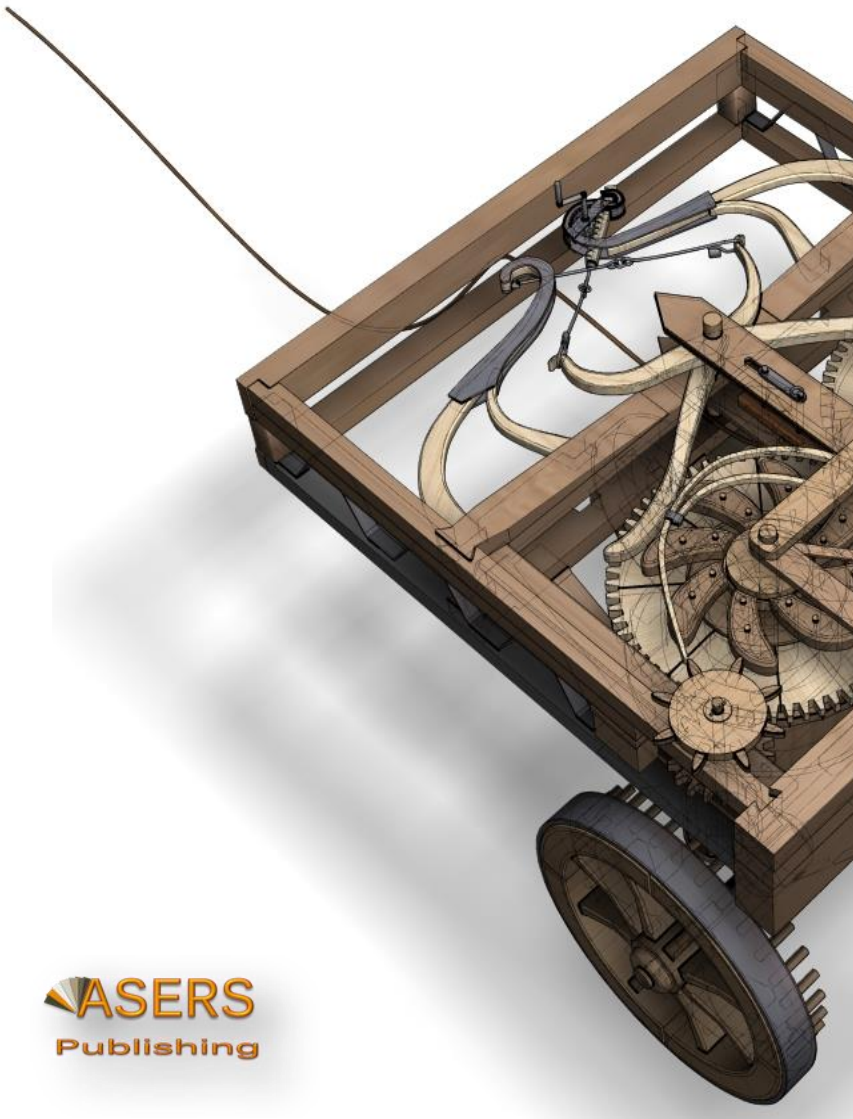
Theoretical and Practical Research in Economic Fields



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Volume XIV, Issue 1(27), Summer 2023
Theoretical and Practical Research in Economic Fields

Many economists today are concerned by the proliferation of journals and the concomitant labyrinth of research to be conquered in order to reach the specific information they require. To combat this tendency, **Theoretical and Practical Research in Economic Fields** has been conceived and designed outside the realm of the traditional economics journal. It consists of concise communications that provide a means of rapid and efficient dissemination of new results, models and methods in all fields of economic research.

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MODELING COMMERCE IN TERMS OF CHEMICAL REACTIONS

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Abstract:

After first explaining the basis for such modeling, namely, changes in money in commerce appearing to mirror changes in 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 supply and demand, and using the somewhat literal example of a taxi journey up a hill, to help make sense of the approach. The modeling of supply and demand is then explained, the effect on prices being attributed to the spreading-out of energy from sellers to buyers. An expression for this effect is then derived, in terms of the corresponding concentrating of money. Various implications of the model are then expounded, concerning the nature of money, price and its relationship to value, and intelligence, and some supporting evidence given. Two secondary implications, concerning economics and political science, are then discussed to conclude.

Keywords: modeling; commerce; coupled chemical reactions; thermodynamics; free energy; theory of value; intelligence; political science.

JEL Classification: A12; E37; R15.

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 Figure 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 unfavorable reaction is forced to proceed (free energy goes up) by its being coupled to a favorable reaction that outweighs the unfavorable one (free energy goes down to a greater extent).

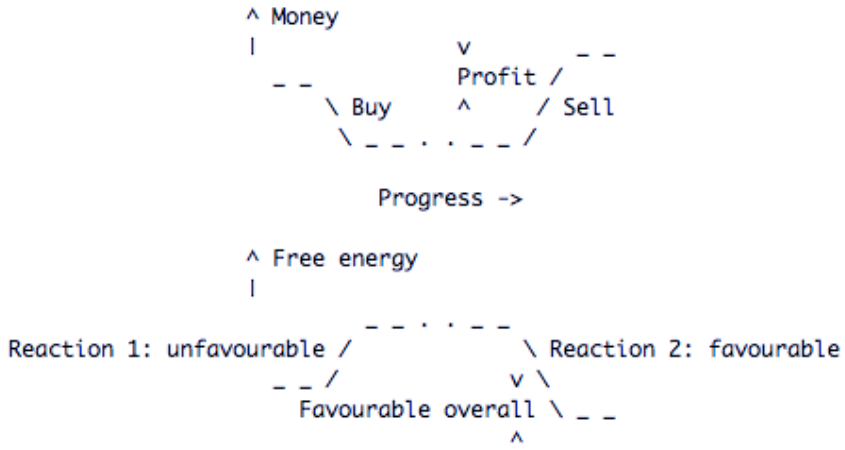
For an example of some coupled chemical reactions, consider the formation of the following oxides:

$$2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s)\ \Delta_f G^o - 740.9\ kJ/mol^{\dagger};$$

$$2Al(s) + \frac{3}{2}O_2(g) \rightarrow Al_2O_3(s)\ \Delta_f G^o - 1576.4\ kJ/mol^{\dagger}.$$

† (Brian Smith, Appendix I)

Figure 1. Commerce vs coupled chemical reactions



The second reaction is so much more favorable 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. $Fe_2O_3(s) \rightarrow 2Fe(s) + \frac{3}{2}O_2(g)$

$\Delta_r G^o + 740.9\ kJ/mol;$

2. $2Al(s) + \frac{3}{2}O_2(g) \rightarrow Al_2O_3(s)$

$\Delta_f G^o - 1576.4\ kJ/mol;$

$1. + 2.\ Fe_2O_3(s) + 2Al(s) + \frac{3}{2}\cancel{O_2(g)} \rightarrow 2Fe(s) + \frac{3}{2}\cancel{O_2(g)} + Al_2O_3(s)$

$\Delta_r G^o - 835.5\ kJ/mol$
$(740.9 + -1576.4).$

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 favorable overall, in order that the unfavorable 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 favorability 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.

1. Constructing the Model

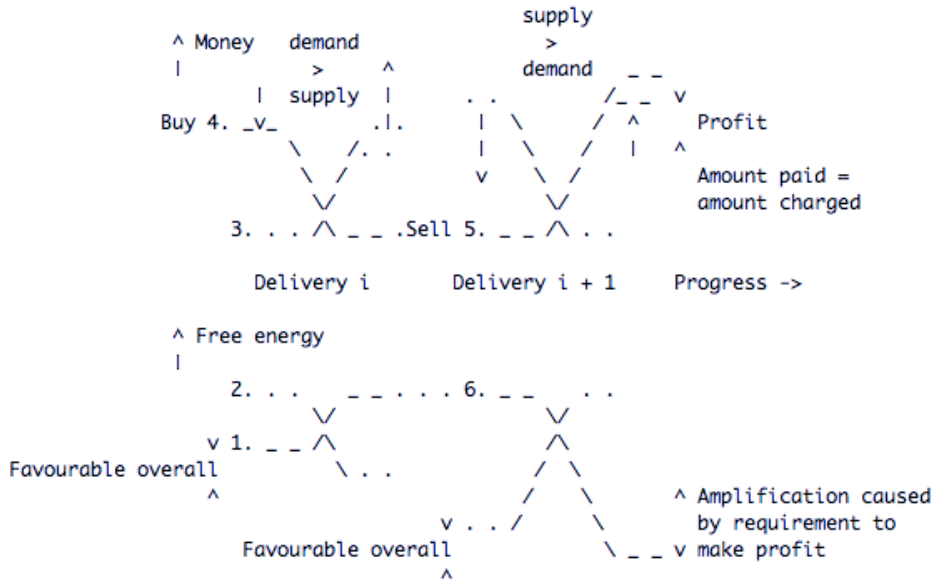
Now, given that every purchase is somebody else's sale, we proceed by overlaying each change in money and free energy with one in the opposite sense, and therefore now refer to the original (coupled) purchase and sale as (coupled) 'Deliveries', as shown in Figure 2.

Since we are using the two reactions in Figure 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 favorable reaction must always outweigh that of the unfavorable one (in order that the overall reaction is favorable). The favorable 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, as in the balance of supply versus demand, henceforth, supply and demand, that determines the resultant effect of these two opposing 'forces', and this we must therefore also model. Figure 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.

Figure 2. Coupled Deliveries



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 favorable 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 Figure 2., and therefore the higher the price; the more efficient the taxi, the smaller the difference between | change 2. | and change 1., and therefore the lower the price; the more that demand exceeds supply, the more the price (change 3.) will exceed the amount that mirrors change 2.

3. Modeling Supply and Demand

3.1. Consumption of Free Energy Means Energy Spreads Out

So, a favorable reaction (or coupled pair of reactions) is favorable because it brings about a reduction in free energy. But what does this actually mean? It does not mean a reduction in energy, since energy is conserved (Atkins, 54). What it means is that the energy has become more spread out – or put more formally, entropy (S) has increased (Atkins, 131). Some other examples of this tendency of energy to spread out, that are easier to appreciate, include the wave that radiates on the surface of a pond into which a stone has been dropped - the spreading-out of kinetic energy - and the cooling of a hot drink - the spreading-out of heat energy.

3.2. Energy Spreads Out When Demand Exceeds Supply

Notice that each Delivery involves the transfer of energy - change 1. in Figure 2. - from seller to buyer. Therefore, if there are more buyers than sellers (as is the case when demand exceeds supply), energy will be spreading out.

However, this is rather a strange example of energy spreading out, since the spreading-out has been driven by buyers and sellers seeking to maximize their respective profits, as discussed earlier. Therefore, at first sight, it would appear that energy has been able to spread out without there being any reduction in free energy. However, there is also the small matter of the increase in the price, change 3. minus | change 2. |. We are therefore bound to conclude that *this increase in the price is the manifestation of the reduction in free energy brought about by the spreading-out of energy when demand exceeds supply.*

3.3. Money Concentrates When Energy Spreads Out

The fact that an increase in the price should be a manifestation of a decrease in free energy is in keeping with the mirroring observed in the introduction. It is explained by the fact that the money is being transferred in the opposite direction to the energy and is therefore concentrating - a positive change in the concentration - rather than spreading out - a negative change.

Just as the amount of spreading-out of energy is a measure of the reduction in free energy, so the amount of concentrating of money is a measure of the increase in the total amount of money spent by all the buyers due to the increase in the price of each Delivery. If we consider a fixed number of buyers and sellers, and imagine the total amount of money spent to be first concentrated over the buyers, and then concentrated over the sellers, then the amount of concentrating of money is this change in concentration, which may be expressed as follows:

$$(total\ amount\ spent)/(number\ of\ sellers) - (total\ amount\ spent)/(number\ of\ buyers),$$

or $(total\ amount\ spent) * [1/(number\ of\ sellers) - 1/(number\ of\ buyers)]$.

If we take this to *be* the increase in the total amount of money spent (as opposed to just a measure of it), then the fraction of the total amount spent that is due to demand exceeding supply will be given by,

$$1/(number\ of\ sellers) - 1/(number\ of\ buyers).$$

4. Implications of the Model

4.1. Money as a Form of Energy

The fact that we now ascribe the difference between change 3. and | change 2. | in Figure 2. to a reduction in free energy implies that the coupling that occurs between these two changes can be regarded as being similar in nature to that which occurs between change 2. and change 1. – namely, a conversion from one form of energy into another, where the reduction in free energy may be regarded as the 'cost' of that conversion. In other words, the model implies that money is a form of energy.

Let us turn once again to the taxi example to illustrate this. Just as the cost of the conversion of chemical energy (fuel) - change 2. - into potential energy (ascending the hill) - change 1.- depends on the efficiency of the taxi, so the conversion of money - change 3. - into chemical energy (fuel) depends on the 'efficiency' afforded by supply and demand – for example, this will be 'less efficient' if demand for taxis (and therefore fuel) exceeds supply.

Note that, whereas the conversion of chemical energy into potential energy is a *transformation* of one physical form into another, the conversion of money into chemical energy is an *exchange* of a non-physical form into a physical form, where both forms existed beforehand and continue to exist afterwards, but it is nevertheless a conversion from the point of view of the buyer or seller. However, the fact that the exchange involves the money being transferred in the opposite direction to that of the

physical form of energy means that money concentrates whenever the physical form spreads out, as discussed earlier.

4.2. Price versus Value

Figure 2. gives us a clear visualization of price - change 3. - in relation to the value it represents - change 1. - implying that price is composed of the value together with the two conversions 'costs' described above.

4.3. Utilization of Intelligence

In Figure 2., we have already observed that the coupling between the Deliveries - between changes 4. and 5. - is non-directly-physical, and here we make the further observation that this is dependent on intelligence: Delivery i + 1, together with the reduction in free energy it gives rise to, is only brought about in order to recover the investment made in Delivery i, together with a profit - it would not otherwise take place; the same goes for Delivery i itself, since it is similarly coupled to Delivery I - 1 (not shown). This implies that intelligence is being 'utilized' in order to bring about the consumption of free energy. If this is not the ultimate 'purpose' of intelligence, perhaps it is the other way round – the ultimate purpose of the consumption of free energy is to bring about intelligence.

4.4. Advent of Money as Key Threshold for Intelligent Life

As soon as intelligence crosses the threshold required to conceive of money, the above 'utilization' comes into play. While this makes possible the consumption of free energy by a mechanism that was not previously available, a key point to note is that this necessarily involves 'the driving of taxis up hills'. As explained above, this is the transformation of one form of energy into another, where the amounts involved are greater than the amount of free energy consumed, and therefore more significant. This implies a significant transformation of the surroundings of the intelligent life in question.

5. Supporting Evidence

5.1. Money as a Form of Energy

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 the seller - change 4. in Figure 2.- who makes use of that energy - change 2.

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

The model implies that money is a non-physical form of energy that is converted into physical forms by exchange rather than transformation, such that it concentrates whenever the physical form spreads out. Since physical forms have a tendency to spread out (since this corresponds to a reduction in free energy), this implies that money has a tendency to concentrate. Evidence of this is the 2016 statistic (5.) that the richest 1% had as much wealth as the rest of the world combined. Further evidence is the existence of national lotteries, where 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).

5.2. Parallels between Commerce and the Living World

Consider the metabolism (Stryer 274, 479) of an organism that derives its energy from food. Work such as biosynthesis (anabolism) is made possible by coupling it to the breaking down of the food (catabolism). This is very similar to the coupling of change 1. in Figure 2. to change 2., that we have used to model a Delivery.

Just as the efficiency of the taxi (in the example) will determine how much fuel will be required, and therefore the magnitude of change 2., so the efficiency of the organism's metabolism will determine how much food will be required in order to sustain the organism.

And just as the amount of fuel required will in turn determine how many Deliveries can be made, so the amount of food required will determine how many organisms can be sustained.

Finally, just as competition between taxi service providers will see taxis that employ innovations that improve their efficiency displace others, so competition between species for food will see organisms with more efficient metabolisms displace others. A key point to note here is that, in both cases, even though the increase in efficiency reduces the amount of free energy consumed per Delivery or organism, it results in an increase in the number of Deliveries or organisms, such that the total amount of free energy consumed still increases.

5.3. Transformation of Surroundings by Humans

It would be remiss of us not to begin with the taxi being driven up the hill. As explained, this transforms chemical energy into potential energy, which involves transforming fuel and oxygen into mainly carbon dioxide and water. Given that carbon dioxide is known to persist in the atmosphere, and to absorb heat energy that would otherwise have radiated out into space, Deliveries of this nature are thought to be contributors to climate change (7.).

A more visible transformation of the surroundings is to be found in the case of Deliveries that entail the destruction of rainforests (4.).

Perhaps most strikingly, one could imagine that the night side of the Earth as seen from space would look a lot less interesting if money had yet to be conceived of, not to mention space as seen from the night side of the Earth (6.).

6. Secondary Implications

6.1. Implication for Economics

The implications that money is a (non-physical) form of energy (that may be converted into physical forms by exchange), that commercial transactions may be modeled as coupled pairs of chemical reactions, and that the effect of demand exceeding supply on prices may be explained as the manifestation of the reduction in free energy that arises when energy spreads out from sellers to buyers, all in turn imply that there is, after all, a foundation for economics in the natural sciences.

6.2. Implication for Political Science

The tendency towards increasing numbers of organisms that are more efficient (as well as increasing numbers of Deliveries that are more efficient) implied by the earlier discussion on parallels between commerce and the living world must therefore apply to humans, but with two important differences, on account of our intelligence: we can choose not to reproduce, and we can engage in commerce. In other words, we have the option of consuming free energy by making Deliveries rather than babies. This in turn implies that a foundation for political science, also, is to be found in the natural sciences.

Conclusion

Based on the observations discussed, it is possible to construct a model of buying and selling in terms of coupled chemical reactions, in which money behaves as a non-physical form of energy that is converted into physical forms by exchange rather than transformation, and the effect on prices of demand exceeding supply is explained as the manifestation of the reduction in free energy due to the spreading-out of energy from sellers to buyers. A clear definition of price in terms of the value it represents emerges, and a simple expression for the effect of demand exceeding supply on the total amount spent in the case of fixed numbers of buyers and sellers can be obtained.

When advances in the intelligence of an organism, brought about in the pursuance of a more efficient metabolism - acquiring and pre-processing the food to be broken down must also be taken into account - cross the threshold required to conceive of money, the model implies that a new, more effective mechanism for consuming free energy becomes available, that is, at the same time, a new,

more effective mechanism for the advancement of intelligence. This mechanism, as described by the model, involves the transformation of large amounts of energy relative to the amount of free energy consumed, such that the impact of the intelligent life on the surroundings is much greater than before.

The above implications in turn imply that the social science of economics has a foundation in the natural sciences.

Finally, the implication that humans have a choice about how they wish to consume free energy in turn implies that political science, too, has such a foundation.

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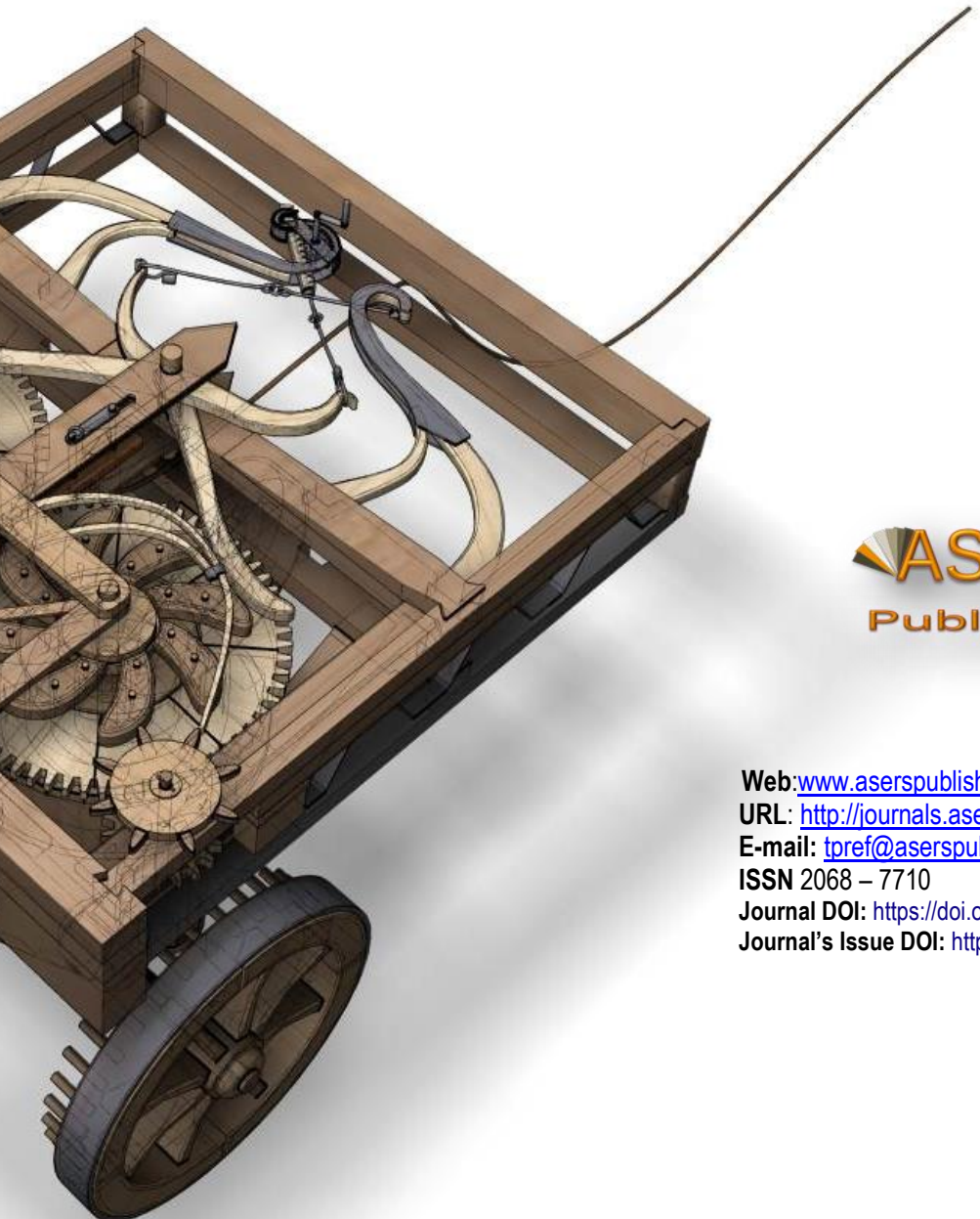

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