

**Pools of Money:  
Information Cycles for the Production and Maintenance of Financial  
Information**

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**ABSTRACT**

The ‘information cycle’ is an evolutionary model of the selection and maintenance information in the face of Second Law depreciation of its carriers. It is a general model of information, originally conceived by HT Odum, that applies to information of any kind. The model has been applied now to DNA information and to many forms of cultural information, including conversation, social media, television, ritual, classroom lecture, and others. And it has been applied now to the manufacture of material goods. This paper aims to conceptualize money and the financial system in forms that permit application of the information cycle model. A principle insight has been to conceive of money in the financial industry not as flow but as storage or concentration. Products of the financial industry are concentrations of money (*pools of money*), which are then available to move in countercurrent to real wealth in productive economic processes. The concentrations produced are of many sizes, which can be organized as a hierarchy. In the financial industry, as money concentrations increase in size they are also produced less frequently, requiring longer cycle time, they require larger inputs of energy and materials, and they apply to larger spatial areas within the economy, as predicted by Odum’s Fifth Law Hierarchy Principle. Money concentrations are produced and maintained in “information cycles.” Their form and application are tested in the market, and if successful they are copied into conceivably many new forms. This cycling maintains successful designs against Second Law depreciation. Money concentrations joint together the major components of the financial industry. A general model of the industry is produced with components located within scales of the hierarchy of natural and human systems. This includes the nested hierarchy of forms of cultural information. It is within this model that financial information interacts with the other scales of cultural information, which results in the contestation and negotiation of

ideas that characterize human cultural information as it self-organizes and as it feeds-back control to systems of nature and industry.

## **Introduction**

It is commonly said that money serves several critical functions in an economy: (1) medium of exchange, (2) store of value, (3) unit of account, and (4) basis of credit. As a *medium of exchange* it solves the problem of needing a double coincidence of wants. Unlike in barter, money can be exchanged for an object, for which at a later time the recipient can spend that money for their own want. This depends on the second function; money is a *store of value* (if no severe inflation). If the money became less valuable before it was used in the second exchange, it would not be acceptable as a medium of exchange. Next, as a *unit of account* it is a common measure of the value of goods and services being exchanged. Last, money is the *basis of credit*, or put another way, it is the standard of deferred payment. Money makes borrowing and lending much easier. This last function will be the focus of this paper. But it will place credit in a new light. This paper calls for a re-conceptualization of credit as an object of energy transformations into a hierarchy of concentrations, which is made possible by the maintenance of financial information. The motivation for this new view is an unlikely source, the ‘information cycle’ model of systems ecologist HT Odum (1996), and its re-application to the production of cultural information (Abel 2014), of manufacturing (Abel 2018), and now of the financial industry in its production of credit.

Money is a form of information. It signals value that society places on goods and services from the ‘real’ economy. And it facilitates the transactions for those goods and services. As we will see, it is not simply money that aids economic production, but money in *concentration*—pools of money.

The financial industry is in the business of building pools of money (among other things). A colossus of companies with banks at the center, the financial industry includes exchanges, law firms, accounting firms, insurance companies, central banks, rating agencies, regulating agencies, brokerages, institutional investors, and others. We think of the economy as global, but the financial industry is among the most spatially concentrated of all economic entities, centered in a few global cities, and found in these agglomerations of related companies that share strong interfirm cooperation (Coe, Kelly et al. 2013:207).

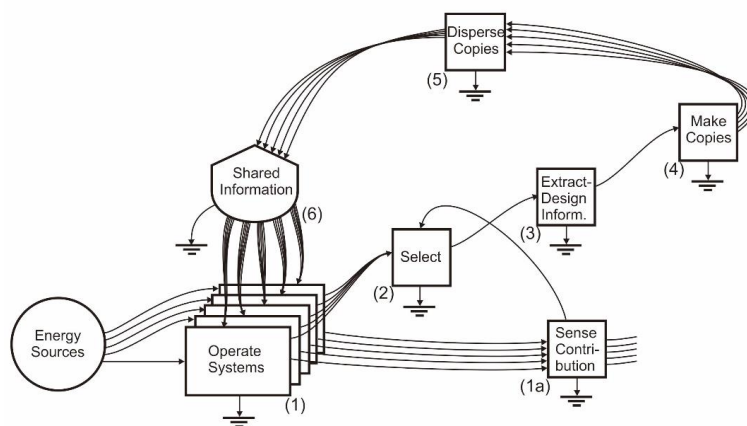
The financial industry has been the subject of thorough economic study, but this paper will take a different approach, utilizing the energy systems model of the ‘information cycle’ (Odum 1996). Systems models of the financial industry are not by nature politically conservative or submissive of the status quo, as was once a common criticism (Taylor), but instead expect action and contrast<sup>1</sup>. This position will focus attention on the production, maintenance, and evolution of the pools of money used by the economy, and the knowledge required to sustain and reproduce them.

Economies are physical networks of companies controlled by flows and pools of money, and the forms of those pools and the knowledge it takes to produce them have evolved for centuries, as information cycle, as have all form of symbolic culture (Abel 2014).

### The Information Cycle

Evolution is a special form of self-organization that makes use of information to store knowledge of past successful configurations. A developing organism need not discover efficient energy pathways because they are encoded in its DNA. This is more efficient than the self-organization of simple non-living structures such as tornadoes or typhoons that lack a blueprint of past successful configurations and must each time organize anew. The information of DNA records a vastly more complex design of successful species adaptation to ecosystem contexts and all parts within.

HT Odum has proposed a general model of information and its reproduction, maintenance, and use. Information is never produced once and extended abstractly thorough time. It is perpetually cycled and tested, with errors eliminated and adjustments incorporated. The ‘information cycle’ (Figure 1) depicts the cycling of genetic information in the evolution of living organisms. Organisms within an ecosystem (1) are selected (2) by that system context (1a) for reproduction. DNA information from a pair of successful organisms is extracted and combined (designed) into a new configuration (3). Typically many copies (4) of that new design are made and dispersed (5) back into the ecosystem, where they live their lives, to perhaps be selected again.



**Figure 1: Information Cycle**

An information cycle as diagrammed by H.T. Odum (1996:223, with minor modifications and step numbers added, used with permission). This general model applies to the production and maintenance of all forms of information. For example, referring to the genetic information of life, we observe a life-cycle in which *natural selection* (1a and 2) chooses successful mating pairs from which DNA information is *extracted and assembled* (3) and *copied* (4) to offspring, which then *disperse* (5) to live

their lives in the larger *world* (1) where they may or may not be chosen to transmit their DNA to the future. Cultural information, including money, is also maintained in information cycles (Abel 2014), as discussed in the text.

Odum intended the information cycle to reach beyond biology, to be applied to the evolution of all forms of information, including especially the information of culture (Odum 1996:233ff). Abel (2013, 2014, 2015, 2015) has introduced the information cycle into the understanding of conversation, social media, television, ritual, education, academic research, finance, and legal codes. In human culture, wherever there is selection, there is an information cycle. This paper is the first detailed exploration of finance, or the financial industry, that makes use of the information cycle and its many implications.

The story of genetic information and evolution is well known. But the information cycle adds fresh insights and emphasis to this often-told tale. First, it highlights the energetic contributions to each step of the cycle, contributions that are wholly necessary and that come from distinct sources. The energy to disperse (5) seeds is very different from the energy of meiosis (3) or the energy expended by predators that remove those prey *not* selected (1a&2). In cases of cultural information, the energy to disperse information (5) can include the work of paper ‘carriers’ and trucks, or electronic broadcast networks, or the energy of sound waves in a classroom lecture. The energies of selection, extraction, and copying are equally varied for each of the cultural information forms.

The information cycle emphasizes the total environmental systems context in which selection is made, which includes multiple scales of selection, from DNA, to organisms, to clades, to material cycles in ecosystems, to biosphere self-organization (Depew and Weber 1995).

The information cycle draws attention to the intermediate ‘carriers’ of cultural information. Information is always ‘carried’ on a material substrate, and as any material configuration, an information carrier has a lifespan or turnover time, and hence the need for cycling of useful information. For each of the forms of cultural information listed above, the carriers and turnover times differ. In the case of the information of money, carriers have changed over time and place. The intermediate carriers of the information of money have included, among others, clay bullae, scarce metals, seashells, tally sticks, paper currencies, tobacco, and now bits in electronic memory (Graeber 2011).

When applied to cultural information, the information cycle draws our attention to the often complex technologies required for all steps, but especially for making copies (4) for their dispersal (5), and for their stored forms (6). Technologies for making copies (4) of gold coins have been replaced by elaborate technologies for producing and maintaining paper currencies that cannot be easily counterfeited. In addition, newer forms of money exist only in the electronic balance sheets of banks and other

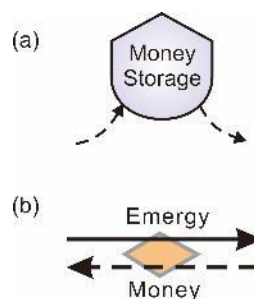
financial institutions, which require elaborate electronic protections of their own. The technologies of dispersal (5) of the forms of money have also changed dramatically as money itself has changed. Today dispersal requires armored cars or elaborately secured electronic transfers. And last, the final stored forms (6) of shared money exist in paper carriers in great vaults and in secured electronic warehouses. Finally, as a representation of value, information of money is carried in the minds of people.

### Money in Storage and Flow

Banks are for-profit companies. The financial industry, and banks in particular, perform many roles in society today. In simple terms, one of the oldest and still fundamental reasons for their existence is to pool together household savings, and to then lend the pools for profit:

“In general, banks *pool together* our money / savings as capital and use that capital to *finance productive activity* such as commodity production, the manufacturing of goods, and the provision of services (Coe, Kelly et al. 2013:193).”

Banking produces pools of money, or in systems language, *concentrations* of money. In the energy systems language (ESL), concentrations are typically represented with a storage symbol (Figure 2a). In systems thinking, concentrations are a fundamental component of any system because they drive opportunistic pathways (Odum 1983:25), or in simple terms, they make things happen. In economies, concentrations of money move goods and services to where they are needed. They flow in counter-current to (concentrations of) goods and services in systems of economic production (Figure 2b).



**Figure 2: Storage and Money Flow**

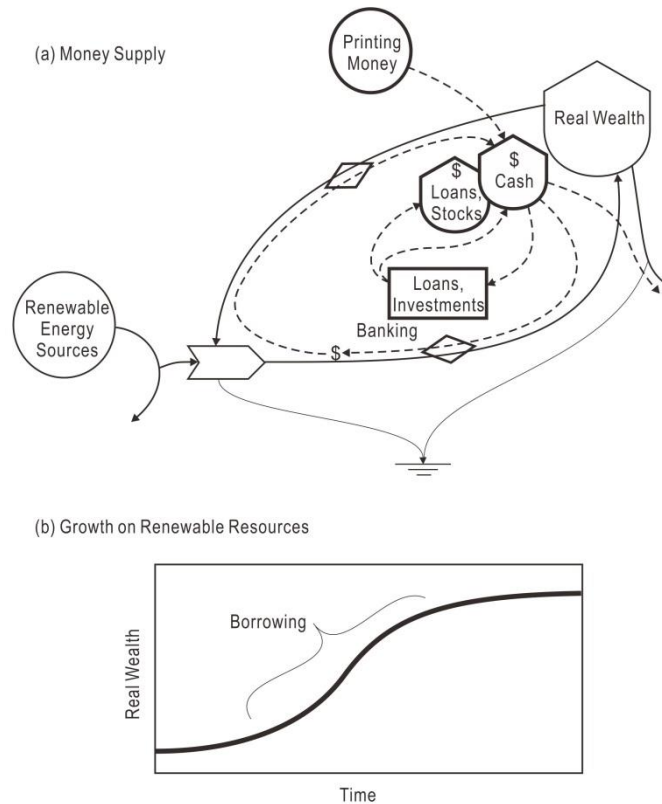
In the Energy Systems Language (ESL), a storage tank (a) typically represents a concentration of energy or matter. In self-organization, systems develop storages to supply sufficient and reliable inputs to some process. Storages provide force in proportion to the storage size (Odum 1983:25ff). A storage tank is also a reasonable model for a concentration of money (information). In (b), money moves in countercurrent to goods in economic systems, and the diamond ‘transaction’ symbol shows the link between the two flows. A concentration of money supplies the force needed for economic activity. Odum states that the tendency for more money to cause higher spending could be called a ‘first law of economics’ (Odum and Odum 2000:116). We will see that the rapid formation of money concentrations is essential to economic activity in current economies.

Banks profit from the pooling and lending process because they pay small rates of interest to savers who deposit their money, and they receive larger rates of interest from borrowers who take their loans. In normal times, most people do not need access to their savings, and not at the same time. In the past, banks came to realize that as long as they kept enough money on hand for day-to-day operations, they were free to make loans from the remaining funds (Dorman 2014:147).

Today, this 'fractional-reserve' approach to lending a portion of bank 'reserves' is still a part of the 'depository' banking business. Banks create money when they make loans, and that money is destroyed when the loan is repaid. Today the quantity of money created by loans far exceeds the existing currency, as will be explained.

### **Systems Diagrams of the Financial Industry**

In addition to representing the information cycle, systems diagrams will also be used in this paper to depict the financial industry and its components. This should help to visualize the rather complex arrangements of pieces of the industry. H.T. Odum did not describe the financial industry in detail, but we have this overview diagram (Odum 2007:265). It shows an economy that uses pools of money in two institutional forms, stocks and loans, to generate growth when resources are available (Figure 3). Odum explains, "The successful businesses start first by borrowing. They can pay back interest because of their growth (2007:263)."



**Figure 3: Systems View of Money Supply and Growth (reproduced with minor modifications from Odum 2007:265)**

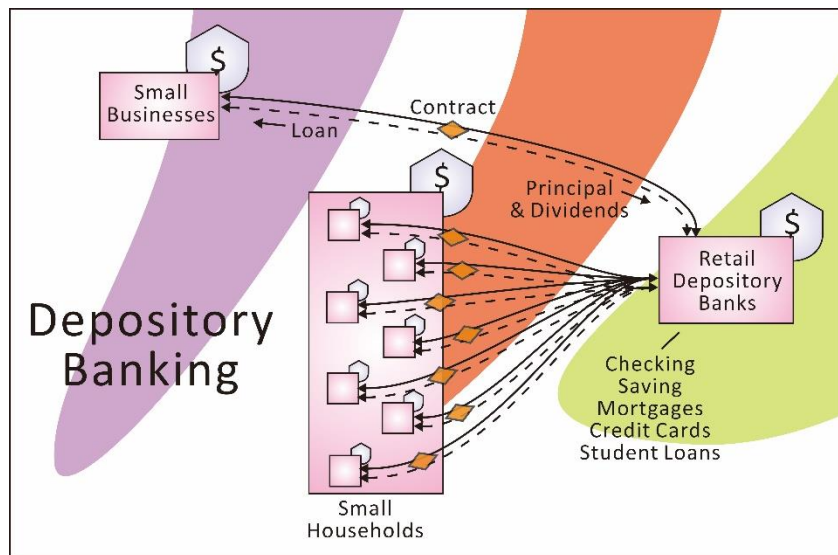
When energy is available, (a) an infusion of money from loans and investment (borrowing) can drive (b) the rapid growth in real wealth (process rectangle and ‘Banking’ added).

In Figure 3, we see that borrowing adds a sudden injection of money to the economy (as does printing money or issuing stocks). Odum does not elaborate on the banking system that creates loans (though we should picture his “Loans, Investments” as components of a ‘process’ that could be labeled ‘Banking’ (Figure 3a) (process shape and ‘Banking’ added)), but he clearly singles out the borrowing process as the trigger to growth (Figure 3b), again, when energy resources are available to sustain growth. The next two diagrams zoom in on the banking systems that create the pools of money for lending, so-called, depository banking and investment banking (Figure 4 and Figure 5)<sup>ii</sup>.

### **Depository Banking**

In systems terms, the components of depository banking can be represented as in Figure 4. To keep this introduction simple, depository banking will be described as it was traditionally practiced. The contemporary story will be added shortly. In Figure 4, the Depository Bank is shown as the place for household checking and savings accounts. With that money, the bank makes loans to businesses. In addition, they

make loans to households in many forms, mortgages, student loans, credit cards, and others. The small households (as opposed to the minority wealthy households, next) are depicted as a hierarchy in Figure 4, indicating that even at lower income levels there are differences between household incomes, and thus some degree of inequality (Chang 2014:204, Dorman 2014:151).



**Figure 4: Depository Banking**

Depository banks receive savings deposits from households, from which they make loans to businesses and households. In fractional-reserve banking, the banks lend more than they receive in deposit, retaining only a fraction of the original deposits in reserve (see text). An unusual notational convention is used in this diagram and others of the financial sector. As usual, money moves in countercurrent to materials, energy or goods. But in the financial industry, the exchanged good is a contract, which travels to both parties. Therefore, money flows in both directions, as when a loan moves in one direction and principal and interest move in the opposite.

In Figure 4 can be seen a unique diagramming convention that exists for the financial industry. In all other parts of the economy, money moves in one direction, while the commodity purchased moves in the opposite, in countercurrent (Figure 2b). In the financial industry, however, the material ‘commodity’ is always a ‘contract’ of some sort that travels to both parties. Therefore, money also flows in countercurrent to both parties. For instance, when households deposit savings (money flow to a bank) they receive regular interest payments (return flow to saver). Similarly, when a business receives a loan they must later return principal plus interest. The return flows are always later in time and could be drawn separately, but that would add confusion to the diagram.

The financial system is unique because its true ‘product’ is pools or concentrations of money, which are then used to move goods or services in other parts of the economy.



We must recall that money is information. Information of all forms functions to maintain self-organized systems. Information has feedback control over system reproduction and maintenance, whether it is DNA information, or the information of social media, TV, religion, education, etc. (Abel 2014). Concentrations of money are information that controls and maintains the systems of economic production.

Over the time that depository banking has evolved, the storages of money have changed form (now mostly electronic and located in a complex technological and legal system), and there are new connections to other parts of the financial system (to be discussed below). But the general form of Figure 4 remains useful. Depositors, banks, and borrowers are linked by the concentrations of money that they produce and the loans made from those concentrations.

### Investment Banks Borrow Money to Make Concentrations

A second type of bank uses other strategies to build large concentrations of money (Figure 5). In their original form, investment banks borrowed money from investors on behalf of their customers. A large domestic company or transnational company (TNC) in need of significant funds to start or expand its business could hire an investment bank to raise money for it. Typically, investment banks made use of ‘exchanges’ for trading stocks (shares) or bonds. The banks assisted the business in offering stocks or issuing bonds that could be traded on an exchange to raise the needed concentrations of money (Chang 2014:209, Dorman 2014:151).

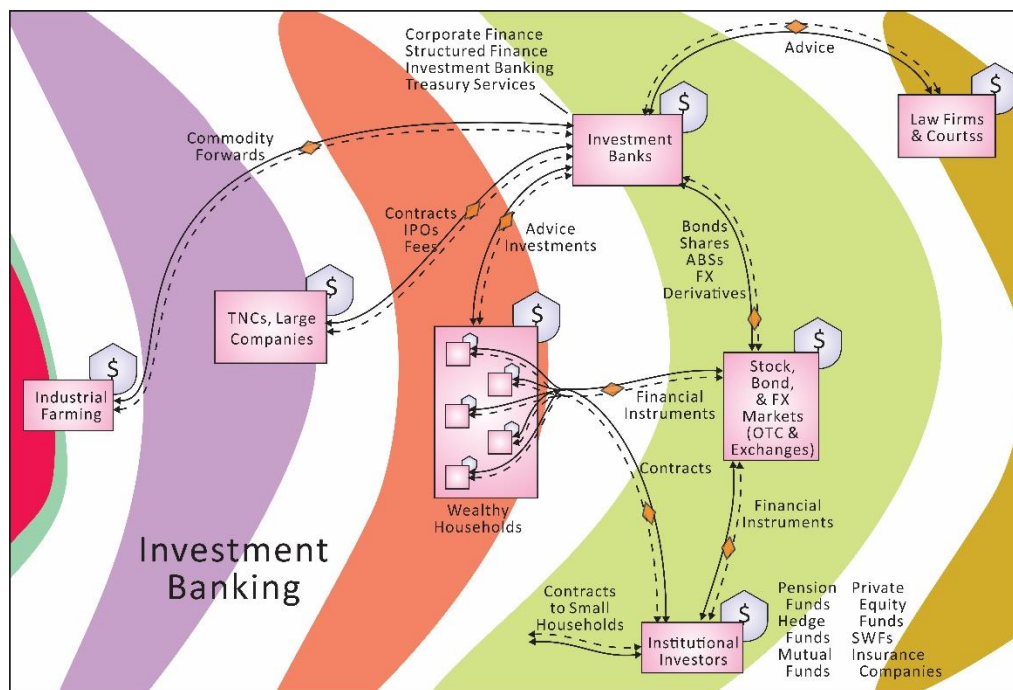


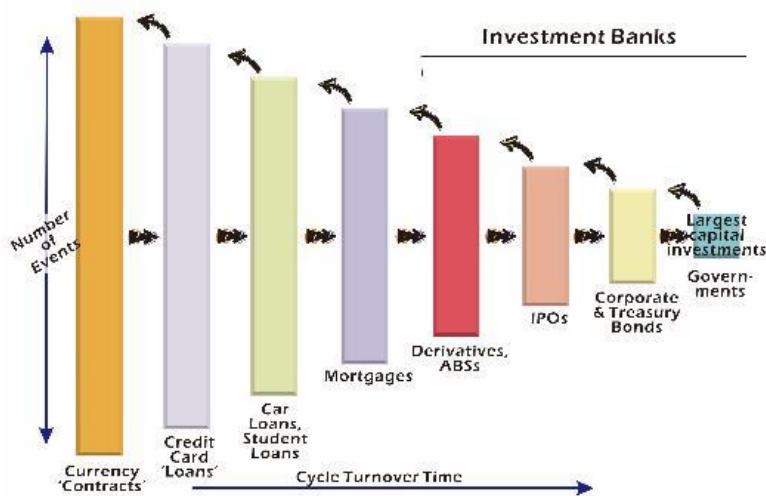
Figure 5: Investment Banking

Investment banks are at the core of the financial industry, and they provide numerous services to the industry. In traditional investment banking, they assist corporations to raise capital to meet their needs. They may also be hired to assist corporations with capital structure, budgeting, and accounting (called corporate finance). Today, much of their business is in the production of securitized assets that transfer risk and generate profits for the bank and for institutional and wealthy investors (structured finance). They assist companies in currency exchange to permit international trade (treasury services). And they provide still other services. They thus connect corporations (including industrial firms), law firms, wealthy individuals, institutional investors, and the markets for stocks, bonds, commodities, and foreign currencies.

Today, investment banks lie at the heart of the financial industry (Figure 5). Concentrations are produced in new ways via more ‘exotic’ financial instruments in addition to stocks and bonds, and the role of trading financial instruments on exchanges and over-the-counter has been dramatically transformed. It is argued that the exotic financial instruments have made the financial system safer and more efficient, although the financial crisis of 2008 has severely challenged that claim (Chang 2014:217). Investment banks today also earn money by assisting companies with mergers and acquisitions, now ubiquitous processes that transform the structure of the economic production hierarchy (Teitelman 2016). They have also played a significant role in shaping the behavior of managers and the allocation of profits within companies, toward shareholder value maximization and away from long-term investment in companies (Chang 2014:210).

### **A Hierarchy of Money Concentrations**

In the financial industry, as in all systems of production, there is a ‘hierarchy of products’ (Abel 2018x), here concentrations of money (Figure 6). Systems of all kinds produce hierarchy as a natural outcome of energy self-organization, explained in the Hierarchy Principle, Odum’s proposed Fifth Law of Thermodynamics (Odum 1996):16).



**Figure 6: Hierarchy of Money Concentrations**

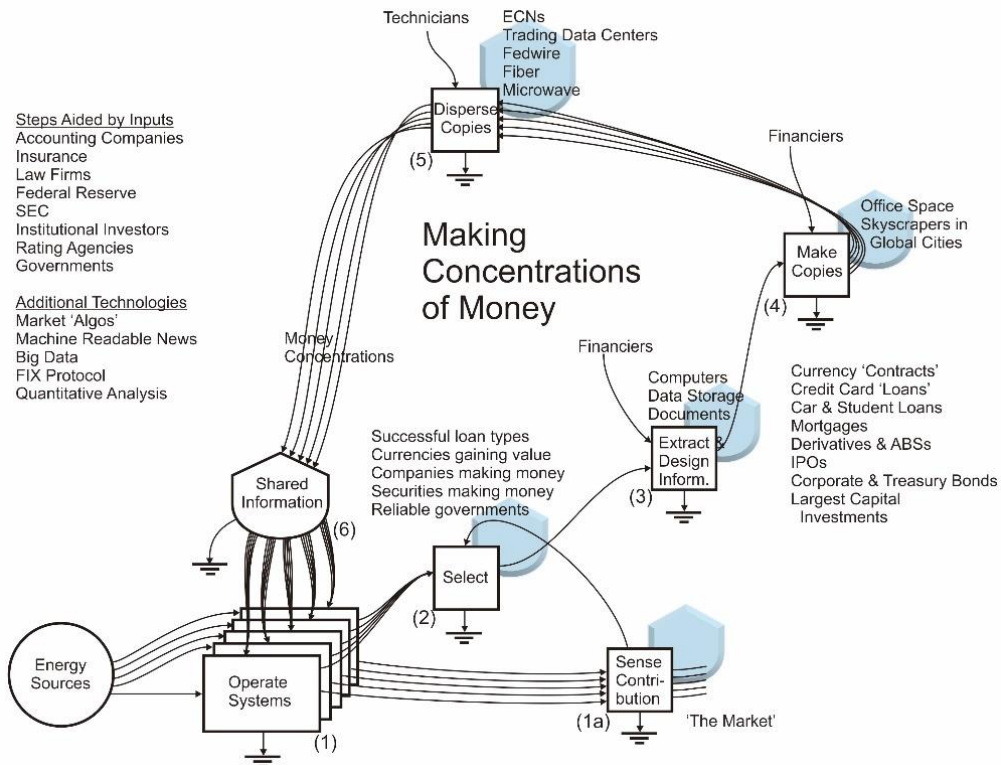
A hierarchy diagram of some of the concentrations of money produced in the financial industry. Hierarchies typically indicate convergence, that is, the movement of matter, energy, or information (including money), into fewer and fewer objects that last longer and have controlling feedback effects on preceding scales (Odum 1996).

Implications for conceiving of a realm of human activity as a hierarchy are several. Hierarchies typically indicate convergence, that is, the movement of matter (biomass, goods), energy, or information into fewer and fewer objects that last longer and have controlling feedback effects on preceding scales.

While objects to the right in the hierarchy last longer, they also take longer to produce. Therefore, changes to the systems of production at these larger scales come more slowly, and are less responsive to shifting conditions. This can add stresses to the production system they are designed to control, an issue that will be of focus in the final discussion.

### **The Production and Maintenance (Evolution) of Money Concentrations in Information Cycles**

The ‘production’ of concentrations of money is the business of banks (and governments). They make money by making concentrations (they get a cut). Will they succeed in making a concentration, and how big? ‘The market’ chooses to add investor’s money to a concentration (to buy stocks, bonds, etc). As in any form of ‘selection’, we can break down the selection process into essential steps using the ‘information cycle’ (Figure 7). In human culture, wherever there is selection, there is an information cycle.



**Figure 7: The Evolution of Money Concentrations in Information Cycles**

The information cycle model can be used to conceptualize the production and maintenance of any form of information, including concentrations of money. Successful concentrations and their design are selected by the market and reproduced throughout the industry in many copies. The information cycle draws attention to the supporting resources and technologies required at each stage of design, copying, and dispersal of the money concentrations. Additional inputs are listed on the left and incorporated in Figure 9.

In this information cycle for the financial system, we see the necessary cycling of some of the many forms of money concentrations produced. In the market, successful loan types, currencies making money, securities making money, corporate bonds and treasuries, companies making money, even reliable governments are all ‘selected’ as models to be reproduced (2). In depository and investment banks, as well as other financial institutions, successful forms of equities and loans are recognized and their designs extracted (3) to be assembled into new financial instruments. These designs are then replicated into many copies (4). Those copies are dispersed (5) into the economy (1) where they ‘live their lives’. Again, if they are successful within the larger economy, they may be selected to be copied again.

Some of these cycles are extremely fast, for example, cycles for currency ‘contracts’, which are sold at blistering speeds by computer programs in high frequency trading (HFT). Credit card ‘loans’ are also relatively rapid; as we might produce many in one

day (hence they are located to the left in Figure 6). Data regarding these cycles is collected and successful designs are identified. Other designs of money concentration cycle much more slowly, and industries that reproduce them take more time to refine successful designs for their next iterations. Examples are home mortgages, derivative types, asset-backed securities, initial public offerings (IPOs) of shares for a company, treasury bond issuances, corporate bond issuances, needed for building oil refineries or the largest capital investments, many of which come from concentrations of taxes by national governments (located to the right in Figure 6).

Figure 7 also lists a few of the elaborate technologies that have made these cycles possible, and we can imagine many more represented by 'storage' symbols attached to each of the step 'processes'. Some listed include the technologies that support the dispersal of concentrations (5), such as electronic communication networks (ECNs), trading data centers, the Fedwire (explained below), miles of fiber optic cables, microwave transmission, and there are many others. Technologies that support the extract (3) and make copies (4) steps include computer networks, data storage, paper documents, and office space, commonly located in skyscrapers of global cities.

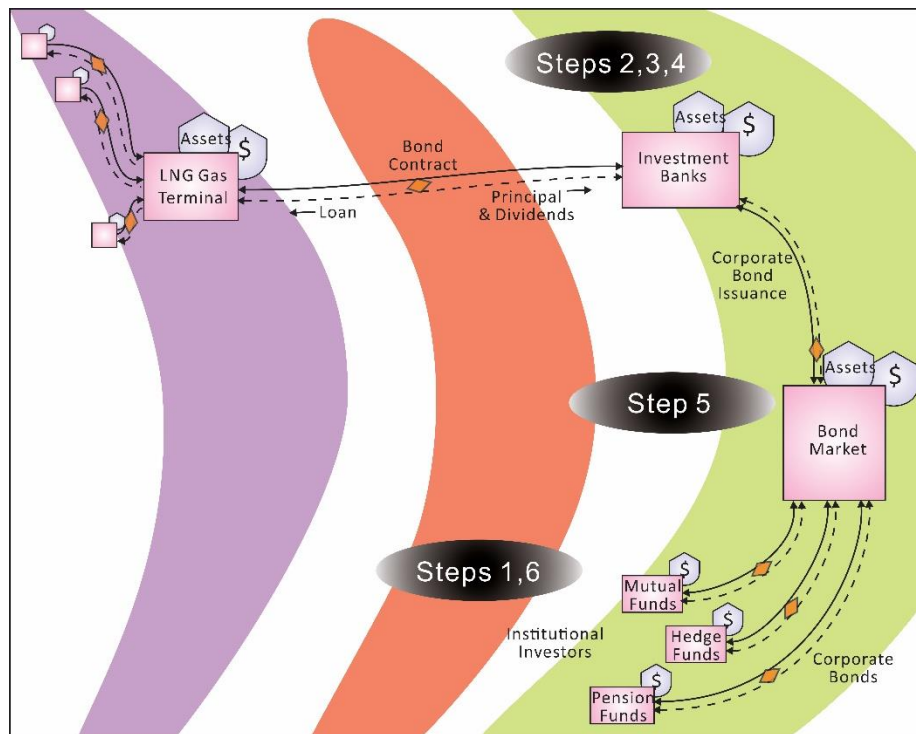
In addition to technologies, essential financial services also contribute to steps 3 and 4. Many financial services are provided by banks in global cities, but as stated in the introduction, investment banks are typically found in 'agglomerations' with strong interfirm cooperation between companies in law, accountancy, insurance, and consulting (Coe, Kelly et al. 2013:207).

Some additional inputs are listed to the left in the diagram and include of course the securities and exchange commission (SEC), rating agencies, quantitative analysts, institutional investors, and governments, and additional technologies such as big data, machine readable news, the FIX protocol, and the countless HFT algorithms (Algos) that populate the new world of electronic trading, as will be discussed in Figure 9.

### **Building a LNG Terminal**

An example of the production and use of concentrations of money will animate this theoretical argument and bring the abstract prepositions to life. An instructive demonstration could be the case of building a liquid natural gas terminal in a southern state along the Gulf of Mexico (Figure 8) (based loosely on the story of Cheniere Energy in Sabine Pass, Louisiana, though the true story is far more complicated and intriguing (Zuckerman 2013)). Over ten billion dollars would need to be raised, and a company would contact an invest bank for that service. The bank could help the company issue stocks or corporate bonds to be sold in the stock or bond markets. They would select (Step 2, Figure 7) known successful forms of stock or bond issuances, extract and copy forms (Steps 3 & 4, Figure 8), and disperse the new issuance through exchanges (Step 5, Figure 8). Institutional investors (including the Blackstone Group's GSO fund, the Paulson & Co. hedge fund, Temasek Holdings a

Singapore SWF, private equity firm RRJ Capital) would be willing to purchase those assets if they were rated favorably and seen to be a good investment (in Steps 6 & 1).



**Figure 8: Building a Liquid Natural Gas Terminal**

An investment bank raises financing for construction of a LNG terminal by issuing corporate bonds. Investors purchase those bonds, and in this diagram a few of the key institutional investor types have been identified – mutual funds, hedge funds, and pension funds (Steps 1, 6 refer to Figure 7). Bond money flows to the terminal and dividends and later principal flow in the opposite direction. With bond money, the terminal can purchase necessary supplies, components and services from many subcontractors. Notice between subcontractors and the gas terminal that goods flow in one direction and money in the opposite, which is the standard (non-financial) convention in an economy (Figure 2b).

If stock or bond sales were successful, needed concentrations of money would flow to the LNG company and they could begin construction. With that money they would hire and pay many subcontractors to construct the terminal. The company would be responsible for paying a regular schedule of interest or bond dividends. At maturity, the company would need to repay the principle to bond holders. Hopefully by that time the company is making profits that can pay off the bonds.

### Central Banks

A Central Bank is the bank of a nation (Dorman 2014:293ff). Most are non-profit institutions owned and operated by a federal government. The US Federal Reserve is

a unique central bank as a private institution, but as all central banks, it has the responsibility to promote economic stability and growth. Central banks typically issue currency, regulate and supervise the banking system, and devise a national monetary policy. Monetary policy has typically been focused on preventing inflation by controlling the money supply. Sometimes called the Money Supply Channel, the Federal Reserve of the US would add money to the economy by buying US Treasury bonds (Dorman 2014:299). Money to purchase bonds is 'created' when the Fed makes those purchases, and is thus added to the economy. Conversely, as inflation rises, the Fed can sell its Treasury bonds, removing money from the economy. In the past decade, however, this Money Supply Channel has been 'broken' due to a number of factors including low interest rates. In response, the Fed and other Central Banks worldwide have taken other steps to invigorate the economy, sometimes called the Asset Price Channel, in which central banks purchase a number of asset types directly from the market, thus injecting more money into the economy, and removing some of the more troubling assets that contributed to the financial collapse of 2008. The US Fed currently holds almost a trillion dollars in mortgage backed securities (MBSs) that sparked the financial crisis. This practice of buying a range of assets is called Quantitative Easing.

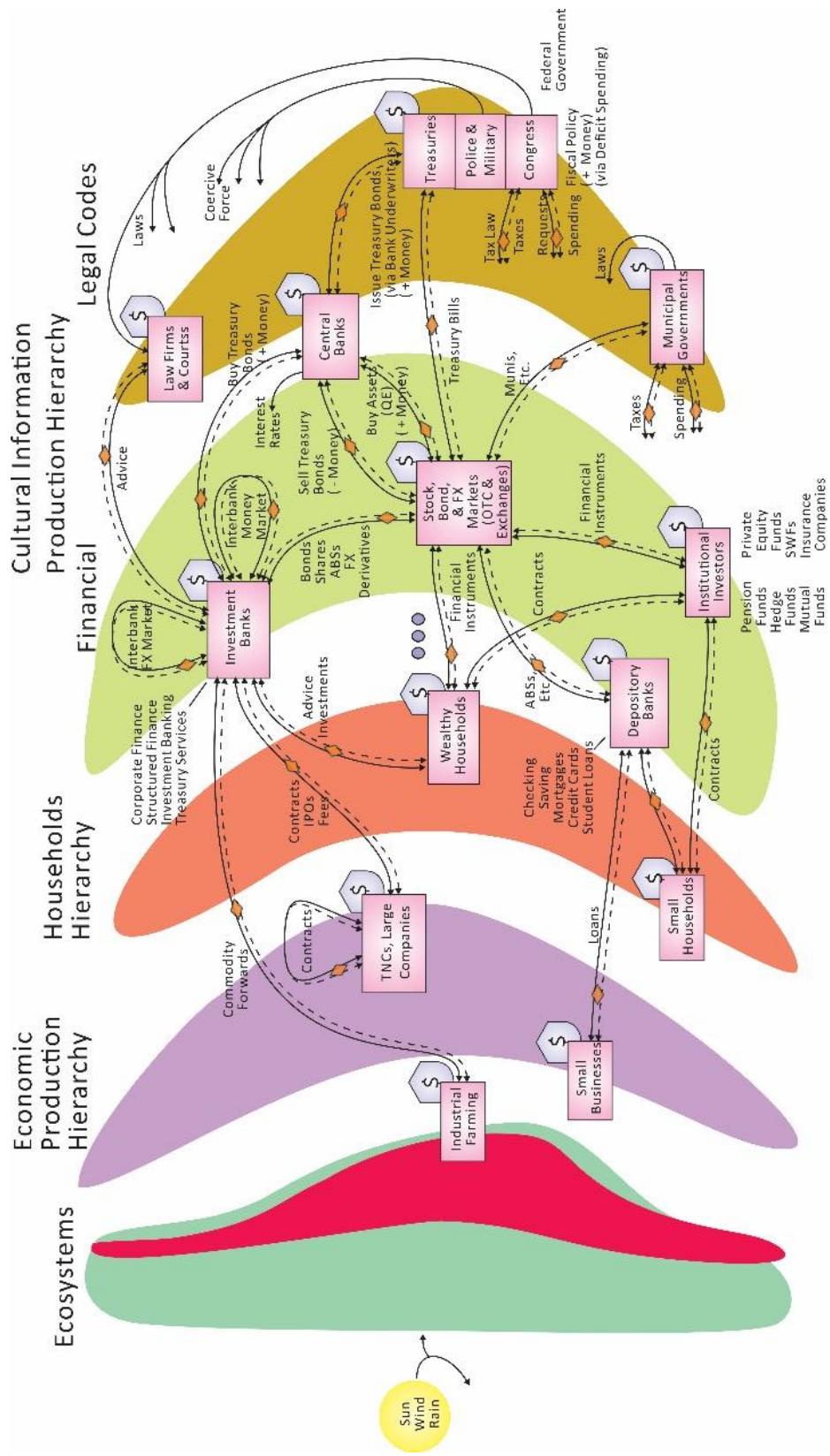
Central banks are also managers of foreign exchange for a country. They need to keep supplies of foreign currencies on hand to facilitate international transactions. The majority of US dollars in the world are held by foreign central banks, as dollars remain the preferred currency for international business transactions.

Last, central banks are the bankers to the government. The banks manage government tax revenue, pay government employees, and purchase Treasury bonds when government spending exceeds tax revenue (in most years). Two technologies aid these functions. The Automated Clearing House (ACH) processes payments electronically, including payroll, mortgages, tax refunds, Social Security and other government transfers. The Federal Reserve Communications System (Fedwire) speeds transactions among financial institutions, government agencies, and citizens.

### **The Financial System**

We can now locate the main features of the financial system within the larger economy and society (Figure 9). Key ingredients are Investment Banks, Depository Banks, Exchanges and OTC Markets, Central Banks, and Institutional Investors such as Insurance Companies, Pension Funds, Hedge Funds, Mutual Funds, Private Equity Funds, and Sovereign Wealth Funds (SWFs). Law firms and courts implement the vast array of legal codes related to the structure and behavior of the economy. These pieces connect and serve corporations, wealthy and small households, national treasuries, and government agencies for taxing and spending. The financial system located within the larger society and biosphere is represented in Figure 9.





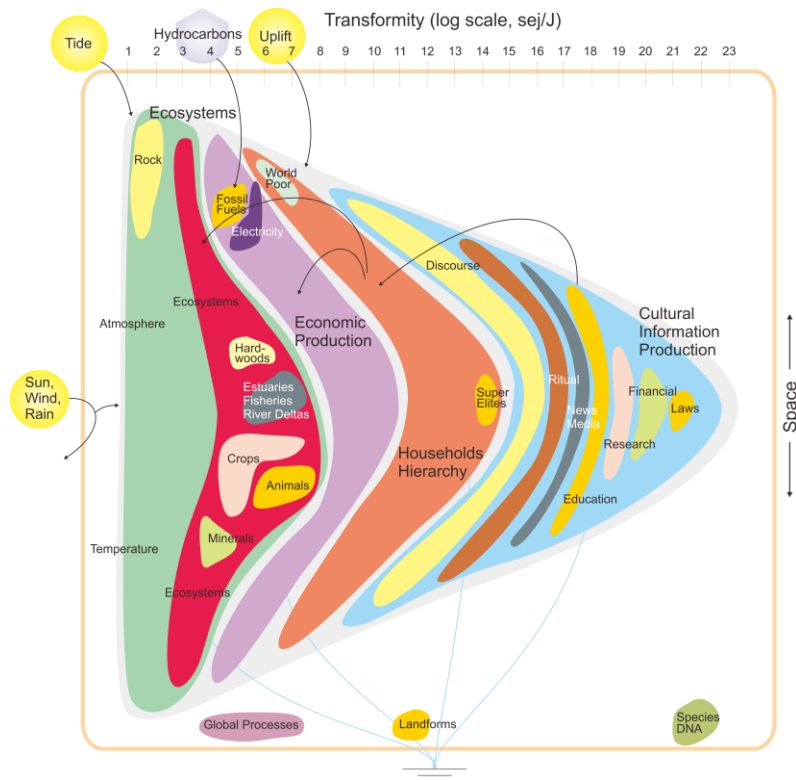


**Figure 9: The Financial System within Economy and Society**

The pieces of the financial system from preceding diagrams are assembled in this diagram, including depository and investment banking, corporations, farms, individuals, markets, institutional investors, and law firms. Central banks are now included on the border of the legal and financial scales they are often private corporations, but all central banks work with governments to manage money supplies. Perhaps the most essential entities in the financial system, often overlooked or underappreciated by economists, are the municipal and federal governments. They produce some of the largest concentrations of money and spend that money on national scale projects, including space exploration, dams, energy infrastructure, and military systems. Perhaps more important still, by the production of laws and their use or threat of force, through police, military and the courts, they assure the value of money and endeavor to create opportunities for corporations.

In this diagram are assembled the two bank types from Figure 4 and Figure 5, depository banks and investment banks. As in those diagrams, they are connected to small and wealthy households, transnational corporations (TNCs), and institutional investors. The diagram adds connections to Central Banks, and to National and Municipal Governments with their Treasuries and Law producing bodies. Notice that now the colored regions are labeled, and the diagram is a depiction of *scales* in a global hierarchy of the biosphere. Scales are Ecosystems, an Economic Production Hierarchy, a Households Hierarchy, and a Hierarchy of Cultural Information Production, and each of these is a nested hierarchy itself. As stated above, systems of all kinds produce hierarchy as a natural outcome of energy self-organization (Odum 1996:23).

The hierarchy of natural and human systems within the biosphere has previously been depicted by Abel (2011) (Figure 10). The locations of the shaded scales in the diagram were determined in large part by individual energy analyses. The scales are spatially organized around global centers of economic production. Production peripheries are located top and bottom. Therefore, for example, the centers of economic production, household inequality, finance and law are aligned in the center of the diagram and furthest to the right within their scales, i.e., arranged by transformities. Figure 9, above, is an abbreviated form of this diagram, that uses the same hierarchical configuration.



**Figure 10: The Hierarchy of Natural and Human Systems within the Biosphere**

In final form, Figure 9 can be located here in Figure 10. The same arrangement of Ecosystems, Economic Production Hierarchy, Households Hierarchy, and Cultural Information Production are also found in this still more inclusive diagram of the biosphere. Humans and our economies are parts within a biosphere whole. The shape of this diagram is based on emergy research (transformities), and is assembled in Abel (2011). This diagram adds the dimension of space, with curved scales centered vertically on global urban cores, homes to the financial industry. Flow of energy and materials move generally from left to right, with control feedback depicted by arrows. The Cultural Information Production Hierarchy includes the financial and legal scales from Figure 9, and can now be seen among other information forms, including TV, ritual, education, and research (Abel 2014). The products of these information industries are nested and interacting forms of communication that we all know, while in a systems sense they provide feedback ‘control’, as do concentrations of money in the economy. The interactions among the Cultural Information Scales can be seen in Figure 11.

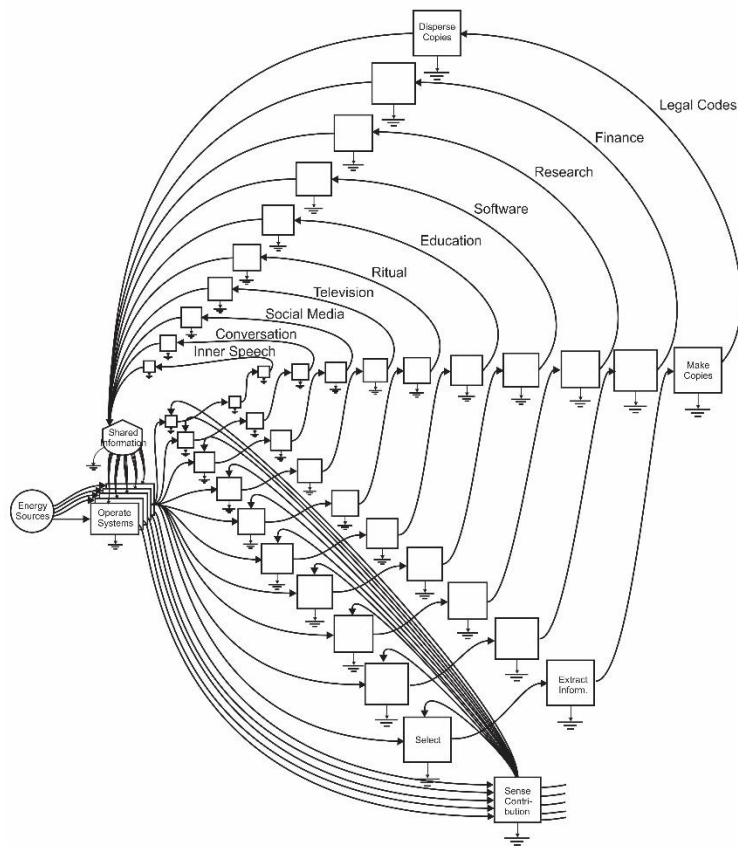
Figure 10 includes more detail for the hierarchy of Ecosystems (left) found in the world. And it includes a more detailed representation of the Hierarchy of Cultural Information forms (right), of which most scales were omitted for clarity from Figure 9. The financial industry can be located in this diagram, centered mainly in the two far right scales of Cultural Information Production (Finance and Law). Again, the arrangement of the scales within the global hierarchy is largely the result of individual emergy analyses conducted for systems within those scales, and thus acquires a higher degree of validity than other conceptual arrangements, though the detailed analysis of cultural information forms is only beginning.

The overarching value of this diagram is to clearly depict the location of finance, and cultural information generally, as nested and dependent upon the totality of planetary and ecosystem context, upon which human economy and household have self-organized. In a recent study of the evolution of ideas from foragers to farmers to our current fossil fuel societies, the archaeologist and historian Ian Morris has argued that each age ‘gets the ideas it needs’ (Morris, Seaford et al. 2015)<sup>iii</sup>. From an energy systems perspective, those ideas must include reinforcing nurturance of all scales of human-nature systems, including ecosystems, primary economic production, and the diversity of human households. This does not suggest that we are today living in the best of all possible worlds (Footnote i). The struggle for useful and just financial systems is never-ending, and is only a piece of that societal self-organization.

In his detailed reconstruction of world history, Morris identifies a few ‘hard ceilings’ reached in the process of social development that awaited more dramatic innovations to push onward (Morris 2010). While Morris does not identify the current stagnating energy regime as a new hard ceiling, it is difficult to look at this diagram and not see material and energetic limits to growth.

### **Nested Hierarchy of Cultural Information Production**

This last diagram (Figure 11), expanded from Abel (Abel 2014), is an alternative depiction of the multiple, nested scales of Cultural Information production (the assemblage of scales furthest to the right in Figure 10). What this diagram adds is a clear depiction of the *interaction* between scales of culture production. It might appear from the previous diagrams that financial information and legal codes feedback dominating control over the hierarchy of natural and human systems, shaping other information forms and leaving households powerless to resist the interaction of finance, law, and economy. That is not the implication.



**Figure 11: Nested Hierarchy of Cultural Production**

This diagram is an elaboration of Odum’s (Figure 1) model into the realm of cultural production (revised from (Abel 2014)). When anthropologists think of the construction of culture in context, negotiation, struggle, in ‘discourse’, they regularly refer to (the ‘scale’ of) conversation. I argue that culture is equally produced and reproduced in each of the other scales shown in this diagram. Cultural information produced in any scale may be ‘picked-up’ by same or any other scale to be cycled again. By moving out to larger scales, new energies are applied, information may be shared more widely, and its turnover time is increased. Notice each scale returns information to the world where it is ‘lived’ and continually (con)tested. The fate of any piece of information is unknowable, but we should expect that information that is selected will over time contribute to self-organization at some scale of the social-ecological-information context. The scales in this diagram are also found to the right in Figure 10.

What Figure 11 suggests is the constructive and negotiated nature of culture, as emphasized now several times. Ideas produced at all scales return to people in ‘the world’ (the process box ‘Operate Systems’, in Odum’s terse phrase, the ‘systems’ location of all material, energetic, and information interactions in this highly aggregated diagram), where they have the potential to be picked up by any other scale. All ideas, whether produced by social media, ritual performance, classroom lecture, or everyday conversation, return to the world where they are (con)tested and selected, or not, for cycling anew. Ideas of value, by whatever metric, can be shared

at any scale. What is added by moving up-scale is the *wider sharing* made possible by additional energies and technologies for dispersal and durability of information. At the conversation scale, ideas are shared among a few people, carriers are sound waves and human memory, and transmission is imperfect. At the scales of finance and legal codes, ideas are transmitted worldwide, and carriers include redundant and highly protected electronic storage, and even more durable paper carriers, stored in libraries or repositories in copies around the world. They thus have powerful controlling force. But again, those ideas are the *products* of endless interaction of information in all scales of cultural production. And systems that persist require reinforcing feedbacks to all inputs of value, including essentially the work of natural ecosystems, primary economic production, and households, and all must be nurtured. As was stated above, each age gets the ideas it needs, and the ideas at all scales must contribute ultimately to total system nurturance, again, if the system is to persist.

The challenge for the current age can also be seen in this diagram. As cultural information is bumped up to higher scales, the cycle times of information increase. The time required to cycle and select useful academic ideas can be years. The maintenance and fundamental reforms within a financial system can take longer. And as we know, amendments to fundamental laws, such as the US Constitution, can take decades. While we all live at the temporal scales of our everyday lives, thoughts, and conversations, these slower temporal scales of cultural production and innovation lead to the appearance of unresponsiveness, creating stresses and frustrations. The current caustic social milieu of TV, social media, movies, and conversation reflect those stresses. But this is valuable, as it is only the continuous struggle and negotiation at these smaller temporal scales of cultural production that can lead to the 'needed' innovations of science, finance, and law<sup>iv</sup>.

### **Doing its Part?**

To return this abstract conversation to the specific topic of the financial industry, we should ask whether or not the financial industry is doing its part in producing concentrations of money to move resources for real production. Is there grand purpose or only pedestrian explanation for the current frenzied tumult of market and investor that we find in the financial system today? According to Dorman, writing in a textbook for Economics majors (Dorman 2014):401):

The financial sector...does not produce anything directly useful. Instead, it provides an input into the production and consumption opportunities available to its clients, in the same way that an electricity producer provides energy that its customers use for their own purposes.

The electricity analogy, though imperfect, is instructive. Electricity, and fuels, at one end push the economy, while concentrations of money at the other pull it forward (Figure 10). As such, it is efficiency that matters most in the production of these two enablers. As Dorman continues:

What should matter is not how much profit can be made from financial services, but how much profit and consumer benefit they help the rest of society enjoy. It is not the mark of an efficient economy to have an especially large financial sector any more than it is desirable to spend a lot of money on electrical power (Dorman 2014):401).

In the lead up to the financial crisis of 2008, the production of concentrations of money in the mortgage market grew at a frenzied pace, as did profits in the financial industry, while other sectors stagnated and the price of oil reached new highs—until it all collapsed. Post-crisis, lending has not recovered, as banks hold on to their money despite incentives from the Federal Reserve such as near-zero interest rates, while the stock market hits new highs and banks are again awash with profits. It appears that in its role of producing concentrations of money to move resources for real production the financial industry is not doing its part. Instead, the economy as a whole is wasting its money on overpriced financial services, as an elite minority of bankers and other industry elites enrich themselves.

## **Conclusions**

The ability to produce pools or concentrations of money is utterly essential to any economic system today. The forms of those pools and the knowledge and technologies to produce them have been evolving for centuries. The evolution of any information form is the product of information cycles. Due to the fragility of all information carriers, it is necessary to copy and disperse successful designs, only later to select again successful forms for a new cycle. By this process, valuable information is maintained against loss and depreciation, and, with chance and innovation, evolves. This paper has used the information cycle model to tease apart the necessary steps for the production, maintenance, and evolution of pools of money within the financial industry. The pools of money are the information that guides or directs the real economy of goods production.

The information cycle model, together with systems concepts of hierarchy and self-organization, force us to conceptualize economic production and the financial industry in new light. The financial industry builds concentrations of money in a hierarchy of forms that differ in increasing frequency, size, duration, and space (Figure 6). With increasing scale, the concentrations of money have increasing ability to direct and control the structure and function of the real economy. The various forms of money concentrations and the knowledge and assets to produce them are maintained in information cycles.

Within the hierarchy of natural and human systems, therefore, financial information production is in a key controlling position furthest to the right. Only the legal codes produced by government and backed by the coercive forces of the state exceed it in a position of control. This paper draws attention to these powerful controlling forms of information produced by society. But as in Figure 10 and Figure 11, we recognize

that financial and legal information are not isolated from any other component in human and natural systems. Financial and legal information must feed-back reinforcing controls for the household, economy, and ecosystem scales of the biosphere system that supports them. National and global economic systems must be resisted and replaced if they do not serve this end. The production of cultural information occurs in a nested hierarchy of information forms (Abel 2014), and all forms, beginning with simple discourse, converge ideas up-scale to the right. In other words, in the production of all forms of information we have the potential to transform the powerful information scales of finance and law. Information from any scale is (con)tested and potentially upgraded to those scales of greatest control.

People occupy and manage each scale of the hierarchy. While none conceptualize the total of nested scales of process, institution, and idea, each person responds to stresses within their context of interaction with the world. Responses to stress vary widely and may seem uncoordinated, but they are responses nonetheless and actions in parts reverberate up and down scales including the scales of cultural information. Objections to the current state of finance, listed at the beginning of the paper, are becoming widely known. Demands for reform are growing. At the same time demands for upheaval are also heard. Due to the fact that turnover times increase as one moves to the right in each of the scales of ecosystem, economy, household, and idea, the often slow and halting paces of dramatic change to slower-turnover-time objects of material and idea (finance and law especially) can themselves add extra stresses. And there is no guarantee that any system or part will not be replaced rather than reformed. But whatever the process, ultimately, changes to driving inputs and natural systems on the left of Figure 10 will demand changes on the right. At the same time, changes to the right will seek to amplify and manage inputs from the left. The forms that information takes are the product of negotiation, and must ultimately include preservation, not consumption or destruction, of the human and natural systems that support it all.

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<sup>i</sup> The best of all possible worlds? Finance is a politically charged and controversial topic. Systems thinking that recognizes the cycling of culture is not politically conservative and acquiescent to the status quo, but instead incorporates contingency and action, resistance and choice. The financial industry, and the economy it widely but incompletely controls, is nested in the multiple scales of nature and idea, and must self-organize with the whole. Countless authors, including economists, have raised reasonable and serious objections to the present state of global finance. These include



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the current diminishing of prudential regulation, the shrinking time-horizon of management, shareholder value maximization, the financialization of non-financial corporations, regulatory capture (the revolving door between industry and regulators), an expanding pro-finance ideology in which finance workers develop ideological conviction in support of the industry (in the same way that pro-military ideology has engulfed weapons producing countries), the rise of shadow banking outside of most forms of regulation, for-profit rating agencies, our consumptive behavior in which our borrowing composes debt instruments that are ironically purchased by the very pension funds we depend upon, the growing use of margin debt for investing with borrowed money, stock buy-backs that pump up stock prices and siphon away money that could improve company real value, foreign direct investment with little positive and many negative spill-over effects, ‘free trade’ agreements that stifle democratic processes around the world, and in general the financialization of the world economy, in which all sorts of assets and things are transformed into financial instruments for trading in international markets, just to name a few of the well-known problems with the current financial system (Chang 2014, Dorman 2014). All of this is hardly the Panglossian outcome of benevolent forces of self-organization, a slander sometimes aimed at systems theorizing. Instead, this suggests that struggle and resistance are an essential part of the self-organization of ideas with economy and nature. As you will see, the energy systems theory of the information cycle expects contest, negotiation, and struggle as information self-organizes with its dynamic, multi-scaled human-nature context.

<sup>ii</sup> In Europe, these two forms of banking are typically included within one institution, while in the US they were separated in 1933 under the Glass-Steagall Act, only to permit rejoined after its recent repeal.

<sup>iii</sup> HT Odum was often heard to say something similar (personal communication). Odum and Odum 2001:286 is an example.

<sup>iv</sup> HT Odum explained this slow accumulation of ideas, resulting eventually in a sudden shift of opinion or action with his pulsing model (Odum and Odum 2001:270). The slow turnover time of cultural ideas explains that pulsing behavior in his model as it does the model in this paper, however, this model offers a more detailed explanation of the process.