Modelling commerce in terms of chemical reactions

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Abstract

After first explaining the basis for such modelling, namely, money in commerce appearing to mirror free energy in coupled chemical reactions, with a striking correspondence between profit and reduction in free energy, a model of two 'coupled Deliveries' is constructed, noting the need also to model the market, and the somewhat literal example of a taxi journey up a hill is used to help make sense of the approach. The modelling of the market is then explained, where changes in the concentration of money over buyers and sellers is assumed to behave like changes in the degree to which energy is spread out over the microstates of a system. An expression for the profit due to the market is then derived, and a possible method for verifying this proposed. Further evidence that supports the model is then presented, followed by a discussion of the implications of the model's being found to be valid.

Introduction

The idea for such a model is based on the observation that the changes in money in commerce mirror the changes in free energy in coupled chemical reactions, as shown in Fig. 1. Thus, in commerce, a purchase is made (money goes down) with a view to making a sale that outweighs the purchase (money goes up to a greater extent); in coupled chemical reactions, an unfavourable reaction is forced to proceed (free energy goes up) by its being coupled to a favourable reaction that outweighs the unfavourable one (free energy goes down to a greater extent).

For an example of some coupled chemical reactions, consider the formation of the following oxides:

$2Fe$ (s) + $3O_2$ (g) → Fe_2O_3 (s) $\Delta_f G^o$ -740.9 kJ/mol [1]

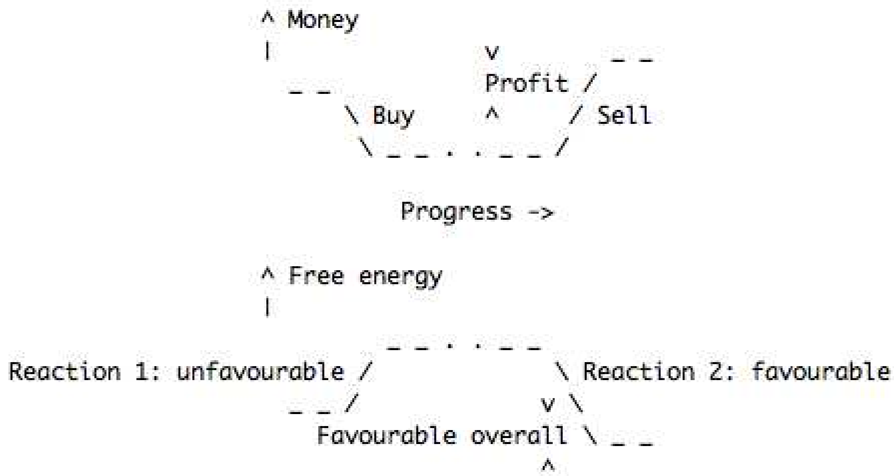

Figure 1: Commerce vs coupled chemical reactions

2Al (s) + $3O_2$ (g) $\rightarrow$ Al_2O_3 (s) $\Delta_f G^o$ -1576.4 kJ/mol [1]

The second reaction is so much more favourable than the first that the second can force the first to go in reverse (if the product of the first is available) in order to acquire the oxygen that way:

1.	Fe_2O_3 (s)	$\rightarrow$ 2Fe (s) + $3O_2$ (g)	$\Delta_r G^o$ +740.9 kJ/mol
2.	2Al (s) + $3O_2$ (g) $\rightarrow$	Al_2O_3 (s)	$\Delta_f G^o$ -1576.4 kJ/mol
1. + 2.	Fe_2O_3 (s) + 2Al (s) + ~~$3O_2$ (g)~~	$\rightarrow$ 2Fe (s) + ~~$3O_2$ (g)~~ + Al_2O_3 (s)	$\Delta_r G^o$ -835.5 kJ/mol (740.9 + -1576.4)

What is particularly striking is the correspondence between the requirement that a profit be made, in order that the purchase is entered into, and the requirement that the two coupled reactions be favourable overall, in order that the unfavourable reaction can proceed. Furthermore, the readiness with which the purchase is entered into is proportional to the size of the profit, and this too corresponds with reaction favourability being proportional to the size of the net decrease in free energy. For this reason, we will also now regard the purchase and sale as being coupled.

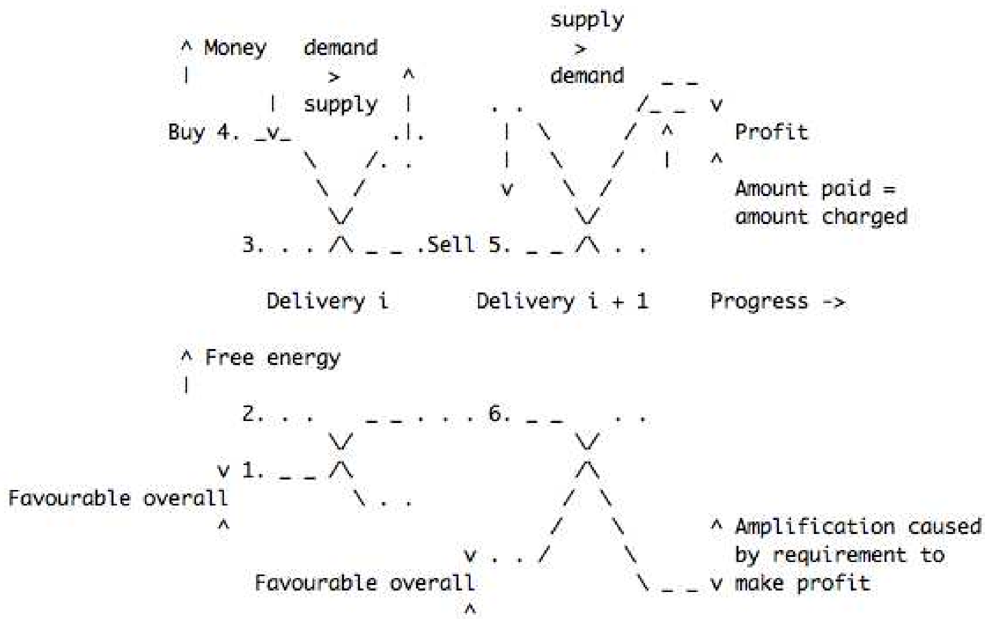

Figure 2: Coupled Deliveries

Constructing the model

Now, given that every purchase is somebody else's sale, we proceed by overlaying each change in money and free energy with one in the opposite sense, and therefore now refer to the original (coupled) purchase and sale as (coupled) 'Deliveries', as shown in Fig. 2.

Since we are using the two reactions in Fig. 1. to model separate activities, we now consider them to be coupled *indirectly*, along the route labelled 1. to 6. Here, the direct coupling occurs between each reaction and the one that overlays it (changes 1. and 2.), with the coupling between the separate activities being made possible by the non-directly-physical nature of the coupling between a purchase and a sale (changes 4. and 5.).

There are several other points to note. Whereas the magnitude of each change in money matches that of the one it overlays (since the amount paid must equal the amount charged), this is not the case for the changes in free energy that they mirror, since the magnitude of the change in free energy of the favourable reaction must always outweigh that of the unfavourable one (in order that the overall reaction is favourable). The favourable reaction is the one mirrored since this reflects the actual effort the seller goes to and therefore charges for in order to do the required amount of work for the buyer. As well as the coupling between purchase 4. and sale 5., which inclines the buyer to select the offering of the Delivery i product or service with the *lowest* price tag, there is also coupling between sale 3. and the purchase of Delivery i - 1 (not shown), which inclines the seller to put the *highest* possible price tag on their offering of the Delivery i product or service, *that the market for it will bear*. Thus, it is the market for the product or service in question that determines the resultant effect of these two opposing 'forces', and this we must therefore also model. Fig. 2. depicts an occasion when the market is on the side of the seller of Delivery i, and the buyer of Delivery i + 1. Finally, the requirement that a profit should always be made requires that the price of Delivery i + 1 should always exceed that of Delivery i, which suggests that change 6. should always exceed change 2.

Example product or service: taxi up a hill

Our model represents each Delivery as a pair of (directly) coupled reactions, and one kind of product or service that illustrates why this might make sense is a taxi journey up a hill.

Thus, the work to be done is literally, to drive something (somebody) up hill, while the favourable reaction to which this is coupled (by the taxi's engine and transmission) is the combustion of the taxi's fuel.

The factors affecting the price are as follows: the higher the destination, the larger change 1. in Fig. 2., and therefore the higher the price; the more efficient the taxi, the smaller the difference between changes 1. and 2., and therefore the lower the price; the more that demand exceeds supply, the more the price (change 3.) will exeed the amount that mirrors change 2.

Modelling the market

Significance of concentration of money

We proceed by imagining there to be, not just one buyer and one seller, but many of them, where all the sellers are competing with each other to sell their offering of the product or service in question.

If we further imagine lots of payments being made by different buyers to different sellers, we see that this can give rise to a change in the concentration of money over the participants, this change being given by the total amount of money being received by sellers divided by the number of sellers, minus the total amount of money being paid by buyers divided by the number of buyers.

Assuming that all these payments are being made with a view to making a profit, and therefore that the mirroring upon which our model is based is at play, we now further assume that changes in this *concentration* of money over participants behave like changes in the degree to which energy is *spread out* over the simultaneous microstates of the system in which it resides, such that, for any increase (or decrease) in one, there would be a corresponding increase (or decrease) in the other. We have done this because, as we shall see, changes in the latter property determine the favourability of a chemical reaction, suggesting that changes in the former property might determine the profitability of a market

Condition for a chemical reaction to be favourable

Chemical reactions are understood to be favourable if they would result in a decrease in (Gibbs) free energy, $G = H - TS$ (at constant pressure), where H is enthalpy, T is temperature (constant) and S is entropy [2]. That is, they are favourable when,

$$\Delta G = \Delta H - T\Delta S < 0,$$
or $$\Delta H < T\Delta S,$$
or $$T\Delta S > \Delta H. \text{ (Cond. 1.)}$$

Note that ΔS and ΔH can be negative as well as positive, meaning that there are two ways in which Cond. 1. can be met:

1. increase in TS > increase in H (endothermic)
2. decrease in TS < decrease in H (exothermic)

Now, returning to the discussion of the previous section, if we regard TS as the simultaneous microstates, and H as the energy that is spread out over them, it can be seen that 1. and 2. both increase the degree to which the energy can spread out.

Condition for a market to be profitable

Taking into account the following three considerations,

1. the ('striking') correspondence between the amount by which a coupled purchase and sale is profitable and the amount by which (a reaction that is composed of) a pair of coupled reactions is favourable,

2. the above condition that there must be an increase in the degree to which energy can spread out in order for a reaction to be favourable,

3. the above assumption that, for any increase in the degree to which energy is spread out, there would be a corresponding increase in the concentration of money,

it follows that the condition for a market to be profitable is that the concentration of money must also increase,

i.e. that (total income)/(number of sellers) -
(total outgoings)/(number of buyers) increases,

or change in (total income)/(number of sellers) -
change in (total outgoings)/(number of buyers) $>$ 0,

or change in (total income)/(number of sellers) $>$
change in (total outgoings)/(number of buyers). (Cond. 2.)

As in the case of chemical reactions, there are two ways in which Cond. 2. can be met:

1. increase in (total income)/(number of sellers) $>$
increase in (total outgoings)/(number of buyers) ('endothermic')

E.g. (£0 $\rightarrow$ £2)/seller (£2 increase) $>$
(£0 $\rightarrow$ £1)/buyer (£1 increase)

This may be thought of as being 'endothermic' in the sense that money is entering the market as buyers spend more.

2. decrease in (total income)/(number of sellers) $<$
decrease in (total outgoings)/(number of buyers) ('exothermic')

E.g. (£4 $\rightarrow$ £3)/seller (£1 decrease) $<$
(£3 $\rightarrow$ £1)/buyer (£2 decrease)

This may be thought of as being 'exothermic' in the sense that money is leaving the market as buyers spend less.

Profit due to market

Determination of

Comparing terms in Cond. 1. and Cond. 2. gives the following correspondences:

$T\Delta S \Rightarrow$ change in (total income)/(number of sellers)
$\Delta H \Rightarrow$ change in (total outgoings)/(number of buyers).

Therefore,

$\Delta G = \Delta H - T\Delta S$
$\Rightarrow$ change in (total outgoings)/(number of buyers) -
change in (total income)/(number of sellers). (Corr. 1.)

Since changes in money *mirror* the changes in free energy, we also assume that,

$\Delta G \Rightarrow$ -profit. (Corr. 2.)

Finally, eliminating ΔG in Corr. 1. and Corr. 2.,

-profit = change in (total outgoings)/(number of buyers) -
change in (total income)/(number of sellers),

Therefore, profit = change in (total income)/(number of sellers) -
change in (total outgoings)/(number of buyers).

Interpretation of

The simplest interpretation of the profit obtained above is that it is *that part of the average selling price that is due to the market*, such that, if it were possible to obtain the average cost price, then adding this to the profit would give back the average selling price.

How the model might be validated

Since the modelling of the market—in particular, the condition for a market to be profitable—is based on the rest of the model (in particular, the 'striking correspondence'), to validate the model, it ought to be sufficient to verify the above interpretation of the profit due to the market.

Further supporting evidence

The tendency of money to concencentrate that we see around us

Note that we of course mean concentrate as in *be* concentrated (by buyers and sellers).

Concentration of wealth

This is supported by the 2016 statistic [3] that the richest 1% now has as much wealth as the rest of the world combined.

National lotteries

Here, large numbers of people willingly and regularly pay small amounts of money to a central authority that then pays back large amounts to only a few of them (selected at random).

The profusion of technological innovations that exists

This is comparable to the profusion of different species to be found in nature. Just as new species that are able to have more offspring in given surroundings and thereby bring about a larger reduction in free energy overall emerge, so too do sellers employing new technological innovations that enable them to make more Deliveries in a given market and thereby generate a larger profit overall.

Conservation of money

Like energy, money is never destroyed. Although it is *possible* to destroy legal tender, our intelligence prevents this.

Although, unlike energy, money *is* created (when banks make loans or buy assets), this may be seen as money being made available in response to corresponding amounts of energy becoming available: a buyer borrows the money in order to pay a seller who will make use of that energy.

If the model were valid

If the above interpretation of the profit due to the market were indeed to be verified, as well as confirming the model's ability to accurately calculate profit, it would have some quite far-reaching implications.

Changes in amounts of available money mirroring changes in amounts of available (free) energy would imply that money, if not value itself, is just another form of energy. This is highly intuitive. In this case, although the transformation does not happen literally—both the money and the other form of energy are conserved—from the point of view of the buyer or seller, it does happen effectively.

We would see that our intelligence was being ‘utilised’ to enable the spreading out of energy by non-directly-physical means. One could even imagine that this was the ‘purpose’ of intelligence, or at least an inevitable consequence of it.

It would establish the ability to invent (discover!) and use money (and thereby enable the above ‘utilisation’) as an important threshold for intelligent life. Although this increases the spreading out of energy, it necessarily involves ‘the driving of taxis up hills’, and one could imagine that the night side of the Earth as seen from space would look a lot different if money had still not been thought of, not to mention space as seen from the night side of the Earth [4].

The spreading out of energy has always driven the fitness of species, including their intelligence, with advances being recorded in DNA. The above ‘utilisation’ would mean that it was now driving intelligence more directly, with advances being recorded in knowledge bases.

It would turn part of economics, which is a social science, into a hard science. This would mean that a high-level process that depends on people’s decision-making could now be explained as though it were an artillary gun being aimed at a target.

Finally, the pursuit of wealth could be seen in a new light. All living things are bound to make energy spread out as much as possible, which they do by having as many offspring as possible (as mentioned earlier in connection with technological innovations). If valid, what the model would show is that living things that are intelligent enough to use money, i.e. humans, can also do this spreading-out of energy by generating profit. The extent to which different societies and different individuals within those societies are able and inclined to pursue this second method, perhaps at the expense of the first, could be recognised as the origin of much of the separation into different political factions that arises.

References

[1] Journal of Chemical Thermodynamics, 3, 1 (1971).

[2] Atkins, P.W., PHYSICAL CHEMISTRY, Oxford University Press, Oxford, p 250, Fig. 9.1.

[3] Oxfam says wealth of richest 1% equal to other 99%. http://www.bbc.co.uk/news/business-35339475 (2016)

[4] Satellite constellations: Astronomers warn of threat to view of Universe. https://www.bbc.co.uk/news/science-environment-50870117 (2019)