Inflation Rates, Car Devaluation, and Chemical Kinetics

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Recently, Swiegers, noticing the educational value of the many analogies between human behavior and chemical behavior, proposed to apply the principles of chemical kinetics to population growth problems (*1*). Among the many human phenomena that have an analogy with chemical kinetics [some of them have been collected and elaborated in Formosinho's book (*2*)] are our countries' inflation rates and the devaluation of car worth with time. The inflation rate problem will be treated in the present paper in a detailed way, as it offers an interesting analogy with chemical kinetics; and the car devaluation problem will be presented and solved as a normal chemical kinetic problem, where the order of the rate law and the value of the rate constant are derived.

Inflation Rate

Many people nowadays are worried about the inflation rate of their country and about the concomitant declining value of their money. Rapid and elementary estimations are brought up and tested with the aim of establishing the declining value of a given capital with inflation, that is, with the growing prices of the wares on the market.

Method

After one year at the constant annual inflation rate, k, where inflation means the price index on the market, a price P_0 will have the following value form:

$$P_1 = P_0(1 + k) \quad (1)$$

after two years

$$P_2 = P_1(1+k) = P_0(1 + k)^2 \quad (2)$$

and so on. Thus, after t years its real value will be

$$P_t = P_0(1 + k)^t \quad (3)$$

The time period, t_2, the prices take to double when $k = 0.05\ \text{yr}^{-1}$ (i.e., the approximate actual yearly inflation rate in Italy and Portugal) can be easily estimated by the aid of the logarithmic form of expression 3 with $P_t = 2P_0$

$$t_2 = \ln 2/\ln(1 + k) = 14.21\ \text{yr} \quad (4)$$

This means that, with the given inflation rate, k, our money will have lost half of its value after nearly 14 years. Thus the time t_2 can be also considered as the time, $t_{1/2}$, a given amount of capital takes to lose half its value.

Now, if the time interval (the whole year or some portion of it) is small enough to satisfy the condition $k<<1$, eq 3 can be rearranged into the following form (this means the inflation rate is calculated in a continuous way):

$$P_t = P_0 \cdot \exp[t \cdot \ln(1+k)] = P_0 \cdot \exp(kt) \quad (5)$$

as for a small enough k, $\ln(1+k) = k$. The final expressions for P_t and t_2, then, are

$$P_t = P_0 \cdot e^{kt} \quad (6)$$

$$t_2 = \ln 2/k \quad (7)$$

Discussion

Equation 6 with a negative exponent and concentration brackets around first and second P is the well-known integrated form of a first-order reaction rate for the consumption of a reactant P, while with a negative k, t_2 of eq 7 becomes $t_{1/2}$, the half-time for P consumption ($P_t = 0.5 \cdot P_0$). Economically speaking, a negative exponential in eq 6 specifies either deflation processes (the contrary of inflation: the prices go down) for prices or capital devaluation during inflation periods. In this case t_2 becomes $t_{1/2}$, the half-time for devaluation of money or prices.

By analogy with chemical kinetics (see eq 6), the inflation lifetime $< t >$ can be defined as the time required for the value of the wares to rise to e times P_0 (or the value of the money to decay $1/e$ times P_0); that is, $< t > = 1/k$.

It has to be noticed that while in chemical kinetics k can assume any positive constant value, the same is not valid in economics for inflation and deflation processes. Let us find out, numerically, when eq 6 can be used, with a negative exponent, for capital devaluation prognosis. Let us study this problem by comparing the outcome of eqs 4 (exact) and 7 (approximate), considering the half-time, $t_{1/2}$, for capital devaluation because this economic aspect has a more direct analogy with chemical kinetics. The evolving difference between $t_{1/2}$ (eq 4) and $t_{1/2}$ (eq 7) can be better understood if the following set of different $k \cdot t$ values is considered (where t stands for a generic time, usually one year).

$k \cdot t$	$t_{1/2}$(eq 4)/t	$t_{1/2}$(eq 7)/t
0.8	1.179	0.866
0.08	9.006	8.664
0.008	86.99	86.64
0.0008	866.8	866.4
0.00008	8664.7	8664.3

The first impressive difference between the two $t_{1/2}$ values clearly means that, for high inflation rates, devaluation and chemical kinetic problems are formally very different from each other. The growing similarity between the two $t_{1/2}$ values with decreasing inflation rates means that low inflation rates or inflation measured over short periods and first-order chemical reactions are formally similar problems and can be treated by the aid of the same mathematical relationship. Practically, the formal meet-

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ing point between inflation rates and reaction rates (eqs 3 and 6) is at $k \cdot t \le 0.01$.

Car Devaluation

The devaluation of our cars as they get old is the other problem that shows some interesting similarities with chemical reaction kinetics. Furthermore, it should not be forgotten that the aging of a car is basically a (complex) chemical process. In the following lines are shown the prices of two different models of European cars: a compact FIAT, F (FIAT Uno 70, 1376 cc), and a standard Mercedes, M (Mercedes 250 TD SW 2497 cc). The prices (inflation included) of these models were followed for 7 years, from 1986 until 1993 (*4*). (In 1994 both models disappeared from the market.). The 1986 price was taken as the zero point. The prices for F and M are given below in millions of Italian Lire (L = Lire × 10^{-6}).

	Time (yr)							
	0	1	2	3	4	5	6	7
L(F)	13.7	12.2	10.1	8.9	7.8	5.5	4.8	4.0
L(M)	45.0	39.9	34.9	31.1	27.3	23.6	19.8	16.0

When this paper was written, 1650 Lire ~$1, but this is rapidly changing. Time (yr) is the age of the new (yr = 0) or used (yr > 0) car. Thus the price at yr = 0 is the price of a new car in 1993, while the price at yr = 7 is the price of a used 1986 car (*4*).

The price half-time, $t_{1/2}$, of these two models (the time it takes a price to halve its initial value) tells us that the value of the two cars follows a zeroth-order kinetics

$$[P_0] - [P] = k \cdot t \tag{8}$$

with

$$t_{1/2} = [P_0] / 2 \cdot k \tag{9}$$

where $[P_0]$ can be considered the actual price of the 1993 car. These prices fall to half of their original value in 4.5 yr for F and 5.5 yr for M. This means (by the aid of eq 9) that k(F) ≅ 1.5 L/yr and k(M) ≅ 4.1 L/yr. Plotting price [P] versus t, shown in Figure 1, allows us to derive the following more accurate values for k: k(F) = 1.43 L/yr and k(M) = 4.06 L/yr.

The linear correlations of the data show the following correlation coefficients, r, and standard deviation of estimate, s (ln[P] shows a linear correlation with nearly similar r but worse s): r(F) = .992 and s(F) = 0.47; r(M) = 0.998 and s(M) = 0.69.

Figure 1 shows that expensive cars lose value at a higher specific rate than small compact cars and that after 11–12 years both cars can be acquired at nearly the same price. In reality, car models are removed from the market after a number of years of devaluation and are replaced by new models, and the cycle starts all over again.

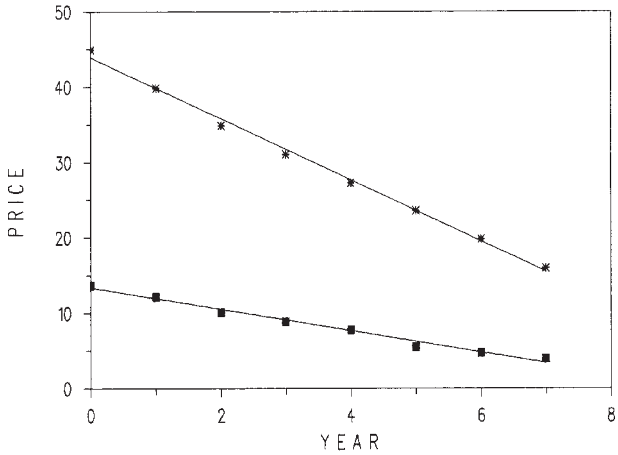

Figure 1: Evolution of compact (■) and expensive (*) car prices along the years.

Conclusion

The inflation rate problem and the car devaluation problem show interesting formal similarities between economics and chemical kinetics. Capital devaluation during periods of very low inflation rates follows a kinetic relation formally similar to that followed by first-order reactions in chemical kinetics, whereas car devaluation follows a kinetic relation formally similar to a zeroth-order chemical kinetic relationship. Normally car devaluation is much faster than money devaluation in those countries where inflation rates are rather modest.

Literature Cited

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