The Mathematical Economics of Compound Rates of Interest: A Four-Thousand Year Overview Part I

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By Michael

"Whoever enters here must know mathematics." That was the motto of Plato's Academy. Emphasizing such abstract ratios as the Pythagorean proportions of musical temperament and the calendrical regularities of the sun, moon and planets, its philosophy used the mathematics of nature to reveal an underlying harmony and order in the universe and hence, in an ideal society. But there was little quantitative analysis of economic relations. Although the Greek and Roman economies were increasingly wracked by debt, there was no measurement of this phenomenon, or of overall production, distribution and other macroeconomic measures.

The education of modern economists still consists largely of higher mathematics whose use remains more metaphysical than empirically measuring the most important trends. Over a century ago John Shield Nicholson (1893:122) remarked that "The traditional method of English political economy was more recently attacked, or rather warped," by pushing

the hypothetical or deductive side . . . to an extreme by the adoption of mathematical devices. . . . less able mathematicians have had less restraint and less insight; they have mistaken form for substance, and the expansion of a series of hypotheses for the linking together of a series of facts. This appears to me to be especially true of the mathematical theory of utility. I venture to think that a large part of it will have to be abandoned. It savors too much of the domestic hearth and the desert island.

To contemporary economists, mathematics has become the badge of scientific method. But are the right things being mathematized? Do today's models correlate the appropriate phenomena, or do they confuse cause and effect while omitting key dynamics? Is the use of mathematics scientific *ipso facto*, regardless of how it is applied?

The preferred method of mathematical economics is general equilibrium analysis in an environment in which only small marginal disturbances are envisioned, not major structural problems or legal changes in the economic environment. Marginal analysis avoids dealing with quantum leaps. It selects and correlates a rather narrow set of phenomena (supply, labor and materials costs, the interest rate, income and the pattern of demand) to produce models that show how economies might settle at an equilibrium point if left free from outside political interference.

Many economists are trained in calculus and higher mathematics without feeling much need to test their theories quantitatively. They tend to use mathematics less as an empirical measuring tool than as an expository language or simply as a decoration to give a seemingly scientific veneer to their policy prescriptions. Mathematical economics rarely is used to statistically analyze the inherent tendencies at work to polarize wealth and income.

In fact, the mathematical "badge of science" has distracted attention from the tendency for economies to veer out of balance.[1] The problem is that to achieve a single determinate, stable solution to any given problem (always posed as a "disturbance" to a pre-existing balance), general equilibrium theorists are driven to assume diminishing returns and diminishing marginal utility in order to "close the system." A narrow set of variables is selected that all but ignore the economy's growing debt overhead relative to its assets, and the associated flow of interest.

Economies change their shape as they grow. This shape is distorted by the inherent tendency for financial claims – bonds, bank loans and other financial securities – to grow more rapidly than the economy's ability to carry them, much less to pay them off. The volume of such claims tends to grow by purely mathematical principles of self-expansion, independently from underlying economic trends in wealth and income, and hence from the ability of debtors to pay.

The task of economic regulation is reduced to setting an appropriate interest rate to keep all the economy's moving parts in equilibrium. This interest rate is supposed to be controlled by the money supply. An array of measures is selected from the overall credit supply (or what is the same thing, debt securities) to represent "money." This measure then is correlated with changes in goods and service prices, but not with prices for capital assets – bonds, stocks and real estate. Indeed, no adequate statistics presently exist to trace the value of land and other real estate.

The resulting economic models foster an illusion that economies can carry any given volume of debt without having to change their structure, e.g., their pattern of wealth ownership. Self-equilibrating shifts in incomes and prices are assumed to enable a debt overhead of any given size to be paid. This approach reduces the debt problem to one of the degree to which taxes must be raised to carry the national debt, and to which businesses and consumers must cut back their

investment and consumption to service their own debts and to pay these taxes.

Excluded from the analysis is the finding that many debts are not repayable except by transferring ownership to creditors. This transfer changes the shape of the economy's legal and political environment, as creditors act as rentiers to subordinate labor and capital to the economy's financial dynamics.

Rent-seeking exploitation and the proverbial free lunch are all but ignored, yet real-world economics is all about obtaining a free lunch. That is why one seeks to become a political insider, after all, yet such considerations are deemed to transcend the narrow boundaries of economics. These boundaries have been narrowed precisely so as to limit the recognized "problems" only that limited part of economic life that can be mathematized, and indeed, mathematized without involving any changes in social structure ("the environment").

A particular kind of mathematical methodology thus has come to determine what is selected for study, recognizing only problems that have a single determinate mathematical solution reached by or what systems analysts call negative feedback. As noted above, such entropic behavior is based on the assumption of a falling marginal utility of income: The more one earns, the less one feels a need to earn more. This is fortunate, because most models also assume diminishing returns to capital, which is assumed to be invested at falling profit rates. Income and wealth thus are portrayed as tapering off, not as soaring and polarizing until a financial collapse point, ecological limit or other kind of crisis is reached.

A model acknowledging that positive feedback occurs when the rich get richer at the expense of the poorer, and when the "real" economy is dominated by an expanding overhead of financial capital, will depict an economic polarization that has an indeterminate number of possible resolutions. The economic problem becomes essentially political in the sense that conflicting trends will intersect, forcing something to give. This is how the real world operates. But to analyze it would drive economists out of their hypothetical entropic universe into an unstable one in which the future is up for grabs. Such a body of study is deemed unscientific (or at least, uneconomic) precisely because it cannot be mathematized without becoming political.

The mathematical universe of modern economics was not created without some degree of protest. A generation ago F. J. Dyson (1964:132f.) commented that "Mathematical intuition is more often conservative than revolutionary, more often hampering than liberating." Citing Ernst Mach's observation that "The power of mathematics rests on its evasion of all unnecessary thought and on its wonderful saving of mental operations," he worried that too much real-world complexity might be discarded. Nowhere is this problem more pronounced than in the treatment (or lack of recognition) of the economic role played by money and debt.

The exponential growth of debt

Dramatists and novelists often have paid more attention to debt than do modern economists. The novels of Dickens, Balzac and their contemporaries, as well as earlier British drama, are filled with debt imagery. In fact, one of the earliest applications of Napier's logarithms, developed in the late 1500s, occurs at the outset of Shakespeare's A Winter's Tale. Floridly expressing gratitude for the nine months of hospitality he has received, the character Polyxenes jokingly uses the metaphor of a burdensome debt that can never be repaid. The idea is that to take the time to thank his host properly would consume yet more time, using up yet more hospitality for which yet more thanks would be due, creating a never-ending obligation.

> Nine changes of the watery star [the moon] hath been
> The shepherd's note since we have left our throne
> Without a burden: time as long again
> Would be fill'd up, my brother, with our thanks;
> And yet we should for perpetuity,
> Go hence in debt: and therefore like a cipher,
> yet standing in rich place, I multiply
> With one we-thank-you many thousands more
> That go before it.

"Without a burden" means without debt. The "cipher . . . standing in a rich place" is the language used in the early 1600s to indicate the logarithmic exponential. The imagery was that of a debt mounting up unpaid at compound interest, multiplying to the point where it engulfs the kingdom.

Economic writers in earlier times were more ready than their modern counterparts to confront the problem of debts growing so large as to be unpayable. In The Wealth of Nations (V, iii), Adam Smith observed that "Bankruptcy is always the end of great accumulation of debt. The liberation of the public revenue, if it has ever been brought about at all, has always been brought about by a bankruptcy; sometimes by an avowed one, but always by a real one, though frequently by a pretended payment."

The tendency of debts to accumulate at compound rates of interest explains why Smith's axiom applies so universally. The principle was described graphically by one of Smith's contemporaries, the dissenting Anglican minister and actuarial mathematician Richard Price. It was Price who first popularized the distinction between compound and simple interest that later came to be associated mainly with Malthusian population theory.

In the 1770s when Price and Smith wrote, Britain's war in America had forced the nation deeply into debt. It was largely out of their opposition to such debt that they urged Britain to grant freedom to its colonies. As for the debts that already had mounted up, Price proposed an idea that had been anticipated a half century earlier by Nathaniel Gould, a director of the Bank of England. Parliament would pay off the national debt by setting aside a million pounds sterling in a sinking fund, to accumulate at compound interest by reinvesting the dividends annually until the fund grew large enough to pay off the entire debt. Price's 1772 Appeal to the Public on the Subject of the National Debt described the seeming magic of

how money could grow at compound interest:

Money bearing compound interest increases at first slowly. But, the rate of increase being continually accelerated, it becomes in some time so rapid, as to mock all the powers of the imagination. One penny, put out at our Saviour's birth at 5% compound interest, would, before this time, have increased to a greater sum than would be obtained in a 150 millions of Earths, all solid gold. But if put out to simple interest, it would, in the same time, have amounted to no more than 7 shillings 4½d.

Price elaborated this idea in his *Observations on Reversionary Payments*, first published in 1769 and running through six editions by 1803. "A shilling put out at 6% compound interest at our Saviour's birth would . . . have increased to a greater sum than the whole solar system could hold, supposing it a sphere equal in diameter to the diameter of Saturn's orbit." He concluded that "A state need never, therefore, be under any difficulties, for, with the smallest savings, it may, in as little time as its interest can require, pay off the largest debts."

What Price had discovered was the exponential growth of money invested at interest, multiplying the original principal by plowing back the dividends into new saving. What he failed to appreciate was that never in history has any economy been able to turn a penny or any other sum into a surplus large enough to pay creditors a solid sphere of gold reaching out to Saturn's orbit. Marx accordingly poked fun at Price's calculations in his Grundrisse notebooks (1973:842f.) on the ground that no society's productive powers are able to support such compound rates of growth in interest claims. "The good Price was simply dazzled by the enormous quantities resulting from geometrical progression of numbers. . . . he regards capital as a self-acting thing, without any regard to the conditions of reproduction of labour, as a mere self-increasing number," subject to the growth formula

Surplus = Capital (1 + interest rate)n

Economists estimate that during the two thousand years since the birth of Christ the European economy has grown at a compound annual rate of 0.2 percent, far less than the level at which interest rates have stood. No wonder Adam Smith found that no nation in history had paid off its public debt. As he observed in The Wealth of Nations (loc. cit.) England's tax revenues had become "a fund for paying, not the capital, but the interest only, of the money which had been borrowed . . ." Sinking funds established ostensibly to pay off this debt were not effective, as governments invariably reborrowed the money. Smith concluded that the availability of such funds merely "facilitates the contraction of new debts. It is a subsidiary fund always at hand to be mortgaged in aid of any other doubtful fund, upon which money is proposed to be raised in any exigency of the state."

The contrast between geometric and arithmetic rates of growth has long been established in the popular mind not by reference to the interest rate at which savings and debts double and redouble, but by Thomas Robert Malthus with regard to the growth of population relative to the food supply. Malthus first published his theory in 1798, a generation after Price put forth his argument for a sinking fund. Picking up his fellow minister's mathematical imagery, Malthus asserted that population tended to grow "geometrically" at compound rates, but was held back by the fact that the means of subsistence could only grow at an "arithmetic" rate, that is, at simple interest.

Malthus did not foresee that fertility rates historically have tapered off as incomes have risen. Over time, breakthroughs in agricultural and mining technology have increased productivity in these sectors even more rapidly than has occurred in manufacturing, so that food and other consumption goods have increased even more rapidly than has population.

Although Malthus's demographic ideas have been disproved, the financial analysis drawn by Price remains apt. What indeed grow geometrically are the economy's financial claims – its bonded debt, mortgages and bank loans, whose interest charges have tended throughout history to accrue in excess of society's wealth-creating powers.

It was inevitable that private individuals would attempt to make use of the compound interest principle by leaving savings to accumulate over a protracted span of time. In 1800 a Mr. Thelluson set up a trust that was to accumulate its income for a hundred years. At the expiration of that time the trust was to be divided among his descendants. His estate of £600,000 was estimated to yield £4500 per year (at 7 ½ percent), producing a final value of £19,000,000, some thirty times the original legacy.

As matters turned out, Thelluson's will was contested in a litigation that lasted some 62 years, from his death in 1797 through 1859. By the time the lawyers were paid, "the property was found to be so much encroached on by legal expenses that the actual sum inherited was not much beyond the amount originally bequeathed by the testator."[2] Meanwhile, under the leadership of William Pitt, the government calculated that at four per cent compound interest the trust would own the entire public debt by the time a century had elapsed. Some legislation known at the time as Thelluson's Act was speedily passed, limiting such trusts to twenty-one years' duration.

Orthodox academic models rarely acknowledge the problems posed by the exponential growth of debt overhead. Such models typically make government policies appear unnecessary to cope with this problem, by focusing on the kind of world that might exist if the financial overgrowth of savings and debts did not double every decade or so, having multiplied again and again over the past century. It thus has been left mainly to non-mainstream writers to address the structural problems created by an accumulation of interest-bearing debt. The socialist Proudhon (What is Property, quoted in Flürscheim 1902:326), for instance, observed that "If men, united in equality, gave to one of their number the exclusive right of property, and if this single proprietor placed with humanity a sum of 100 francs at compound interest, repayable to his successors of the twenty-fourth generation after the lapse of 600 years – this sum of 100 francs would, if invested at 5 per cent., amount to the sum of 107,854,010,777,600 francs, a sum 2,696 times as large as the capital of France, estimated at 4,000 millions (50 years ago), or 20 times as large as the value of the whole globe with all movable and unmovable wealth."

Marx's analysis of the financial dynamics of debt

The most sophisticated analysis of financial capital in the 19th century was that of Marx. In Volume III of Capital (ch. xxx) and Vol. III of Theories of Surplus Value (both published posthumously) he referred to high finance as being based on "imaginary" or "fictitious" capital. It was fictitious because it consisted of claims on tangible wealth rather than constituting the direct means of production. These financial claims took the form of bonds, mortgages, bank loans and commercial paper. Marx (Capital, III.461) called these financial claims "a void form of capital" inasmuch as they represented a financial overhead whose interest charges ate into industrial profits. Such profits were earned actively by employing labor to produce goods and services for sale – a process Marx summarized by the formula M-C-M', spending money to produce commodities that would sell for yet more money. But the growth of interest-bearing financial capital was characterized by the disembodied M-M', making money simply from money itself, i.e. in an essentially sterile way.

Marx spelled out how financial capital tended to assert its domination over tangible capital above all in monetary crises and the foreclosures that followed in their wake. To illustrate how the inexorable force of such usury capital and its stipulated debt service tended to exceed debtors' ability to pay, Marx (Capital, III: 463) cited Martin Luther's imagery likening it to the beast Cacus, and Dr. Price's calculations about the power of compound interest. The volume of financial claims grew willy-nilly as a result of this mathematical principle, inexorably surpassing the ability of the economy's tangible productive powers to keep pace.

Yet after analyzing finance capital's tendency to grow geometrically at compound interest, Marx abruptly dropped the subject. He believed that finance capital was becoming thoroughly subordinated to the dynamics of industrial capital. "In the course of its evolution, industrial capital must therefore subjugate these forms and transform them into derived or special functions of itself," he speculated (1971:468). "It encounters these older forms in the epoch of its formation and development. It encounters them as antecedents, but not as antecedents established by itself, not as forms of its own life-process." It was the destiny of industrial capitalism to mobilize finance capital to fund its own economic expansion. "Where capitalist production has developed all its manifold forms and has become the dominant mode of production," Marx concluded, "interest-bearing capital is dominated by industrial capital, and commercial capital becomes merely a form of industrial capital, derived from the circulation process."

If this were true, the economy's means of payment would be able to keep up with the exponential growth of interest-bearing debt claims. Alternatively, the overhang of financial capital – savings and their counterpart debts – would be wiped out by monetary crises. More than any other economist, Marx drew attention to this problem, but he nonetheless viewed finance capital as playing a subordinate role. He thus shared the 19th-century optimism of the French utopian socialist Fourier and of the St. Simonians that industrial progress might solve the debt problem by mobilizing savings more productively than ever before had been the case.

German historical economists such as Roscher pointed to the fact that interest rates tended to fall steadily with the progress of civilization; at least, rates had been falling since medieval times. Credit laws were becoming more humanitarian, and debtors' prisons were being phased out throughout Europe as more lenient bankruptcy laws were freeing debtors to start afresh with clean slates. Most important, European and North American public debts were on their way to being paid off during the relatively war-free century 1815-1914. Lending was mobilized to fund heavy transport, industry, mining and construction. For awhile, the economy's debt burden seemed likely to become self-amortizing. The broad consensus was that the debt problem was curing itself by being co-opted into a more socially productive credit system.

Modern observers can trace how these salutary trends gave way to the overgrowth of debt experienced in recent decades. The drives of finance capital have tended to overshadow those of industrial development. Indeed, finance capital was absorbing industrial capital even in the Victorian era as emperors of finance surpassed captains of industry.

Flürscheim's financial critique

Marx and his socialist followers directed their invective mainly against industry and its profits, not financiers collecting interest. Henry George attracted many followers by focusing on the rentier income taken by landowners reaping rents that enriched them at society's expense, while their rent takings slowed economic progress. George's major European follower, Michael Flürscheim, wrote one of the few books focusing primary attention on the problems caused by interest-bearing debt. "It is true that the employer is the sponge which sucks up the profit, the greater value (*Mehrwerth*, as Marx calls it) of labor's product," he wrote (*A Clue to the Economic Labyrinth*, 1902:116), "but only to yield it to the rent and interest lords, as well as to the middlemen, who together press it out of him as quick as he gets it, barely leaving him on the average the hard earnings of his own work, and, what is worse, taking the power from him of increasing production to its full potentiality." He accordingly recommended that labor and capital combine to attack "the real enemy," the *rentiers*.

To do this in an informed way, finance capital had to be distinguished from physical capital. Pointing out (p. 347) that "Tribute Claim Capital constitutes the Bulk of the World's Capital," Flürscheim explained that "When an orator or writer has to reply to a socialist's attack upon capital as the oppressor of labor, he points to what orthodox economy calls capital, and speaks of our wonderful progress due to our improved means of production and distribution, whereas his antagonist thinks of Government bonds, of land monopoly, of mining rights, of all kinds of tribute claims selling at Exchange for certain amounts, and not at all falling under the orthodox definition of capital, though representing that capital which people principally have in view when they use the term." But he was almost alone in focusing on this target.

Flürscheim elaborated that "All exertions, all improvements in the methods and tools of labor, the strictest economy, the severest self-denial, are all powerless to compete with the rapidity of self-increase possessed by capital placed at compound interest, and they cannot keep up with its demands." To illustrate this point he composed the following allegory to illustrate the dynamic at work. Many ages after man was driven from Paradise and told by the Lord "to earn his bread by the sweat of his brow, mercy began to prevail. A loving angel was sent down by the Great Master, charged with the task of lightening the burden. The angel's name was Spirit of Invention. He began his work by teaching man to make useful tools," to tame animals, mobilize water power, air and wind power, fire and steam power to drive

machinery.

"It seemed that at last the golden era had come of which men had dreamed for ages past, without ever hoping to attain it. Without trouble, with almost no exertion, except that of wealth for the satisfaction of wants which, in former times, even the richest did not know or dream of." But "that envious spirit, that fallen angel, Satan, who once before, in the shape of the serpent, had driven man from Paradise by seducing him to sin," was jealous and angry that his own empire would soon be over for ever.

Among the follies of man, one little imp, called Interest, managed to attract Satan's attention. "'What is the matter with you, Interest?' he asked the saucy imp. 'You don't seem to be so dejected as your comrades are?'"

"'Why should I be dejected, master?' replied the spirit, 'Am I not one of your favorite soldiers? Haven't I always been victorious under your august guidance?'"

But Satan answered sadly, "Alas, You are no match for the Spirit of Invention." The imp, however, volunteered to demonstrate his prowess in a dual.

"'You little imp! Fight the powerful angel who is defeating all my army?' laughed Satan."

"'Yes, I alone; provided, of course, you allow my son, Compound Interest, to help me.'" He explained with regard to the goblins of technology, that "Instead of their being a source of blessing to mankind, I shall make them the producers of untold misery – worse than ever man suffered from thy hands." So "Satan let him have his way. The battle of giants began."

In the beginning the angel laughed, for, though twenty squares were passed, no noticeable diminution of his forces was perceptible. Demon Interest said nothing, but attended to business, quietly doubling his army on every succeeding square. At the thirtieth square the angel ceased to laugh, and soon saw he was lost.

'I despised you, little fellow,' he signed despairingly, 'and I am punished for my vanity. I see there is no use fighting against you. Demon Interest is more powerful than the Spirit of Invention. I am your slave. Command your servant!'

'I am the only servant of my great master,' dryly replied the demon. 'Here I see him coming. He will give you his orders.'

And Satan gave his orders. He commanded that the angel was to continue in his work with all his troops, which were to be increased with all possible exertion, so that humanity – which did not know the nature of the antagonist it had to fight against – would always keep in fresh hope of final success when the new troops were forthcoming. But as fast as they appeared, Demon Interest was to send forth a larger army to capture the new forces, to enslave them, and – instead of their benefiting man – make them increase the slave-chains which weigh him down.

To the surprise of the king, this series of doublings "produced an amount larger than the treasures of his whole kingdom could buy. It is this kind of chess-game which capital is continually playing with labor." The remarkable growth of compound interest would "soon swallow products, capital, the earth and even the workers."

Flürscheim concluded (1902:333f.) by asking, "What is compound interest? Is it anything else than the fresh investment of earnings of capital?" He added the story that "Napoleon Bonaparte, when shown an interest table, said, after some reflection: 'The deadly facts herein lead me to wonder that this monster Interest has not devoured the whole human race.' It would have done so long ago if bankruptcy and revolution had not been counter-poisons."

This problem has a pedigree dating back some four thousand years. What is surprising is the clarity with which ancient economies dealt with it in a more straightforward way than is favored today.

What the Babylonians recognized that modern economists don't

At past Heilbronn symposia I have discussed the importance of tracing civilization's economic trends back to Sumer and Babylonia.[3] It was in this epoch, over two thousand years prior to classical antiquity, that the basic elements of modern economic relations first appear. These elements included interest-bearing debt and ways of coping with the problems caused by its spread.

Mathematics played a major role in the training of scribes. This hardly is surprising, as cuneiform writing's first application (c. 3200 BC) was to economic account keeping. Already in the 3rd millennium BC, scribes were trained in mathematical procedures such as manpower allocation problems (e.g., how many men were needed to dig canals of a given size or to produce a given amount of bricks), the surveying techniques needed to calculate surface measurements (including the geometric analysis of squares and circular shapes), astronomical computations and even quadratic equations. Scribes also were trained to calculate the expected growth of herds and the exponential growth of interest-bearing investments.[4]

Rather than reflecting economic productivity, profitability or the general ability to pay, the accrual of interest was essentially a mathematical phenomenon. For ease of computation, the normal commercial rate had been built into the system of sexagesimal weights and measures. Interest accrued at the rate of one shekel per mina per month, that is, the "unit fraction," 1/60th. This rate remained constant over many centuries (indeed, millennia), and worked out to 12/60ths per year, 60/60ths in five years. Compounding occurred quinquennially, once the initial principal had reproduced itself in five years.[5] Interest rates in Greece, Rome and the Byzantine Empire likewise were based on ease of computation in their local systems of weights, measures and arithmetic.[6]

The fact that these interest rates were not economically based or responsive to changing economic conditions made repayment problems inevitable. Debt problems also develop today, of course, but contemporary theory insists that

economies can adjust to any given level of debt charges. The Babylonians made no such assumption. Their student exercises show that they recognized that herds, for instance, increased at a slower pace than did the growth of debts mounting up at 20 percent per year, to say nothing of agrarian rates typically around 33 1/3 percent.

In light of these exercises I would like to make a suggestion that initially may seem outrageous. Mesopotamian economic thought c. 2000 BC rested on a more realistic mathematical foundation than does today's orthodoxy. At least the Babylonians appear to have recognized that over time the debt overhead became more and more intrusive as it tended to exceed the ability to pay, culminating in a concentration of property ownership in the hands of creditors.

Scribal students (nearly all of whom were employed in temple and palace bookkeeping) were taught to calculate how rapidly investments doubled when lent out at interest. A model exercise appears in a Berlin cuneiform text (VAT 8528): How long does it take a mina of silver to double at the normal commercial rate of interest of 1/60th (that is, one shekel per mina) per month? (This often is expressed a 20 percent annual interest, inasmuch as 12/60ths = 1/5 = 20 percent.) The solution involves calculating powers of 2 ($2^2 = 4$, $2^3 = 8$ and so forth).[7]

The answer is five years at simple interest, as compounding began only once the principal sum had entirely reproduced itself after 60 months had passed. At this rate a mina multiplies fourfold in 10 years, eightfold in 15 years, sixteenfold in 20 years, and so forth. A related problem (VAT 8525) asks how long it will take for one mina to become 64, that is, 26. The answer is 30 years, six times the basic five-year doubling period (Illustration 1).

The basic idea of interest-bearing debt is one of doubling times. An ancient Egyptian saying that "If wealth is placed where it bears interest, it comes back to you redoubled."[8] Babylonian agricultural debts at the typical 33 1/3% rate doubled in three years. The Laws of Hammurapi appear to reflect the view that held that when creditors had received interest equal to their original principal – after three years of service – the debt should be deemed to be paid off and the debt bondservants freed.

Babylonians recognized that while debts grew exponentially, the rest of the economy (what today is called the "real" economy) grows less rapidly. Today's economists have not come to terms with this problem with such clarity. Instead of a conceptual view that calls for a strong ruler or state to maintain equity and to restore economic balance when it is disturbed, today's general equilibrium models reflect the play of supply and demand in debt-free economies that do not tend to polarize or to generate other structural problems.

Adam Smith grounded such ideology in a Deist religious view of the Lord as having started up the universe and then let it proceed harmoniously by its own laws of motion. But in Babylonia the earning capacity of subsistence rural producers hardly could be reconciled with creditor claims mounting up at the typical 33 1/3 percent rate of interest for agricultural loans (or even at the commercial 20 percent rate). Such charges were unsustainable for economies as a whole. At no time in history has agricultural output grown at sustained rates approaching these levels. In situations where the loan proceeds were used for basic consumption needs, interest charges ate into the cultivator's modest resources and finally absorbed them in toto. Once the usury process got underway and debtors were called on to pay sums beyond their ability to produce, creditors were enabled to draw the land and other wealth into their own hands.

Economic relations were put back in balance by Babylonian rulers acting from outside the economic system. They cancelled agrarian barley debts no less frequently than every thirty years, proclaiming clean slates on the occasion of their ascending to the throne, or as military or economic conditions dictated.[9] Modern economies would rely on income and price adjustments. But prices for most essentials, and most non-commercial incomes in Mesopotamia, were administered or set by custom. There was no idea that the economy by itself might automatically provide such balance.

Today's economists have a problem analyzing the relationship between the debt overhead and the capacity to pay. Academic orthodoxy holds that economies can adjust to any volume of debt, given sufficient price and income flexibility to facilitate the transfer of revenue and assets to creditors. What is not recognized is that the resulting economic polarization reduces the economy's ability to function well. In addition to missing this negative feedback (the proverbial vicious circle), modern economists tend to overlook the fact that interest-bearing debt grows according to its own exponential laws of increase. The economy rarely can keep up.

If Sumerian and Babylonian students could learn the mathematics of compound interest and the associated exponential growth of debts, it should not be out of reach for modern economists to do so. But today's economic ideology does not encourage mathematical models based on intersecting financial and physical trends. For it is at such points of intersection that something has to give, that is, a political solution must be imposed from outside the system.

The mathematics of wealth addiction and hubris

Ancient economic thought did not endorse the ideal of accumulating wealth and riches. Rather than praising ambition as the mainspring of progress, Mesopotamian religion condemned the amassing of property. Excess was held to be the primary cause of injustice, and it was characteristic above all of creditors abusing the weak and poor and foreclosing on their lands. It was to avenge the economic injustice done by the rich and strong against the weak that the Sumerian goddess Nanshe moved, as would the Greek goddess Nemesis in classical antiquity.

Nearly every ancient society recognized that physical consumption might bring satiety, but that financial riches and property did not. The biblical prophets described how the selfish principle of insatiability led to hubris, a form of wealth addiction whose exponential upsweep in greed was akin to the growth of money at compound interest. When Isaiah declaimed "Woe to you who add house to house and join field to field till no space is left and you live alone in the land," he was condemning not only the greed of creditors but the inexorability of interest-bearing debt that gave them the power to amass property at the expense of the society around them.

The Greek reaction against the insatiable desire for property found its counterpart in the Delphi Oracle's motto, "Nothing in excess," and in the political poetry of Solon (frag. 13.71-73): "No manifest limit of ploutos 'wealth' exists for men;

whoever of us has now the greatest substance for life, they are eager for twice that. Who will satiate everyone?" Hesiod's Theogony (596) bore the same message: "there is satiety of everything except ploutos," for (1157-58) "you cannot satiate your spirit with ploutos."[10]

Addictive egoism was epitomized by the table manners of drinking wine at symposia. Eating and drinking represented a daily social exercise in equity and moderation – or immoderation, as the case might be. Economically, wealth addiction was epitomized by the drives of creditors to amass more and more wealth without limit. Such uncontrolled appetites were held to reflect a lack of proper philosophical training, a less civilized mode of behavior.

The world's major religions are replete with this attitude.[11] Proverbs 30:8 asks "Give me neither poverty nor riches." The Confucian (Analects XI, 15) advise that "Excess and deprivation are equally at fault," each causing problems. The Tao Te Ching announces that "He who knows that he has enough is rich." The Hindu (Bhagavad-Gita II, 71) teaches that "That person who lives completely free from desires, without longing . . . attains peace." And Buddhism's Dharmapada 336 advises that "Whoever in this world overcomes his selfish cravings, his sorrows fall away from him like drops of water from a lotus flower."

The hubristic spirit of evil was that of insatiability, a wealth addiction that led its prey to victimize the rest of society – what Martin Luther depicted the drive for usury as the all-consuming monster, Cacus. Today's world seems to be embracing this spirit, viewing moderation as uneconomic behavior. In its place is being put a self-referential economics of moral obesity. Ivan Boesky is reported to have announced in 1986 to a seminar convened at Stanford University that "There is nothing wrong with greed." If the fictional corporate raider Gordon Gekko elaborated this passage more overtly in the 1987 movie Wall Street – "Greed is good" – it was a theme that ancient Greek poets and dramatists dealt with as hubris, the drunken arrogance of wealth and power. The very word "greed" was coined to describe something sinful. It was a word of condemnation, not praise of the sort found in such recent texts as C. B. McConnell's Economics (1984:16): "The principal task of the economy is to attain the maximum fulfillment of society's unlimited material wants."

Utilitarianism since Jeremy Bentham and Stanley Jevons has deemed satiety to be the guiding principle of human psychology. Schoolbook economic models assume that each added unit of consumption goods yields less and less pleasure ("utility"). This theory of diminishing marginal utility holds that people tend to reduce their economic drives as they grow richer. Instead of wanting to consume more and more, they save more of their income or simply choose leisure. Left out of account is the insatiable drive on which ancient societies placed such great emphasis – the drive to accumulate property, most typically through the dynamics of usury. Modern utilitarian theory views wealth is ultimately as something to be consumed, much like food or clothing – an amassing of the means of consumption rather than as the means of production or, ultimately, a social power relationship.

A repertory of mathematical economic functions, real and imaginary

Four types of mathematical curves describe how economies grow and, sometimes, collapse (Illustration 2).

Straight-line growth ($y = bx$) represents constant returns to scale, as in Mesopotamian exercises in calculating the amount of labor needed to perform everyday tasks, including the cultivation of land. It is short-term and microeconomic in that it relates to an economic context in which factor proportions and productivity remain unchanged.

An exponential curve ($y = e^{rx}$) describes growth with time x of a sum starting with a value of 1 at compound interest r. When plotted on log paper, this growth appears as a straight line. When the growth due to compound interest is modeled by $y = e^{rx}$, this describes the growth when accrued interest is added continually to the loan. But the typical way of compounding interest is to add accrued interest after a fixed interval, for example a year, as already discussed. Then the growth equation changes to $y = (1+r)x$. This is also exponential growth, just as dramatic as in the continuous case. In this case with discrete and equal time intervals, exponential growth is also called geometric growth. Rates of growth are often expressed in terms of doubling times. The doubling time is $\ln 2 / \ln(1+r)$. Here "ln" is the natural logarithm.

An S-curve describes most biological growth. It is characterized by an accelerating upswing that tapers off as it reaches an asymptotic limit. Economies tend to grow exponentially as they recover, as long as under-utilized capital or land is available to employ labor. The typical business cycle, for instance, tapers off as capacity and debt-servicing limits are reached. Business upswings are brought to an end suddenly, by financial tightness caused by over-borrowing, that is, over-indebtedness. Defaults occur, and a crash follows. The ensuing business downturn occurs much more quickly than the upswing.

The characteristic shape of most business "cycles" is thus scalloped and ratchet-like. An upsweeping log curve encounters financial constraints and collapses rapidly. Actually, this shape represents a combination of two curves intersecting. The upswing ($y = a + bx + cx2$) is intersected by the exponential growth in debt ($y = x2$). Something has to give at the point of intersection. A financial collapse ensues, often with political overtones and institutional changes.

Most economists seek to explain the economy in terms of a single curve. Joseph Schumpeter used a smooth sine curve ($y = \sin x$) as an analogy to describe the business cycle. This is especially attractive to theorists who postulate automatic stabilizers, such as Wesley Clair Mitchell and the program of leading and lagging indicators he pioneered in America at the National Bureau of Economic Research. Yet this does not acknowledge the extent to which the world's financial overhead has multiplied over the past century.

How compound interest shapes business behavior

The next millennium is likely to see the Thelluson principle operate on an economy-wide scale. "Saving" will take the form largely of creditors earning interest, which will be plowed back increasingly into new lending rather than new tangible capital formation. This will increase the economy's debt overhead rather than its capacity to carry its debts.

Nearly all sectors are now seeking to use the principle of compound interest for their own gain at the expense of the rest of society. It has become normal for insurance companies, for instance, to stall in paying the claims of their customers, so that they can continue to invest their money (while charging off their taxable income by placing it in a "reserve fund" as if they actually paid the money out). By the time five years or so have elapsed, the money built up in the companies' reserve funds is able to cover nearly the entire sum due their policy holders.

Real estate speculators benefit by not having to pay taxes on their land as it appreciates in price, but only at the point of sale when their capital gains are taken (Gaffney 19–:19):

The basic preference for land gains is tax deferral. Land gains are not recognized and taxed as income when they accrue, but only later upon sale for cash.

'A' puts $1 in a savings account paying 7.2% compounded annually. (That is the rate at which money doubles every 10 years.) He gets 3.6% after taxes [assuming a 50 percent tax rate], and plows it back, at which rate it takes twice as long, 20 years, for money to double. After 60 years his wealth has grown to $8.

'B' puts his $1 into land whose value rises at 7.2% per year. After 60 years its value has doubled 6 times to $64. He sells it and pays taxes of 50% on the gain of $63. He thus clears $32.50 after taxes. B's wealth has grown to over 4 times A's wealth, although both made the same rate of return, and both paid taxes at the same rate. The difference is timing.

To tax capital gains as they accrue thus would produce a very different result from taxing these gains only at the point they pass through the market.

In view of these practical applications, why has mainstream economics dropped this understanding, so important in earlier epochs and still of central importance?

The hypothetical "parallel universe" approach to economics

Marx (Capital, I:14) defined political economy's task as being "to lay bare the economic laws of motion of modern society." By contrast, equilibrium theory describes how market relations might settle at a stable resting point if only the world were something other than it is. A world is envisioned that is characterized by automatic self-adjusting mechanisms, so that active government policies appear unnecessary to ensure economic balance. It is a world free of the financial dynamics of debt growing at compound rates of interest.

One must suspect a political reason for the aversion felt by economic model-builders to these financial dynamics. To acknowledge their tendency to create structural problems would imply just what it did in Sumerian and Babylonian times: the restoration of economic balance by public fiat, that is, from outside the economic system. Neglect of the debt overhead therefore is a prerequisite for economic models to generate laissez faire conclusions. A "what if" universe is postulated – the kind of world that might exist if finance capital were not a problem. After all, what is not perceived or quantified is less likely to be regulated.

Economies are supposed to be able to pay their debts simply by saving more. The working assumption is that sufficient saving and investment will to enable any society's growth in debt to proceed ad infinitum. Monetarist theory in particular assumes that creditors will invest their earnings to further expand output and raise living standards.

This logic treats "investment" in an ambiguous way. Any increase in saving is deemed to be good, regardless of whether it is invested productively or parasitically, physically or financially. Yet such saving in reality consists not only of direct investment in tangible capital formation. It also takes the form of stock market investment and real estate speculation in the ownership of assets already in existence, merely bidding up their price.

What is neglected especially is today's most characteristic pattern of lending: the investment of savings to extract interest charges that are recycled into new loans rather than financing new means of production to help economies "grow their way out of debt." Such a pattern of recycling savings serves to enlarge the volume of financial claims attached to existing productive assets. These financial claims on wealth – bonds, mortgages and bank loans – are lent out to become somebody else's debts in an exponentially expanding process. In recent decades such claims have grown more rapidly than tangible investment in factories and farms, buildings and homes, transport and power facilities, communications and other infrastructure.

For the past two decades, economies have been obliged to pay their debts by cutting back new research, development and new physical reinvestment. This is the essence of IMF austerity plans, in which the currency is "stabilized" by further international borrowing on terms that destabilize the economy at large. Such cutbacks in long-term investment also are the product of corporate raids financed by high-interest junk bonds. The debts created by businesses, consumers and national economies cutting back their long-term direct investment leaves these entities even less able to carry their mounting debt burden. They are forced to live even more in the short run. Interest rates rise as debt-strapped economies become riskier, for as Adam Smith observed, "interest rates usually are highest in countries going fastest to ruin." And as interest rates rise, yet more money is shifted away from direct investment into lending at interest, until the system is torn apart from within. Capital flees abroad, the currency falls and unemployment rises.

No doubt a point must come at which the burden shakes the public out of its hope that matters somehow will return to normal. In the end the global economy must be obliged to do what Adam Smith said every debtor economy historically has been obliged to do: let its debts go. (Now that global debts are becoming dollarized, it is less possible for a national economy simply to inflate its way out of debt and make Smith's less costly "pretended payment.")

But it has become academic fashion to imagine alternative "virtual realities" in which no such debt problems exist. The effect is to turn economics into something akin to science fiction. The literary critic Colin Wilson has observed that in evaluating such fiction, the proper question to be asked is, what if the world were really like this? What does such

speculation teach us?

Let us ask this question of today's monetarist economic fantasies. Fearing governments to be corrosive, monetarism warns that they should not act to shape the economic environment. In particular they should not seek to steer or otherwise regulate financial markets, for that will kill the proverbial goose that lays the golden eggs. Society has no reason to be disturbed by interest-bearing debt accruing more rapidly than the means to pay.

But is this really Planet Earth? Or is it a hypothetical world in which the charging of interest either was never invented, or was banned by Judeo-Christian-Islamic-Communist anti-usury laws winning rather than losing out? Such theorizing may be useful as an amusing exercise in "alternative history," that is, history as it might have evolved in some other way in some parallel universe. But the monetarist mathematics are not those of earthly reality.

As in science fiction, the main criterion for success in modern economics is its ability to maintain internal consistency in the assumptions being made. The trick is to convince readers to suspend their disbelief in these assumptions. The audience is asked to take seriously problems posed in terms of a universe in which money is not lent out at interest or spent on stocks, bonds, real estate and other financial claims on wealth, but is spent only on the production of current goods and services. The student is asked to believe that debts will not tend to grow beyond the means to pay, and that any disturbance in the economic balance will be met by automatic stabilizing responses rather than requiring action from outside the market economy.

According to equilibrium theory, the growth in debt overhead in recent decades should not have developed into a serious problem. All that is necessary is for us to suspend our natural disbelief in the fiction that shifting the money supply can steer interest rates to a particular level that will keep the economy in balance.

In sum, rather than tracing the incompatibility between the growth in debt claims and the economy's ability to pay, most economists have simply ignored the problem. Not being amenable to the usual "mathematical" solution, the problem itself is deemed unscientific, rather than theory being rejected as such.

Economics vs. the Natural Sciences: The airy methodology of "as if"

What is even more remarkable is the idea that economic assumptions need not have any relationship to reality at all. This attitude is largely responsible for having turned economics into a mock-science, and explains its rather odd use of mathematics. Typical of the modern attitude is the textbook Microeconomics (1964:5) by William Vickery, long-time chairman of Columbia University's economics department, 1992-93 chairman of the American Economic Association and winner of the 1997 Nobel Economics Prize. Prof. Vickery informs his students that "pure theory" need be nothing more than a string of tautologies:

Economic theory proper, indeed, is nothing more than a system of logical relations between certain sets of assumptions and the conclusions derived from them. The propositions of economic theory are derived by logical reasoning from these assumptions in exactly the same way as the theorems of geometry are derived from the axioms upon which the system is built.

The validity of a theory proper does not depend on the correspondence or lack of it between the assumptions of the theory or its conclusions and observations in the real world. A theory as an internally consistent system is valid if the conclusions follow logically from its premises, and the fact that neither the premises nor the conclusions correspond to reality may show that the theory is not very useful, but does not invalidate it. *In any pure theory, all propositions are essentially tautological, in the sense that the results are implicit in the assumptions made*. [Italics added.]

This disdain for empirical validity differs from the method found in the physical sciences. Why strive to be logically consistent if one's working hypotheses and axioms are misleading in the first place? Ptolemaic astronomers were able to mathematize models of a solar system revolving around the earth rather than the sun. The phlogiston theory of combustion was logical and even internally consistent, as is astrology, former queen of the medieval sciences. But these theories no longer are taught, because they are seen to have been built on erroneous assumptions.

The sophistical tendency can be traced back to John Stuart Mill's 1844 essay "On the Definition of Political Economy; and on the Method of Investigation Proper to it":

In the definition which we have attempted to frame of the science of Political Economy, we have characterized it as essentially an abstract science, and its method as the method a priori. . . . Political Economy, therefore, reasons from assumed premises – from premises which might be totally without foundation in fact, and which are not pretended to be universally in accordance with it. The conclusions of Political Economy, consequently, like those of geometry, are only true, as the common phrase is, in the abstract; that is, they are only true under certain suppositions, in which none but general causes – causes common to the whole class of cases under consideration – are taken into account.

But lacking empirical testing and measurement, economics narrows into a mock-science of abstract assumptions without much regard as to whether its axioms are historically grounded. The self-congratulatory language used by economists euphemizes the resulting contrast between economics and science. "Pure" theorists are depicted as drawing "heroic" generalities, that is, banal simplicities presented in a mathematical mode called "elegant" rather than simply air-headed. To the extent that the discipline uses mathematics, the spirit is closer to numerology than to the natural sciences.

The problems inherent in this approach are typified by Nobel Prizewinner Paul Samuelson's article on "The Gains from Trade" (1939:205): "In pointing out the consequences of a set of abstract assumptions, one need not be committed unduly as to the relation between reality and these assumptions." This statement did not deter him from drawing policy conclusions affecting the material world in which real people live. For instance, he wrote concerning his Factor-Price Equalization Theorem (which claims that under a regime of free trade, wages and profits will tend to equalize throughout the global economy):

"Our problem is . . . a purely logical one. Is 'If H, then inevitably C' a correct statement? The issue is not whether C (factor-price equalization) will actually hold; nor even whether H (the hypothesis) is a valid empirical generalization. It is whether C can fail to be true when H is assumed to be true. Being a logical question, it admits of only one answer, either the theorem is true or false" (reprinted in Caves and Johnson 1968:59).

Contrasting this theorem with the real-world tendency of international incomes and wages to polarize rather than equalize, Gerald Meier (1968:227) observes that "It need not . . . come with any surprise that factor returns have been so different . . . when in short, the restrictive conditions of the theorem have been so clearly violated in reality." But is it not sophistical to speak of reality violating a theory? Theory violates reality, not the other way around.

If one must be logical, why not start with realistic rather than merely hypothetical assumptions? The answer, I am afraid, is that realistic assumptions do not lead to the policy conclusions pre-selected by economic ideologues. This explains why Samuelson-type trade theories continue to treat the international economy as a thermodynamic system to be analyzed by entropy theory, whereas the real-life world economy is an expanding system, in which labor migrates and capital flows from low-income "cold" economies to high-income "hot" ones.

Wrong-headedness rarely is accidental; there usually is a self-interested policy motive. In his essay on "How Scientific are the Social Sciences," the Swedish economist Gunnar Myrdal (1956:336) observes that "Facts do not organize themselves into systematic knowledge, except from a point of view. This point of view amounts to a theory." He emphasizes that "contrary to widely held opinions, not only the practical conclusions from a scientific analysis, but this analysis itself depends necessarily on value premises."

We therefore are entitled to ask whose interests are served when economists claim that their assumptions need have no connection with reality, yet then proceed to give policy recommendations. Why have they settled on the particular assumptions of, say, the Heckscher-Ohlin-Samuelson theory of international equilibrium rather than starting from more realistic assumptions capable of explaining the real world's financial and economic polarization between debtor and creditor nations?

The products of poor-labor countries exchange for those of better-paid labor not only because of productivity differences, but because the currencies of poor-labor countries depreciate as a result of the capital transfers they make in a vain attempt to service their foreign debts. In the end these debts will prove unrepayable, and must face default, as they mount up at interest beyond the economic means to pay. But in an attempt to conceal this mathematical inevitability, creditor-oriented model builders in the IMF and other such institutions design austerity programs which deprive debtor economies of capital, educational programs and other basic infrastructure. Such programs make it even harder for poor countries to catch up. And matters are further aggravated by attempts are made to encourage such countries to stave off their mathematical fate by undertaking privatization programs, that is, a voluntary and self-imposed forfeitures of national assets to foreign and domestic creditors.

Creating a statistical picture of this phenomenon is impaired by the fact that wealthy domestic families operate out of offshore banking centers nominally as "foreigners" in their own countries. Another statistical black hole consists of land statistics and other asset values. The blame rests mainly on economists themselves, for constructing models in which foreign debt, offshore banking centers, land values, and the composition of savings and debt do not seem to be necessary at all.

Even the existing statistics suffice to show that just as poor countries have become dependent on richer ones, so domestic economies polarize as debtors (including the government itself) become increasingly dependent on creditors. Such phenomena nowhere appear in the polite world of orthodox economic model building in the service of this untenable status quo. In these fairy tales everyone ends up in a more or less equitable equilibrium.

To date, mathematics has been used in a way that does not admit a discussion of institutional and structural transformation. This is not the fault of economics as such. What needs to be done is to project the point at which trends intersect, that is, the point at which something must give. At these crises the "solution" is not inherently economic, but political.

Of course, it is axiomatic that wealth tends to be turned into political power, forcing "solutions" to crises that increasingly favor vested interests as the economy polarizes. But the analysis of such phenomena is dismissed by general equilibrium theorizing that assumes a constant and unchanging political environment, on the logic that changes in laws are "exogenous" to the subject matter of economics proper. The word "exogenous" is heard so often these days that one wonders just what is left to be relevant in economics proper.

Another way in which mathematics has been abused by the economics profession is in the failure to pinpoint what has become a universal economic problem: the impossibility of the world's financial savings continuing to grow at compound interest ad infinitum. A striking analogy of the inherent mathematical problem was pointed out recently by Edward O. Wilson, in Consilience (New York: 1998:313), citing "the arithmetical riddle of the lily pond. A lily pod is placed in a pond. Each day thereafter the pod and then all its descendants double. On the thirtieth day the pond is covered completely by lily pods, which can grow no more." He then asks, "On which day was the pond half full and half empty? The twenty-ninth day."

This provides a helpful answer to financial optimists who insist that there are two sides to every question, and that what one person sees as a glass half empty, another will realize is a glass half full. Growth the economy's savings is, simultaneously, growth its debt overhead, except as such saving is recycled into equity ownership and tangible direct investment. By the time people feel obliged to argue over whether the economic glass if half empty or half full, we probably are on the brink of the Last Days.

Are some debts productive? Certainly they are. Ancient societies drew the distinction (which was made down through the classical economists) between productive and unproductive credit, that is, between commercial loans which provided

the business borrower with the resources to earn the money to repay his debt with interest; and consumer or government loans on which the interest had to be paid out of the debtor's remaining resources. The Bronze Age core economies coped with the debt problem simply by canceling society's unproductive debts when they grew too large. However, the Sumerians and Babylonians only annulled consumer barley-debts; they left commercial silver-debts intact. (This implicit distinction between productive and unproductive debt represents a third way in which Babylonian economics may be deemed more sophisticated than modern economics (in addition to the afore-mentioned focus on the destabilizing role of debts multiplying at compound interest, and the phenomenon of wealth addiction.) But the modern failure to distinguish between productive and unproductive credit shows the adverse effects of building internally consistent logical models on the basis of unreal or irrelevant economic assumptions.

At issue is not the individualistic economics of Robinson Crusoe on his desert island, but the long dynamics of social history. The economic historian is struck by the great wealth that has been accumulated again and again by the richest families throughout history. But as this wealth has grown, the harder it has been to keep it viable. This is because purely financial wealth (that is, financial claims on resources that find no counterpart in a corresponding growth in tangible investment and the means to pay) tends to be invested in ways that impoverish the surrounding society. This blocks the circular flow that is necessary for a viable economy. For this reason, the great monied fortunes tend to be lost. They tend to be plowed back into yet new loans, which become especially riskier. At a point the government itself becomes the debtor of last resort (as in modern financial bailouts), and we are brought back to Adam Smith's maxim that no government has ever repaid its debts.

The great 12th-century accumulation of wealth of the Templars was seized by Philip the Fair, who dissipated it in warfare. The wealth of the great Italian banking families was lost in loans to Britain's kings, who dissipated the proceeds in waging the Anglo-French wars. Most early debts were wiped out by wars, and increasingly by their inflationary aftermath. Others financial fortunes were lost through bad judgment such as risky foreign investments. Some fortunes were dissipated by one's heirs. The relevant point for the social analyst is that financial fortunes cannot continue to accumulate in the aggregate, precisely because of the inexorable mathematics of compound interest.

So obviously, there are different kinds of mathematical economics. What the Cornell philosopher E. A. Burtt referred to the metaphysical foundation of modern physical science has become a politically tinged metaphysics in the hands of monetarists and neoclassical economists. Just how far their non-quantitative mathematical spirit diverges from the origins of economics is reflected in the closing words of David Hume's Enquiry Concerning Human Understanding:

> When we run over libraries, persuaded of these principles, what havoc must we make? If we take in our hand any volume; of divinity or school metaphysics, for instance, let us ask, Does it contain any abstract reasoning concerning quantity or number? No. Does it contain any experimental reasoning concerning matter of fact and existence? No. Commit it then to the flames: for it can contain nothing but sophistry and illusion. It is impossible to keep aggrandizing wealth at compound interest.

[1] I discuss this problem in Trade, Development and Foreign Debt: A History of Theories of Convergence and Polarization in the World Economy (London: Pluto Press, 2 vols., 1993).

[2] Palgrave's Dictionary of Political Economy, citing the Annual Register (1797) and Chambers's Encyclopaedia (vols. 8 and 10). Geoffrey Gardiner (Towards True Monetarism, London 1993:135) observes that in the late 1970s, "the burgeoning oil revenues of the producers were further gilded by the addition of high interest earnings. At their highest British interest rates had the effect of doubling the cash deposits of the oil-producers in only five years, or 16.3 times in twenty years! . . . The wisdom of an earlier age, which had led to the passing of 'Thelluson's Act' to discourage the establishment of funds which compounded interest indefinitely, had been forgotten."

[3] "Roscher's Victorian Views on Financial Development," Journal of Economic Studies 22 (Spring 1995), and Karl Bücher's Role in the Evolution of Economic Anthropology," in press.

[4] Karen Rhea Nemet-Nejat, Cuneiform Mathematical Texts as a Reflection of Everyday Life in Mesopotamia (New Haven 1993 = AOS Series Vol. 75) provides a bibliography. For the growth of herds, see Ignace Gelb, "Growth of a Herd of Cattle," Journal of Cuneiform Studies 21 (1967).

[5] The Babylonians were well aware of the phenomenon of compound interest, but did not apply it in practice. Assyrian long-distance trade investments typically ran for five years (Larsen 1976), the time it took for the investment to double at the rate of 1/60th per month. The money typically was re-invested in a new contract. From the Old Babylonian period (2000-1600 BC) to the neo-Babylonian epoch (c. 600-333 BC), no compound interest is found in agricultural or commercial practice. When loans were not paid off, interest was calculated and a new loan document was drawn up.

[6] I explain the details briefly in "Why did interest rates in the ancient world consistently decline over the millennia," Archaeological Odyssey, July 1999. A more thorough discussion will appear in JESHO early in 2000.

[7] Hildagard Lewy, "Marginal Notes on a Recent Volume of Babylonian Mathematical Texts," JAOS 67 (1947):308 and Nemet-Nejat, op. cit.: 59f.

[8] Miriam Lichtheim (Ancient Egyptian Literature, II:135).

[9] My forthcoming Bronze Age Finance reviews this practice, as does the forthcoming ISLET colloquium on "Debt in the Ancient Near East," ed. Michael Hudson and Marc Van Der Mieroop (Harvard: Peabody Museum Press). For the time being see my article "'Proclaim Liberty Throughout the Land,'" Bible Review 15 (Feb. 1999).

[10] Thomas J. Figuera, "KHREMATA: Acquisition and Possession in Archaic Greece," in K. D. Irani and Morris Silver, eds., Social Justice in the Ancient World (Westport, Conn.: Greenwood Press, 1995):41-60.

[11] Alan Durning, "Asking How Much is Enough," in Linda Starke, ed., State of the World 1991 (New York:

1991):166. "Humanist Economics: From Homo economicus to Homo sapiens," (1995), collects relevant quotations from modern economics textbooks.

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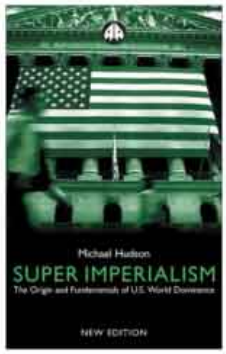

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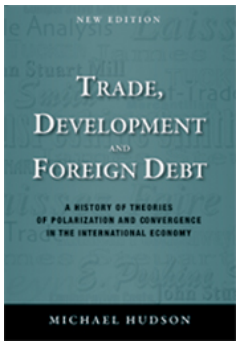

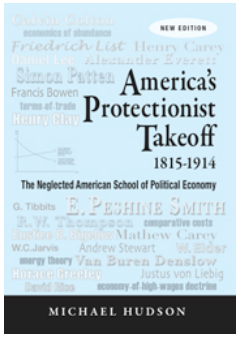

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