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**The Double Paradox of Elementary Economics  
Education**

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## The double paradox of elementary economics education\*

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### Abstract

Elementary economics textbooks have become less attractive to students requiring only an introduction to economics, given that their content is pervaded by mathematical diagrams and simple equations. Also they are of relatively little value to those interested in, for example, attempting to gain an understanding of the New Economy, for they rarely emphasise business innovation and its crucial dynamic role. These factors engender something of a *double paradox*. First (*paradox of the tools and the audience*), newcomers are frequently ‘turned off’ by existing economics textbooks due to the pervasive use of mathematics. Second (*paradox of the content and relevance*), those newcomers who are not initially turned off tend to be disenchanted with economics because they perceive that economics is of little use in understanding the New Economy in which they work, or will come to work. We suggest an integrated solution to both paradoxes. The implementation entails a minor reorientation of the traditional pedagogical strategy for teaching introductory economics.

## 1. INTRODUCTION

This paper is about a relatively simple strategy to make the study of economics more accessible and relevant for the public in general and to business students in particular. It should be emphasised from the outset that it is not a paper on scientific methodology. The issues to be discussed here are usually obscured by not distinguishing the psychological problems of economics education from issues of economics methodology. For example, the psychological problem of perceiving economic truth and injecting it into the heads of one's business students is different from the nature of true logical implications derived from specified assumptions.

The paper revolves around both mathematics as a teaching tool and direct inspection of the economic reality as source of contextual reality, not on the role of mathematics as a tool of scientific progress or on the role of induction as a source of scientific hypotheses. Having said this, it will become apparent that economics methodology has direct implications for the way we show the importance of economic ideas.

Many laypeople seem to be genuinely interested in what economic science can do for them, on the job and elsewhere. Among economists there is general agreement that everyone should learn the fundamental ideas that economics has to offer because this discipline is of great value in helping people make better decisions in the workplace, the home and the voting booth. However, newcomers are frequently turned off by existing economics textbooks due to the pervasive use of geometry and algebra. They typically give up hope and turn their minds to other disciplines where they imagine the "real thing" is.

The source of this paradox, henceforth the *paradox of the tools and the audience*, is not far to seek. Economics is a social science that almost all of the time uses formal language (mathematical diagrams and formulas) to present and develop economic insights. The level of complexity of these mathematical concepts is not high, but their pervasive use repels those readers who lack the necessary knowledge and skills.

A second paradox emerges from the opinions of those who have not found economics textbooks difficult to understand, but who doubt about the usefulness of what they have been taught. In fact, we often hear complaints that economics is not much use in today's New Economy. Shapiro and Varian (1999, p. ix), for example, suggest that our business friends at party conversations are in part correct when they emphasise that the economics they learned either at high school or at university is of little use in their attempts to gain an understanding of the mechanics of the New Economy. These readers tend to be disenchanted because of two (not mutually exclusive) reasons. First, they may only see curves with different slopes shifting everywhere and conclude that economics is just a futile

exercise in geometry. Second, they perceive that textbook supply and demand graphs are not of much help in understanding markets where technological change is important (such as information technology and biotechnology). For lack of a better term we will refer to this paradox as the *paradox of the content and the relevance*.

The source of the second paradox is of a different nature to the paradox of the tools and the content. Most introductory economics textbooks do not appear to provide, at least to those coming to the study of economics for the first time, an understanding of economic change. The most common reason for this is that business innovation does not play any noticeable role in most of the contemporary introductory economics textbooks. Generally speaking, these books deal with existing products not with the creation of new products or processes, let alone organisational innovation.

In this paper, we suggest one, possible, integrated solution to both paradoxes that, we believe, is not only satisfactory but also achievable. It may also help to answer the question of what changes in the way we teach introductory economics will enhance the use and appreciation of economic analysis? The implementation of our proposed solution entails a minor reorientation of the traditional pedagogical strategy for teaching economics.

The rest of the paper is organised as follows. In Section 2 we describe the nature of the first paradox by making contact with the distinction between appreciative economics and formal economics. Section 3 considers the second paradox. A conclusion and some concluding comments follow.

## **2. THE PARADOX OF THE TOOLS AND THE AUDIENCE**

The study of economics helps us to understand the complex and variable system called the economy, makes us –hopefully– a more shrewd participant in the economy, and allows us to evaluate the possibilities and limitations of economic policy. Ideally, we would like to transmit the economist’s view of the economy to the widest possible audience. The reality is, however, that many people are turned off by the mathematical tools (and we are referring here to simple diagrams and elementary algebra, not advanced mathematics) that pervade the teaching of elementary economics. We call this seemingly absurd situation, the *paradox of the tools and the audience*. It is a situation noted by many of our colleagues, for example, Coase 1988, 1994, Williamson and Winter 1991 and McCloskey, 2000.

It seems to be axiomatic that while a good management teacher should choose words that convey the desired message an effective economics teacher must choose the type of mathematical tools that best suit the purpose at hand. The implicit justification of this axiom appears to be as follows. Economics is a way of thinking. This way of thinking

emphasises deductive reasoning (i.e. what conclusions can be derived from a set of assumptions) and requires models. These models (even those addressed to the freshman) contain some mathematical tools. As a result if someone wants to *start* ‘thinking like an economist’, they have no choice, they need to use mathematical reasoning in a fundamental way. In a nutshell, mathematical methods of reasoning play a decisive role in gaining a basic understanding of economics.

## **2.1 *Thinking Like an Economist***

What does it mean to think like an economist? The best answer to this question comes from the well-known paper by Siegfried et al. (1991). What this paper says has been interpreted in the following way: thinking like an economist means to follow the model-building approach. According to this interpretation, to think like an economist means first to decide which assumptions to make and then build simplified models in order to understand the economy around us.

Economic models are constructed more or less in line with Euclid’s geometry, namely: first, formulation of assumptions, then, development of logical implications. They are usually stated mathematically, but obviously they do *not* have to be. They can be described in words or in diagrammatic form using non-mathematical diagrams such as flow charts.

It should be noticed that the paper by Siegfried et al. (1991) specifically refers to students *majoring* in economics, not business students in general. It seems reasonable to assert that if we are focusing on a wide audience the main objective of any elementary economics course or text should be to enable newcomers to *start* thinking like economists. It should also be noticed that the equivalence between thinking like an economist and the model-building approach appears to overlook several key points mentioned in Siegfried et al. (1991), including the importance of contextual reality in the sense that one needs to have a minimum background knowledge or big picture or a caricature of the economy in which to insert the model.

Summarising, the predominant approach followed by authors of elementary economics books and economics teachers tends to emphasise the use of formal models, and this approach constitutes an integral part of mainstream economics.

## **2.2 *Mainstream Economics and Different Styles of Doing Economics***

There is no generally accepted definition of ‘mainstream economics’. What we have in mind is this: mainstream economics consists of two sets: the concepts and tools that most economic teachers teach to their students, and a well established set of economic insights

expressed in mathematical terms, a subset of which is frequently used in papers published in top economic journals (such as *American Economic Review* and *Journal of Political Economy*) by leading economists. For example, general equilibrium models, Keynesian macro models, and game theory, are included in contemporary mainstream economics.

Economics was initially a descriptive subject based on unproven assertions. As theoretical developments became increasingly complex, purely verbal or written treatments gradually became less capable of dealing with that complexity -losing their utility. Hence, in the first half of the 20<sup>th</sup> century economists became divided into two groups: what might be called the *literary* (or non-mathematical) economists and the *mathematical* economists. However, this sharp division broke down with the passage of time because the mathematical tools became an integral part of the toolbox for all economists.<sup>1</sup>

More than a century ago, Alfred Marshall (1842-1924) recognised that there are two levels of analysis in economics, appreciative and formal. Appreciative economics is story telling 'close' to the empirical details. In contrast, formal economics is abstract modelling designed to check proposed logical connections between variables under specified assumptions.<sup>2</sup> Marshall had substantial mathematical training, but he kept the algebra and even mathematical diagrams in the background.

Marshall believed that the onus was on the economic theorist to use mathematics to check the coherence of her contributions, but once we know that there are no logical inconsistencies it would be a waste of time to repeat the mathematical proofs:

The chief use of pure mathematics in economic questions seems to be in helping a person to write down quickly, shortly and exactly, some of his thoughts for his own use: and to make sure that he has enough, and only enough, premises for his conclusions (i.e. that his equations are neither more nor less in number than his unknowns). But when a great many symbols have to be used, they become very laborious to any one but the writer himself. (...) yet it seems *doubtful* whether any one spends his time *well* in reading lengthy translations of economic doctrines into mathematics, that have not been made by himself. (...)

A. Marshall (1890, p.ix) [*Italics added*]

Marshall to some extent 'pooh-poohed' the use of mathematics in economics. It is not clear, however, whether Marshall referred here to the use of mathematical tools to advance the study of economics or whether he had in mind the widest possible audience of laypeople trying to understand the 'ordinary business of life.'

What we do know is that Marshall saw the role of mathematics in economics as a 'shorthand language.' Indeed, in a letter written six years after the publication of his *Principles of Economics* to A.L. Bowley, he was more specific about the way he saw the role of mathematics in economic research:

(...) I had a growing feeling in the later years of my work at the subject that a good mathematical theorem dealing with economic hypotheses was very unlikely to be good economics: and I went more and more on the rules- (1) Use mathematics as a shorthand language, rather than an engine of inquiry, (2) Keep to them until you have done. (3) Translate into English. (4) Then illustrate by examples that are important in real life. (5) Burn the mathematics. (6) If you can't succeed in (4), burn (3). This last I did often.

A.C. Pigou (1956, p.427)

Speaking loosely, economics stopped being merely discursive and became increasingly mathematical from the late 1930s. More precisely, the publication of Paul Anthony Samuelson's *Foundations of Economic Analysis* in 1947 stimulated a veritable tidal wave in the use of mathematics in economics. Samuelson saw the explicit use of mathematics in economics as a means for advancing its scientific study. The following remark helped change the course of economics for ever:

(...) I have come to feel that Marshall's dictum that "it seems doubtful whether any one spends his time well in reading lengthy translations of economic doctrines into mathematics, that have not been made by himself" should be exactly *reversed*. The laborious literary working over the essentially simple mathematical concepts such as is characteristic of much of modern economic theory is not only unrewarding from the standpoint of *advancing the science*, but involves as well mental gymnastics of a peculiarly deprived type.

P.A. Samuelson (1983, p.6) [*Italics added*]

Few economists would deny that Samuelson was right in stressing the importance of mathematics for advancing the science. When the audience consists of professional economists, formal economics tends to be not only desirable but also necessary.

Surprisingly, at a time where the use of mathematics in economics was flying high Samuelson also wrote an article "not to praise mathematics, but rather debunk its use in economics." How come? He claimed that mathematics can not be better than verbal

reasoning simple because there is a one-to-one correspondence or strict equivalence between mathematical symbols and literary words.

(...) In principle, mathematics cannot be worse than prose in economic theory; in principle, it certainly cannot be better than prose. For in deepest logic –and leaving out all tactical and *pedagogical* questions- the two media are strictly identical.

P.A. Samuelson (1952, p.56) [*Italics added*]

To reinforce the view that there exists an identity between mathematical language and verbal language he goes on and writes:

(...) As Professor Leontief has pointed out, the final proof of the identity of mathematics and words is the fact that we teach people mathematics by the use of words, defining each symbol as we go along. It is no accident that the printer of mathematical equations is forced to put commas, periods, and other punctuation in them, for equations are sentences, pure and simple.

P.A. Samuelson (1952, p.59)

The foregoing suggests that a first year degree student could obtain a reasonable grounding in the field of economics without learning mathematical models and tools.

### **2.3 A Three-floor Building without a Ground Floor?**

Nowadays, economics teachers impart an understanding of the economy using a combination of non-formal logic and mathematical tools (reasoning based on mathematical diagrams or formulas). Furthermore, they go over the same theme with more and more mathematical rigour several times in introductory, intermediate, and advanced courses.

In this sense, the generally accepted pedagogical sequence for teaching economics can be thought of as a three-floor building.

- **First Floor (Introductory Economics):** The basic concepts are introduced with the help of mathematical diagrams, such as supply and demand graphs, and elementary algebra; mathematical diagrams are extensively used to provide visual proofs of the most important results.

- Second Floor (Intermediate Economics): Mathematical diagrams, high school algebra and elementary calculus are the central organizing feature. At this level, the geometric development of economic intuitions is not simple (think of, for example, the graphical interpretation of the Slutsky equation).
- Third floor (Advanced Economics): The conceptual frameworks are cast in mathematical terms (using differential calculus, differential equations, advanced algebra, etc.); mathematical diagrams are used to illustrate the intuition behind the proofs.

This building reflects an indisputable fact, namely: that mathematics provides the economist with a set of tools often more powerful than ordinary speech or the written word. We believe that it is a correct teaching technique to cover the same theme several times with increasing mathematical rigour. However, it is a *mistake* to think that purely verbal or written methods (as opposed to mathematical procedures) are cumbersome and useless. Verbal and written analyses are preferable to mathematical developments for some purposes. They serve to fill in many details, state important qualifications, and suggest new topics for rigorous investigation.

The compelling point – obvious, but systematically forgotten – is that there is *no* 'ground floor' level where the logic of the argument is based on verbal reasoning *without* using mathematical tools. Somewhat roughly, this *ground floor* level of economic argumentation is a sort of story telling approach where we *do* know that the story is logically *correct* but we *deliberately* omit the use of mathematical tools to illustrate or prove the story. Moreover, this ground floor articulates analytical elements such as first principles, insights, non-mathematical conceptual frameworks, and facts.<sup>3</sup>

One obvious question immediately suggests itself. Is the explicit mathematical reasoning an appropriate way to help the layperson to gain an understanding of economic science? To many such newcomers formal models present a psychological problem. Each meets this barrier to understanding in her own way, and for some of them the use of formal models is an insurmountable barrier. Yet, from the point of view of the professional lecturer in economics, the convenience of formal models showing the implications that follow from the assumptions is indisputable. However, we want to raise the following issue: if we know in advance that the deductive logic is correct (because someone has proved that), why should we repeat the proofs in mathematical form and disenchant novices – particularly those who have no intention of moving on to major in economics or become professional economists?

For example, suppose we are teaching first year microeconomics. We have already explained (not necessarily using mathematical diagrams) the following empirical regularities: the law of demand (*ceteris paribus*, price and quantity change in the opposite

direction), the law of supply (*ceteris paribus*, price and quantity change in the same direction), and the law of demand and supply (the price change is proportional to the difference between demand and supply). And we want to point out that in general in any highly competitive market the equilibrium price will prevail.

We know this because many years ago Paul A. Samuelson proved mathematically the following theorem: if the demand function is negatively and the supply function is positively sloped, and the instantaneous rate of price change is directly proportional to the excess demand function, then the equilibrium price is dynamically stable. This can be rigorously proven by verifying the existence of global stability of the solution of a simple first-order differential equation. Alternatively, the global stability of the equilibrium price can be visualised by drawing the familiar demand and supply graph.<sup>4</sup>

Thus, we can omit the employment of formal mathematical tools in such situations (because we do know in advanced that the alluded theorem is true), and offer a verbal explanation to students as follows. Assuming that ① the law of demand, ② the law of supply, and ③ the law of demand and supply hold, then the market price will converge to the equilibrium price. These are the sorts of explanations that we have in mind when we talk about the ‘ground floor’ level of economic argumentation.

It should be emphasised that we are not claiming that in order to understand how the economy works one *has* to start from the ground floor. To be sure, there are quick learners out there that will be able to master the key economic ideas and conceptual frameworks starting at any floor. What we are suggesting here is just that if we want to interest a lot of people in economics and make economics more accessible for the average citizen, the teaching of economics should *start* on the ground floor.

Regarding business students a special comment is in order here. If one chooses to prove results either analytically or with elaborate mathematical diagrams, one knows the probable outcome: as with all mathematical developments one may enlighten a few readers, dazzle others, and probably blind the rest.

For example, the discussion of the winners and losers from international trade is one of those themes that will give a headache to students who do not have a solid background in two-dimensional geometry. At the ground floor level one could explain this important topic developing the following (intuitively obvious and well-proven) result: when we open an economy to international trade there will be winners and losers, the gains of the winners will exceed the losses of the losers, and the size of the domestic economy will increase. A discussion of the problem of compensation for the losers from international trade can also be clearly developed without visiting the labyrinth of welfare economics. It is better to

leave the job of discussing this theme to the instructor who teaches a course in international trade theory which is typically taken by students majoring in economics.

Summarising, a partial solution to the paradox in question consists of advancing as far as we can by using verbal reasoning without cluttering the picture with mathematical treatments. There are many important topics in economics for which non-explicit mathematical reasoning enables us to see through the key issues. Later on, when students go to the first floor, things would be pedagogically easy because they already have a grasp of analytical elements together with a piece of contextual reality.

The ideal solution to the paradox of the tools and content would be to present and develop the *totality* of economic ideas without using mathematics. This is not theoretically impossible, but it is certainly impracticable. We can only aspire to a realistic solution focused on a wide audience, say first year business students. In practice, the partial solution proposed here would imply that economics teachers should relegate decision-making issues based on marginal analysis to the end of, or later in, the course.

A first course for business students could well consist of a substantial proportion (say, 70%) devoted to appreciative economics and the rest dedicated to marginal analysis (including elasticity), a geometrical presentation of the demand and supply model, and the geometry of monopoly and perfect competition.<sup>5</sup>

### **3. THE PARADOX OF THE CONTENT AND THE RELEVANCE**

We want to focus now on the issue of variability of the economic system because it has profound implications for the way we should impart an understanding of the economy. The point that we wish to make here is simple, yet fundamental: the fact that the economy is a *variable* system automatically implies, at the least, that business innovation is an integral part of economics.

Variability arises because *new* elements (such as new institutions or the Internet or new products) *change* the economic landscape. Note, however, that the economy, like a large airplane carrier, does not change direction or transform itself quickly. For example, the economy today is not the same as in the 1890s. More specifically, at the beginning of the 20<sup>th</sup> century the US economy, for example, was largely based on bulk processing of natural resources such as grain, metal ores, and chemicals. A century later, the USA economy revolves around both bulk processing of resources and, in addition, the production of new ideas. That is, the US economy has undergone a *transformation* from resource-based bulk processing to processing of resources *and* deliberate creation of profitable new ideas.

The variability of an economy does not change existing economic laws. Or to put it differently: “Technology changes. Economic laws do not.” Shapiro and Varian (1999, p. 2). Having said this, two points should be emphasised. It is a mistake to think that we know *all* economic laws. Second, economic laws do not operate in a vacuum. They have conditioning clauses or suppositions under which they hold, including the specification of an economic environment or contextual reality. For example, it would be foolish trying to apply an economic law revolving around a major technological innovation to a sector where only minor innovations exist.

Quite obviously contextual reality matters in economics. The paradox of the content and relevance arises because readers tend to be disenchanted with the light shed by traditional economics textbooks on the New Economy, at least for new students, especially those not training to become economists.

The arrival of the New Economy in the late 1990s is an undeniable fact.<sup>6</sup> A natural question to ask is: does the New Economy still exist or was a passing curiosity? A New Economy characterised by rapid creation and adoption of innovation still exists. If we want to understand the modern economy we do not have a choice we must understand business innovation.

### **3.1 Contextual Reality**

The concept of ‘thinking like an economist’ requires more than the model building approach. In fact, Siegfried et al. (1991) stress additional factors that emphasise the importance of the contextual reality:

Thinking like an economist is facilitated by practice in applying the deductive and creative skills to a wide variety of economic issues, problems, and policies in *diverse*, economic, political, and social settings. It is only through continued and extensive practice that the process of thinking like an economist becomes internalized and an integral component of one’s intellectual equipment. Thinking like an economist is also facilitated by breadth and depth of knowledge and by the *general forms* of economic reasoning that cut across the disciplines. An understanding of economic institutions and their historical context is an essential ingredient of economic analysis. An economic argument contains not only logic and facts but also analogies and stories. Facts and logic alone rarely suffice; *context is important*.

Siegfried et al. (1991, p. 5) [*Italics added*]

Current practice does not emphasise contextual reality because it does not explicitly differentiate the economy and economics in a fundamental way. The object of study of the economic science is the economy. A reasonable starting point would be to paint a ‘big picture’ of the economy, a superficial description with particular reference to economic institutions, emphasising that the economy is a complex *and* variable system.

A ‘purist’ might argue that you cannot describe the economy without using elements of economics. ‘Which comes first, theory or observation?’ is a chicken-and-egg question that we do not need to answer. We will only say that, without some sort of superficial description of the economy theorizing is pretty hopeless for newcomers because many of them are not ‘street wise’, they do not have much experience outside the classroom other than, for the most part, as sales assistants in fast food outlets, coffee shops, restaurants, etc.

### **3.2 Innovation**

The fact that innovation lies at the heart of economics can easily be shown. Economics is the study of the economy, and the economy is a complex evolving system. This implies that economic evolution is an integral part of economics. In turn, economic evolution is largely brought about by innovation. Consequently, nothing could be plainer than the proposition that innovation is at the centre of economics.

In other words, innovation is a key characteristic observable in the real economy because the economy is a complex evolving system, changing over time. If you delete the word ‘innovation’ from economic discourse, then a vital dynamic dimension is missing. Innovation lies at the heart of any understanding of how the economy changes over time.<sup>7</sup>

The foregoing suggests that to learn economics one has to acquire a working knowledge of business innovation and related issues. Otherwise, the role of one of the essential concepts of economics is lost and the learning process would be unduly incomplete.

It is interesting to note that the topic ‘innovation’ is now discussed in the legendary economics textbook by Paul Anthony Samuelson.<sup>8</sup> Indeed, one of the features that distinguishes the sixteenth edition of *Economics* from earlier ones is the incorporation of rudiments of *Schumpeterian economics*. The motivation can be found in the preface of *Economics*:

One of the striking features of the modern economy is the rapidity of innovations in virtually every sector. We are accustomed to the dizzying speed of invention in computers, where new products and software appear monthly. Nowhere in recorded history do we find such a rapid rate of improvement as

has been seen for computers over the last three decades. But other sectors are witnessing rapid innovation. The pulse of change is rapid virtually everywhere in the modern economy –we run in athletic equipment made of miraculous new materials and relax while listening to crystal-clear audio equipment. Our *understanding* of economic trends and policies *must* reflect this rapid change in our societies.

P.A. Samuelson and W.D. Nordhaus, *Economics* (1998, p.xxix) [*Italics added*]

Samuelson's *Economics* has been a particular good predictor of *where* mainstream economics is going. As Samuelson noted at the golden birthday of *Economics*, “A historian of mainstream economic doctrines, like a palaeontologist who studies the bones and fossils in different layers of the earth, could date the ebb and flow of ideas by analyzing how Edition 1 was revised to Edition 2 and, eventually, to Edition 16.”

A solution to the second paradox is easy to state but difficult to put into effect. It is more fruitful, we argue, to spend less time working out formal models in introductory economics and more time describing the New Economy, defining precisely the vocabulary of innovation, and explaining the impact of business innovation on market behaviour.

If we want first year business students to become interested in our discipline start thinking like economists, first and foremost, we need to provide contextual reality, and then, do the ‘ritual’ practice of shifting demand and supply curves, develop the mathematical rules for profit-maximization, explaining the concept of Nash equilibrium, and so on.

To implement the solution suggested here (succinctly, provide a working knowledge of business innovation to business students) is not an easy task because most introductory economics textbooks show a preference for mathematical models over prose arguments by description and analogy, and tend to consider the economy only as a complex system, not as a variable one.

We might also point out, as suggested by one of our reviewers, that the introduction of thinking about innovation in introductory economics units might also be useful for students who intend to gain further units or even full degrees in economics in order, at the least, to demonstrate that static models have their limitations.

#### 4. CONCLUSION AND CONCLUDING COMMENTS

Nowadays, most economic models are taught by using the tools of mathematics. The use of mathematics is both a very efficient way to condense the core of a model and powerful machinery for discovering the implications of the assumptions. But it comes at a cost: It is also a barrier to entry of novices.

The three key points of this paper are as follows. First, mathematics is the servant of economics, not the master. This does not imply that we are decrying the importance of, or indeed the eventual necessity for, mathematics to prove economic propositions. It simply reflects our conviction that to adequately absorb a substantial proportion of the essentials of economics we do not need to put the basic ideas into mathematical form. Second, if economists in general and economics teachers in particular really want to reach a wide audience, they will have to incorporate the ‘ground floor’ level. Finally, if we want to ensure students gain an understanding of the New Economy, the economics of innovation and new technology is of absolutely fundamental importance.

We have already started the construction of the ground-floor level with the publication of the twin books *An Introduction to Economics with a View to Innovation* and *An Introduction to the Creative Economy*. These two texts provide a non-mathematical introduction to economics with a focus on innovation.

In the first book we stress from Chapter 1 that economics deals with a complex and variable system, and that variability arises (in a fundamental way) from business innovation. This chapter also contains a rigorous (but non-mathematical) discussion of the New Economy and the Internet bubble. Chapters 2 and 3 separates the invisible hand ‘result’ from the invisible hand ‘doctrine’ in order to highlight the interaction between economic freedom and business innovation. Chapter 4 emphasises the importance of Schumpeterian economics.<sup>9</sup> The final chapter consists of a systematic development of the innovation vocabulary (including R&D nomenclature and indicators of R&D activity), a presentation of the two basic models of business innovation (linear and ‘chain-link’ models), and a discussion of knowledge spillovers and related topics. In the second book we explain in words the fundamentals of an ideas-driven economy (including non-rivalry, partial excludability, and intellectual property rights), the ecology of the creative economy (including Porter diamond and international competitive advantage), and we close the book with a chapter on the economic impact of different types of innovations. Both books contain a number of appendices revolving around innovation.

Reverting to the double paradox of economics education, it should hardly be necessary to reiterate that the paper refers to an audience consisting of economics beginners (including business students). In a nutshell, our suggested integrated solution to the double paradox of

economics education lies in the use of verbal logic and non-mathematical conceptual frameworks with particular emphasis on business innovation.

Our paper is not the first to discuss the double paradox of economics education, nor will be the last. This problem has been addressed by many economists and philosophers. It would therefore be virtually impossible to provide a comprehensive bibliography of the existing literature. A small sample, which by no means exhausts the list of authors, would include Ronald Coase (1994), David Colander (1992), and Deirdre McCloskey (2000).

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## ENDNOTES

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<sup>1</sup>According to Joseph A. Schumpeter (1954, p. 955), Johann Heinrich von Thunen (1783-1850) and Agustin Cournot (1801-1877) are two distinguished pioneers of mathematical economics. Von Thunen was the first to use calculus as a form of economic reasoning. The French mathematician Cournot constructed a formal model of oligopoly that attracted considerable attention and is still cited. His book, *Researches into the Mathematical Principles of the Theory of Wealth*, was first published in 1838.

<sup>2</sup> This point is forcibly made by Nelson and Winter (1982, esp. pp. 46-47). These authors use the expressions ‘appreciative theory’ and ‘formal theory’ instead of ‘appreciative economics’ and ‘formal economics’, respectively.

<sup>3</sup> For the purposes of this paper, *first principles* are statements suggested by the empirical evidence that we do not propose to challenge (example: people react to incentives), an *insight* is a penetrating mental vision (example: innovation is the critical dimension of economic change), a *conceptual framework* is an intellectual construct for organizing thinking about a problem (example: business innovation can be described by a non-mathematical diagram involving a central chain of innovation with the corresponding interactive steps), and *facts* are essentially statistical data.

<sup>4</sup> Samuelson (1983, p.263) only showed the *local* stability of the equilibrium price in a single market. Defining a Liapunov function as the squared distance of the actual price from the equilibrium point, it is not difficult to show that the equilibrium price is also *globally* stable.

<sup>5</sup> We would relegate marginal analysis to the end of a first course (or maybe to a second course) in economics on pedagogical grounds. The main reason is that marginal analysis is inextricably linked to mathematical reasoning. We mention, in passing, that marginal analysis is not identical with differential calculus. As is well known, marginal analysis considers one-unit changes and differential calculus deals with infinitesimal changes. This often creates confusion among business students. For example, marginal cost can be defined as incremental cost for a finite-step change in the output level (marginal analysis version) or as the cost for an infinitesimal amount of output measured by the slope of the tangent line at the pre-selected output level (differential calculus version). The discrepancy between the two definitions of marginal cost is an obvious fact for economics instructors, but tends to disconcert many students.

<sup>6</sup> There is a significant number of important contributions on the New Economy, including Gordon (2000), Bailey and Lawrence (2001), and Jorgenson (2001).

<sup>7</sup> The line of reasoning showing that innovation must be considered as one of the primitive concepts of economics is compelling. If the reader thinks that this is obvious, so much the better, However, in most (if not all) definitions of economics, innovation is kept at the background; nowadays this is not acceptable. Innovation also occupies a central place in economics along with the traditional “twin themes” of scarcity and efficiency. The reason is not far to seek. The creation of new ideas with the aim of making money is one of the most potent forces that helps to solve the problems faced by human kind about nutrition, clothing, housing, and health.

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<sup>8</sup> This famous textbook was first published in 1948, authored by P.A. Samuelson alone. As Professor William Nordhaus joined Samuelson, *Economics* has continued to be a classic.

<sup>9</sup> Schumpeterian economics revolves around innovation, creative destruction, and entrepreneurship. Not all historians of economic thought recognise the existence of Schumpeterian economics. The main reason is that they see Schumpeter as a prophet of capitalism rather than a genuine revolutionary economist. For instance, Landreth and Colander (2002, p. 411) state that: “For the most part, economists in the first half of the twentieth century did not deal with growth. An important exception was Joseph Schumpeter who does not fit neatly into any school.” On the same page, they go on and write: “Before Schumpeter was thirty years old he had laid the foundations for his theory of growth in *The Theory of Economic Development*. (...) A brilliant conception, it has laid almost dormant because it is so broad-based that it does not lend itself to the economic model building that has been in vogue in mainstream economics for some fifty years. (...). On the following page, Landreth and Colander (2002, p. 412) seem to belittle the economic relevance of Schumpeter’s contribution: “Schumpeter’s explanation of the process of growth does not fit into the orthodox mold, because he stressed the noneconomic causes of growth. Though he examined some strictly economic factors, he insisted that the principal elements in the past growth of the system and the elements that will reduce growth in the future are noneconomic.”

We find this assertion disconcerting. It is generally agreed that Schumpeter’s fundamental contribution led to the following axiom: if we want to understand economic growth, we must understand business innovation. Few economists would deny that business innovation is essentially an economic phenomenon. Furthermore, the vision of capitalism as a dynamic process has inspired a generation of formal Schumpeterian growth models initiated by Paul Romer’s 1983 PhD thesis. These models provide a consistent answer to the most fascinating question in economics, namely: What sustains economic growth in a physical world pervaded by scarcity and diminishing returns?