house holders from starving or freezing in their own well-functioning home would clearly be insane. The obvious action to take is to fairly share the decreased workload and to use the time freed up to pursue aesthetic and/or recreational pursuits which enhance the quality of one's life.

This is also the correct solution at the wider level of social organization if we are serious about limiting the impact of human economic activity on the environment. In the face of relatively rapidly increasing production efficiency and a relatively slowly changing standard of consumption we could lower working hours, and we could dedicate more resources to reeducation which will allow more people to participate effectively in the production process. I will address the question of how to effectively make provisions for continuing education in the next chapter.

17.4 Barriers to an economic transition that might necessitate a lowering in standards of consumption

So far in this discussion of an evolution towards a post growth society I have been adopting a comparatively optimistic viewpoint in which humanity acts with sufficient foresight about the negative ecological impacts of expanding economic activity and has sufficient natural and technological resources at its disposal that the main problem of the transition will be social adjustments to a slowly changing standard of consumption. But in point of fact the combined effects of resource limitations, negative externalities of human economic activity, and limits to human technological prowess may combine to make the transition to an ecologically sane society much more difficult than imagined in this optimistic scenario.

Techno-optimists like to point to Moore's Law and the exponential progress of the computer industry in packing more digital logic switches into a given area on a silicon wafer as evidence that short to intermediate term obstacles to further human economic progress are largely imaginary. However, creating a human economy with long term ecological resilience requires addressing a number of basic problems which are unlikely to be solved merely by waving our digital magic wand.

17.4.1 Energy storage and/or grid strengthening are required for an electricity system based on solar energy flows (wind power is an indirect form of solar energy harvesting)

I have discussed this point earlier in the book but a review is appropriate here. Our current electricity system is heavily dependent on energy storage in the form of solid and liquid hydrocarbon fuels. These energy dense fuels are highly stable and they can be cheaply transported over large distances. Steam generators and gas turbines can be turned up and down to match variable demand over short and long time scales to meet variable electricity demand. To get maximum value out of our renewable energy infrastructure we need to generate electricity whenever the sun shines or the wind blows. Storing electricity in batteries is an expensive proposition. Fossil fuels are naturally stored in the earth and constructed storage facilities can be simply tanks or pipelines. In the case of coal, which is a solid, a container is not required. Coal can be stored in piles on the ground. Battery electrodes on the other hand are engineered materials requiring complex manufacturing processes. Sometimes the constituent materials of battery electrodes (e.g. cobalt) are expensive in and of themselves. Batteries have a finite cycle life and are potentially subject to loss of energy through self-discharge if long storage times are required.

There is also a potential material supply problem if we try to scale up battery manufacturing to the high levels required for an energy system based entirely on variable renewable energy flows. The current cost of important battery materials like lithium and cobalt may be much lower than the cost would be under the very high usage rates that would be required in a fully implemented global system of renewable energy supply. The cost of mining and smelting metals is not going to exponentially reduced to zero by the use of digital computing and information technology.

Some people have proposed reducing the amount of storage required by building a very high capacity electrical grid spanning a large geographical area, possibly even the whole globe as Buckminster Fuller suggested in his 1981 book *Critical Path.* Solar energy flow is roughly constant averaged over the whole surface of the earth, so that if power could be delivered though a strong grid to wherever it is needed energy storage requirement might be very low. However, large scale grids spanning many countries are very ambitious (and expensive) infrastructure projects both from engineering and social planning perspectives. For an energy system based primarily on solar energy at minimum the northern and southern hemispheres would have to be connect to large energy generation systems near the equator in order to avoid the need for very long storage times.

If wind and solar are both major components of the energy system then the rough anticorrelation of solar and wind energy flows over the seasonal cycle might allow a grid system in a single hemisphere to eliminate the need for seasonal energy storage. Nevertheless such grid infrastructure projects are very ambitious and they are still not sufficient to eliminate the need for very large installations of electrical energy storage capacity.

17.4.2 Food production

I have previously discussed some of the problems of our current system of food production. We need to use soil, water, and nutrients in non-depleting ways. The current intensive use of pesticides on huge monocultural crop plantations which adversely affect human and environmental health and which tends to produce resistant pests through natural selection needs to be replaced by more environmentally sound methods of pest control. Dependence on a small number of grains crops (Corn, wheat, and rice account for more than half of all the calories consumed by human beings.) make the human food supply vulnerable to the rise of super pests which could devastate a large fraction of the food supply. Climate change potentially increases this threat both by stressing crops so that they are more vulnerable to pests, and by creating new environmental niches where previously relatively harmless pests can thrive. Pine bark beetles which are currently destroying vast swathes of North American evergreen forests are an example of this phenomenon in a non-agricultural ecosystem. Many of the actions which might lead to more resilient system of food production exhibit interrelationships between the problems described above:

1. More diverse crops = better pest resistance
2. More diverse crops = better resilience to climate change
3. Better water/soil management = better resilience to climate change
4. Better soil management = better water retention
5. More diverse crops = better use of soil nutrients

Another important aspect of nutrient management in the long term is the need to recycle the nutrients in human waste streams into the food production system. China has done such nutrient recycling for centuries using so-called night soil made from human manure as a crop fertilizer. In the long run the larger global society also needs to make an attempt to close the nutrient cycle. Many people have raised concerns about the safety of using human manure compared to using animal manure. I do not have the time or the expertise to investigate these claims in detail. Part of the concern arises from the fact that sewage streams in cities have non-biological contaminants such as heavy metals. Some experts maintain that with proper treatment of sewage the levels of such contaminants in fertilizer produced from this source can be reduced to safe levels. Also, in the long run an ecologically sane society would figure out how to reduce the level of this kind of pollution in the first place. It is also possible to make indirect use of fertilizer produced from the human waste stream by raising tree crops (e.g. fodder, mulberries, acorns, etc) which can be fed to animal such as hogs.

One possible means of better soil, nutrient, and water management is the use of deep rooted perennial crop plants such a trees and perennial grasses. Russell Smith, in his 1929 book, *Tree Crops: A Permanent Agriculture* [2] , promoted the idea of integrating trees in food productions systems as a means of preserving topsoil, and as means of better utilizing the water and nutrient content of soils. So-called agroforestry, the practice of integrating long lived trees and shrubs into food production systems, has been practiced for centuries without it having been given a specific name. This practice goes beyond merely planting orchards of high value fruit or nut trees, and includes the use of trees as food for animals (either as a source of fodder or of edible fruits/seeds), windbreaks to protect against wind driven erosion, protection against water driven erosion, better use of soil water and nutrient content, and as a source of firewood and lumber.

In tropical areas high yielding tree crops which can serve as staples (i.e. an alternative to staple grain crops) already exist (e.g. bananas, plantains, coconuts, breadfruit, etc.). In temperate areas high yielding staple tree crops do not exist. It is conceivable that such crops could be eventually developed through cross breeding and cultivar selection. However, as Russel Smith pointed out in his book the development of new tree crops by such methods is long process requiring patience and a long term vision of human and ecosystems welfare. In the short to intermediate term development of tree based agriculture will utilize existing species of trees and bushes.

Natural grasslands are populated by diverse groups of deep rooted perennial plants which preserve soil, and effectively utilize the available water and nutrients. The Land Institute, a non-profit organization based in Salinas Kansas, has been working for four decades in developing food production systems based on diverse crop mixtures of deep rooted perennial plants. Their search for perennial crops is proceeding in two directions.

1. They are attempting to create perennials from existing annual crops with good taste and high yields

2. They are attempting to domesticate (i.e. improve yield and taste) of existing wild long lived vigorous perennials

[2] Smith, J. Russel; 1987, *Tree Crops: A Permanent Agriculture*, Island Press, Washington D.C.

They claim to be approximately one decade away from developing initial perennial crops with acceptable yields and taste. One might ask why after four decades of development they are still a decade away from some kind of practical success? The answer is that developing new crop species from cross breeding and selection of promising cultivars is a long slow process, which requires a long term vision of human ecosystem welfare. The goal of developing perennial polycropping systems which make more effective use of soil nutrients and which confer better resistance to pests will take even longer than developing individual perennial crops.

Perennial polycultures may make more effective use of soil nutrients, but they cannot in and of themselves solve the problem of closing the nutrient cycle. In natural grass lands the animals and birds who live off of perennial plants deposit their wastes (and eventually their decaying bodies) back onto the land. As I have already mentioned an ecological sound system of food production will required recycling human wastes back into the food production system.

Although suitably designed polycultures may make better use of soil, water, and nutrients as well as provide greater drought and pest tolerance, they may require higher inputs of human labor particularly for harvesting. We may not be able to harvest polyculture plantings with the giant machines which are used to harvest vast monoculture fields of wheat or corn. If ecologically sound food production requires a higher intensity of human labor then new work may appear that faster computer chips may not be able to mechanize.

Of course, if the primary goal of economic activity is to increase the available array of toys, games, and luxury products forever without limit, then such a need to devote more effort to producing food will be viewed as a disastrous impediment to the achievement of that goal. If, on the other hand, the goal of economic activity is to provide a reasonable, slowly changing standard of consumption, produced by deeply satisfying work, then the need of a more widespread application of earth wisdom applied to ecologically sound methods of food production may be a boon to human psychological health and general life satisfaction rather than a negative disturbing factor.

Of course one can argue against this vision of the transformation of food production to a system with more long term environmental and resource resilience on the basis of yields rather than on the basis of costs. The argument goes as follows: For the short to intermediate term current monocrop food production systems based on high inputs of chemical fertilizers will out yield any alternative form of agriculture. And because the earth's human population will continue to increase for at least several decades into the future we cannot afford to give an inch on yield. Perhaps sometime in the future when the human population has declined in some degree such alternative forms of agriculture can be considered, but at the present time they are an impractical distraction from realistic prospects of continuing to feed the earth's still increasing human population.

I have neither the detailed knowledge nor the expertise to pass judgment on such claims. I am certainly not calling for a rapid short term abandonment of current methods of food production. However, the development of ecologically sound methods of food production is a long term project and waiting until short term market signals indicate that current methods are in trouble is not an intelligent strategy. Even if a major portion of our food continues to come from high input farming methods using the traditional staple crops of corn, wheat and rice for the short to intermediate term, prudence dictates that a serious global effort should be made to develop more robust and resource conserving methods of food production in various climates and ecological niches around the world. Furthermore when one considers the fact 40% of the U.S. corn crop is used to produce ethanol for motor fuel and 36% is used as animal feed, while a majority of that part of the crop which is used for human food ends up on grocery store shelves in the form of high fructose corn syrup added to various packaged foods, one can question the claim that any drop in yields will immediately raise the specter mass hunger.

17.4.3 Space heating and cooling plus water heating

In addition to agriculture other aspects of our infrastructure will need major changes to fit them for a post fossil fuel world. An obvious example is space heating. Even in the era of cheap coal based electricity when pollution controls were relatively minimal, electricity provided only a small fraction of the energy for space heating. The direct production of heat via the combustion of fossil fuels (e.g. natural gas, fuel oil, etc.) was found to be much cheaper. There is some prospect of being able to use solar energy to provide space heating (plus water heating) and cooling since on an annual basis the solar flux is highest when cooling is most needed and because storing several months' worth of low grade heat in dirt or rock under the earth's surface is a far less formidable economic/technological task than trying to store several months' worth of electricity. In addition buildings designed using passive solar principles will need less energy for cooling and heating in the first place. However, the current architectural infrastructure has been designed under the assumption of the availability of cheap fossil fuels. The widespread implementation of passive solar building design with the inclusion of underground storage facilities is a major long term infrastructure project which will provide a lot of work. However, this work is not going to increase our short term supply of goods and services and therefore will be a drag on economic growth. Again reasonable standards of consumption can free up production resources to be directed to the required long term infrastructure projects.

17.4.4 Construction materials

The two very important construction materials concrete and iron are sources of carbon dioxide emissions that cannot be eliminated simply by switching to carbon free electrical generation. Concrete is produced from limestone whose base chemical constituent is calcium carbonate ($CaCO_3$) and from clay or shale which acts as a source of silicon. This mixture is heated inside a kiln and calcium carbonate is transformed into other compounds the most important of which are tricalcium silicate (Ca_3SiO_5) and dicalcium silicate (Ca_2SiO_4). This process produces CO_2 in two ways. Natural gas (CH_4) is burned to provide the heat (Very high heat is needed: approximately 1500°C), with the carbon in the gas ending up as CO_2. Also the carbon in the $CaCO_3$ ends up in the atmosphere as CO_2. Roughly 65 percent of the emitted CO_2 comes from calcium carbonate and 35% from the burning of natural gas.

In traditional iron making with a blast furnace iron ore is mixed with layers of coking coal which essentially pure carbon. Inside the blast furnace the coke combines with oxygen to form carbon monoxide (CO) which then chemically reacts with the iron ore to produce pure iron and carbon dioxide. The temperature in the hottest part of a blast furnace is nearly 1800°C. Some amount of limestone is mixed into the iron ore/coke stack to act a fluxing agent. The carbon in the limestone also ends up being emitted as carbon dioxide although the percentage of emissions from this source is relatively small compared to the emissions from coke. Blast furnaces also use natural gas to heat air which is injected along with some amount of gas into the furnace.

In recent decades a small but significant percentage of commercial iron making has employed new methods (direct reduction and smelting reduction) which do not use blast furnaces or coking coal. However, these methods are still dependent on fossil hydrocarbons both as a heat source and as a source of reducing gases, and thus are still significant sources of CO_2 emissions. Also at large scale these methods are not economically competitive with blast furnaces. The new methods have found economic niches where a full-sized blast furnace is not appropriate, but converting the whole of our iron production to these new processes would have significant economic consequences.

Transforming the production of iron and concrete so that they are not sources of CO_2 emissions represent major technical challenges which cannot be solved simply by converting electricity production to carbon free sources. The heat required for these chemical transformations could conceivably be supplied by electricity since electrical furnaces operating at very high temperatures are used for the production of specialty ceramics, but such electrical furnaces are likely to be much more expensive than the natural gas fueled furnaces currently in use. Furthermore, electrically supplied heat does not solve the problem of direct carbon emissions from calcium carbonate and from coking coal or other hydrocarbon sources of reducing gases.

Some research efforts are being made to reduce carbon emissions (in the ideal case all the way to zero) associated with the production of iron and concrete. Iron oxides can be reduced to pure iron without the use of CO gas. In the direct reduction process mentioned earlier reformed natural gas is used as the reducing agent. This reducing gas contain both carbon monoxide (CO) and molecular hydrogen (H_2). CO reacts with iron oxide to produce iron and CO_2 while H_2 reacts with iron oxide to produce iron and water (H_2O). This process suggests the possibility using electrolytically produced hydrogen rather than natural gas for the production of iron. It is also possible to find a catalytic electrode that will directly reduce iron rather than going through the two step process of electrolytically producing H_2 from water and then using the H_2 gas to reduce iron. Both of these methods of reducing iron oxides to pure iron without the use of CO as a reducing agent have been demonstrated in a laboratory setting. However, producing a small amount of iron in a laboratory experiment is not same thing as creating a high throughput industrial process which can economically compete with blast furnace production of iron.

The Austrian steel making company Voestalpine AG has formed a partnership with Siemens and the renewable energy company Verbund to develop a carbon free steel making process based on electrical furnaces and renewable hydrogen produced by the electrolysis of water. This consortium known as the H2FUTURE project admits that it may take decades to develop a process which is economically competitive with blast furnace production, and in fact ultimate success in this endeavor is not guaranteed.

Iron oxides can be reduced to pure iron in an electrolytic cell with carbon free electrodes in a process known as molten oxide electrolysis (MOE). The oxygen that was bound to the iron atoms appears in the form of O_2 and not as CO_2. However, while iron MOE has been carried at a small scale in a laboratory setting (see for example the open access paper /Electrolysis of iron in a molten oxide electrolyte/ by Wiencke et al) [3] the technical barriers to scaling this process up to a high throughput low cost (i.e. competitive with blast furnace production) method of production are very significant. For one thing the cell must operate above the 1550°C melting temperature of iron. In the paper reference above the cell operating temperature was 1823°C. This high operating temperature makes the job of designing long lived, high reaction rate electrodes extremely challenging. In addition iron ions have multiple valance states which tends to lead to undesired side reactions. The experiment referred to above was a proof of concept demonstration so that expensive high performance noble metal electrodes were chosen: a platinum anode and a platinum/rhodium alloy cathode. These high cost electrodes would not be practical in a manufacturing system.

Several years ago a paper published by Allanore et al [4] demonstrated than an anode of chromium/iron alloys is useful for producing comparatively low cost, long-lived electrodes for MOE production of iron. A flurry of news articles about “green” iron and steel production followed this publication. However an open access review article entitled *Features and Challenges of Molten Oxide Electrolytes for Metal Extraction* [5] published by Allanore several years after the original paper makes it clear that practical technology for low cost high volume production of iron and other metals using MOE is not just around the corner, but is still very much a long term research project facing a number of difficult technical challenges.

In some ways decarbonizing the production of concrete is even more difficult than decarbonizing the production of iron. Concrete is produced when a binding powder called cement is mixed with water and rock aggregates. The water and the cement powder form a paste. This paste undergoes a chemical

[3] Wiencke, Jan; Lavelaine, Hervé; Panteix, Pierre-Jean; Petitjean, Carine; Rapin, Christophe, 2017, *Electrolysis of iron in a molten oxide electrolyte*, Journal of Applied Electrochemistry, available online at: https://www.researchgate.net/publication/322275580_Electrolysis_of_iron_in_a_molten_oxide_electrolyte (viewed 16/04/2020)

[4] Allanore A., Yin L., and Sadoway, D., 2013, *A new anode material for oxygen evolution in molten oxide electrolysis*, Nature 497, 353-356

[5] Allanore, Antoine; 2015, *Features and Challenges of Molten Oxide Electrolytes for Metal Extraction*, Journal of the Electrochemical Society 162 (1) E13-E22, online at: https://dspace.mit.edu/bitstream/handle/1721.1/101745/Allanore_Features%20and%20challenges.pdf;sequence=1 (viewed 04/17/2020)

reaction which causes it to set up and harden forming a solid matrix within which the rock aggregates are bound. It is the production of cement powder which is the primary source of carbon emissions in this overall process.

Cement is formed from calcium carbonate ($CaCO_3$) the principle ingredient of limestone and from clay. The calcium in the limestone reacts with silicon from the clay and with oxygen to form compounds called calcium silicates. It is these compounds in their hydrated form after the addition of water which give concrete its strength. An essential initial step to the formation of calcium silicates is driving out the carbon from $CaCO_3$. This decomposition is carried out by heating the limestone to 900°C in a kiln. $CaCO_3$ decomposes into CaO (quick lime) and CO_2.

In the production of the most widely used form of binding powder called Portland cement, limestone and clay are mixed and processed together in a rotary kiln. The decomposition of limestone and clay and the subsequent the chemical reactions which produce calcium silicates all take place in a continuous throughput process within a single kiln.

An older type of concrete called lime concrete uses quick lime itself as a binder. CaO mixed with water will eventually harden into a solid compound called calcium hydroxide $Ca(OH)_2$ also known as portlandite. However, this older process does not change the fact that $CaCO_3$ is transformed to CaO and CO_2 in a high temperature kiln. Thus the only way to decarbonize the production of cement is to capture the carbon and sequester it in some manner.

Chemist Stuart Licht has demonstrated an electrolytic process for quicklime (CaO) from calcium carbonate ($CaCO_3$) which he calls Solar Thermal Electrochemical Production (STEP) [6]. The STEP process outputs pure carbon when it is run below 800°C and carbon monoxide (CO) when it is run above 800°C. Carbon monoxide is a gas at room temperature and above so that it could be continuously pulled out of the electrolysis cell during processing. Pure carbon on the other hand remains solid up to nearly 4000°C so that removing the carbon from the electrolysis cell would periodically removing the electrode and cleaning it. Licht has proposed using the generated CO from the higher temperature operation of the electrolysis cell in various industrial chemical processes which require this compound. Unfor-

[6]Licht, Stuart; Wu, Hongjun; Hettige Chaminda; Wang, Baohui; Asercion, Joseph; Llau, Jason; Stuart, Jessicad; 2012, *STEP cement: Solar Thermal Electrochemical Production of CaO without CO_2 emission*, Chemical Communications 48, 6019–6021, (on line at https://www.researchgate.net/publication/224856443_STEP_cement_Solar_Thermal_Electrochemical_Production_of_CaO_without_CO2_emission/download, viewed 04/21/2020)

tunately for this proposal the yearly supply of carbon (produced in the form of CO) from all of the $CaCO_3$ used in cement production would far exceed the industrial demand for CO. Robbie M. Andrew has estimated that yearly supply of carbon from cement production is 395Mt [7] . Approximately 53% [8] of these emissions (247Mt) come directly from $CaCO_3$. The equivalent weight of CO is 576Mt while the yearly industrial demand for CO is only 3.8Mt [9] . Therefore this process could eliminate less than 1% of the total CO_2 emissions from the production of quicklime. Furthermore Licht does not address the issue of the end of life fate of the CO used in the industrial production of chemicals. That is does the all of the carbon used in this fashion end up permanently sequestered in some in environmentally benign form, or does some portion of it end up being oxidized back to CO_2? Until this question is answered we do not know what proportion of the avoided CO_2 emissions is permanent.

Solid carbon is an extremely stable compound which could be sequestered without fear of it ending up in the atmosphere as carbon dioxide. However, whether or not the version of STEP which produces solid carbon could be run in a high throughput process with reasonable operating costs is not clear.

However, regardless of whether we can find an economical means of dealing with the carbon based outputs of the STEP process which avoids putting CO_2 into the atmosphere another economic barrier exists to using the STEP process for avoiding carbon emission associated with the production of concrete. Quicklime (CaO) can be used to make a form of cement known (unsurprisingly) as lime cement. Lime based cement was used in Roman buildings (e.g. the Pantheon) which are still standing today. However, in the mid-19'th century a new form of cement called Portland Cement was invented. Portland Cement has economic and technical advantages over lime cement for many applications and has come to be to the dominant cement used in global construction today. Portland cement does not use quick lime. Instead limestone and clay mineral are mixed together and heated up to a high temperature. Carbon is driven off from the kiln in the form of CO_2

[7] Andrew, Robbie M., 2018, *Global CO2 Emissions From Cement Production*, Earth Systems Science Data, 10, 195-217 (https://www.earth-syst-sci-data.net/10/195/2018/essd-10-195-2018.pdf, viewed 04/21/2020)

[8] Hanle, Lisa J., 2004, CO2 *Emissions Profile of the U.S. Cement Industry*, 13'th International emission Inventory Converence "Working for Clean Air in Clearwater", (https://www3.epa.gov/ttnchie1/conference/ei13/ghg/hanle.pdf, viewed 8/6/2018)

[9] *Global Carbon Monoxide Market Research Report 2017*, Report Description, QYResearch (https://www.researchmoz.us/global-carbon-monoxide-market-research-report-2017-report.html, viewed 4/20/2020)

and various calcium silicate compounds are formed. Licht's STEP process cannot be used to produce Portland cement. Therefore in order to have a significant impact on carbon emissions a first requirement is that the quick lime produced by the STEP process must as cheap as Portland cement. But even if this cost goal is achieved other significant barriers exist to discontinuing the use of portland cement. Portland cement hardens much more quickly than lime cement, and since time is money this speed advantage is economically important. Also, although lime concrete will resist water once hardened the hydrated lime will not set up in wet or damp conditions. Therefore lime concrete cannot be used for poured in place structures in wet or damp conditions. Lime concrete blocks could be pre-hardened and set in place but such a procedure will have economic consequences since in many instance poured in place structures have significantly lower labor costs.

Gaurav Sant, an environmental engineer, has explored a different route to lowering emissions from concrete production [10] . Part of the process of cement hardening involves interaction with CO_2 from the atmosphere. This interaction converts some of the calcium present in the concrete back into calcium carbonate ($CaCO_3$). One might think that such a conversion is a bad thing since it undoes a reaction that had to be carried out to create cement in the first place. But in point of fact such carbonation increases both the compressive and tensile strength of concrete. Diffusion of atmospheric CO_2 into concrete is a slow process so that the degree of carbonation that has taken place by the time the concrete has set is relatively small. Inspired by this fact Sant decided to try to increase the carbonation of concrete by contacting the concrete with liquid CO_2 or a dense fluid of supercritical CO_2 in an effort to greatly increase the degree of carbonation. If this approach to carbonation works then CO_2 generated by the process of cement production could be captured and then recycled back into the finished concrete.

In the case Portland Cement Sant was not able to find any combination of parameters which resulted in rapid carbonation. In any reasonable time period only a small percentage of the captured CO_2 would be taken up. In the case of lime cement composed exclusively of portlandite Sant was able find conditions which resulted in the uptake of more than 80% of the captured carbon in a time period of two hours. Two comments about this proposed process for recycling CO_2 from lime kilns are in order. First 80% is not 100%. If carbon-neutral cement production is the goal then then

[10]Vance K., Falzone G., Pignatelli I., Bauchy M., Balonis M., Sant G., 2015, *Direct Carbonation of Ca(OH)2 Using Liquid and Supercritical CO2: Implications for Carbon-Neutral Cementation*, Industrial & Engineering Chemistry Research 54, pp 8908–8918 (https://pubs.acs.org/doi/10.1021/acs.iecr.5b02356, viewed 04/21/2020)

remaining 20% of emissions would have to be compensated by carbon capture and storage. Secondly the same comment made previously about the unsuitability of lime cement for poured in place concrete structures applies to this method of production.

Obviously iron and concrete are not the only materials which produce carbon emissions during their production. I chose to focus on them because of the very large volumes of these materials which are produced every year and because of their importance as basic construction materials. I would like to discuss briefly one other important material: aluminum. Aluminum is much less dense than iron so that machine parts made out of aluminum are much lighter than parts made out of steel. Therefore automobile and aircraft manufactures like substituting aluminum alloy parts for steel ones where possible in order to improve fuel efficiency. However, giving aluminum the requisite mechanical and thermal properties for many applications requires alloying it with other metals, and in many case these alloys are difficult to manufacture and consequently expensive. Some recent work by a group of Russian materials scientists on producing high strength aluminum alloys by a new method which promises much lower production costs than current methods [11] . Suppose that this research effort or others of a similar nature bear fruit and that it becomes possible to more widely substitute aluminum alloys for steel than is presently possible. Would this development help us with respect to carbon emissions or is the production of aluminum just as dirty the production of steel?

As it turns out the dominant method for reducing aluminum from its primary oxide Al_2O_3 (also called alumina) is molten oxide electrolysis (MOE). The melting point of Al_2O_3 is over 2300°C apparently making it an extremely poor candidate for MOE. However the American chemist Charles Martin Hall discovered in the mid 1880s that if alumina was dissolved in a molten mineral called cryolite it could exist in a liquid state at about 1000°C. This temperature is high but still considerably less challenging that the nearly 1600 degree temperature required for iron oxides. Furthermore a single valence state of aluminum (Al_3^+) predominates in the electrolyte which further simplifies the design of the electrolysis cell. Hall (and independently the French chemist Paul Louis Toussaint Héroult) found a pair of reasonably cheap electrodes which allowed for the efficient production of aluminum metal by an MOE process. The so-called Hall-Héroult process is

[11] Akopyan T.K.; .Belov N.A.; Naumova E.A.; Letyagin N.V; 2019, *New in-situ Al matrix composites based on Al-Ni-La eutectic*, Materials Letters Volume 245, 15 June 2019, Pages 110-113

the primary production method for aluminum metal from its oxide ores.

At first blush it might appear that aluminum could be produced without carbon emissions if the electricity for the MOE process were provided from carbon free sources. As it turns out, however, the production of aluminum like that of iron uses carbon as a reducing agent to remove oxygen from metal oxides. One of the electrodes in a Hall-Héroult cell is a consumable electrode made out of a form of carbon known as petroleum coke. The carbon in this electrode reacts with the oxygen and Al_2O_3 and produces CO_2 (as well as CO). Thus carbon free electricity does not imply carbon free aluminum. By the way petroleum coke, as the name implies is a by-product of the refining of petroleum. Thus the production of aluminum by the Hall-Héroult is doubly unsustainable. Not only does it directly produce carbon emissions, but it also requires the continued use of oil in order to manufacture its electrodes.

However the aluminum manufacturing giant Alcoa claims that it has developed an MOE process for the reduction of Al_2O_3 which uses a purely catalytic carbon free electrode. This electrode will produce pure oxygen rather than CO_2 and CO. Alcoa is forming a joint venture with the mining and manufacturing company Rio Tinto to further develop and commercialize this technology. The joint venture company known as Elysis will be based in Canada. In addition to Alcoa and Rio Tinto the Canadian government and Apple Computer are contributing capital to this startup company. Elysis has announced that it expects to have a technology package ready for sale by 2024.

The fact that Alcoa is licensing this technology to a joint venture with the Canadian government as a major investor is a pretty good indication that this technology is not ready for commercial prime time. Even if the technology is delivered on the announced schedule I suspect that it will be used for niche markets where consumers are willing to pay a premium for green products. It may well be that even the mature technology will require carbon taxes or some form of subsidy in order to compete with the Hall-Héroult process. Nevertheless the prospect of aluminum production without direct CO_2 emission gives a new significance beyond weight reduction to the possible replacement of steel with aluminum alloys.

I have written this long (and possibly tedious to many readers) aside on the direct carbon emissions of important manufacturing materials in order to make clear that zero carbon processes that are economically equivalent to current mature production processes not imminent. Potential strategies for dealing with the direct carbon emissions produced by the manufacturing of important construction materials such as cement and steel include:

1. Implement low emission (ideally zero emission) manufacturing processes. However if low emission manufacturing remain stubbornly more expensive than established manufacturing processes then additional actions will be necessary.

2. Implement reasonable standards of consumption. The less stuff we manufacture in the first placed, the less emissions we will produce.

3. Emphasize long lived products. This item also fits into the manufacture less stuff category. If you only have to buy a new water heater every forty years rather than every ten years then less steel has to be manufactured. Unfortunately we seem to be moving backwards with respect to the long term durability of appliances. The latest models may have bunch of fancy digital bells and whistles but they do not keep running for decades the way appliances used to do. The concrete dome of the Pantheon in Rome is the largest free standing dome erected prior to the modern era. It is 1900 years old and still going strong. Now there is a durability goal for you. Unfortunately concrete reinforced with steel rebar cannot achieve these long lifetimes because the steel rusts significantly after just a few decades and loses structural integrity. Steel is cheap but long lived alternatives such a basalt fibers can bring a double carbon emission benefit: lower steel production and longer lived concrete structures.

4. Emphasize the recycling of metals. A lot of steel and aluminum is recycled already. Direct carbon emissions are avoided in recycled metals and furnaces for melting scrap can be powered electricity (In fact electric arc furnaces are already used in the recycling of steel). We should strive to achieve even higher metal recycling rates. I like the idea of putting the onus for recycling directly on the manufacturers of consumer products. That is such manufacturers would be given recycling targets for various materials and would be required to demonstrate what percentage of recycling is achieved in fact. If the percentage falls short of target then penalties would have to be paid. One can argue that the logistics of such accounting would be difficult in an era of complex global supply chains, but the fact is that with the aid of computers and a global communications system we already manage these complex supply chains. Therefore I see no reason why managing the logistics of recycling chains should be impossible to achieve.

5. Use alternative materials with low or zero carbon emissions when pos-

sible. For example the ancient earth building techniques of adobe, cob, and rammed earth are beginning to gain some popularity as building techniques which do not require concrete. Adobe uses mud bricks which require mortar but concrete mortar is too stiff and adobe mud itself which can shrink and swell with the bricks is the preferred mortar. These kinds of construction are very durable. Some sections of the Great Wall of China were made of rammed earth and are still standing after two thousand years. Great Britain contains a number of cob buildings that are more than 500 years old. These building techniques are more labor intensive than more modern techniques, and I do not think that you can build skyscrapers with such materials. Of course it is possible to doubt whether or not skyscrapers are an essential feature of a humane civilization.

6. Implement some amount of carbon capture and storage. If the carbon emissions of construction materials cannot be reduced to zero then the only way to achieve carbon neutrality is to implement some carbon capture.

17.4.5 The transportation system

Almost all portions of our passenger and freight transportation system continue to depend almost exclusively on fossil fuels. Components of this system include passenger automobiles, buses, trucks, trains, ocean going ships, airplanes, and canal freight. Even those portions of the transportation system which use electricity (e.g. light rail, battery electric automobiles, electric buses, and electrified heavy rail) still largely use electricity generated by fossil fuels. The inroads that battery powered automobiles have made into passenger transportation is still very small. As for long distance freight transportation (rail, truck, ship, and airplane) and air passenger transportation the current impact of battery electric vehicles on these modes of transportation is essentially zero.

The assumption that we only have to wait for inevitable rapid large improvements in battery technology in order to completely replace fossil fuels by renewable energy in the transportation system is highly questionable for two reasons:

1. Progress in electrochemical battery technology is slow.

2. The flow of renewable energy is highly variable on long time scales thus requiring energy storage performance far beyond anything currently

available.

With respect to point 1 the best illustrative example is the lead acid battery. This technology which is the oldest type of rechargeable battery, having been invented by the French physicist Gaston Planté in 1859, is still going strong in a number of market segments nearly one hundred and sixty years later. Lead acid batteries do not have the right performance characteristics for intermediate to long range BEVs so that lithium ion batteries have prevailed in the market segment in spite of their much higher up-front costs and their inferior safety characteristics. The current generation of lithium ion battery types being used for BEVs are using relatively mature electrode chemistries the cost of which is being driven down by improvements to the manufacturing process and economies of scale as a number of large volume manufacturers are competing for market share. Some of this cost improvement is being counteracted by the rising cost of cobalt which is an important element used in the positive electrode (i.e. the cathode) of these batteries, but the overall cost movement is still downwards. The energy density of this generation of batteries is also slowly improving but the need new superior designs will be needed for a truly large scale replacement of fossil fuel powered vehicles by BEVs.

A number of proposed lithium battery chemistries exist which theoretically have much higher maximum energy density than the currently dominant chemistries. However, very substantial technical barriers exist to the practical implementation of all of these chemistries. First of all real implementations always fall short of theoretical maximum energy density and often far short. Secondly the energy density achieved must have relatively small degradation over many cycles (typically a thousand or greater) in order to be useful for BEV applications. For example zinc-air button cells which have been used in hearing aids and medical devices since the 1970s have significantly higher energy densities than the current generation of lithium ion batteries used in BEVs, but their cycle life is one cycle. Researchers are working on rechargeable versions of the zinc-air battery, but they have not yet brought a product to market. Thirdly the life cycle cost (i.e. up-front cost plus replacement costs if the battery pack wears out before the end of vehicle life) of the battery must be acceptably low. Fourthly the batteries must meet stringent safety standards.

I am not an expert in electrochemistry, but I have a strong science and engineering background and in the seventeen years in which I have been following developments in energy technology fairly closely no spectacular forward jumps in battery performance have occurred. Instead progress is has been slow and gradual. I believe that if significant engineering and scientific resources are dedicated to battery technology that progress will continue for a long time into the future, but a spectacular breakthrough in the next couple of decades which would allow BEVs to rapidly dominate the whole of the transportation industry should not be counted upon.

The second point about the time variability of renewable energy flows and the consequent need for grid strengthening and/or the addition of large scale, long time period energy storage to the grid system has been made previously in the general discussion of the infrastructure needs of a renewable energy system. However, the addition of a major new electricity consuming sector of the economy means that the infrastructure cost of renewable energy grid will be even higher than a cost estimated from a projection of current electricity use patterns.

17.4.6 Mobile heavy machinery

The challenges of electrifying the mobile heavy machinery used in farming, forestry, construction, mining and so forth are more severe than those of electrifying passenger transportation. The problem is not with the electric drive train itself which I believe can accomplish any task that drive trains powered by internal combustion engines can accomplish. The problem is with energy storage. An aerodynamic passenger automobile traveling at optimum speed along a smooth highway does not need to burn a lot of energy. On the other heavy mobile machinery typically burns a lot of energy per unit of time thus upping the energy storage requirements of such machinery. Hydrogen powered fuel cells could overcome the limitation of electrical storage batteries, but the prospect of hydrogen fuel infrastructure costs anywhere near to the current cost of diesel fuel and gasoline derive from petroleum is still quite remote.

17.5 A system of community finance should be able handle a lowering of consumption standards without resulting in an unemployment disaster

If, when we get our teeth deeply into the problems of the infrastructure transformation required for creating an ecologically sane society we find that maintaining current standards of consumption is not a realistic option, then a system of community finance combined with progressive consumption taxes provide tools for managing the economy without major disruptions to employment. If infrastructure transformation creates work without creating a concomitant increase in consumer goods then the transformation must be paid for by lowering standards of consumption. A system of community finance which can charge zero (or even negative interest) can insure that the necessary credit is available to finance infrastructure projects, and progressive consumption taxes based on a dynamically defined basket of goods and service can insure that consumption patterns are consistent with the productive capacity of the economy.

As the work of transformation is carried out the overall skill set required by the labor force will change and evolve. An effective program of retraining and ongoing education will be required to adapt to these changing circumstances. I give an outline of possible adjustments to the education system to meet these need in the following chapter.

Chapter 18

Flexible education for an economy in transition

If a widespread agreement is reached that our economic effort should be focused on creating an infrastructure with long term ecological stability and greater resource resilience rather than on increasing consumption as a means of creating work and supporting growing private credit markets, we will enter a period of transition in the job marketplace requiring many workers to acquire new skills. Some of the new work created by the transition may be permanent because the price for lower ecological impact and sustainable resource use may be greater labor intensity for certain kinds of production (e.g. food production, construction, etc.). Other kinds of work involved in creating new infrastructure will have higher labor requirements during the transition than they will in an eventual long term equilibrium when the new infrastructure is essentially complete and enters a maintenance mode rather than a growth mode. Thus on the far side of the transition another adjustment in the mix of work skills may be needed.

The current higher education system with its emphasis on very expensive multi-year credentials does not seem well adapted to the kind of ongoing long term learning required for an economic system in transition. Indeed, one can argue that this educational system is not all that well adapted for the current economic situation in which rapidly changing technology and a concomitant rapidly changing mix of consumer goods requires ongoing adjustments in knowledge and job skills long after the initial educational credentials have been obtained. One can argue with some degree of justification that obtaining such credentials demonstrates that their possessor is capable of sophisticated learning and therefore has the right stuff to adapt to changing methods of economic production. However, one can reasonably doubt that current system of college and university degrees is the most efficient method of demonstrating such learning ability. Furthermore one can doubt whether or not concentrating such a high level of educational resources in a single multi-year period starting at age eighteen is really that wise considering that long term ongoing learning and skill development is so obviously useful and often indispensable. Therefore I would like to spend some time in this chapter exploring ideas for alternative systems of learning.

In the current education system emphasis is placed on gaining a credential in the form of a degree (formally symbolized by a diploma) from a particular educational institution. A degree is obtained by choosing from a set or courses offered by the institution in question and by completing a set of tests and assignments set out by the teachers of each individual course. A numerical grade is assigned based on the scores obtained on these tests/assignments, and if the grades is above some minimum level then a certain number of credits are granted to the student. When the required number of credits are obtained in various subject areas as determined by the requirements of the particular institution then a credential is granted to the student in question. This credential along with a transcript of the grades obtained in all of the courses taken can then be used by the student as evidence of competence in the search for a job or in the effort to gain admittance to some other institution of education. Except for public primary and secondary schools which admit students based on geographic proximity, there is a formal educational contract between the student and the educational institution in question which has to be signed before admittance to a degree program is allowed.

I would like to suggest replacing degrees granted by single institutions with transcripts built by students which are not tied to a particular institution. The transcripts would consist of two types of information. One type of information would be scores from standardized competency tests. In some ways these tests would be similar to the SAT tests used today for making decisions about college admissions, except that a far greater variety of such tests would exist, each test being specialized to demonstrate competency is some particular skill/knowledge. The significance of scores on competency tests has no dependency on how or where the material was learned. Whether you followed a course of self study using books and instructional videos, or were tutored by your grandmother, or you studied under a famous professor at a prestigious institution, a score of 98/100 is still a score of 98/100 and proves that you have mastered the material. A person can of course take a competency test multiple times and on their transcript they will include only the most recent (and presumably the best) test score. Mastery is mastery and the fact that a person may have been an indifferent student at one point in their life does not change the fact they have finally mastered the material. The idea of replacing traditional educational credentials with competency testing was promoted by Ivan Illich in his 1970 book *Deschooling Society*[1] .

I will not attempt here to describe the variety and scope of such competency tests. However, unlike current college admittance tests which are attempting to predict how students will perform in traditional college course work, competency tests will be attempting to predict how students will perform in real life problem solving situations such as mini-apprenticeships or in jobs. I do not envision such tests coming from a single central source such as a college board, but rather from a variety of centers of competence. That is various groups of professionals will develop a series of tests which experience shows predict with reasonable accuracy performance in various problem solving situations.

The second type of information that would be included in transcripts would be written evaluations of a form of study which I call mini-apprenticeships. In a mini-apprenticeship a student contracts with a teacher to work on project or series of projects as a means of gaining practical experience in a certain subject/discipline. The teacher could be working in academia or in industry or could be merely a private citizen with specialized knowledge and skills. I call these contracts mini-apprenticeships to emphasize the fact that I envision them as typically being of shorter length and narrower subject focus than the classical apprenticeships of the medieval guilds. However, for some kinds of very advanced learning the apprenticeship might last for a period of several years.

I envision the contract for the mini-apprenticeship as being between the teacher and the individual student. In many cases the teacher/mentor will be associated with some institution such as a school, a research institute, or a manufacturing business. In such cases the teacher/mentor may utilize a human resources department to perform preliminary evaluation of the transcripts of apprenticeship candidates, but the final decision for acceptance lies with the teacher, and the contracts is between the student and the teacher.

In the case of private businesses special incentives may have to be provided for business to allow and encourage this kind of activity by their employees. The mentors/teachers would actually earn money by this activity since students will pay to gain this experience and to receive an intelligent

[1] Illich, Ivan, 1970, *Deschooling Society*, Harper and Row Publishers, New York

evaluation by their teacher which they can add to their transcript.

The written evidence of the outcome of a mini-apprenticeship could involve three levels of detail. A summary level would contain the length of the apprenticeship, the approximate hours worked, a brief description of the included projects, and a brief description of the quality of the student's work. A second section would describe the projects and the contributions of the student in more detail. In some cases the student's might write their own detailed reports about their work, which reports could be made available if requested or which could posted in an on line database.

In this conception of educational transcripts I have allowed no place for traditional graded classroom work. Nevertheless formal classes which include scored tests might still exist in some cases if students perceived a use for them. One use might be as relatively low cost means of training for particular proficiency tests.

It is also possible that mini apprenticeships could take the form of a "class" in which multiple students are working with one instructor or master. The emphasis of such a class would be on carrying out projects in some area specialization. However, lectures and problem assignments could be included if desired by the students or if practical experience showed that such activities are a useful aid in effectively completing the projects which are the real object of the study

In this conception of education, the student becomes the primary decision maker about what sort of transcript he or she wants to build rather the educators who determines the curriculum requirements of a particular educational institution. Of course certain opportunities in higher education or in a particular job market will depend on the details of one's transcript so that students who are interested in specific jobs or higher level apprenticeships will seek out practical advice on what kind of transcript they need to build.

One question which arises about this sort of educational system is the extent to which tutors/instructors need to be certified. For tutors who are preparing students for specified competency test certification is not strictly necessary. You can be tutored by your next door neighbor or your cousin, and if you score well on the competency test no one will care whether or not your tutor was certified. Some people might prefer to have some certification available to help them make choices about tutors and if experience shows that such certification is practically useful then a system to provide it can be devised.

In the case of mini-apprenticeships certification of instructors may be more important. My idea is that certification would be handled by broad based organizations associated with a particular area of expertise/knowledge rather than with a particular educational/industrial/scientific institution. So if you are going to study with an electrical engineer then a professional Society of Electrical Engineers would handle the process of certifying instructors. If you are going to study with a machinists then a Society of Professional Machinists would handle certification. Certification might not be strictly necessary, but it might strengthen a transcript to include work with certified instructors.

One question that arises in the context of these proposals which put contracts between individual students and individual teachers at the center of formal education is the extent to which education institutions in which many instructors are banded together in a single organization will continue to exist. My feeling is that such institutions will continue to exist although their functioning will substantially change. Having a large group of students and teachers present in a single location will probably have advantages for both students and teachers. Once a student has been accepted to work with particular teacher they will be able to talk to that teacher and to other students present in the same location to learn about other opportunities for mini-apprenticeships within the same institution. For teachers, having a group of students with known performance results working under colleagues they know and trust will help to make the decision process about accepting new students easier. Also it is possible that groups of instructors may be able to hire human resources workers who can prescreen student transcripts thus freeing up time for the professors.

On the other hand since education is no longer focused on obtaining a degree from a particular institution, students will be free to seek out instructors anywhere they see fit to find them. If across town, across the state or province, or even farther afield a particular teacher has a special expertise then an enterprising student can seek out that expertise. Of course having a strong transcript will increase the likelihood that a student will be accepted for an apprenticeship by the teacher that they desire to study under.

Next we come to the question of educational financing under this proposed system of study. Obviously people can spend their own money for instruction as they see fit. However, public financing of education is a well-established tradition based on the realization that raising up a new generation of skilled and educated workers is a general social benefit which should be supported by all productive citizens. The least bureaucratic way to provide such financing is to make funds available to each citizen which they can use as they see fit for obtaining instruction.

If some kind of accountability is needed to make sure than such funds are being used wisely then a requirement can be instituted to periodically submit each citizen's transcript to public scrutiny. If the transcript is judged to be too weak relative to the funds which have been expended then some kind of corrective action or intervention can be undertaken.

In my view some level of such funding should be available throughout a citizen's life time and not just until they are in their early twenties. Also special funding can be provided for exceptionally talented students in the form of scholarships. Students desiring scholarships will submit proposals for a course of study along with their transcripts. Again the scholarship is not tied to a contract with a specific educational institution. The student uses the funds as they see fit. However, periodic review of the transcript may be required, after certain levels of expenditure to see whether the student's progress justifies the continuation of the scholarship.

For students with less promising transcripts student loans could be made available as in the current educational system. In this case periodic reviews of the student's transcripts may or may not be required as practical experience dictates.

My emphasis in the above discussion has been on ongoing education for adults who need to gain new knowledge and skills, but the same ideas can applied to primary and secondary education. Many people are so accustomed to the idea that children must sit in class rooms for many hour as day for many years following predefined curricula in order to become educated that this new idea of student centered transcript building may seem strange. Schools would not necessarily disappear in such a system but they would take on a different focus when their job is no long providing credentials. For schools to play an effective role in transcript building they would have provide two kinds of services. First they would have to provide tutoring which would aid student in getting decent scores on various kinds of competency tests. As I have pointed out above these competency test are not created by the schools themselves but by professional societies of some sort. The French Buddhist monk and writer Matthieu Ricard has promoted what he calls cooperative education as opposed to competitive education. In this model students work in groups and the students who can master a certain skill more quickly and easily act as mentors to the students who are having more difficult with that particular skill. If the goal of education is to gain competency rather than to outscore your fellow students in competitive testing then the potential usefulness of this model is immediately evident.

Secondly the schools would have to facilitate contacts between students and instructors for various kinds of mini-apprentice ships. In addition to maintaining contact with a network of instructors, the school can work with students to make sure that they are properly prepared for the particular types of apprenticeship which they wish to pursue so that they can maximize the value that they get out of their experience.

Of course the current school system has an immense institutional inertia which cannot be easily overcome. Furthermore new ideas need to be experimented with and their practical utility demonstrated before existing institutions undergo a major reform. Luckily in this case there seems to be no reason why traditional education credentials and student built transcripts cannot exist in parallel. The initial emphasis for transcript building might be on continuing adult learning. If practical experience showed that such transcripts were useful predictors of performance then students in traditional schools might start also do some amount transcript building in addition to their other school work. Eventually pressure could mount on the schools to aid the students in this activity and a transition in the emphasis of school work would start to take place.

Appendix: The effect of capital taxes on savings

In a growing economy capital taxes would reduce saving to zero only if the tax rate were greater than the average rate of return on capital. However, in this appendix I am considering the case of a quasi steady state economy in which normal interest rates are zero. In such an economy one might still introduce progressive capital taxes in order to control the available pool of credit. The purpose of such a tax would be encourage people to spend at a rate which would keep their total savings below the taxable limit. Nevertheless certain people might be tempted to hoard money rather than spending it or taking losses due to taxes. Society as whole cannot really hoard. When we avoid spending our income by saving we are allowing someone else to spend above their current income in the present in the expectation that we will spend above our current income at some time in the future. Any large scale attempt at hoarding (which is to say consuming less than we produce) will immediately result in an economic recession. Nevertheless an individual saver might be tempted to try hoarding in the presence of a capital tax. The existence of consumption taxes, which in my view should be much higher than capital taxes will discourage hoarding. Remember that any income which is not saved is assumed to have been consumed and will therefore be taxed at consumption rates rather than at capital rates.

We can use this fact to compare the savings success of the saver and the hoarder. Suppose that the consumption tax rate expressed as a fraction (i.e. % rate/100) is R and the marginal capital tax rate for the money in question is r. Further suppose that each saver is setting aside D dollars of their income every year. After n years the total savings of each individual is given by the following formulas:

$$S_{Hoarder} = nD(1 - R) \tag{18.1}$$

$$S_{Saver} = D(1 - r)^n + D(1 - r)^{n-1} + \cdots + D(1 - r) \tag{18.2}$$

The hoarder's total savings are easy to calculate. Each year she set aside D dollars to put into her private hoard, but $R \times D$ dollars must be paid to the tax man since anything which is not formally saved (and therefore subject to the capital tax r) will be taxed at the consumption tax rate R. Thereafter the $D(1 - R)$ dollars which remain will sit unchanged in the hoard. After n years the total money in the hoard is given by the formula above.

The saver's total saving are more complicated to calculate. Each year she puts D dollars into her saving account and she must pay $r \times D$ dollars to the tax man. However the $D(1-r)$ dollars remaining are not in an invisible hoard. Every year the remaining dollars will be subject to a new tax so that they will be reduced by a factor of $(1 - r)$. The same thing happens every year so that the longer ago that a deposit was made the smaller will be the remaining dollars. The above formula expresses this effect of capital taxes in each of the n years in which a deposit was made.

The formula for the saver can be simplified. We multiply S_{Saver} times $1 - r$ and write the result beneath the first sum:

$$\begin{aligned} S_{Saver} &= \qquad\qquad\qquad\quad D(1 - r)^n + \cdots + D(1 - r)^2 + D(1 - r) \\ (1 - r)S_{Saver} &= D(1 - r)^{n+1} + D(1 - r)^n + \cdots + D(1 - r)^2 \end{aligned}$$

If we subtract the second equation from the first we find:

$$S_{Saver} - (1 - r)S_{Saver} = D\big[(1 - r) - (1 - r)^{n+1}\big] \tag{18.3}$$

Solving for S_{Saver} we find:

$$S_{Saver} = D\frac{(1 - r)\big[1 - (1 - r)^n\big]}{r} \tag{18.4}$$

One can sanity check this formula by substituting n=1. The result of this substitution is:

$$S_{Saver} = D(1 - r) \tag{18.5}$$

This result is as expected for the first year's savings.

One can use equations (1) and (3) to determine how long it takes the hoarder to catch up to the saver. In the first year the hoarder is certainly behind because $D(1-R)$ smaller than $D(1-r)$. That is the consumption tax rate R is greater than the capital tax rate r. I used a spreadsheet to calculate $\frac{S_{Hoarder}}{D}$ and $\frac{S_{Saver}}{D}$ for the case $R = 0.2$ and $r = 0.02$ and the results are tabulated in table A.1. Under these conditions it takes 22 years for the hoarder to catch up with the saver.

Note that after 22 years the savers reserves are $17.6D$. Since they have been saving D dollars each year the percent of their savings left are $100 \times \frac{17.6}{22} = 80\%$. This fact shows that even in the presence of a capital taxes saving could play some role in establishing long term consumption rights. In chapter 16 I characterized this role by the half-life of savings as a function of the marginal capital tax rate. Here I will derive the formula for calculating the half-life. If n year have passed since a deposit of D dollars was made the amount of savings left is given by:

$$S_{remaining} = D \times (1-r)^n \tag{18.6}$$

If we set the remaining savings equal to $\frac{1}{2}D$ we can calculate the half-life n:

$$D \times (1-r)^n = \frac{1}{2}D \tag{18.7}$$

Eliminating the common factor D we find

$$(1-r)^n = \frac{1}{2} \tag{18.8}$$

Taking the log of both sides we find:

$$n \times log(1-r) = log(\frac{1}{2}) \tag{18.9}$$

Solving for n gives the savings half-life:

$$n_{half} = \frac{log(\frac{1}{2})}{log(1-r)} \tag{18.10}$$

One can substitute various values of the capital tax rate r into this equation and thus calculate the savings half-life in years. I already presented this data in tabular form in chapter 16, and I reproduce the table below.

Table 18.1: Saver vs hoarder performance by year

Year	Saver	Hoarder
1	0.98	0.8
2	1.94	1.6
3	2.88	2.4
4	3.8	3.2
5	4.71	4
6	5.59	4.8
7	6.46	5.6
8	7.31	6.4
9	8.15	7.2
10	8.96	8
11	9.76	8.8
12	10.55	9.6
13	11.32	10.4
14	12.07	11.2
15	12.81	12
16	13.53	12.8
17	14.24	13.6
18	14.94	14.4
19	15.62	15.2
20	16.29	16
21	16.94	16.8
22	**17.58**	**17.6**
23	18.21	18.4
24	18.83	19.2
25	19.43	20
26	20.02	20.8
27	20.6	21.6
28	21.17	22.4
29	21.73	23.2
30	22.27	24

Table 18.2: Savings Half Life

Marginal Tax Rate	Savings Half Life
0.00%	infinite life
1.00%	69 years
2.00%	34 years
3.00%	23 years
4.00%	17 years

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