Emergy of the Occupations

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ABSTRACT

In this paper we calculated the emergy contributed to the economy of the United States in the work done by the workers of 558 occupations in 2008. We determined the empower (semj/yr) delivered by an individual engaged in each occupation, the transformity of the occupation's work or the emergy delivered per joule of work done by a participant in an occupation, the emergy delivered per hour of work done and the total contribution of emergy to the economy from the work done by the occupation's workers in a year. We analyzed the data on U.S. occupations on the basis of the individual occupations and the occupations aggregated by Standard Occupational Classification Code (SOC) and Job Zone. Based on theoretical arguments illustrated with three Energy Systems Language models, we hypothesized that there should be a linear relationship between monetary compensation received and emergy measures of the knowledge and experience delivered in the work done as measured by the emergy of the education and training required for performing the work of an occupation. Our results were consistent with the predicted results of the hypothesis. We characterized the structure of the workforce of the U. S. from an analysis of employment, empower production and compensation received by Job Zone. We found that the lower to middle range (Job Zones 2 and 3) were the heart of U.S. economy from both an emergy and an economic perspective. However, when the emergy delivered by the occupations to the U.S. economy was analyzed, economic measures tended to overvalue the skilled occupations and undervalue the unskilled ones compared to emergy measures of the education and experience contributed. We noted the theoretical and practical limitations of this analysis and the need for future work to better characterize the contributions of on-the-job training to the emergy delivered by the workers in an occupation.

INTRODUCTION

This is the fourth in a series of studies undertaken to establish an emergy basis for evaluating and understanding social systems. To accomplish this end, our work has focused on developing methods to document the emergy required for the delivery of human services (work of all kinds performed by people) within a socioeconomic system. We assumed that people deliver information (i.e., their know-how) to the system, in the course of providing their work, which contains emergy equivalent to that required to develop their knowledge of and experience in performing the particular occupation. The work done within the system must be that for which the person has been trained for this assumption to be valid. This paper builds on three prior papers: (1) Campbell and Lu (2009a), in which the authors revisited the emergy basis for the United States by incorporating a more complete accounting of the minerals used in the U.S. economy and updating the transformities for those minerals by using, and in some cases modifying, values given in Cohen et al. (2007); (2) Campbell and Lu (2009b), in which the authors evaluated the education system of the United States from 1879 until 2006 and provided estimates of the emergy required to create an individual at each stage in their educational development from elementary school through professional school and the doctorate degree; and (3) Campbell, Lu, and Kolb (2011), in which, the emergy of educational attainment in the U.S. was documented from

1948 to 2006. The emergy of the workforce was calculated by adjusting educational attainment for those too young to work, retirees, and the unemployed. Next the emergy delivered by the workforce was taken as an additional source of emergy driving the U.S. economy, along with the emergy of local renewable and nonrenewable energy sources and imports. Furthermore, we recognized that the emergy of the work force is delivered to the U.S. economy through the work of people participating in the occupations. In the current study, we documented the emergy of 558 occupations by drawing on data from Campbell and Lu (2009b) and data from the U.S. Bureau of Labor Statistics, (http://www.onetonline.org/link/summary/51-3011.00), *i.e.*, O-NET Online, to calculate the emergy required to train an individual in each occupation in solar emjoules per individual (semj/ind.), the emergy delivered by a practitioner of each occupation per hour (semj/h) and per joule (semj/J) of work done, and the emergy delivered to the U.S. economy by each occupation in 2008.

In this paper, we are concerned with the emergy required for the human service work performed in an economy, which is also the emergy delivered by an hour of work performed in an occupation (Campbell 2001). We hypothesized that there should be a relationship between the monetary value of the work done and some aspect of the real wealth delivered by that action. Real wealth is what an item can do when it is used for its intended purpose, *e.g*., a gallon of gas will allow a given car to drive only a certain number of miles regardless of the price paid at the pump. Real wealth is measured by emergy. The fundamental nature of this hypothesized relationship can be understood by returning to John Locke's observation that the one thing that a human being possesses, which is uniquely his own, is his labor. This is the underlying reason money is paid for the work done by an individual. The logical follow-up question is, "what is the real wealth delivered in an hour of a person's work?" The answer is, it depends on what the person does in that hour of time and this depends on what the person knows how to do, which in turn is a product of the knowledge and experience of the person at that point in time. Therefore, we formulated the following hypothesis: the money paid to a worker in an occupation should be linearly related to the emergy of the knowledge and experience possessed by an individual trained to do the work of that occupation. One caveat being that the person must be employed to carry out the work for which they have been trained. A second caveat is that this relationship will depend on the existence of equilibrium prices in the labor market, i.e., there are no perturbations in the labor market due to an unforeseen shortage or surplus of workers in a given occupation.

One objective of this study was to perform an analysis of the data on U.S. occupations to determine if observed relationships within the U.S. economy in 2008 were consistent with the hypothesized relationship. A second objective was to provide a ready source of detailed data on the emergy delivered through the labor of U.S. workers in a broad range of occupations for use in future emergy analyses. A third objective was to gain a better understanding of the structure of the U.S. workforce as revealed by emergy evaluation.

METHODS

A method for evaluating the education and training requirements for occupations was found in Scoville (1966). He relied on a U.S. government publication *"Estimates of Worker Traits Requirements for 4000 Jobs"* as a starting point for the data and methods used in his study. In this work, the necessary educational and training times were defined as "… the amount of educational development and vocational preparation necessary for a worker to have acquired the knowledge and abilities essential for average performance in a specific job" (U.S. Department of Labor, 1956). These two elements were classified as General Education Development (GED) defined in 7 steps of school equivalent years from 0 to 18 and Specific Vocational Preparation (SVP), which was quantified as 9 levels of vocational preparation from 0 to 12 years. This early paper validated our general assumption that, ideally, we wanted to document both the education and work experience required for each occupation. The question then became, "Can we find the necessary information to document education and experience levels for each occupation in the U.S. economy?

We found that the U.S. Bureau of Labor Statistics collects a wealth of information on U.S. occupations. This information is available as a detailed outlook for each occupation (http://www.bls.gov/oco/ooh_index.htm) and in O-NET, which provides comprehensive information on key characteristics of the occupations including Job Zone and educational level attained by the workers performing the various occupations (http://www.onetonline.org/link/summary/51-3011.00). We collected information on the occupations used in this analysis from these two U.S. Bureau of Labor Statistics websites. These data are reported in the online supplement (http://www.epa.gov/aed/research/desupp6.html): Standard Occupational Classification (SOC) Code; Number Employed (2008); Median Annual Salary (2008); Bonuses; Benefits provided, *e.g.*, Health (H), and Life (L) insurance and Retirement (R); Basic Education Required; On-the-job training in months; Degree or Training for Advancement; Job Zone (from O-NET); Licensure, continuing education, etc.; Average Education Level (from O-NET survey data) classified as the percent of total workers with the following education levels: Primary School; High School; Some College, no degree; Associates Degree, 2 years; Bachelors Degree; Masters Degree, including MBA; Professional Degree, JD, DDS, MD, etc.; Ph.D. Degree; MD with Internship and Residency; Advanced Dental Training. The emergy of each education level was calculated for 2006 from data supplied in Campbell and Lu (2009b), except for the emergy associated with advanced medical and dental training, which was calculated in this study from data in Campbell and Lu (2009b) as well as data from other sources. When 2008 data were not available, 2010 data were first used as the best replacement. If 2010 data were unavailable then 2011 data were used. Data from 2010 were used for missing data on the number employed and salaries, whereas, 2011 data was used occasionally to supply data on salaries.

Initially, we collected data on 845 occupations, but only 650 occupations reported survey data on the education levels that existed within the occupations and only 48% of these occupations reported quantitative information on the additional training required. In addition, examples of inconsistent and unreasonable values for the SVP data used in an earlier study were discussed by Scoville (1966). We decided that we were unable to consider on-the-job training and experience in a consistent and thorough manner within the time limits available for this study. We were fairly confident that the education data associated with the occupations was reasonable, since it was derived from a statistically evaluated survey (American Community Survey, http://www.census.gov/acs/www/) performed by U.S. Census Bureau. For this reason, we chose to only use education data to estimate the emergy supplied by the practitioners of each occupation. We recognized that this choice would lead to a conservative estimate of the emergy indices of the occupations, but for this initial study we felt the consistency and justifiability of the estimates outweighed the benefits of a partial and less accurate estimate of experience levels. Once we had determined that we would use education levels within an occupation to estimate the emergy required to create the knowledge of an individual practitioner, we proceeded to calculate the emergy per individual, the emergy delivered per hour of work and per joule of metabolic work of an individual in an occupation and the total emergy contributed to the U.S. economy in a year based on the work performed in each occupation. All emergy per unit factors used in this study are expressed relative to the 9.26 E+24 semj/yr base line recommended by Campbell (2000) and Campbell et al. (2005).

Several assumptions were needed and several parameters had to be chosen to make these calculations. We could easily calculate the emergy required to create the knowledge of an individual in each occupation by multiplying the fraction of the total participants with each level of education by the emergy required to train a person with that level of education based on existing studies of the U.S. education system (Campbell and Lu 2009b). With this primary decision in place, we could calculate the emergy of an average individual engaged in a particular occupation based on the prorated emergy of education observed within the occupation. However, when we wanted to determine the emergy delivered per hour of work or per joule of metabolic work a question arose with regard to the amount of time that it would take for a person to deliver their knowledge to the system. Whereas, it takes the training of the entire knowledge base to deliver a given action (*e.g.*, because the nature of any discrete action is unknown, *a priori*), in fact, only a small fraction of the total information base of an individual

is delivered in action during any increment of time. We note that knowledge is reinforced by use and that after a certain period of disuse, knowledge may be expected to fade. Without doing a more sophisticated analysis of the dynamics of information storage in the mind, we assumed that the entire knowledge-base of an individual would be drawn upon, directly or indirectly, over the course of a year's work in the occupation. This is certainly a simplification but it is perhaps not an unreasonable one, when one considers the variety of problems that an individual in any given occupation may confront over a year. With this assumption in place we could define the emergy delivered per joule of metabolic work given that a person consumes about 2500 kcal per day (Odum 1996), the metabolic energy required to support a person over a year is 3.82E+09 joules and the emergy per individual divided by the joules of potential metabolic work performed in a year gives the transformity of the work in an occupation in solar emjoules per joule (semj/J).

To determine the emergy delivered per hour of work on the job we simply determined the average number of joules that would be expended in an hour of labor based on the annual available energy used and then multiplied it by the transformity of the work. Data on the hours worked in a week was given for many occupations in O-NET and most people worked a 40 hour week with some exceptions, *e.g*., actors and artists worked longer hours and dental specialists fewer. Finally, the emergy per individual was multiplied by the number of people employed in that occupation to estimate the emergy contributed to the U.S. economy by the work performed in the occupation during a year.

Once the emergy indices were calculated, we checked the data again to make sure that all of the occupations had data recorded that would allow further analysis. We found that employment was not reported for all of the occupations on our list. To accommodate this fact, we aggregated occupations into the classes for which employment was reported. In general, this meant that more detailed information was simplified by taking an average of the values and applying it to the number employed in the more general class. After this process of aggregation was complete we had reduced the number of occupations with complete data to 558 and the aggregated occupations had emergy per individual values that were the averages of the occupations combined to form the aggregate class.

One final adjustment was made to take into account the extra education that medical doctors and dental specialists receive. To do this we estimated the average time spent in internship and residency by a doctor training in the various specialties (http://www.aafp.org/online/en/home/publications/ otherpubs/strolling/specialty/residencyprograms.html). Then we determined the number of doctors practicing each specialty in the U.S. in 2007 (AAMC, 2008) and calculated a weighted average time spent in internship and residency for all doctors. This time was approximately five years (4.86) and oral and maxillofacial surgeons spent a similar time in post-medical school education. Dental specialists like orthodontists and prosthodontists spent an average 2.5 years in post dental school training (http://en.wikipedia.org/wiki/Dental_degree). To estimate the emergy per individual required for this additional training we took the emergy of a professional school graduate 5 years earlier in the case of a MD and added the emergy to support a student at the professional school level for each of the remaining 5 years of education. For example, to determine the emergy per individual of a physician or surgeon in 2006, we took the emergy of this individual when he or she graduated from medical school in 2001 and added the emergy needed to support education within the professional school for the intervening 5 years. This sum was multiplied by 0.5 under the assumption that post medical school education is half work and half learning. In addition, we assumed that the emergy needed to support a teaching hospital is at least as intense as that required for university education. This assumption is validated by the work of Lambert (1999), who showed that Shands Teaching Hospital adjacent to the University of Florida campus had the highest empower density in Alachua County.

Emergy analysis of the occupations was carried out on two scales. First, on the scale of individual occupations, we examined the relationships of employment and earnings compared to the emergy of the information delivered in the work done. Our analysis of the individual occupations allowed us to examine the position of various occupations within the overall distribution of occupations as a way to increase our understanding of work force structure. Second, we examined the relationships between employment, money and emergy measures of the workforce as a function of Job Zone. The U.S.

Bureau of Labor Statistics uses five Job Zones to better understand and plan for changes in the aggregate structure of the workforce. Job Zones are defined by education, related experience, and required job training. The Job Zones with their defining criteria and some example occupations are given in Table 1.

Table 1. Characteristics of the U.S Bureau of Labor Statistics Job Zones.

Job Zone	Education	Preparation Needed	Job Training	Job Zone Examples
Job Zone One: Little or No Preparation.	Some of these occupations may require a high school diploma or GED certificate.	Little or no previous work-related skill, knowledge, or experience is needed for these occupations.	Employees in these occupations need anywhere from a few days to a few months of training. Usually, an experienced worker could show you how to do the job.	These occupations involve following instructions and helping others. Examples include taxi drivers, amusement and recreation attendants, counter and rental clerks, construction laborers, continuous mining machine operators, and waiters/waitresses.
Job Zone Two: Some Preparation.	These occupations usually require a high school diploma.	Some previous work-related skill, knowledge, or experience is usually needed.	Employees in these occupations need anywhere from a few months to one year of working with experienced employees.	These occupations often involve using knowledge and skills to help others. Examples include sheet metal workers, forest fire fighters, customer service representatives, physical therapist aides, salespersons (retail), and tellers.
Job Zone Three: Medium Preparation.	Most occupations in this zone require training in vocational schools, related on-the-job experience, or an associate's degree.	Previous work-related skill, knowledge, or experience is required for these occupations.	Employees in these occupations usually need one or two years of training involving both on-the-job experience and informal training with experienced workers.	These occupations usually involve using communication and organizational skills to supervise or train others to accomplish goals. Examples include food service managers, electricians, agricultural technicians, legal secretaries, interviewers, and insurance sales agents.

Table 1 continued. Characteristics of the U.S Bureau of Labor Statistics Job Zones continued.

Job Zone	Education	Preparation Needed	Job Training	Job Zone Examples
Job Zone Four: Considerable Preparation.	Most of these occupations require a four-year bachelor's degree, but some do not.	A considerable amount of work-related skill, knowledge, or experience is needed for these occupations.	Employees in these occupations usually need several years of work-related experience, on-the-job training, and/or vocational training.	Many of these occupations involve coordinating, supervising, managing, or training others. Examples include accountants, sales managers, database administrators, teachers, chemists, environmental engineers, criminal investigators, and special agents.
Job Zone Five: Extensive Preparation.	Most of these occupations require graduate school. For example, they may require a master's degree, and some require a Ph.D., M.D., or J.D. (law degree).	Extensive skill, knowledge, and experience are needed for these occupations. Many require more than five years of experience.	Employees may need some on-the-job training, but most of these occupations assume that the person will already have the required skills, knowledge, work-related experience, and/or training.	These occupations often involve coordinating, training, supervising, or managing the activities of others to accomplish goals. Very advanced communication and organizational skills are required. Examples include librarians, lawyers, aerospace engineers, wildlife biologists, school psychologists, surgeons, treasurers, and controllers.

RESULTS

The results of this study are given in three sections. The first section presents three Energy Systems Diagrams, one relevant to understanding the role of human knowledge and experience in global society and two more depicting human service as the major source of value in market exchange and its role in determining an agreed upon contract price. The second section explores the relationships of the occupations present in the U.S. economy in 2008 and of the number of individuals participating in those occupations as they relate to the annual flows of emergy and money that

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characterized society in that year. Finally, we present results on the aggregate structure of the U.S. workforce in 2008 as indicated by the distributions of people, emergy and money by Job Zone. Also, we have provided data on the emergy per individual for the practitioners of 558 occupations in the Appendix for immediate use in emergy studies. Additional supporting information for the calculation of values for the emergy per individual, transformity, the emergy per hour of work, and the emergy delivered by these occupations to the U.S. economy in 2008 can be found in an online supplement posted at http://www.epa.gov/aed/research/desupp6.html.

Figure 1 gives an overview of global society first presented in Campbell et al. (2005). In this study, the diagram has been altered to show the role of knowledge and experience, K&E, in operating global society. The development of human knowledge and experience is supported by the cycle of teaching and learning and it is applied in the operation of society through the work of the occupations. The knowledge of the occupations is carried into the economy to operate systems at the environmental-economic interface, such as forestry, agriculture, fisheries, mining, *etc.*, *i.e.*, economic use of the environment. In addition, the knowledge of the occupations is used to operate the main economy and all of its important tasks, such as research and development that are needed for technological advances. Human resources are matched with resources from the environment, such as fuels and minerals, F&M, which are the nonrenewable, N, component of environmental resources, ER. Accumulated environmental resources also supply emergy, N_0, to support the global system when potentially renewable resources are used in a nonrenewable manner, *i.e.*, their rate of use is faster than their rate of replacement. Thus, soil erosion, timber harvest and fish catch can be used to support unsustainable economic and social organizations under the aforementioned conditions. In the diagram, Ecosystems, *i.e.*, natural ecosystems, are separated from those environmental systems that lend direct support to human socioeconomic systems. Environmental emergy sources, *e.g.*, sun, wind, rain, waves, etc. support both the natural ecosystems and interface environmental systems. The natural ecosystems also provide ecosystem products and services, EP&S, to support the environmental-economic interface systems as well as the main economy. Wastes from economic and social activities are recycled to the natural ecosystems and the environmental interface systems either directly or after some processing is done. Money, $, flows as a counter-current to material and energy flows between the main economy and the environmental-economic interface systems and between the main economy and other human systems. Used energy, *i.e.*, energy that no longer has any capacity to do work is carried on the gray pathways and exits the system through the heat sink, which is at the background temperature of the environment.

Figure 2a is a diagram of an economic exchange, in which the forces of supply and demand between buyers and sellers determine the market price for Product A, *i.e.*, there are no monopolistic practices at work that distort prices. The economic transaction symbol, the diamond, is in the center of the diagram with money flowing from buyers to sellers and the real wealth in Product A flowing in the opposite direction. The real wealth in the product is measured in solar emjoules (semj) and it appears in two forms: first as the work of the environment that is required to produce the energy and materials comprising Product A, *e.g.*, the iron ore and timber, if product A is a park bench, and second the human service work that has gone into all phases of the production process from mining the ore and harvesting the timber to assembling the manufactured components into a park bench. On one hand, the work done by the environment in producing natural products can be easily documented using emergy accounting, but this value is not part of the economic consideration of market value, because no money is paid to the environment. On the other hand, the work of human service required for the product is easily documented by economic methods, because money is always paid to people for their work and thus under the condition of equilibrium prices, the monetary value of the product carries the accumulated monetary value of the human service work done to arrive at any phase in the production process. As mentioned above we have hypothesized that the emergy of the knowledge and experience of the occupations (semj$_{KE}$) represents the real wealth of human service (*i.e.*, labor) incorporated into Product A. The total real wealth in the park benches above is (semj+ semj$_{KE}$) or the emergy in the materials plus the emergy of all the labor that has been done up to the point of sale.

Figure 1. *An Energy Systems Diagram of Global Society showing the role of human knowledge and experience, K&E, as an additional source of emergy running economic and social systems and their interface with the environment. Renewable resources absorbed, R_a, dispersed, N_0, and concentrated nonrenewable resources, N; provide the remaining emergy supporting order and organization in the global system.*

In Figure 2b, we have represented some factors that affect the exchange of a single product between buyer and seller, assuming that the negotiation between the buyer and seller will determine the contract price. Other economic factors (*e.g.* tastes and preferences, scarcity, opportunity costs) and marginal pricing theory are not explicitly addressed in the diagram, but they are assumed to enter into the knowledge and experience that each individual uses to decide on an acceptable contract price. In the diagram an individual buyer and seller are each depicted as consumers, hexagon symbol, each with a stock of money and a certain amount of knowledge about and experience with Product A. In addition, Product A is composed of two moieties, the emergy and materials in the product, which has an emergy value, represented as solar emjoules, semj, but no monetary value and the human services required to make the product, which has both a monetary value, $, and an emergy value represented by $semj_{KE}$, which stands for the emergy of the education and experience required to do the work. The model looks at the factors considered by the buyer and seller in the process of coming to an agreed upon contract price for the sale. Both buyer and seller know the $ value of the human service in the product and they know the physical quantity of the product in terms of weight, number, etc. They know or can determine the $ value of the labor, energy and materials and negative effects (*e.g.*, CO_2 emissions) required to deliver the product. The buyer and the seller can compare the information that they have on Product A, *e.g.*, weight, dollar cost and the dollar and energy cost, etc. to ship Product A to the destination with their knowledge and experience with regard to the product to decide on the price that each is willing to pay or accept, respectively. Neither the buyer nor the seller knows the actual value of the exchange in terms of real wealth, *i.e.*, emergy. If the dollars paid cover the transportation cost then the price paid for Product A as emergy per $ is ($semj$+ $semj_{KE}$ + $semj_T$ + $semj_{TKE}$) /$, where semj is the emergy of the material in Product A, $semj_{KE}$ is the emergy of the knowledge and experience that was required both directly and indirectly in the manufacture of Product A, $semj_T$ is the emergy of the energy and materials used to transport Product A to the destination and $semj_{TKE}$ is the emergy of the knowledge and experience needed to transport Product A to the destination. In this hypothetical transaction, it seems logical to assume that the buyer and seller will

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rely most heavily on the information with which they are most familiar to decide on a contract price, *i.e.*, the dollar values of the human service required for Product A and its transport to the destination. If we assume that the cost of transportation is small relative to the cost of Product A and that neither the buyer nor seller has an attachment to special interest causes, *e.g.*, reducing CO_2 emissions, the decision will be made primarily on the basis of the value of human service required for the production of Product A, which in turn should be strongly related to the knowledge and experience required to produce the product, except when other factors distort the salaries paid, *e.g.*, the importance each person places on their health raises the compensation given to doctors and nurses over and above what might be expected based on their education.
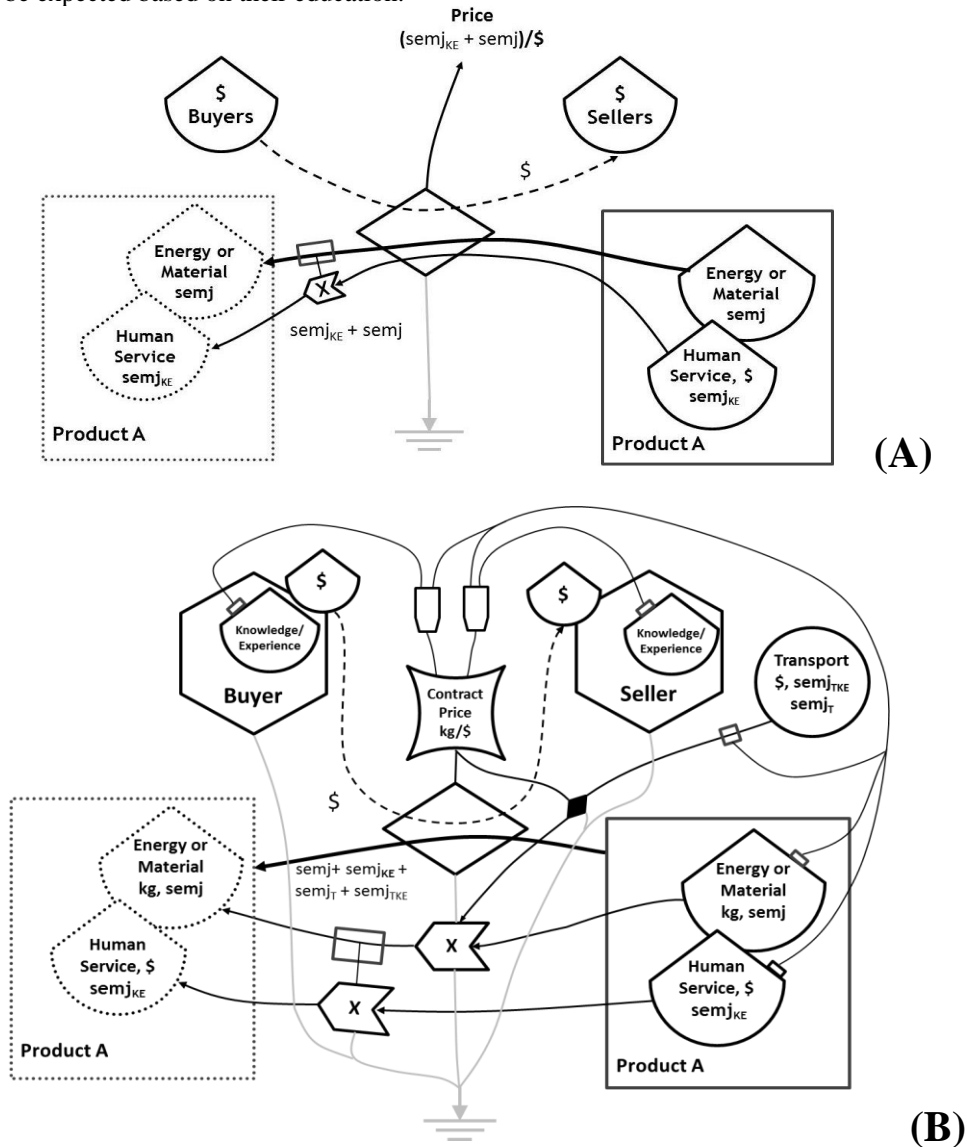

(A)

(B)

Figure 2. Energy Systems Diagrams of the basis for determining value in an exchange. A) Value determined by the forces of supply and demand in the market for a particular product. B) Value determined by the negotiation between buyer and seller to establish a contract price for a particular product.
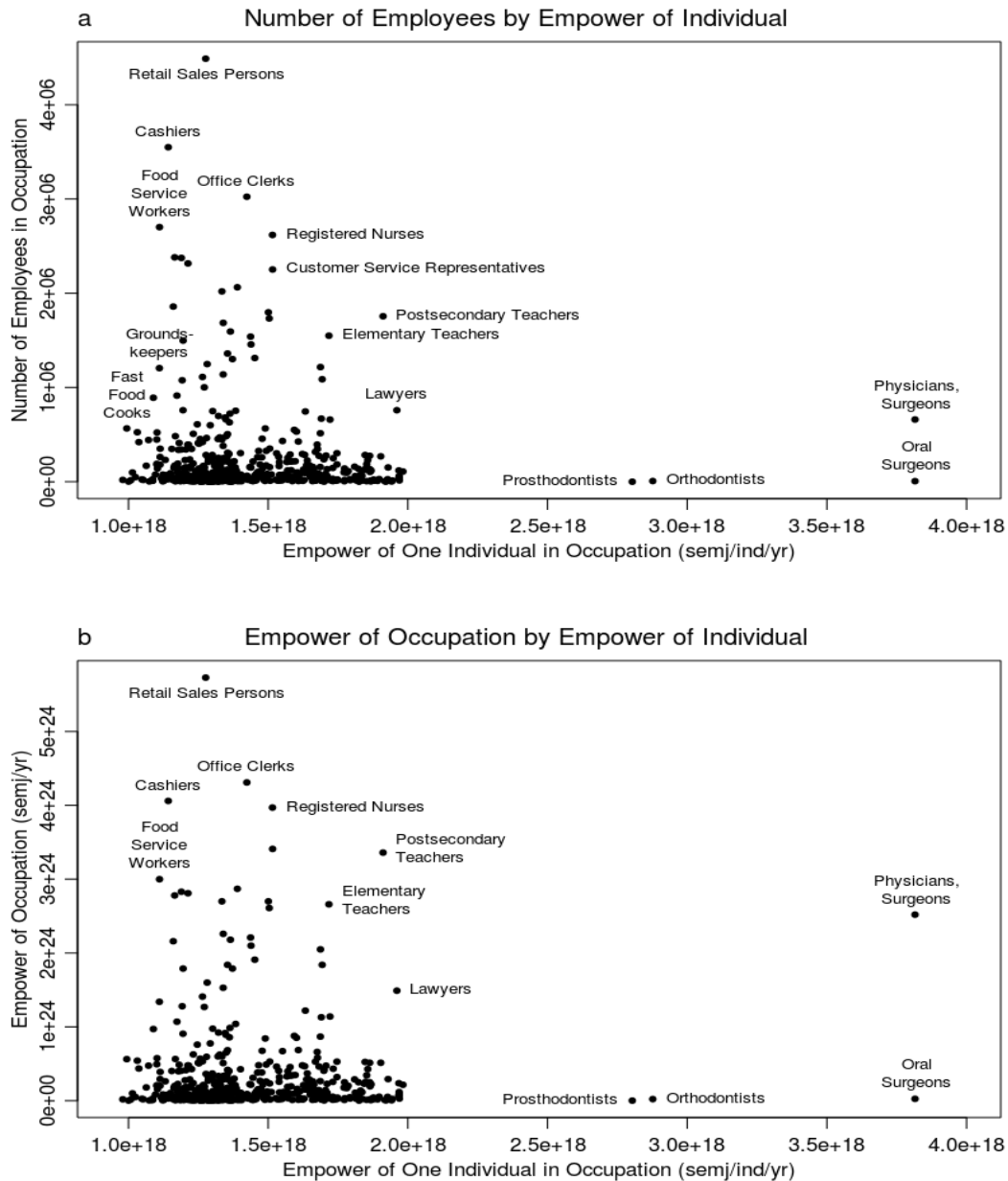
Figure 3. *The distribution of characteristics of the occupations in the U.S. economy in 2008 is shown as a function of the emergy per individual practicing the occupation. A) The number of people employed. B) Empower delivered to the economy by the individuals working in a particular occupation.*

The distribution of the number of individuals in an occupation as a function of the emergy per individual is shown in Figure 3a. Many of the occupations with the largest number of employees are labeled. Retail Sales Persons, Cashiers, Office Clerks, Food Service Workers and Registered Nurses are the dominant occupations by number of employees. In Figure 3b, the annual empower delivered to the economy by an occupation is plotted as a function of the emergy required to train an individual to perform that occupation (semj/individual). In this plot the pattern of the annual empower delivered to

the economy by the occupations is similar to that shown by the distribution of employment (Fig 3a), but the contributions to society made by several occupations are enhanced relative to expectations based on the number employed; especially, note that physicians and surgeons, registered nurses, post-secondary teachers, elementary teachers and lawyers among others are positioned on the ordinate at a higher point in the overall distribution than is implied by their numbers alone. Plotting the total compensation ($/yr) received by an occupation against the empower delivered to the economy by the occupation in a year (semj/yr), revealed a relatively strong linear relationship (R^2=0.76) between the two variables (Figure 4a). The total compensation earned by Physicians and Surgeons, General Operations Managers, Registered Nurses, Post-Secondary Teachers and Lawyers exceeded the expected values based on the regression line; whereas, the compensation realized by Retail Sales Persons, Office Clerks, Cashiers, Waiters and Waitresses and Child Care Workers fell well below the regression line. Also, we found a relatively strong linear relationship (R^2=0.60) between the median salary of an occupation and the empower of the work done by an individual practicing that occupation (Figure 4b). Certain occupations commanded higher median salaries than would be expected based on the transformity of the work done, including Air Traffic Controllers, Airline Pilots, Judges Dentists, Orthodontists and Physicians and Surgeons; whereas, the median salaries of other occupations were lower than expected based on their education and training, *e.g.*, Marriage and Family Therapists and Forest Conservation Workers.

The aggregate structure of the economy is represented by the panel of plots in Figure 5, in which the examined variables are given as a function of the Standard Occupational Classification system, SOC, Job Zone. Of the nine variables we plotted by Job Zone, five were of median values. We used medians as a measure of central tendency, because almost all of the distributions of the five variables within the five job zones had a strong positive skew (or negative for transformity in Job Zone 4). These distributions are given in the online supplement mentioned above.

The first row of plots (Figure 5 a, b, and c) shows the number of employees, the median number of employees in an occupation and the number of occupations as a function of Job Zone. The plots in Figure 5 d, e, and f show the total empower of the occupations, the median empower of the occupations, and the median transformity of the work delivered by Job Zone. The third row of plots (Figure 5 g, h, and i) gives the total compensation of the occupations, the median compensation of the occupations and the median salary of the occupations by Job Zone. The patterns shown in the first and second column are similar within the columns. The patterns of the plots in Figure 5 f and i of the third column are also similar, but the pattern of the number of occupations by Job Zone (Figure 5c) is different from the other two plots in this column.

Most employment and the greatest empower is found in Job Zones 2 and 3 with Job Zone 2 slightly greater than Job Zone 3. However, total compensation gives a somewhat different picture with the occupations in Job Zone 3 receiving the most money. All the plots in the central column in Figure 5 are of the median values of the different variables of the occupations in a Job Zone and exhibit a similar pattern. In this case, the pattern (Fig. 5b) is determined by the total number of occupations in each Job Zone (Fig. 5c) divided into the total number of employees in a Job Zone (Fig. 5a). In turn, the patterns in Fig. 5e and h are given respectively, by the product of the median number of employees in a Job Zone (Fig. 5b) times the median transformity (Fig. 5f) or the median salary (Fig. 5i). The dominant feature of the pattern in the Column 2 plots is that Job Zone 1 has the greatest median number of employees, median empower and median compensation per occupation. This pattern is observed, because the number of occupations in Job Zone 1 is the lowest (Fig. 5c) and the number of employees is moderately high. In contrast, Job Zone 2 contains the largest number of occupations, so the median number, empower, and compensation per occupation is the lowest observed. There is a secondary peak in Job Zone 4 of the median value of the occupations by Job Zone for all three variables. These peaks are the result of the number of occupations falling from Job Zone 3 to 4 while the median transformity and salary increase at a steeper rate, thus the number of employees, empower, and compensation in Job Zone 4 are somewhat higher than similar values in Job Zones 3 and 5.
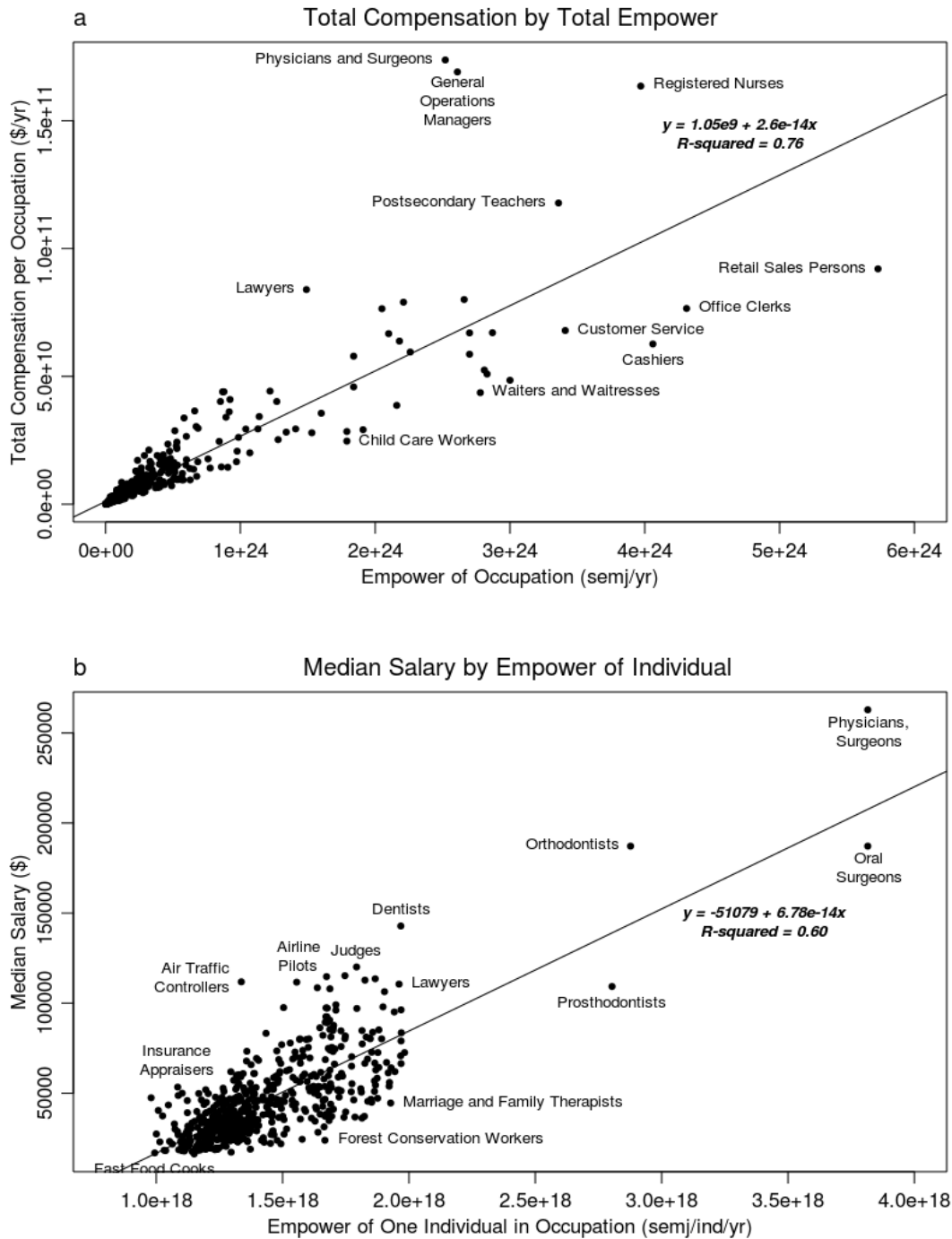
a Total Compensation by Total Empower

Physicians and Surgeons •
General Operations Managers
• Registered Nurses

$y = 1.05e9 + 2.6e\text{-}14x$
$R\text{-squared} = 0.76$

Postsecondary Teachers •

Retail Sales Persons •

Lawyers •

• Office Clerks
• Customer Service
Cashiers •
Waiters and Waitresses

Child Care Workers

Total Compensation per Occupation ($/yr)

Empower of Occupation (semj/yr)

b Median Salary by Empower of Individual

Physicians, Surgeons •

Orthodontists •
Oral Surgeons •

$y = -51079 + 6.78e\text{-}14x$
$R\text{-squared} = 0.60$

Dentists •

Airline Pilots
Judges

Air Traffic Controllers

Lawyers

Prosthodontists •

Insurance Appraisers

Marriage and Family Therapists

Forest Conservation Workers

Fast Food Cooks

Median Salary ($)

Empower of One Individual in Occupation (semj/ind/yr)

Figure 4. The relationship of monetary measures to emergy measures of the value provided to the economy by the workforce in 2008. A) The compensation received by the workers practicing an occupation as a function of the annual empower delivered to the economy by the workers in those same occupations in the same year. B) The median salary of individuals in an occupation as a function of the emergy required to educate an individual to carry out that occupation.
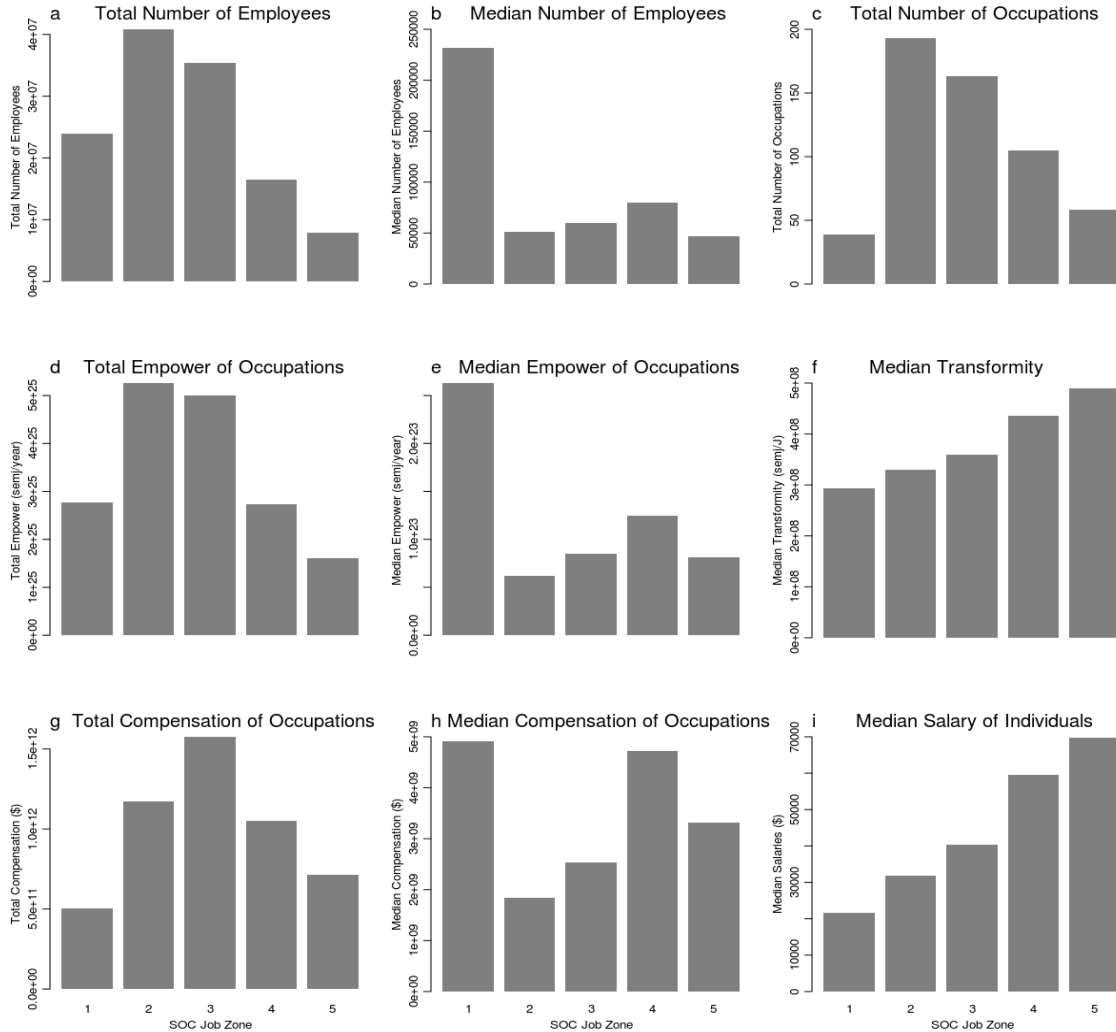
Figure 5. The characteristics of the work force in the U.S. economy in 2008 as a function of SOC Job Zone. A) The total number of employees. B) The median number of employees in an occupation. C) The number of occupations. D) Total empower of the occupations. E) Median empower of occupations. F) Median transformity of individuals. G) Total compensation of occupations. H) Median compensation of occupations. I) Median salary of individuals.

DISCUSSION

The role of the knowledge and experience of people participating in the occupations operates global society (Fig. 1). The work of people in the various occupations provides the mechanism through which the stored emergy of education and experience is delivered to support the economy and society. If this model, *i.e.*, knowledge and experience constitute an independent source of emergy to run systems in addition to the emergy of renewable and nonrenewable resources (Campbell et al. 2011), is broadly accepted by emergy analysts, accurate values for the transformity of the work delivered by a participant in the various occupations will be needed to estimate the emergy delivered in labor to any system or production process. These estimates are independent of the money exchanged for that

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emergy input and are provided for the U.S. occupations in 2008 in the online supplement mentioned above.

The theoretical basis for our hypothesis is illustrated by the Energy Systems Diagrams (Odum 1971, 1983) shown in Figure 2a, where the forces of supply and demand determine the price of a good and in Figure 2b where two individuals are negotiating a contract price for a good. In both cases that of buyers and sellers in aggregate and that of individual buyers and sellers a value for the goods can most easily be determined from the monetary value that has been spent to bring the goods to their current position, *i.e.*, goods for sale on the market. However, in our earlier discussion, we have shown that money is paid for what people know how to do and that what they know how to do, in turn, depends on the knowledge and experience that they have accumulated in a particular occupation. Therefore, we have a strong theoretical basis for thinking that their should be a statistically significant relationship between the money paid for work done in an occupation and the knowledge base required to perform the work.

The pattern of employment in and empower of the 558 occupations examined shows that the economic structure of the U.S. economy is centered on the business of buying and selling, *e.g.*, retail sales persons, cashiers, office clerks, and food service workers dominate employment in the U.S. When the emergy delivered to the economy by the occupations is considered, the weighting of the occupations changes, so that registered nurses, physicians and surgeons, post-secondary teachers, and lawyers become relatively more important, indicating the important roles of health care, higher education, and legal protection in our society.

The results shown in Figure 4 support our hypothesis, but cannot prove it. Seventy-six percent of the variance in the total compensation received by an occupation was explained by the empower of the occupation in semj/yr, thus there appears to be a strong relationship (r = 0.87) between the emergy of the workers' education incorporated into a year's work and the money received for doing that work. Similarly, 60% of the variation in the median salary received by a worker in an occupation can be explained by the empower delivered per individual per year or the transformity (semj/J) of the work of a person practicing the occupation. In this case, there is also a fairly strong linear relationship (r= 0.77) between the money received as the median salary and the position of an individual in terms of the education required for the occupation. While the existence of strong correlations between the money received for the work done in the occupations and the emergy of the education required to deliver that work is not conclusive, it is entirely consistent with what we would expect, if our hypothesis was correct.

We noted that some occupations shown in the plot in Figure 4a appeared to be above or below the apparent confidence intervals of the regression line, i.e., some occupations appeared to be over compensated relative to the overall contribution of emergy to the economy from that occupation, while others appeared to be under compensated. All of the overcompensated occupations are in Job Zones 3 to 5, whereas the undercompensated occupations are in Job Zones 1 and 2 implying that jobs that require little training are undervalued in our economy based on the knowledge that the workers possess. Over compensation tends to be awarded to those workers who are highly trained and who are employed in occupations that provide services valued highly by people, because of their direct relationship to the well-being of the individual person, e.g., health care, education, legal matters, and success in business.

The panel of data in Figure 5 gives an overall picture of the structure of the U.S. workforce in 2008. The heart of the American workforce is found in the middle skill jobs, Job Zones 2 and 3. These jobs require some (*i.e.*, high school) to a moderate level (*e.g.*, an associate's degree) of preparation, *i.e.*, education and training. Holzer and Lerman (2007) report on America's middle skill-level jobs and our results are consistent with their conclusions. They state that "substantial demand remains for individuals to fill skilled jobs in the middle of the labor market, with many jobs paying quite high wages". We found that the highest total compensation in the economy was received by the occupations in Job Zone 3 and that Job Zones 2 and 3 dominated employment and empower, as well as, total compensation. Job Zones 2 and 3 also contain the greatest variety of occupations and Job Zone 1 the

least. The dominance of Job Zones 2 and 3 in the magnitude of all three variables along with the secondary peak in the median number of employees, median empower of the occupations, and median compensation per occupation in Job Zone 4 may be indicative of a developed and highly technical society. For example, Job Zone 4 jobs require considerable preparation (*e.g*., often a college degree) and include occupations such as accounting, sales managers, database managers, teaching, engineering, and criminal investigation.

Monetary measures of workforce structure differ somewhat from the emergy measures of the same structure. For example, Job Zone 3 is the dominant Job Zone based on compensation, whereas the occupations in Job Zone 2 produce the most empower in the workforce. In general, the higher skill levels in the workforce are overvalued and the lower skill levels are undervalued based on monetary measures, when compared to emergy measures of the education levels in the workforce. This may be explained by the fact the median salary of an individual increases more rapidly with Job Zone than does the median transformity, which is based on the emergy of the education required to do the job.

The analysis of the workforce based on data in Figure 4a and Figure 5 supports the general conclusion that money overvalues highly skilled and undervalues low skill occupations relative to the emergy measures. However the pattern shown in Figure 4b, which is based on the compensation received by the individuals practicing an occupation modifies this picture. In the regression of median salary on the empower of an individual practicing an occupation, all the occupations that lie outside of the apparent confidence limits both above and below the regression line are skilled occupations, i.e., from Job Zones 3 to 5. The median salary data for individual occupations indicates a more complicated situation than a systematic bias in monetary measures. Other factors related to the importance of a given occupation to the well-being of the individuals deciding how to spend their money may be responsible for the observed differences.

This study presented evidence that the emergy required for the education of the workers in an occupation is strongly correlated with the money paid for the work done. Our approach to determining the emergy value of human service is to first relate it to the education required for an occupation and second to the experience or on-the-job training needed to become fully competent in performing the work. In most cases it was not possible to determine the necessary on the job training without doing considerable additional research. However, we decided to include the additional training for physicians and surgeons and dental specialists. By including the extra education and training for these occupations, but not the on-the-job training that many of the other occupations require, we may have biased the results, *e.g*., the distribution of occupations in Figure 3 shows a gap between physicians and surgeons and dental specialties and all other occupations. This gap may be due to the fact that we documented the additional education and training required for physicians, surgeons, and dental specialties, but we did not include continuing education and on-the-job experience for the other occupations. If this additional emergy input had been documented, we would expect the data cloud on the left in Figure 3 to shift toward the right and fill in some of the empty space on the abscissa between 2.0 and 4.0E+18 semj/ind./yr. Despite the fact that the distribution of occupations could have been represented more accurately, we feel our decision to use education only for this study is justified because the educational position of physicians and surgeons was clearly out of place in the original plots that failed to include their considerable additional education and training. By adding in their additional years of training, we established an outline of the expected relationship between employment, empower, and compensation and the intensity of education as represented by the emergy required for training an individual. Other sources of uncertainty in the determination of the emergy of an individual practicing an occupation in the U.S. in 2008 are from the uncertainty in the American Community Survey of the education level of people in the occupations and Campbell and Lu's analysis of the emergy required for the various education levels in the United States. Both of these sources of uncertainty are estimated to be ±10 to 15% (based on Campbell and Ohrt, 2009, which used similar government survey data and emergy data), which is less than the probable uncertainty introduced by not including experience (± 47% based on a comparison between dentists and dental specialists and jobs with no required training) in the calculation of the emergy delivered by an

occupation. Additional sources of uncertainty in the analysis ($< \pm 10\%$) are introduced by using 2006 data for 2008 education levels, using 2010 and 2011 data for missing values of employment and salaries and assuming a constant value for the calories consumed in a day. In the future, we plan to complete the research that will allow us to determine accurate values of time spent in on-the-job training for all occupations in our study.

Finally, we note that the emergy in human service as determined by the emergy required for the education and training necessary to accomplish the work is relative to the system in which the service is provided. Traditional knowledge (Bergquist et al. 2011), extreme wealth (Abel 2010) and political power, for example, are developed within their own systems embedded in the larger social system and must be evaluated accordingly. Our values are appropriate for a developed economy and are calculated based on the education system of the United States, so that an emergy value for this knowledge can be applied to the work of occupations present in the U.S. workforce. Our values for the emergy delivered by individuals trained to perform an occupation can be of immediate use in emergy evaluations by providing emergy-based measures of the contributions of human labor to production processes and territorial systems, *e.g.*, counties, states, provinces and nations.

ACKNOWLEDGEMENTS

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APPENDIX

The emergy in solar emjoules per individual (semj/ind.) required to attain the average education of individuals practicing 558 occupations in the United States in 2008. For physicians and surgeons and dental specialists the emergy required includes their education through professional school and training experience through residency or other post-graduate training.

Occupations	Emergy (semj/ind.)
Accountants and Auditors	1.687E+18
Actors	1.153E+18
Actuaries	1.814E+18
Administrative law judges, adjudicators, hearing officers	1.881E+18
Administrative services managers	1.477E+18
Advertising and promotions managers	1.569E+18
Advertising sales agents	1.539E+18
Aerospace engineers	1.671E+18
Agents and business managers of artists, performers, athletes	1.527E+18
Agricultural and Food Science technicians	1.485E+18
Agricultural engineers	1.701E+18
Agricultural Inspectors	1.457E+18
Air traffic controllers	1.337E+18
Aircraft cargo handling supervisors	1.336E+18
Aircraft mechanics and service technicians	1.386E+18
Aircraft structure, surfaces, rigging, and systems assemblers	1.278E+18
Airfield Operations Specialists	1.389E+18
Airline pilots, copilots, and flight engineers	1.556E+18
All other human resources managers	1.711E+18
Ambulance drivers and attendants, except emergency medical technicians	1.270E+18
Amusement and recreation attendants	1.113E+18
Animal breeders	1.455E+18
Animal scientists	1.923E+18
Anthropologists, Archeologists	1.922E+18
Appraisers, Real Estate, Assessors	1.511E+18
Arbitrators, mediators, and conciliators	1.624E+18
Architects, except landscape and naval	1.773E+18
Architectural and Civil Drafters	1.311E+18
Architectural and Engineering Managers	1.746E+18
Archivists	1.852E+18
Art directors	1.496E+18
Athletes and sports competitors	1.008E+18
Athletic trainers	1.749E+18
Atmospheric and space scientists	1.691E+18
Audio ,video equipment technicians	1.422E+18
Audiologists	1.944E+18
Audio-Visual, Multimedia Specialists	1.659E+18
Automotive body repairers	1.223E+18
Automotive glass installers, repairers	1.223E+18
Automotive mechanics and service technicians	1.363E+18
Avionics Technicians	1.386E+18
Baggage Porters and Bellhops	1.190E+18
Bailiffs	1.321E+18
Bakers	1.206E+18
Barbers	1.329E+18
Bartenders	1.232E+18
Bicycle repairers	1.198E+18
Bill and account collectors	1.249E+18
Billing, Cost, and Rate Clerks	1.355E+18
Biological technicians	1.649E+18
Biomedical engineers	1.815E+18
Boilermakers	1.315E+18
Bookkeeping, accounting & auditing clerks	1.390E+18
Brick masons and block masons	1.327E+18
Bridge and lock tenders	1.123E+18
Broadcast news analysts	1.608E+18
Broadcast technicians	1.359E+18
Brokerage Clerks	1.459E+18
Bus and truck mechanics and diesel engine specialists	1.297E+18
Bus drivers, school	1.257E+18
Bus drivers, transit and intercity	1.231E+18
Athletic trainers	1.749E+18
Atmospheric and space scientists	1.691E+18
Audio and video equipment technicians	1.422E+18
Audiologists	1.944E+18
Audio-Visual and Multimedia Collections Specialists	1.659E+18
Automotive body & related repairers	1.223E+18
Automotive glass installers, repairers	1.223E+18
Automotive mechanics & service technicians	1.363E+18
Avionics Technicians	1.386E+18
Baggage Porters and Bellhops	1.190E+18
Bailiffs	1.321E+18
Bakers	1.206E+18
Barbers	1.329E+18
Bartenders	1.232E+18
Bicycle repairers	1.198E+18
Bill and account collectors	1.249E+18
Billing, Cost, and Rate Clerks	1.355E+18
Biological technicians	1.649E+18
Biomedical engineers	1.815E+18
Boilermakers	1.315E+18
Bookkeeping, accounting clerks	1.390E+18
Brick masons and block masons	1.327E+18
Bridge and lock tenders	1.123E+18
Broadcast news analysts	1.608E+18
Broadcast technicians	1.359E+18
Brokerage Clerks	1.459E+18
Bus, truck mechanics & diesel engine specialists	1.297E+18
Bus drivers, school	1.257E+18
Bus drivers, transit and intercity	1.231E+18
Butchers and meat cutters	1.177E+18
Camera operators, television, video, and motion picture and film editors	1.494E+18
Cardiovascular technologists	1.457E+18
Career/technical education teachers, middle school	1.723E+18
Career/technical education teachers, secondary school	1.635E+18
Cargo and freight agents	1.667E+18

Carpet installers	1.173E+18
Cartographers & photogrammetrists	1.534E+18
Cashiers, except gaming	1.142E+18
Cementing and gluing machine operators and tenders	1.212E+18
Chemical engineers	1.731E+18
Chemical equipment operators	1.250E+18
Chemical plant and system operators	1.326E+18
Chemical technicians	1.367E+18
Chemists	1.705E+18
Child care workers	1.372E+18
Chiropractors	1.969E+18
Choreographers	1.440E+18
Civil engineers	1.707E+18
Claims Examiners, Property and Casualty Insurance, adjusters, investigators	1.579E+18
Cleaners of Vehicles and Equipment	1.155E+18
Cleaning, washing, and metal pickling equipment operators and tenders	1.160E+18
Clergy	1.690E+18
Clinical Nurse Specialists	1.847E+18
Clinical Research Coordinators	1.674E+18
Clinical, Counseling, School Psychologists	1.929E+18
Coaches and scouts	1.640E+18
Coil winders, tapers, and finishers	1.129E+18
Coin, Vending, and Amusement Machine Servicers and Repairers	1.289E+18
Combined food preparation and serving workers, including fast food	1.111E+18
Commercial and industrial designers	1.553E+18
Commercial divers	1.365E+18
Compensation and benefits managers	1.700E+18
Compensation, benefits, and job analysis specialists	1.642E+18
Compliance officers, Licensing Examiners and Inspectors, Govt. insp.	1.587E+18
Commercial and industrial designers	1.553E+18
Commercial divers	1.365E+18
Compensation and benefits managers	1.700E+18
Compensation, benefits, and job analysis specialists	1.642E+18
Compliance officers, Licensing Examiners and Inspectors, Govt. insp.	1.587E+18
Computer, information scientists, research	1.897E+18
Computer hardware engineers	1.672E+18
Computer Operators	1.385E+18
Computer programmers	1.608E+18
Computer software engineers, applications	1.687E+18
Computer software engineers, systems software	1.675E+18
Computer support specialists	1.490E+18
Computer systems analysts	1.601E+18
Computer, automated teller, and office machine repairers	1.382E+18
Computer-controlled machine tool operators, metal and plastic	1.252E+18
Concierges	1.268E+18
Conservation scientists, Soil & water and range	1.613E+18
Construction and building inspectors	1.474E+18
Construction and rough carpenters	1.271E+18
Construction laborers	1.282E+18
Construction managers	1.594E+18

Continuous mining machine operators	1.087E+18
Control and valve installers and repairers, except mechanical door	1.328E+18
Cooks, fast food	9.939E+17
Cooks, institution and cafeteria	1.215E+18
Cooks, private household	1.297E+18
Cooks, restaurant	1.174E+18
Cooks, short order	1.165E+18
Cooling, freezing equipment operators	1.242E+18
Correctional officers and jailers	1.320E+18
Commercial divers	1.365E+18
Compensation and benefits managers	1.700E+18
Compensation, benefits, and job analysis specialists	1.642E+18
Compliance officers, Licensing Examiners and Inspectors, Govt. insp.	1.587E+18
Computer, information scientists,	1.897E+18
Computer hardware engineers	1.672E+18
Computer Operators	1.385E+18
Computer programmers	1.608E+18
Computer software engineers, applications	1.687E+18
Computer software engineers, systems software	1.675E+18
Computer support specialists	1.490E+18
Computer systems analysts	1.601E+18
Computer, automated teller, and office machine repairers	1.382E+18
Computer-controlled machine tool operators, metal and plastic	1.252E+18
Concierges	1.268E+18
Conservation scientists, Soil and water and range	1.613E+18
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Cooks, institution and cafeteria	1.215E+18
Cooks, private household	1.297E+18
Cooks, restaurant	1.174E+18
Cooks, short order	1.165E+18
Cooling, freezing equipment operators	1.242E+18
Correctional officers and jailers	1.320E+18
Correspondence clerks	1.291E+18
Cost estimators	1.597E+18
Costume attendants	1.370E+18
Counter and Rental Clerks	1.101E+18
Counter attendants, cafeteria, food concession, and coffee shop	1.032E+18
Court Reporters	1.427E+18
Court, Municipal and License Clerks	1.354E+18
Craft artists	1.397E+18
Credit analysts	1.541E+18
Crossing guards	1.136E+18
Crushing, grinding, and polishing machine setters, operators	1.201E+18
Curators	1.876E+18
Customer service & patient representatives	1.516E+18
Cutters and trimmers, hand	1.311E+18
Cutting and slicing machine setters, operators, and tenders	1.196E+18

Cutting, Punching, and Press Machine Setters, Operators, Metal and Plastic	1.219E+18	paramedics	
Dancers	1.173E+18	Engine and other machine assemblers	1.268E+18
Data Entry Keyers	1.300E+18	Engineering technicians except drafters	1.464E+18
Database administrators	1.569E+18	Engineers all other (robotic, manufacturing, energy)	1.686E+18
Dental assistants	1.360E+18	Environmental engineering technicians	1.550E+18
Dental hygienists	1.493E+18	Environmental engineers	1.687E+18
Dental Laboratory Technicians	1.276E+18	Environmental science and protection technicians, including health	1.684E+18
Dentists, general	1.968E+18	Environmental scientists and specialists, including health	1.681E+18
Derrick operators, oil and gas	1.048E+18	Epidemiologists	1.918E+18
Desktop publishers	1.485E+18	Etchers and engravers	1.210E+18
Diagnostic medical sonographers	1.489E+18	Excavating and Loading Machine and Dragline Operators	1.187E+18
Dietetic technicians	1.215E+18	Executive secretaries & administrative assistants	1.365E+18
Dietitians and nutritionists	1.812E+18	Explosives workers, ordnance handling experts, and blasters	1.239E+18
Dining room and cafeteria attendants and bartender helpers	1.037E+18	Extruding, forming, pressing, and compacting machine setters, operators, and tenders	1.242E+18
Directors, religious activities and education	1.614E+18	Farm and home management advisors	1.837E+18
Dishwashers	1.102E+18	Fashion designers	1.488E+18
Dispatchers, Except Police, Fire, and Ambulance	1.315E+18	Fence erectors	1.176E+18
Door-to-door sales workers, news and street vendors, and related workers	1.113E+18	Fiberglass laminators and fabricators	1.330E+18
		File clerks	1.360E+18
Dredge Operators	1.266E+18	Financial analysts	1.699E+18
Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	1.341E+18	Financial examiners	1.681E+18
Drywall and ceiling tile installers	1.272E+18	Fine artists, including painters, sculptors, and illustrators	1.439E+18
Earth drillers, except oil and gas	1.200E+18	First-line supervisors of retail sales workers	1.339E+18
Economists	1.970E+18	First-line supervisors of construction trades and extraction workers	1.322E+18
Editors	1.626E+18	First-line supervisors/managers of correctional officers	1.310E+18
Education administrators, elementary and secondary school	1.857E+18	First-line supervisors/managers of helpers, laborers, material movers	1.471E+18
Education administrators, postsecondary	1.844E+18	First-line supervisors/managers of housekeeping and janitorial workers	1.340E+18
Education administrators, preschool and child care center/program	1.591E+18	First-line supervisors/managers of landscaping, lawn service, and grounds-keeping workers	1.347E+18
Educational, vocational, and school counselors	1.863E+18	First-line supervisors/managers of mechanics, installers, and repairers	1.335E+18
Electric motor, power tool, and related repairers	1.280E+18	First-line supervisors/managers of production and operating workers	1.346E+18
Electrical and Electronic Drafters	1.449E+18	First-line supervisors/managers of transportation and material-moving machine and vehicle operators	1.378E+18
Electrical & Electronic Engineering Technicians	1.438E+18		
Electrical and electronics installers and repairers, transportation equipment	1.351E+18	Fishers and fishing vessel operators	1.118E+18
Electrical and electronics repairers, commercial and industrial equipment	1.383E+18	Fitness workers	1.462E+18
Electrical and electronics repairers, powerhouse, substation, and relay	1.388E+18	Flight attendants	1.376E+18
Electrical engineers	1.660E+18	Floor layers, except carpet, wood, and hard tiles	1.262E+18
Electrical power-line installers and repairers	1.326E+18	Floor sanders and finishers	1.229E+18
Electro-mechanical and robotics technicians	1.376E+18	Floral designers	1.096E+18
Electromechanical equipment assemblers	1.395E+18	Food batch-makers	1.240E+18
Electronic equipment installers and repairers, motor vehicles	1.367E+18	Food preparation workers	1.089E+18
Electronic home entertainment equipment installers and repairers	1.405E+18	Food scientists and technologists	1.738E+18
Electronics engineers, except computer	1.648E+18	Food servers, non restaurant	1.101E+18
Elementary school teachers, except special education	1.717E+18	Food service managers	1.179E+18
Elevator installers and repairers	1.397E+18	Forensic science technicians	1.541E+18
Eligibility Interviewers, Government Programs	1.336E+18	Forest and conservation technicians	1.363E+18
Embalmers	1.489E+18		
Emergency management specialists	1.690E+18		
Emergency medical technicians and	1.285E+18		

Forest and conservation workers	1.667E+18	Janitors and cleaners, except maids and housekeeping cleaners	1.189E+18
Foresters	1.667E+18	Jewelers, precious metal, and gem and diamond workers	1.300E+18
Forging Machine Setters, Operators, and Tenders, Metal and Plastic	1.269E+18	Judges, magistrate judges, and magistrates	1.793E+18
Foundry Mold and Core makers	1.123E+18	Kindergarten teachers, except special education	1.642E+18
Funeral attendants	1.323E+18		
Furnace, kiln, oven, drier, and kettle operators and tenders	1.280E+18	Laborers and Freight, Stock, and Material Movers, Hand	1.213E+18
Furniture Finishers	1.087E+18	Landscape architects	1.720E+18
Gaming, sports book writers & runners	1.248E+18	Landscaping and grounds keeping workers	1.111E+18
Gaming cage workers	1.267E+18	Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic	1.287E+18
Gaming change persons & booth cashiers	1.246E+18		
Gaming dealers	1.150E+18	Lawyers	1.961E+18
Gaming managers	1.405E+18	Legal secretaries	1.353E+18
Gaming supervisors	1.327E+18	Librarians	1.809E+18
Gaming surveillance officers	1.370E+18	Licensed practical and licensed vocational nurses	1.384E+18
Gas Compressor and Gas Pumping Station Operators	1.307E+18		
Gas plant operators	1.306E+18	Lifeguards, ski patrol, and other recreational protective service workers	1.242E+18
General and operations managers	1.504E+18	Loan officers	1.466E+18
Geographers	1.825E+18	Locker room, coatroom, and dressing room attendants	1.217E+18
Geological and petroleum technicians	1.618E+18	Locksmiths and safe repairers	1.275E+18
Glaziers	1.337E+18	Locomotive engineers and operators	1.291E+18
Graphic designers	1.631E+18	Lodging managers	1.450E+18
Grinding, lapping, polishing, and buffing machine tool setters, operators, metal and plastic	1.251E+18	Machine Feeders and Off bearers	1.208E+18
		Machinists	1.265E+18
Hairdressers, hairstylists, and cosmetologists	1.361E+18	Maids and housekeeping cleaners	1.195E+18
Hazardous materials removal workers	1.302E+18	Mail clerks and mail machine operators, except postal service	1.104E+18
Health and Safety Engineers, except Mining Safety Engineers and Inspectors	1.695E+18	Maintenance and repair workers, general	1.355E+18
Healthcare social workers	1.850E+18	Makeup artists, theatrical and performance	1.257E+18
Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	1.268E+18	Manicurists and pedicurists	1.237E+18
		Manufactured building and mobile home installers	1.084E+18
Heating, air-conditioning, and refrigeration mechanics and installers	1.355E+18	Marine Engineers and Architects	1.699E+18
Heavy and tractor-trailer truck drivers	1.501E+18	Market Research Analysts and Marketing Specialists	1.733E+18
Heavy vehicle and mobile equipment service technicians and mechanics	1.366E+18	Marketing managers	1.637E+18
Helpers—brick masons, block masons, stonemasons, tile and marble setters	1.179E+18	Marriage and family therapists	1.928E+18
		Massage therapists	1.364E+18
Helpers—carpenters	1.192E+18	Materials engineers	1.748E+18
Helpers—extraction workers	1.232E+18	Materials scientists	1.892E+18
Helpers—installation, maintenance, and repair workers	1.202E+18	Mathematicians	1.942E+18
		Meat, poultry, and fish cutters and trimmers	1.064E+18
Helpers—painters, paperhangers, plasterers, and stucco masons	1.053E+18	Mechanical door repairers	1.172E+18
		Mechanical drafters	1.478E+18
Helpers—production workers	1.168E+18	Mechanical engineering technicians	1.422E+18
Highway maintenance workers	1.264E+18	Mechanical engineers	1.699E+18
Historians	1.868E+18	Medical and clinical laboratory technicians	1.505E+18
Hosts and hostesses, restaurant	1.113E+18	Medical and clinical laboratory technologists	1.648E+18
Hotel, motel, and resort desk clerks	1.203E+18		
Human resources assistants, except payroll and timekeeping	1.371E+18	Medical and Health Services Managers	1.746E+18
		Medical Appliance Technicians	1.387E+18
Human resources managers	1.711E+18	Medical assistants	1.350E+18
Industrial engineers	1.580E+18	Medical equipment preparers	1.319E+18
Industrial production managers	1.434E+18	Medical equipment repairers	1.495E+18
Industrial Truck and Tractor Operators	1.246E+18	Medical records and health information technicians	1.316E+18
Inspectors, testers, sorters, samplers, and weighers	1.279E+18	Medical scientists	1.983E+18
Instructional coordinators	1.863E+18	Medical secretaries	1.327E+18
Insurance appraisers, auto damage	1.085E+18	Medical transcriptionists	1.337E+18
Insurance claims & policy processing clerks	1.322E+18	Meeting and convention planners	1.552E+18

Occupation	Value
Mental health and substance abuse social workers	1.824E+18
Mental health counselors	1.786E+18
Merchandise displayers and window trimmers	1.275E+18
Metal-Refining Furnace Operators and Tenders	1.241E+18
Meter readers, utilities	1.272E+18
Microbiologists	1.881E+18
Middle school teachers, except special and career/technical education	1.721E+18
Mine cutting and channeling machine operators	1.199E+18
Mining and geological engineers, including mining safety engineers	1.732E+18
Misc. Agricultural workers	1.633E+18
Mixing and blending machine setters, operators, and tenders	1.265E+18
Model Makers, Metal and Plastic	1.347E+18
Model Makers, Wood	1.257E+18
Models	1.000E+18
Molding, Core making, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	1.221E+18
Molecular and Cellular Biologists and Geneticists	1.967E+18
Motion picture projectionists	1.126E+18
Motorboat mechanics	1.272E+18
Motorboat Operators	1.367E+18
Motorcycle mechanics	1.346E+18
Multi-media artists and animators	1.568E+18
Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	1.254E+18
Museum Technicians and Conservators	1.743E+18
Music Directors and Composers	1.634E+18
Musical instrument repairers and tuners	1.269E+18
Musicians, Instrumental (27-2042.02)	1.309E+18
Natural sciences managers	1.826E+18
New accounts clerks	1.304E+18
Nuclear engineers	1.794E+18
Nuclear equipment operation technicians	1.357E+18
Nuclear medicine technologists	1.570E+18
Nuclear power reactor operators	1.358E+18
Numerical tool and process control programmers	1.452E+18
Occupational health and safety technicians	1.507E+18
Occupational therapists	1.865E+18
Office and administrative support worker supervisors and managers (First-Line Supervisors of Office and Administrative Support Workers)	1.439E+18
Office clerks, general	1.424E+18
Office machine operators, except computer	1.208E+18
Operating engineers and other construction equipment operators	1.253E+18
Operations research analysts	1.836E+18
Ophthalmic Laboratory Technicians	1.304E+18
Opticians, dispensing	1.355E+18
Optometrists	1.969E+18
Oral and maxillofacial surgeons	3.816E+18
Order clerks	1.286E+18
Orthodontists	2.877E+18
Orthotists and prosthetists	1.773E+18
Outdoor power equipment and other small engine mechanics	1.274E+18
Packaging and filling machine operators and tenders	1.226E+18
Packers and Packagers, Hand	1.195E+18
Painters, Construction and Maintenance	1.072E+18
Painting and coating workers, except construction and maintenance	1.177E+18
Paper goods machine setters, operators, and tenders	1.199E+18
Paperhangers	1.218E+18
Paralegals and legal assistants	1.538E+18
Parking enforcement workers	1.400E+18
Parts salespersons	1.300E+18
Patternmakers, Metal and Plastic	1.317E+18
Patternmakers, Wood	1.288E+18
Payroll and timekeeping clerks	1.334E+18
Personal financial advisors	1.540E+18
Pest control workers	1.216E+18
Pesticide handlers, sprayers, and applicators, vegetation	1.354E+18
Petroleum engineers	1.687E+18
Petroleum pump system operators, refinery operators, and gaugers	1.317E+18
Pharmacists	1.903E+18
Pharmacy technicians and aides	1.339E+18
Physical therapist aides	1.316E+18
Physical therapist assistants	1.424E+18
Physical therapists	1.853E+18
Physician assistants	1.831E+18
Physicians and surgeons	3.816E+18
Pile-driver operators	1.234E+18
Plasterers and stucco masons	1.025E+18
Plating and Coating Machine Setters, Operators, and Tenders, Metal and Plastic	1.190E+18
Podiatrists	1.866E+18
Police detectives	1.344E+18
Police patrol officers	1.349E+18
Police, fire, and ambulance dispatchers	1.302E+18
Postal Service clerks	1.268E+18
Postal Service mail carriers	1.206E+18
Postal Service mail sorters, processors, and processing machine operators	1.102E+18
Postmasters and mail superintendents	1.328E+18
Postsecondary Teachers All	1.911E+18
Potters, Manufacturing	1.361E+18
Pourers and Casters, Metal	1.229E+18
Power plant distributors & dispatchers	1.375E+18
Prepress technicians and workers	1.366E+18
Probation officers and correctional treatment specialists	1.660E+18
Procurement clerks	1.349E+18
Producers and Directors	1.582E+18
Production, planning, and expediting clerks	1.278E+18
Proofreaders and copy markers	1.664E+18
Property, real estate, and community association managers	1.401E+18
Prosthodontists	2.803E+18
Psychiatric aides	1.346E+18
Psychiatric technicians	1.459E+18
Public address system and other announcers	1.211E+18
Public relations managers	1.669E+18
Public relations specialists	1.682E+18
Pump Operators, Except Wellhead Pumpers	1.298E+18
Purchasing agents and buyers, farm	1.389E+18

products		Set and exhibit designers	1.668E+18
Purchasing agents, except wholesale, retail, and farm products	1.622E+18	Shampooers	1.296E+18
		Sheet metal workers	1.308E+18
Purchasing managers	1.677E+18	Ship and Boat Captains, pilots, mates	1.295E+18
Radiation therapists	1.549E+18	Ship Engineers	1.386E+18
Radio and television announcers	1.466E+18	Shipping, receiving, and traffic clerks	1.301E+18
Radio mechanics	1.445E+18	Shuttle Car Operators	1.227E+18
Radio operators	1.323E+18	Signal and track switch repairers	1.395E+18
Radiologic technologists and technicians	1.446E+18	Skin care specialists	1.341E+18
Railroad brake, signal switch operators	1.260E+18	Slaughterers and meat packers	1.014E+18
Railroad conductors and yardmasters	1.265E+18	Slot key persons	1.252E+18
Rail-track laying and maintenance equipment operators	1.273E+18	Social and community service managers	1.664E+18
		Social and human service assistants	1.506E+18
Real estate sales agents	1.212E+18	Social science research assistants	1.694E+18
Receptionists and information clerks	1.339E+18	Soil and plant Scientists	1.874E+18
Recreation workers	1.493E+18	Sound engineering technicians	9.796E+17
Recreational therapists	1.671E+18	Special education teachers, middle school	1.771E+18
Recreational vehicle service technicians	1.300E+18		
Refractory materials repairers, except brick masons	1.296E+18	Special education teachers, secondary school	1.731E+18
		Speech-language pathologists	1.869E+18
Refuse and Recyclable Material Collectors	1.163E+18	Stationary engineers and boiler operators	1.355E+18
Registered nurses	1.515E+18	Statistical assistants	1.628E+18
Reinforcing Iron and Rebar Workers	1.160E+18	Statisticians	1.877E+18
Reporters and correspondents	1.684E+18	Stock clerks, sales floor	1.160E+18
Reservation and transportation ticket agents and travel clerks	1.268E+18	Stone Cutters and Carvers, Manufacturing	1.236E+18
		Stonemasons	1.327E+18
Residential advisors	1.577E+18	Structural Iron and Steel Workers	1.291E+18
Respiratory therapists	1.464E+18	Structural metal fabricators and fitters	1.240E+18
Respiratory therapy technicians	1.437E+18	Substance abuse and behavioral disorder counselors	1.458E+18
Retail salespersons	1.276E+18		
Riggers	1.265E+18	Subway and streetcar operators	1.318E+18
Rock splitters, quarry	1.074E+18	Surgical technologists	1.384E+18
Rolling Machine Setters, Operators, and Tenders, Metal and Plastic	1.234E+18	Survey Researchers	1.814E+18
		Surveying and mapping technicians	1.402E+18
Roof bolters, mining	1.168E+18	Surveyors including Geodetic surveyors	1.604E+18
Roofers	1.178E+18	Switchboard operators, including answering service	1.330E+18
Rotary drill operators, oil and gas	1.196E+18		
Roustabouts, oil and gas	1.125E+18	Tank Car, Truck, and Ship Loaders	1.294E+18
Sales agents, securities and commodities and financial services	1.669E+18	Tapers	1.189E+18
		Tax examiners, collectors, and revenue agents	1.456E+18
Sales managers	1.677E+18		
Sales representatives, wholesale and manufacturing, except technical and scientific products	1.437E+18	Tax preparers	1.278E+18
		Taxi drivers and chauffeurs	1.132E+18
		Teacher assistants	1.452E+18
Sales representatives, wholesale and manufacturing, technical and scientific products	1.551E+18	Teachers—adult literacy and remedial education	1.781E+18
		Teachers—preschool, except special education	1.479E+18
Sawing Machine Setters, Operators, and Tenders, Wood	1.129E+18	Teachers—self-enrichment education	1.570E+18
		Team assemblers	1.265E+18
Secondary school teachers, except special and career/technical education	1.693E+18	Technical writers	1.651E+18
		Telecommunications equipment installers and repairers	1.372E+18
Secretaries, except legal, medical, and executive	1.334E+18		
		Telecommunications line installers and repairers	1.320E+18
Security and fire alarm systems installers	1.293E+18		
Security guards	1.192E+18	Telemarketers	1.189E+18
Segmental pavers	1.285E+18	Telephone operators	1.226E+18
Semiconductor processors	1.239E+18	Tellers	1.293E+18
Separating, filtering, clarifying, precipitating, and still machine setters, operators, and tenders	1.307E+18	Terrazzo workers and finishers	1.186E+18
		Tile and marble setters	1.123E+18
		Timing device assemblers, adjusters, and calibrators	1.303E+18
Septic tank servicers and sewer pipe cleaners	1.141E+18		
		Tire builders	1.235E+18
Service station attendants	1.181E+18	Tire repairers and changers	1.322E+18
Service unit operators, oil, gas, mining	1.195E+18		

Tool and die makers	1.367E+18
Tool Grinders, Filers, and Sharpeners	1.256E+18
Tour guides and escorts	1.416E+18
Traffic technicians	1.586E+18
Training and development managers	1.702E+18
Transportation attendants, except flight attendants and baggage porters	1.267E+18
Transportation managers	1.604E+18
Transportation vehicle, equipment and systems inspectors, with aviation & freight	1.484E+18
Travel agents	1.329E+18
Travel guides	1.375E+18
Tree trimmers and pruners	1.139E+18
Umpires, referees, and other sports officials	1.276E+18
Ushers, lobby attendants, and ticket takers	1.175E+18
Veterinarians	1.969E+18
Veterinary assistants and laboratory animal caretakers	1.269E+18
Waiters and waitresses	1.165E+18
Watch repairers	1.287E+18
Water and liquid waste treatment plant and system operators	1.367E+18
Web Administrators	1.567E+18
Web Developers	1.530E+18
Weighers, measurers, checkers, and samplers, recordkeeping	1.321E+18
Welders, Cutters, and Welder Fitters, Solderers and Braziers	1.181E+18
Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	1.222E+18
Wellhead Pumpers	1.245E+18
Woodworking Machine Setters, Operators and Tenders, Except Sawing	1.260E+18
Word Processors and Typists	1.316E+18
Writers and Authors, includes Poets, Lyricists Creative Writers & Copy writers	1.481E+18
Zoologists and wildlife biologists	1.774E+18