ENTROPY MAN

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Preface

The seeds for this book were sown in the 1970s, four decades ago, when I was then working as group economist for the engineering corporation Babcock International Plc. At that time the group employed about 30,000 people in subsidiaries spread all around the world, engaged in the design, manufacture and installation of capital plant for a variety of industries, including nuclear & conventional power generation, coal mining, gas, chemicals & petroleum, steel, automotive, cement, construction and environmental engineering. Prior to that, my formal university education had included a degree in engineering at University of Bath and a Masters in management science, allied to student sandwich experience with Amalgamated Power Engineering *[now a subsidiary of Rolls Royce]* and ASEA Brown Boveri, Switzerland, followed by working for SKF, the Swedish bearing manufacturer, often considered to be a bell-weather of world economic output.

From the 1980s onwards I worked as director of a consultancy, and subsequently also as an expert witness to the Courts, which roles I continue to the present day. These experiences have taught me to maintain an enquiring, dispassionate and impartial mind regarding the complex workings of human endeavour, the natural world and changes arising thereof.

My particular research interests in those early years concerned the parallels between the disciplines of economics and thermodynamics *[the science of energy & heat]* and how they relate to each other, as a result of which I published two peer-reviewed papers on the subject in *Energy Economics [1979 & 1982]*. Subsequent to these I gave presentations to international gatherings of government ministers, energy industry executives and academia.

Not being based at a university however, and with no research grant at my disposal, my main thrust had been to make a living from consultancy and therefore, until more recently, opportunities to spend time on research were few. Nevertheless, by the turn of the millennium I was able to find time to return to some research and published another peer-reviewed paper in the *International Journal of Exergy [2007]*, followed up by several working papers on monetary aspects and energy models. Subsequently in 2009 I wrote a technical book on the subject, to bring together all the facets of the work into a coherent whole: *'Thermoeconomics – a thermodynamic approach to economics'*. The book was subsequently revised, corrected and added to, up to a third edition *[2012]*, covering topics such as production and consumption processes, employment, money, interest rates and bonds, energy resources, climate change and sustainability, and including more up to date statistics. It has now been superseded by this book.

Whilst not being tied to a university, government agency, industrial enterprise or other organisation has disadvantages in terms of recognition and time available for research, it does nevertheless have the advantages of freedom to investigate and pursue a course of enquiry of one's own choosing and of drawing conclusions independent of those that pay the piper or who may have pre-set agendas, however well-intentioned these may be.

The nature of the subject requires significant proof for economists and scientists to accept that similarities between thermodynamic and economic phenomena might imply more than just a passing analogy or isomorphism, and relations between the two disciplines have rarely been comfortable, with scientists sometimes having scant regard for the work of economists; and many economists believing that science has little to offer their discipline which, by its nature, can be thought of as anthropocentric rather than eco-centric. One eminent energy scientist advised me that he did not know of an economist who could follow a thermodynamic argument. Certainly a concept such as entropy means very little to most economists, still less to the man in the street – money is their language of communication. The latter is not, however, the language that Nature and the environment converse in.

This book is intended for a mixed readership of scientists, economists and those of an enquiring mind. It is a challenge therefore to convey the nub of the argument in terms that all can appreciate, with particular reference to the effects of potential problems such as 'peak resources', humankind's effect on the ecosystem and the maelstrom that would ensue should resource failure or climate change ever come about to a significant degree.

While some chapters, notably chapters 4 through to 8, do contain some mathematical expressions, explanatory points are included to guide non-

mathematicians onwards. Formal proofs and derivations have been relegated to the notes on each chapter.
Although economic man may currently have the ascendency, he does not actually *'own'* the Earth. He is there on sufferance, and the Earth would quickly forget him along the ecological timescale, should human civilisation fail or spoil the proceedings.

I am indebted to my wife Alison for all her support and for providing me with an atmosphere conducive to my research.

John Bryant

CHAPTER 7 LABOUR AND UNEMPLOYMENT

Having set out the general principles of thermodynamics as applied to economic processes, and seen how money interacts thermodynamically with the economy, it is of interest to return to analysis of the wage sector. It will be recalled that a flow diagram at figure 4.3 of chapter 4, showed the connection between two different stocks, and one might adapt this to the situation between labour, money and the output of productive content, as set out at figure 7.1

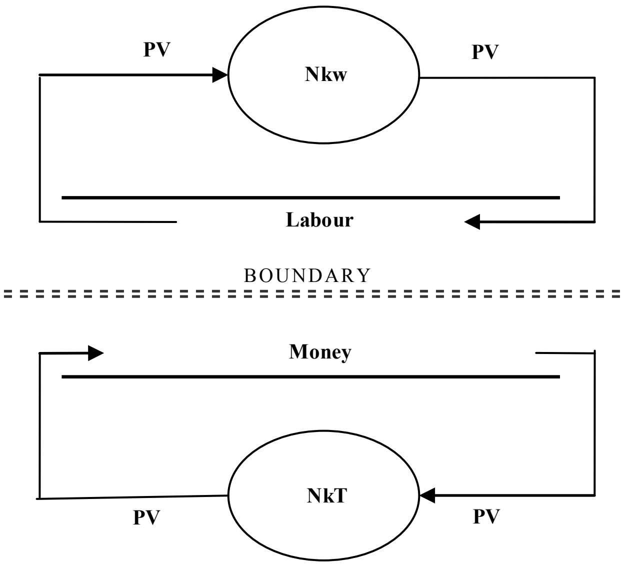

Figure 7.1 Labour and Money.

From a thermodynamic viewpoint, however, such a picture does not wholly account for the source of the productive content, which comes not just from humans and capital stock constructed owned and operated by humans, but *more* from the resources of the Earth, such as energy, minerals and living things which humans are able to commandeer to their benefit. As noted earlier at chapter 4, other economists *[Ayres, Warr, Hümmel]* have shown that natural resource energy constitutes the prime mover in economic growth.

To be fair, human labour and ingenuity is involved and spread right across the productive system, and it is reasonable to expect that human wellbeing and 'wealth' will be affected significantly should the economic system deviate from an equilibrium position. If a racing horse is goaded by it rider to go too fast and consequently trips when attempting to jump over a fence, one might expect its rider to get hurt as well as the horse itself.

A further point to note when investigating employment at a macro level is that averages of both income and productivity are involved and not a spread, though clearly significant differences in value occur the nearer one gets towards the micro-level. We looked at the spread of incomes at chapter 4, and defined an average relationship as:

$$G = PV = Nw$$

With output value flow **G** *[=**PV**]* equating to the number of humans employed **N** multiplied by a wage rate **w**. Such a relationship implies that humans alone are the progenitors of output value even though, from a thermodynamic point of view, much of output is made up of inputs of resources and life forms other than humans. A further implicit assumption made by economists is that one can average the output value and wage of groups of people; which point was made earlier in this book.

The relationship can be further reduced by dividing output volume flow **V** by the number of humans involved in the production process to derive output volume flow per head **v**, or an index of productivity:

$$Pv = w$$

If humans alone were the source of output, then our productivity index would equate to a proportion of human stock *'consumed'* each year to produce output, being similar in concept to the inverse of the lifetime ratio **ω** or to the rate of return **r**, which we met in earlier chapters. Clearly, however, humans are not the lone source of output, and instead the productivity index becomes a measure of how much of *Nature*'s productive content humans can garner to their benefit per unit of time. Likewise our wage rate becomes proportional to this, but adjusted for changes in the price level of output and the prevailing elastic relationships between price and output volume.

Without clogging the narrative with mathematics, an economist could postulate elastic relationships of both price **P** and wage rate **w** to output volume flow per head **v** of the form:

$$Pv^n = C \qquad \text{and} \qquad w = Cv^{1-n}$$

High values of the elastic index **n** are associated with an inelastic position, whereby output volume flow is not affected much by changes in price; and vice-versa.

And using these relationships, in exactly the same way as for money, entropy functions can be constructed to link entropy change to rates of change in output volume flow per head **v** or the wage rate **w**:

$$dS = (\omega - \omega n + 1)\frac{dv}{v} \quad \text{or} \quad dS = \left(\omega + \frac{1}{1-n}\right)\frac{dw}{w}$$

The second expression is just an alternative form of the first, which readers will have met before in this book.

We now turn to the subject of unemployment and its impact on economic output. It is commonly accepted that the level of wage rates is affected by the rate of unemployment, of which the Phillips curve *[William Phillips (1914-1975) see also figure 7.2]* is the most well-known means of illustrating this effect; though there are other more modern variants, including NAIRU *[non-accelerating inflation rate of unemployment]*. When unemployment is high, wage growth and inflation tend to be low, and when unemployment is low wage rates and inflation tend to rise. This is not always the case, as other factors can impact on demand. History has shown that the Phillips curve tends to shift. In the 1970's, many countries experienced high levels of both inflation and unemployment – stagflation, which changed the relationship of the curve.

It is logical to deduce that a rise in unemployment not just takes out a proportion of the workforce, but that it also takes out a proportion of output value flow that might otherwise have been generated, since at that point output value in the economy can no longer support the additional wage costs. In a similar manner to our money system at chapter 6, the following hypothesis might be proposed:

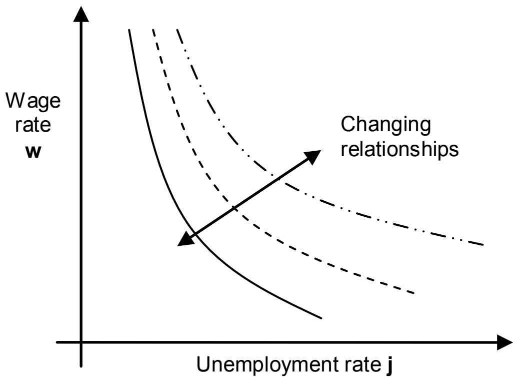

Figure 7.2 Phillips curve.

"In an economic system, the difference between the rate of change in output value attributed to the labour sector and the rate of change in lost value from unemployment is a function of the change in entropy generated."

This could be set out as:

$$dS = \left(\frac{dG}{G} - \frac{dJ}{J} \right)$$

Where **G** represents output value attributed to labour that an economy can support, and **J** is the potential output value flow loss taken out through unemployment, which the economy cannot support.

To test this hypothesis, we can make a number of substitutions to derive the structural relationship between output value flow and lost output value. Principally, a rate of unemployment **j** can be used to define both the actual value flow and the potential lost value flow arising from a given size of the labour force

To avoid showering readers with mathematics, the end result is given as follows. A full derivation is set out in the notes to this chapter.

$$dS_{labour} \approx -\frac{dj}{j} \qquad \text{or alternatively:} \qquad (S_2 - S_1) \approx \ln\left(\frac{j_1}{j_2}\right)$$

Incremental entropy change is equated to the *negative* of the rate of change in unemployment. In the alternative, change in the rate of entropy generation between two points is equated to the logarithm of the inverse of the ratio of the unemployment rates. Low levels of unemployment are associated with high activity rates, and vice versa.

Thus if change in entropy generation is positive the rate of change in the unemployment rate is likely to be negative with a potential rise in employment, and if entropy change is negative the rate of change in the unemployment rate is likely to be positive, with an associated drop in the employed labour force.

The key to the process is the change in entropy generation. Entropy gain provides the impetus to drive an economic system forwards, and a decline in entropy generation will drive it backwards into recession or deflation.

By way of illustration, the charts at figure 7.3 set out a comparison of change in entropy generation taken from the money derivations in chapter 6, versus the negative percent rate of change in unemployment rate **dj/j.** Data of unemployment rates was taken from US Bureau of Labor Statistics (www.bls.gov) and Economic Trends Annual Supplement (www.statistics.gov.uk). Quarterly changes in the unemployment rate were calculated from 4-quarter moving averages of the rates.

The data presented appear to indicate that negative rates of change in unemployment rates in the USA follow the ebb and flow of changes in money entropy. The evidence is less conclusive in the case of the UK, however, perhaps owing to the large inflationary period in the 1970s.

A possible improvement to the above result may be to include statistics of those persons who choose to become economically inactive rather than to claim unemployment benefit, though this has not been attempted in this book.

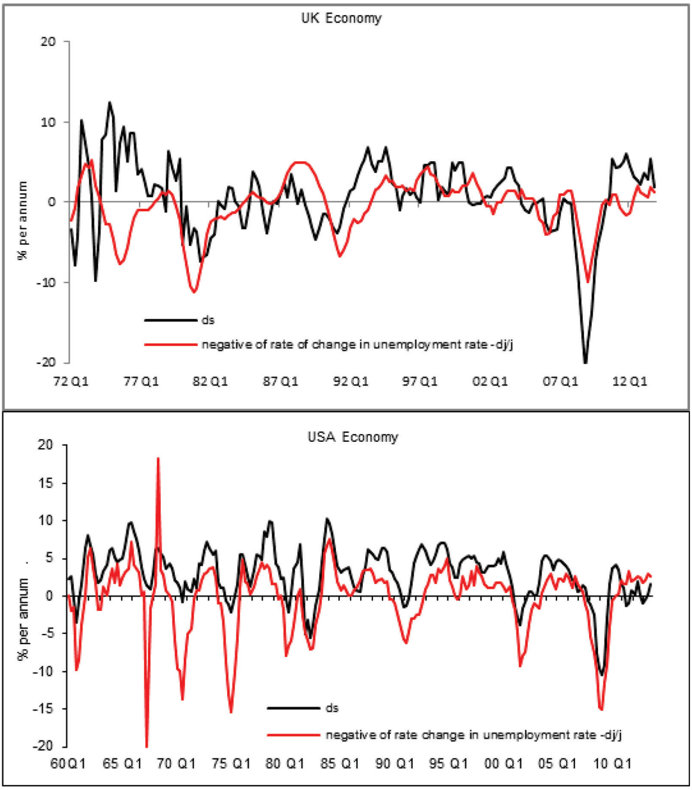

Figure 7.3 Changes in entropy and the negative of the rates of change in unemployment rates.

Finally, we could arrive at an equation setting out the rate of change in the wage rate in relation to the rate of change in the unemployment rate. Again, the mathematics has been relegated to the notes to this chapter, though the final result is presented here:

$$\left(\frac{dj}{j}\right) \approx -\left(\omega + \frac{1}{1-n}\right)\frac{dw}{w}$$

This equation describes the rate of change in the unemployment rate **dj/j** as being negatively related to the rate of change in wage rates **dw/w**, moderated by a function of the elastic index **n** and the lifetime coefficient **ω.** This result follows the format of the inverse relationship of the Phillips curve set out in figure 7.2, with the main influencing factor affecting the relationship being the elastic index **n**, which has the effect of moving the curve in the manner shown.

It should be emphasised again that change in entropy generation in an economic system acts at the margin to regulate output value flow in line with prevailing constraints.