Thermodynamic Laws Applied To Economic Systems

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ABSTRACT

Economic activity in its different manifestations – production, exchange, consumption and, particularly, information on quantities and prices – generates and transfers energy. As a result, we can apply to it the basic laws of thermodynamics. These laws are applicable within a system, i.e., in a country or between systems and countries. To these systems we can apply the thermodynamic principles. In order to work with these concepts, we must first define what a system, in this case an economic system, is and then explain what we mean by a closed or open system. Given that entropy is intimately connected to the level of disorder within a system and, thus, with its information, this multiple vector connects the systems internally and externally.

Keywords: thermodynamics, entropy, systems, heat, information

INTRODUCTION

Each system is a country, though it can also be seen as an industry. In either case it is important to note that a closed system cannot be related to other systems. In an open system, a country relates to other countries and an industry to other industries. The energy of each arises from its ability to produce, sell, communicate, make technical advances, and find new factors of production, new organisations and all the elements that improve production. This is the positive side of the matter. But there may also be adverse energy, such as hyperinflation, which is very entropic in nature.

Heat and force, their maintenance and direction, are relations that express the communications of a system within itself and with other systems. Thus, they determine the economic principles of thermodynamics.

The etymological root of the word thermodynamics is *thermo,* which means heat, and *dynamic,* which means movement. These two words are both fully applicable to economics.

ENERGY

Energy is the capacity of an economic system to generate production, exchange and consumption, and also undertake technical innovation, apply new methods of organising production, discover new sources of energy, etc. By its own inertia, this *heat* tends to vary and set itself in motion in a specific direction in the form of work. This process has various meanings depending on whether the system is closed or open.

One way of talking about the energy of an economy is to use the term *positive perturbations.* These perturbations affect the *real* side of the economy, such as production, productivity, investment and consumption decisions, the size of the working population, etc., Monetary perturbations also have an impact, though not as great, on both the supply of money and the demand for money. The concept of a dynamic capitalist economy, as described by Schumpeter, is a case of real perturbations. In this way, the theories of Finn Kydland and Edgar Prescott, on one hand, can be seen to coincide with those of Schumpeter, on the other, by means of our concept of thermodynamics.

In an open industry, for example, technical innovations spread to other industries or companie, and even other countries. The revolution in information technology generates an energy which operates on the IT industry itself, on other industries and on other countries. The countries that receive the energy change and develop an amount of information work measured, for example, in an increase or creation of GDP and in economies of scale, the latter being a means of receiving and emitting energy.

The process, seen in this way, bears a close relation to the 'end economy' of Walras and a thermodynamic economy of the Schumpeter type.

THE FIRST LAW OF THERMODYNAMICS

This is the principle of conservation of energy which believes that if heat is applied to a system or work, i.e. the heat or work is exchanged for another, the internal energy of the system will change. Why does it change? Given that the same system or the two systems change temperature or work-rate, there must be a cause. This cause is the work of applicable energy. Energy is conserved.

In an economic system, work is applied in production, in exchange and barter (which is a kind of production) and in consumption (which is also energy production). As a result, the system will have changed and acquired new strength and energy. Given that it has acquired new strength, this must be the result of applied energy. We are talking here about a closed economy. If we apply the same concept to an open economy that is stable because it has reached the point of equilibrium of Walras, we can trace two kinds of equilibrium; one before the application of energy and one after. In either case, entropy is zero because the system will have exhausted its information with respect to price and quantity.

In an open economy, a country or an industry transmits its heat to another system, i.e. another country or industry, as a consequence of which the receiving system changes its production heat. This is especially true of a dynamic economy of the Schumpeter type. In this case, the economy breaks out of its state of equilibrium as a consequence of technical innovation, the opening of new markets, the introduction of new merchandise, etc. The receiving system benefits from these changes and incorporates them; its rent and production increase, costs are reduced, and in addition, the country receiving the energy increases its purchasing capacity vis-à-vis the transmitting country.

As a general rule, the situation is as follow:

E that enters – E that leaves = Δ of system E

where E equals energy.

THE SECOND LAW OF THERMODYNAMICS

The second law of thermodynamics indicates the direction in which energy processes move, thereby refuting that they move in another direction. For example, given the present uniform, indefinite, continuously expanding universe of Hubble - that of the 'big bang' - it is unlikely that the universe suddenly becomes an infinitely dense speck - the 'big crush' - or that a spreading cloud of ink in a glass of water resolves itself into a dark blue blob on the end of a fountain pen.

An economy, country or industry that raises its productivity and emits real perturbations of economic energy-supply generates benefits for other economies in various ways; it teaches them new production methods, it sells them cheaper products, and it lets them know that there are improved techniques to be used. The process does not work in reverse. The backward country, with weak production and an immigrant population having a low level of productivity and scant resources, will not answer those real perturbations from its neighbour with positive perturbations of its own. It is a case of dynamic capitalism of the Schumpeter type and also of the perturbations of real supply, such as those described by Kinland and Prescott.

The upshot of this is that energy moves one way only (unidirectional) from the system having more energy to the system having less.

In such processes, the transfer of energy is not complete; there are losses. Varying amounts of energy are dissipated in learning, teaching, appreciating, uncertainty, etc. This is similar to Kelvin's observation that work which absorbs heat from a single source converts itself totally into work, which by no means contradicts the first principle of the conservation of energy.

Another observation is that a machine which works with heat heats the atmosphere. The efficiency of the machine can be measured by the extent to which the heat increases the work-rate and reduces the heat loss to the atmosphere. This is applicable to where a country-system or an industry that undergoes positive perturbation in its real supply tries to take economic advantage by selling the benefits created; technology, reduced costs, improved productivity, etc. This observation is compatible with the fact that although energy is lost in the atmosphere, other countries or systems will use it and the final entropy will be positive.

THE THIRD LAW OF THERMODYNAMICS

The law was defined by Walter Nernst, who said that you cannot reach a temperature that is close to zero by means of a series of finite processes. This is because the closer you approach zero, the more obvious it becomes that entropy adopts a specific value, i.e. not nil.

This example is applicable to Walras' 'diamond' equilibrium in which all prices and quantities are in equilibrium in an adequate auction in which the information is also sufficient and perfect. In a universe such as this, there is not, nor can there be, any perturbation. However, in the real world, the fact is that there will always be some degree of misalignment in prices and amounts and some degree of missing information. These misalignments mark the rate of constant entropy; i.e. entropy not having a nil value.

We could argue the other way around: a positive perturbation, i.e. production, consumption, innovation, etc. will generate energy and move the economy away from the absolute zero of Walras.

THESES

In dealing with human events and systems, it would be better to call thermodynamic laws 'trends' instead of laws. The trend towards learning new techniques, improving production, locating new markets, etc., ensures that human activities are pleasure-seeking, rational and energetic, and that they advance from one place to another. It is unlikely for a company having access to a technical innovation to fail to use it or buy factors of production at a high price when they can be had at a lower price.

At bottom, thermodynamics is measuring energy on one hand and the level of disorder or randomness on the other. An economy of the Walras type, which is forever stationary and infinitely wise in terms of prices, amounts, etc., has an entropy of zero. Although an economy which undergoes Schumpeterian perturbations will suffer disorder in its markets, those markets will expand. Costs undergo change, together with prices, in the same way that the population grows and productivity levels change. All this acts as a multiplier which ends up being rationally disseminated in other systems; i.e. countries or industries.

Here we must question if there are multiplying effects in economic supply; in the thermodynamic parallel, there will be a multiplying effect on energy. Thus, the first law of thermodynamics is not obeyed. In fact, the amount of energy increases. The only way of reconciling the multiplier effect of perturbations with the first law is to allow for greater dissipation of energy.

The fact that certain people's dynamics in culture, law and arms managed to become huge empires, seems to confirm the second law of thermodynamics. However, the fact that - like the Roman Empire - these empires disappeared seems to contradict it, as the clock is turned back and everything returns to its original state. Entropy, it would seem, is present on both sides. But this is not true. Nothing returns to its original state. As Heraclitus said, "things change and mutate". We must consider the possibility of entropic variation, which is by definition energetic, as part and parcel of the downfall of empires.

CONCLUSION

Energy, as a metaphor, is highly applicable to the economy. The national product, the earning of rents, exchange and barter, are all energetic activities, and the principles of thermodynamics can be applied to them. This is equally true whether the systems are close isolated systems or open systems linked to others. The law of the conservation of energy compensates and explains the differences in work rate and entropy. The second law says that energy moves in one direction only. The third says that at the end of the process, there will still be an energy constant.

A Schumpeterian system that generates positive perturbations in supply, generates energy for itself and for others and becomes highly entropic; it may therefore be explained by the law of thermodynamics. A system of frozen balance, such as that of Walras, will keep entropy at equal to zero.

AUTHOR INFORMATION

Jose Villacis Gonzalez has a PhD in economic science; degree in political science and sociology; lecturer in economy at the University San Pablo-CEU; author of various books: Macroeconomía, Microeconomía, Política Monetaria y Política Fiscal; El Origen de la Macroeconomía en España; La Teoría de las Disponibilidades, del Interés y de la Renta; La Máquina de la superación de Leviathan; Germán Bernacer y el Círculo de Alicante.

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