Scientific Reduction, Reductionism and Metaphysical Reduction – A Broad View of Economic Methodology

Henry K. H. Woo
Hong Kong Institute of Economic Science

The Merits of Scientific Reduction

The merits of reduction as a component of the scientific method are seldom disputed. Along with methods such as classification, induction, experimentation, testing, explanation, reduction contributes to the progress of human knowledge and in particular, to advances in science by way of subsuming an existing corpus of knowledge under a more unified scheme. As a result, greater explanatory power is often achieved with a successful reduction.

The usefulness of the reduction method is, of course, not limited to the sciences. Logic and mathematics, as well as philosophy, have been employing extensively the reduction method. In logic, the method is employed to achieve greater rigor as well as coherence of structure. The reduction of arithmetic to logic by Bertrand Russell is a paradigmatic case, illustrating in full the formidable power of reduction. Another classical example in the realm of mathematics is the reduction of rational fractions to ordered pairs of natural numbers, first by the Greeks and eventually by Weiner (1914) and Kuratowski (1920), who successfully reduced the ordered pair to an unordered pair of unordered pairs (Popper 1982 p. 133). In the realm of metaphysics the reduction method is invariably employed by philosophers interested in system building or in exploring the ultimate ontological structure of reality. For our purpose, we will confine ourselves to the reduction method in science.

Successful cases of reduction in the natural sciences are abound. They include, for example, the reduction of Kepler’s and Galileo’s laws to Newton’s theory of gravitation, the reduction of a generalized principle of inertia to a generalized principle of gravitation, the reduction of Wein’s law and Rayleigh-Jean’s Law to Planck’s Law of radiation, the reduction of both mechanics and chemistry to an electromagnetic theory of atomism, the reduction of chemical bonds to quantum mechanics, the reduction of biology to chemistry by way of molecular biology. Not all reductions are successful ones and there are staggering failures in the reduction enterprise. The Cartesian attempt to reduce everything in the physical world to extension and push was a case in point. So was Maxwell’s attempt to reduce Faraday’s electromagnetic field of forces to a Newtonian model of the luminiferous ether.

Even such failures, however, are of importance, for as Popper observed, the number of interesting and unexpected results we may acquire on the way to our failure can be of the greatest value (1982).

Briefly, one might characterize the reduction method as trying to explain something known, or not-fully-known in terms of fewer variables. Any intellectual exercise that aims to explain an existing corpus of knowledge by fewer variables, regardless of whether or not these are ‘deeper’ variables positing ‘theoretical’ entities that reside at a lower stratum of reality or whether or not they are ‘broader’ variables aiming to subsume existing concepts, can be taken as employing the reduction method. In the sphere of science, the reduction usually takes the form of explaining some higher level phenomena or entities in terms of some lower level phenomena or entities. These lower level phenomena or entities are supposed either to be the essential micro-structures that make up the higher level phenomena or entities or to causally affect the properties of these phenomena or entities.

From a methodological stance, it would be interesting to examine the conditions that are conducive to the making of a successful reduction. An important condition appears to be that, before a reduction takes place, an abundance of knowledge or material has already been built up. What motivates or prompts a reduction is that the stock of knowledge in question appears to be internally incompatible in certain ways, or that there are disturbing anomalies that could not be handled by the existing framework, or that the amount of
segmented knowledge within the stock has accumulated to such an extent that some visibility needs to be restored. Whichever the case, for a reduction to be successful, it seems necessary that both the objects of reduction and the reducing variables are to be separately and carefully investigated before a reduction is being attempted.

Another condition, not a necessary one, seems to be that before a reduction is being attempted, there exists no preconceived idea as to what should constitute the reducing variables or about what should be the proper direction of reduction. For example, Maxwell first tried to reduce Faraday’s electromagnetic field of forces to a Newtonian mechanism of the luminiferous ether. But eventually, after Hertz and Thomson, it was the opposite research program that became more attractive, namely, the program of reducing mechanics to electromagnetic theory. In other words, there is no pre-set idea of what the final reduction should look like before the reduction. This condition is particularly relevant to domains where the directions of causation are multiple.

The third condition for successful reduction is that the resultant theoretical framework should be a testable one at least in principle. This means that the reduction should result in a theoretical framework that is in principle, if not directly, falsifiable. A successful reduction is to be commended, but a failure is to be recognised as such and be duly abandoned. A reduction, therefore, does not degenerate into an escape route for a failing theory. On the contrary, the resultant reduction, supposed to be more contentful than the pre-reduced state, should stand a higher probability of being refuted in subsequent tests.

The importance of scientific reduction cannot be over-emphasized. From the cognitive point of view, reduction serves to enhance the visibility or transparency of existing theoretical frameworks, making them more suitable for our ‘cognitive consumption’. As a result, a successful reduction provides the stepping stone for more sophisticated edifices to be erected and further reductions to take place. From the methodological stance, scientific reduction serves to eliminate incompatibilities among co-existing domains, or to reconcile anomalies. Above all, in its promise to yield ever-expanding and more encompassing frameworks, reduction helps to provide both the motivation and the instrument behind scientific progress.

The Dogma of Philosophical Reductionism

In spite of its apparent neutrality as a method, scientific reduction has nonetheless ontological presumptions and ramifications. Ontologically, it tacitly presumes that reality is stratified into layers and that higher-level structures depend on the existence of low-level structures and their operative principles. Precisely how that dependence looks like, however, is controversial and gives rise to different philosophical doctrines. Given that a successful reduction is one that enables higher-level phenomena to be explicable solely in terms of lower-level structures, it is natural that some scholars are led to posit that reality must be so organised that all higher-level phenomena can be analysed exclusively in terms of the processes and laws of lower-level phenomena. This strong thesis is sometimes known as ‘philosophical reductionism’. In essence, this thesis posits that reality being a set of perfectly ordered strata, human knowledge about it, including that which is not yet discovered, could in principle be reduced to the smallest core of knowledge at the lowest stratum of reality, even if that knowledge has yet to be comprehended or articulated. In other words, this thesis implies completeness of reduction and the essential completeness of science.

Historically, philosophical reductionism in one form or another is embodied by different research programs across different disciplines. In both the physical and the social sciences, it is strongly manifested in the thesis of physicalism. This thesis maintains that reality is stratified into layers, of which the bottom one consists of sub-atomic particles. In principle, all higher-level phenomena are materially reducible to these sub-atomic events. This thesis gave impetus to, and at the same time, was encouraged by some successful attempts to reduce biology to chemistry and chemistry to quantum physics. Indeed, many scientists today still share the feeling that there is after all, only one science. To quote a biologist Peter Medawar, “Biology is not just physics and chemistry, but a very limited, very special and profoundly interesting part of them. So with ecology and sociology”. (1974 p. 62).

Such a belief also forms the core of ‘material reductionism’ (or materialism) which is a variant of physicalism and is popular among the social sciences. Different versions of this thesis appear in different realms in the human sciences. Malthus, for example, used a mechanical model
taken from physics to characterize the nature of man. To him, like any physical body, man is an inert mass that must be activated by external forces. Jevons, on the other hand, used Newtonian mechanics to describe the nature and the laws of utility and exchange [1871, (1970)]. On the view of Marx, the mode of production in material life determines the general character of the social, political and spiritual process of life. Freud, in a similar vein, modeled his psychology on mechanistic biology. It rests on the assumption that mental processes are essentially unconscious, the unconscious being an uncontrollable mechanical force.

In its attempts to reduce all human behaviors into the schema of stimulus and response, behaviorism is probably the most paradigmatic of all. On the view of Skinner, a ‘scientific’ analysis of behaviors must assume that a person’s behavior is controlled by his genetic and environmental histories rather than by the person himself as an initiating, creative agent. Human behaviors are nothing but the results of conditioning. Mental life and the world in which it is lived are inventions. They are invented on the analogy of external behaviors occurring under external contingencies. In more recent days, vigorous reductionist efforts are revived in the realm of sociobiology. Scholars like E.O. Wilson and Richard Dawkins expended great efforts to demonstrate the reducibility of human behaviors to biological principles. Dawkins, in particular, attempted to show that man is not a cause but an effect and that life and mind are merely the outcome of genes and of their struggling for survival among themselves.

Methodologically, the difference between scientific reduction and the methodology of philosophical reductionism is that the former does not, at the very start, pre-specify the direction of reduction nor the relation between the objects of reduction and the reducing variables. In the former, phenomena that resist reduction are taken to reflect the failure of the proposed reduction and not as trivial anomalies that can be dismissed. By contrast in the case of the methodology of philosophical reductionism, e.g. behaviorism or sociobiology, we witness clearly pre-conceived ideas as to what the reducing variables should be and we witness ample efforts made to save their hypotheses from falsification. As a result dogmatism prevails. Such dogmatism unwittingly further biases our attention to the reduction exercise itself, rather than to the contents of reduction or the nature of the reducing variables themselves. Too eager to achieve reductionist results, the researchers concerned often do not allow the reduction to evolve upon a rich accumulation of independent facts and principles. As a result, they are generally inclined to amplify the fits, at the same time ignoring the misfits in their reduction exercises.

Such inclinations should not be surprising, for the basic principle of philosophical reductionism is that nothing intrinsically new enters at the higher levels (Popper 1982). And if nothing is intrinsically new, explorations for deeper or broader structures, apart from serving the purpose of proving the thesis of reductionism, are nothing but futile exercises. From this angle, philosophical reductionism can be said to be anti-intellectual in character.

**Metaphysical Reduction and Economics as a Reductionistic Research Program**

Scientific reduction as a valuable method (since even its failures are enlightening and educational) is thus diametrically opposed to the methodology of philosophical reductionism which is dogmatic and degenerative. Together these two methods can be seen to constitute two polarities, one progressive and the other degenerative, between which we can theoretically situate other related methods and different disciplines employing such different methods. The question we are concerned about is, within this schema of polarities, where does economics stand? Is, for example, economics making full use of the progressive method of scientific reduction? Or is economics actually espousing some kind of degenerative methodology of philosophical reductionism that inhibits the search for independent and useful knowledge? Or perhaps is this scheme essentially irrelevant to economics and we need a totally different perspective.

Let us first look at where economics stands. In the first place one may say that economics is anti-reductionistic in the strict sense of philosophical reductionism. This characteristic probably evolved out of the long-standing uneasy relations between psychology and economics1. Specifically, such uneasy relations grew out of the development of value theories, especially from the days of the marginal revolution. On the one hand, the study of the
price phenomena and its underlying patterns of value clearly requires the support of certain psychological variables and concepts, e.g. utility and our articulation of these variables. But on the other hand, some economists were fearful that too much reliance on the psychological foundations for economic behavior would strip economics of the status of an independent discipline and would thereby reduce it to a branch of psychology. As a result, they are more inclined to build economics upon certain fundamental ‘facts’ that are free of psychological variables as far as possible or that remain quite unchanged even with new findings in the realm of psychology. The fundamental facts of scarcity, of production through division of labor, of the use of a medium for exchange, for example, are considered basic economic facts that require little interface with psychology, or with other disciplines e.g. sociology or ethics. This attitude is well manifested by Robbins who said

"the foundation of the theory of value is the assumption that the different things that the individual wants to do have different importance to him, and can be arranged therefore in a certain order. This notion can be expressed in various ways and with varying degrees of precision, from the simple want systems of Menger and the early Austrians to the more refined scales of relatives valuations of Wicksteed and Schönfeld and the indifference systems of Pareto and Messrs Hicks and Allen. But in the last analysis it reduces to this, that we can judge whether different possible experiences are of equivalent or greater or less importance to us. From this elementary fact of experience we can derive the idea of the substitutability of different goods, of the demand for one good in terms of another, of an equilibrium distribution of goods between different uses, of equilibrium of exchange and of the formation of prices."

The advantage of using strictly economic variables for economic theorizing and discourse is obvious. Provided we get the fundamental axioms right, we can build an economics that will not be subject to the vissitudes of discoveries of new facts and theories in other disciplines, in particular psychology. Economics can now claim independence and autonomy. Espousing this position means that economics necessarily rejects the thesis of philosophical reductionism, for economic phenomena need not, and should not be reduced to lower level phenomena and entities.

Whereas this search for autonomy enables economics to avoid the fate of research programs like behaviorism, the autonomy was nonetheless purchased at a high epistemic cost. Value theory is a major casualty in this development. Value theory was first developed with the aid of a subjective base in order to explain the price phenomena. We would consider a value theory a progressive one if it were to continue to refine its subjective foundation by way of say, extracting or positing further orders in the human mind that reflect upon and respond to price data or changes in price data. By corollary, the proper research direction would be to discover new subjective variables and patterns and to analyze how these interact with objective changes in the economic reality. Instead of adopting this approach, two other routes were pursued. One simply took it that a subjective theory of value that is sufficient to derive the law of demand and to establish the existence of the consumer equilibrium should be the last word on the subject and that there is no further need to explore into the deeper relations between price, utility and value. This route was led by Walras himself.

Another approach aimed to reduce the subjective content of the first foundation laid down by the other marginalist economists and to substitute as far as possible the subjective elements by more objective measures. Inspired by the positivist philosophy of the day, this approach made a series of attempts to reduce the dependence on the concept of utility, or inter-personal comparisons of utility in the proof of the law of demand. Very briefly, the notion of cardinal utility was first replaced by the notion of ordinal utility (Hicks 1939). Subsequently purely behavioral hypotheses that are deemed sufficient to establish the existence of the utility function (e.g. Samuelson 1947) were introduced so that the remaining subjective connotations of value can be further reduced. Eventually, the original search for tenable subjective roots of prices in the days of the marginal revolution was transformed into the logic of choice. The result is an impoverishment of the idea of value. The problem situation facing the researcher is no longer one of how consumers actually evaluate preferences and
how such valuations affect price formation in the real world. The neoclassical theory of value becomes a pure logical theory of choice and optimization. In this regard, Georgescu-Roegen's remarks are insightful.

"Neoclassical economists have criticized Marx's theory of value because it reduces concrete kinds of labor to an abstract notion -- general labor. Yet neoclassicalists have done the same; they have reduced concrete wants to the general and abstract want: utility. However, it is on concrete want, not on the general want, that an individual bases economic choices."

The same process of impoverishment took place in welfare economics. The emergence of 'positive' economics, has not only shunned 'normative' analysis in economics, but it has also the effect of ignoring a variety of complex ethical considerations which affect actual human behaviors and which are primarily matters of fact rather than of normative judgement. This point is emphasized by Sen who argues that modern economics has been substantially impoverished by the distance that has grown between economics and ethics (1987). As a matter of fact, the relations between the economic order and the moral order go beyond the normative dimension. The relations are not only causal in nature, but the causality is of a complex and multi-directional kind. Max Weber has long demonstrated how religious precepts and values have effects on economic behavior and how Puritan ethics unwittingly promoted secular successes. Similarly, an economic order of a particular kind (e.g. the socialist system) has effects on the moral codes of its economic actors which, in turn, affect economic behaviors.

Paradoxically, although economics is very much against philosophical reductionism, this very feature has unwittingly rendered economics a 'reductionistic' research program in the sense that its explanatory resources become gradually confined to concepts and principles within the economic sphere. In the first place, this development violates one methodological canon of successful scientific reduction we mentioned earlier, namely the unreined and uninhibited proliferation of research materials prior to the stage of reduction. But the idea of economics being a reductionistic research program goes beyond the restriction imposed on the accumulation of material for later reduction. Unlike physics or chemistry, hypotheses in economics are hardly subject to refutation. Empirical data, rather than potentially useful to falsify a hypothesis, are often selected by the hypothesis itself. It needs therefore a lot of ingenuity to collect empirical data that could independently verify or falsify a particular hypothesis.

With fact-theory relation in economics dominated more by the theory side and with its 'causal' base being constricted by its refusal to interface with its neighborhood disciplines, an alternative route open to economics to build a corpus of apparently 'meaningful' knowledge would be via the route of 'metaphysical reduction'. A metaphysical reduction can be characterized as a kind of reduction approach whereby certain sets of phenomena or entities, or explanatory schemes of a lower level, are subsumed under a broad theoretical framework built upon some highly encompassing, structural features of reality. These features are partly ontological and partly epistemological in character. Being ontological, they represent or reflect the broad outlines of reality, or the basic properties of the causal processes, generative mechanisms or operating principles behind manifest phenomena. But they are not purely ontological, because they need not reflect reality in its working or organising details. They are posited chiefly for the purpose of enhancing the human understanding and are therefore not supposed to match reality in a substantive manner in depth. They are, alternatively put, essentially epistemic categories. Concepts such as symmetry, conservation, equilibrium, reversibility, dialectic, divisibility pertaining to the nature of reality and concepts such as rationality pertaining to the human agent are examples of such high-powered, all-encompassing, epistemic categories by which a wide-range of phenomena or explanatory schemes can be subsumed. As such, we may call them epistemic archetypes. They are meta-patterns that serve to standardize interpretation of empirical data. Acting as some kind of 'idea pigeon-holes', they cut across a multiplicity of disciplines and can fit into a wide range of divergent empirical data, both by virtue of their relatively high level of generality and their apparent openness (Woo 1986).

Economics is a reductionistic research program in the sense that like scientific reduction and the methodology of philosophical reductionism, it makes repeated attempts to simplify its core theoretical framework, making
ample use of epistemic archetypes, in particular the twin concepts of rationality and equilibrium. The development towards the general equilibrium theory is a case in point. Unlike scientific reduction, the core variables to which its theoretical framework are reduced to, are not deep, causal or inter-disciplinary variables. Instead, pure economic variables under the domination of the epistemic archetype of equilibrium are used. At the level of generality the theory is posited, there is no way any set of data could conclusively falsify the status of the theory in question. Conversely, the equilibrium archetype embodied in the theory is amply used to manipulate data for model-building. The basic asymmetry in the fact-theory relations which characterizes economics is thus aggravated by the employment of these non-causal, reductionist epistemic categories.

The consequences for economics arising from its extensive reliance on epistemic categories for its reduction activities are serious. First and foremost, the reduction exercises employed and the apparent endless possibilities of reduction appear to suggest that economics in the way it is practised, is capable of yielding progressive knowledge via this mode of reduction. In spite of its having confined its theoretical discourse to chiefly economic variables, it thus seems justified to continually shut off from inter-acting with other disciplines and to build a larger base of causal knowledge from the interactions. Second, without a rich causal base to generate alternative frameworks, there is no way one could remove the existing framework and to plant a new one in its stead, regardless of the demonstrable incompetence of the existing framework in explaining reality. Without competing frameworks to offer more accurate pictures of reality, empirical data could hardly discharge the function (in the Lakatosian sense) of providing a more objective measure of the merits of the frameworks concerned.

The increasing incompetence of its core framework to explain or to predict reality gives rise to a phenomenon rather unique to economics. On the one hand, economics in its core is highly successful in organizing itself into an axiomatic system with great rigor. But on the other hand, expectations on economics to produce theories to reflect reality do force economists to make attempts to relax these unreal core axioms in order that more realistic theorems are produced. If one were to relax the core axioms at once, one would be left with a much weakened framework generating theorems that are theoretically much less visible and transparent than those of the original (Woo 1990). But on the other hand, if one were to relax the core axioms one at a time, one could hardly produce, in sum, a systematic view of what reality is because each of the ad hoc theorems so derived is still unreal in itself. The result, therefore, of sticking to a non-removable, theoretical 'monopoly' under which all real-world phenomena were to be subsumed and of relying merely on ad hoc adjustments on the periphery, is that economics, at least in the core, cannot claim to be a progressive discipline. At the risk of over-simplification, one may say that such is the deplorable state of present-day economic science?

**Ramifications for Economic Methodology**

To recapitulate, unlike logic or mathematics, the reduction method in economics is constrained by a demand for realism. Hence, economic reduction cannot hope to match in its formalisms the rigor and the coherence of logical reductions and proofs. By virtue of its ontological characteristics, fact-theory relations in economics are such that empirical data, under many circumstances, cannot usefully eliminate incompetent theories. As a result, economics as it is practised, is not in a position to overthrow any reigning 'rationalistic' framework by lower level empirical data, as we expect in the case of scientific reduction. In addition, out of its fear of philosophical reductionism, it naturally discourages free interface between itself and other disciplines and as a result, inhibits unwittingly the accumulation of useful causal knowledge.

When then are the solutions to such a predicament? To restore economics to the status of a science, it is essential we should abide by the spirit of scientific reduction and the methodological canons for successful reductions. But we also know that economic science, being a social science, embodies an ontology that is distinctly different in its crucial aspects to many physical sciences, among which one can say that economic actors and participants are far-from-identical entities and that economic situations, unlike many physical situations, are far-from-equilibrium ones. These characteristics render the testing of an economic hypothesis highly difficult and we do need to
heavily modify the existing scientific method to suit the ontological characteristics of the economic domain. The need for such modification, however, does not give us a reason why we should not open up the economic domain for interfacing with other social sciences and why we should not search for a larger base of causal variables.

Consider the relation between economics and cognitive science. Economic behaviors are invariably governed by our cognitive competence or incompetence, which depends on the nature of our cognitive constitution. Or in a more familiar language, economic results are the products of subjective states and expectations which are partly governed by the innate cognitive factors and patterns peculiar to man. Hence there is much to gain to examine how the cognitive make-up of man affects his economic behaviors. One may, however, raise the following objection. If philosophical reductionism is a false ideal, upon what ground can we justify the search for more causal depth and upon which ground should we reject the quest for autonomy of a discipline? What methodological canons should we develop in order that the fruitfulness of the search for causal depth could be realized without threatening the autonomy of a particular discipline? How far in principle should we dig into the lower strata of reality before we stop, avoiding thereby a lapse into philosophical reductionism? At the risk of over-simplification, one useful rule seems to be that we should start digging, once we realize that the intellectual resources we possess are not sufficient to solve existing problems, to dissolve anomalies or to eliminate incompatibilities. We may consider to stop digging once such problems are considered to be satisfactorily solved.

Consider an example in economic development. From development theories based upon conventional economics, one would expect that countries with more capital endowment should out-perform those with less capital. But development experiences show that many countries with more capital do perform less well than countries with less capital. This suggests that the concept of capital, restricted to the level of the tangibles, might not give us sufficient intellectual resources to deal with the issue. We are thus led to look for additional intellectual resources at the level of the intangibles. Naturally, we are led to the study of the deeper, institutional factors. But a fruitful study of institutional factors to the extent that it can offer a more generalized framework to account for divergent performances in different countries and thereby to avoid a lapse into relativism, seems to require some kind of reduction to the level of cognitive factors, in particular the perception of the future of the economic actor and the plans and provisions he makes for that future.

In the same vein, to understand the price phenomena more thoroughly, it seems that we need to understand how values form in our mind. To understand value formation in our mental maps, we need to study the properties of our mental map and how these properties affect the formation of our value patterns. Similarly, reduction to cognitive factors seems to help us to go a long way to re-articulate the long-standing but unresolved controversy over the roles of the market and the government. On these issues, I will not go into any detail. It suffices to say that while we grant that economics can be and should be an autonomous discipline, it does seem highly fruitful for it to interface with its neighborhood disciplines. Such an interface, as we have already pointed out, does not necessarily entail accepting the thesis of philosophical reductionism.

The result of such interfacing and inter-penetration will be that over time, a number of alternative causal frameworks will appear. With these alternatives, we are in a much more mature position to challenge the orthodox framework. The appearance of these alternatives also means that the role of empirical data, hitherto suppressed under a theoretical monopoly, can be unleashed to provide more objective appraisal of our theoretical ideas in economics.

Notes:
1. An earlier version of this paper was presented at a meeting of REXECO, Paris, on July 3, 1990.
2. In spite of the fact that it turned out to be an incomplete one.
4. For example, von Mises, Lionel Robbins, although Mises prefers to regard economics as a branch of praxeology, or human action in general.
6. There are at the periphery of economics, a number of interesting researches on causal mechanisms that operate in the real world. But there is no doubt that the
best minds and the lion’s share of the material resources in the profession are dedicated to the reductionistic proper.

7. I will not pursue further this direction of enquiring in this article.
8. See Woo, H.K.H., op. cit.
10. See Woo, H.K.H., ibid.

References