Where Did The Money Go?

June 2nd, 2008

Back in April, someone, signing as CCDN, started a new thread at http://mathforum.org/kb/thread.jspa?threadID=1733976&tstart=0 with the following post:

Marketplace and Math Class?

Does anyone have any ideas regarding todays current economic climate and an intriguing math lesson for High School students?

to which I responded with the somewhat desultory,

The Fed prints only so many dollar bills. If one percent of the population takes a disproportionate amount of these dollars, then these are dollars that we don't have. Put more simply, the richer they get, the poorer we get. It's called the law of conservation of money, AKA Where did the money go?

Students seem fascinated.

The ensuing exchange was rather unsatisfactory:

1. Having been reared in Mechanics, specifically in Fluid Dynamics, I had unwittingly taken for granted that "the law of conservation of money" would be seen for what it is, namely an avatar of Stokes' Theorem, other avatars of which include the Law of Conservation of Mass, the Law of Conservation of Momentum and the Law of Conservation of Energy as well as the Fundamental Theorem of the Calculus … and the "extended accounting equation":
   Given a business, at any time t, $Assets(t)$ is what it owns, $Liabilities(t)$ is what it owes and

2. $$NetWorth(t) = Assets(t) – Liabilities(t)$$

3. Thus, $NetWorth(t)$ is the **state** that the business is in at time t. In accounting terminology, $NetWorth(t) = Assets(t) – Liabilities(t)$ is called the "basic accounting equation" but it is really just the definition of $NetWorth(t)$. Written as $Assets(t) = NetWorth(t) – Liabilities(t)$, the "basic accounting equation" says how the assets were financed: with the owner's own money (owner's equity), $NetWorth(t)$, or with borrowed money, $Liabilities(t)$.
4. At any time t, the business sustains **actions**, that is it earns $Income(t)$, and incurs $Expense(t)$ so that, over a period of time $\Delta t = t_2 – t_1$,

   $$NetWorth(t_2) – NetWorth(t_1) = \int_{t_1}^{t_2} [Income(t) - Expense(t)]\, dt$$

5.

which, in accounting terminology, is the "extended accounting equation".

6. Essentially, the rebuttal to my own statement consisted only of the statement: (~Z) [The market] is not a zero sum game.
   At that point, I thought an interesting discussion had begun but I was disappointed and there wasn't any real one. Still, I was intrigued by the fact that ~Z had been presented as, if not a self-evident truth, at least as a universally-known one. So, knowing just about nothing about game theory, I thought I would investigate a bit and started asking around in various contexts "Where did the money go?" The response was indeed universal: The market is not a zero sum game. On the other hand, nobody was able even to begin giving me an argument as to why ~Z should be true: "It's just so, don't you know?" I didn't and still don't.
   At that point, though, I thought I should see how I would support my own assertion. However, since it had been felt by some that the subject was "politics" and thus inappropriate for the mathedcc forum and since I had just started this blog, I thought I would post the result of my cogitations here.
7. But, in spite of my faith in the universality of conservation laws, and even though I still think that economics is essentially a very simple matter, I do realize that economics involves a great deal of psychological issues and is thus a very tricky business and I don't claim to lay down the truth. Comments, corrections, etc are thus more than welcome.

In discussing this, I will also occasionally point out how prevalent these ideas are and how relevant they are to our more mundane preoccupations as "math teachers".

1. A basic idea, at the root of civilization, is that of exchange. I was given an apple for my lunch and you were given a banana but I prefer bananas and you prefer apples. So we exchange the apple for the banana.
   Exchanging is of course at the heart of one way to see systematic counting (See Reasonable Decimal Arithmetic. To appear.): We can exchange a single collection of four hundred sixty two one-dollar bills for a combination of three collections, a collection of four hundred-dollar bills, a collection of six ten-dollar bills and a collection of two one-dollar bills with the advantage that now we can represent each collection with one of TEN digits.
   Exchanging allows us to exchange a combination of two collections for a single collection. If I have three apples and two bananas and if I can exchange each apple for five carrots and each banana for two carrots, then I can exchange my combination of three apples and two bananas for a collection of nineteen carrots. Similarly, if I have three quarters and two dimes and if I can exchange each quarter for five nickels and each dime for two nickels, then I can exchange my three quarters and two dimes for nineteen nickels, i.e. $3/4 + 2/10 = 19/20$. (See Reasonable Decimal Arithmetic.)
2. Exchanging, though, begs the question of what the rate of exchange is to be. I have apples and you have bananas. I would like to exchange some of my apples for some of your bananas and you would like to exchange some of your bananas for some of my apples. But the obvious, immediate question is how do we arrive at a mutually agreeable rate of exchange.
   This usually depends on past history and/or on aggregation. Depending on how we acquired them, my apples and your bananas probably do not have the same "value" for

each of us. At a stock exchange, the question of the rate of exchange is solved in the aggregate: If, altogether, three thousand apples and two thousand bananas are being offered, then a rate of exchange of three apples for two bananas is deemed to be satisfactory to everybody. End-of-the-World Trade by Donald MacKenzie, in the May 8, 2008 issue of the London Review of Books, is an excellent piece on the setting of exchange rates and its role in the credit crisis.

In the case of systematic counting, the rate of exchange, i.e. the base, does not really matter: we count in base THREE exactly in the same manner as in base TEN. In the case of fractions, since the idea of the procedure has already been dealt with, the issue reduces to the more technical one of finding common multiples.

3. At its most fundamental, money is just a particular goods more durable than most other goods so that one can delay bartering by exchanging one's goods for money and thus not have to commit oneself. I have five apples and I know that I need only three but at this time I don't know if I want to exchange my other two apples for bananas or for carrots. So, I exchange my extra two apples for money which I can hang on to until I know whether I want bananas or carrots at which time I will exchange the money I got for my two apples. The price of goods is thus the amount of money it can be exchanged for. Given a vector space of "baskets" and its dual space of "price lists" (rates of exchange for money), co-multiplication gives the value of a basket under a price list. If I have three apples and four bananas in my basket and apples are today at 15 cents per apple and bananas are at 10 cents per apple, then the value of my basket today is 85 cents.

   The monetary mass thus corresponds to the amount of available goods. A change in the money supply without a corresponding change in the amount of available goods causes the rate of exchange to change. I will use the terms inflation and deflation which, according to Wikipedia is a sense only used by classical economists while the usual contemporary definition involves the "general price level"—whatever that means.)

   Thus, if I burn a one-dollar bill (which I believe to be illegal), this results in an—infinitesimal—deflation. If I print a one-dollar bill (which I definitely know to be illegal), this results in an—infinitesimal—inflation. On the other hand, if I pick your pocket and steal a one-dollar bill, I am one-dollar richer and you are one dollar poorer. In all cases, the law of conservation of money prevails.

   An interesting example of this is the well-known way George Soros originally made his fortune, i.e. by, inter alia, "breaking the Bank of England". However I am more familiar with the case in which he borrowed a huge amount of Liras from Italian banks which he then put up for sale thus forcing the price of the Lira down. At this point, the European Rate Mechanism kicked in and Italy was forced to devalue the Lira which allowed Soros to buy them back at a reduced price and thus pay off his loans. In other words, Soros's gain came from the some 60 millions Italians left with devalued Liras. In the case of the Bank of England, he is said to have merely "sold short". The role of the European Rate Mechanism in both cases was crucial but only in the sense that it saved time: Soros could probably have achieved about the same result by buying back slowly. This is where psychology comes in and it is only recently that the subject has started to be investigated by economists—as opposed to the standard blanket recourse to "human nature".

   By the way, and rather obviously, the entity which succeeds in having a particular good accepted as money makes an enormous profit. In fact, the privilege of minting money used to be called seigniorage. According to Wikipedia, the U.S. Treasury estimates that it has earned about US$5 billion in seigniorage revenue from the 50 States series of quarters which many people collect and thus keep out of circulation. Another instance of this is the issue of petrodollars, namely the dollars we use to buy oil and which are not meant ever to come back home and cause inflation with, of course, the ensuing conflict with Europe which doesn't see why it couldn't issue petroeuros.

4. Finally, a couple more remarks:
   - If I lead you to believe that something has more value than it has and exchange it for something whose value is more stable, then, in essence, I stole the difference in value from you.
   - Goods are created and destroyed. But the Laws of Conservation account for this with sources and sinks.

Altogether then, I still don't see what the flaw(s) in my original statement might be, that is, I was not able to imagine any situation that would not be a zero-sum game. Again, comments, rebuttals, corrections are welcome.

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