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ASSRU Newsletter Date July 1, 2011 Vol. 1, # 2

## Algorithmic Social Sciences Research Unit (ASSRU)

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The ASSRU Logo

The ASSRU logo depicts a *Counting table* (woodcut probably from Strasbourg). The spaces between the lines function as the wires on an *abacus*. The place value is marked at the end.

“...and then there were six”  
ASSRU’s Intellectual ‘Patron  
Saints’

Alain Turing

Herbert Simon

Maynard Keynes

Piero Sraffa

Richard Goodwin

Luitzen Brouwer

“The Proustian equation is never simple. The Unknown, using as weapons hoards of values, is also the unknowable”  
Samuel Beckett: *Proust*

### Current ASSRU Work

Research by Resident Members of ASSRU continues to develop the basic themes enunciated in the first number of this Newsletter. In particular, all current research is devoted to one or another aspect of the fields developed by ASSRU’s acknowledged intellectual Patron Saints (see left inset).

The two ASSRU *Junior Research Fellows*, Selda Kao and V. Ragupathy have made substantial progress towards completing their doctoral dissertations well ahead of schedule. Selda Kao’s thesis is titled, *Studies in Classical Behavioural Economics*. Her current research is devoted to studying *Problem Solving*, from the twin perspectives of Herbert Simon and Alan Turing, both of whom used Chess as a paradigmatic example. Selda, in trying to extend their approach, has been working on **Weichi (GO)** as the model for studying problem spaces, strategies and boundedly rational behavior in the setting of Decision problems.

### ASSRU News

We are happy to congratulate the following scholars, all of them associated with ASSRU, on their indicated appointments and awards

(i). Professor Stefano Zambelli as the Head of the Economics Department at the University of Trento.

(ii). Dr Davide Marchiori as an Assistant Professor in the Department of Economics at the National Chengchi University, Taipei, Taiwan.

(iii). Dr Sibilla De Guida on the double success of the completion of her doctoral degree at CIFREM, University of Trento and on her appointment as a Post-Doctoral Research Fellow in the AI-Econ Lab at the National Chengchi University, Taipei, Taiwan.

Ragupathy’s thesis is titled *Studies in Endogenous Macrodynamics* and his present work is on a detailed investigation of the role of existence and uniqueness theorems in nonlinear theories of the business cycle, in the Goodwin tradition. In particular, the role played by the classic *Poincaré-Bendixson* and the *Levinson-Smith theorems* in *existence proofs* in the business cycle models of Goodwin, Hicks and Kaldor. The next step would be an equally detailed study of the way the problem of *uniqueness* has been tackled in such models, invoking some isolated work by Ye Yan-Qian and others.

Stefano Zambelli continues his work on *coupled dynamics* in nonlinear macrodynamic models of the business cycle, *algorithmic production theory* and *endogenous computable growth theory* – in the traditions broached by Goodwin, Sraffa and Turing.

Vela Velupillai has begun a new research program on *Diophantine Economics*, underpinned by the methods and philosophy computable economics and nonlinear macrodynamics.

(iv). Dr Cassey Lee as an Associate Editor of the *Journal of Economic Surveys*.

(v). Professor Stefano Zambelli as a member of the *Editorial Board* of *New Mathematics and Natural Computation*.

(vi). Dr Steve Kinsella on a successful funding award from *INET* for his work on Stock-Flow Consistent Monetary Macroeconomic modelling.

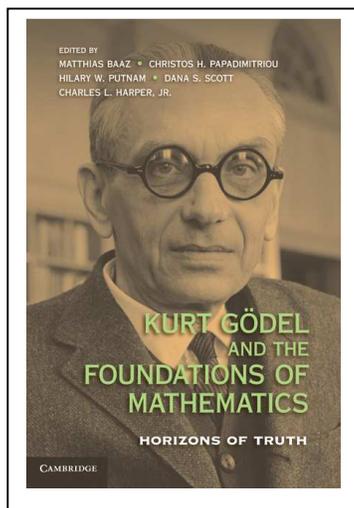
(vii). Professor Vela Velupillai on the *Distinguished Scholar* award from the University of Technology Sydney

“While I am fighting on a somewhat different front, I find it greatly comforting that these outer ramparts of Turing computability are strongly manned, greatly cushioning the assault on the inner lines of empirical computability.”

Herbert Simon



## Absolutely Unsolvable Diophantine Problems (Gödel), Hilbert's Tenth Problem (Hilbert) and Undecidable Dynamics (Goodstein)



At ASSRU, our current frontier research efforts are aimed at reformalising aspects of economic theory – in particular (classical) behavioural economics, macrodynamics, monetary macroeconomics and computable production theory – emphasising their Diophantine Decision Theoretic basis.

The guiding principles for this research program consist in the mathematical framework and results emerging (sic!) from work by Kurt Gödel on Absolutely Unsolvable Diophantine Decision problems, the pioneering results by Yuri Matiyasevic on Hilbert's Tenth Problem and the remarkable results by Paris and Harrington on Goodstein's Algorithm. The books in the left insets deal, respectively, with these problems in illuminating pedagogical ways.

Gödel's summary of the first point is worth recalling (in: *Some Basic Theorems on the Foundations of Mathematics and Their Implications*; italics in the original):

“[I]f the human mind were equivalent to a finite machine, then objective mathematics not only would be incompletable in the sense of not being contained in any well-defined axiomatic system, but moreover there would exist *absolutely* unsolvable diophantine problems.... where the epithet ‘absolutely’ means that they would be undecidable, not just within some particular axiomatic system, but by *any* mathematical proof the human mind can conceive. So the following disjunctive conclusion is inevitable: *Either mathematics is incompletable in this sense, that its evident axioms can never be compromised in a finite rule, that is to say the human mind (even within the realm of pure mathematics) infinitely surpasses the powers of any finite machine, or else there exist absolutely unsolvable Diophantine problems...* (where the case that both terms of the disjunction are true is not excluded, so that there are, strictly speaking, three alternatives).”

It goes without saying we at ASSRU subscribe to the view that ‘there exist

absolutely unsolvable Diophantine problems’, especially because we maintain that Diophantine decision problems are pervasive in economics, from the ground up: basic supply-demand analysis, classical behavioural economics, economic dynamics, monetary macroeconomics and game theory.

*Hilbert's Tenth Problem* is the fountainhead for the development of recursion theory and, hence, for the mathematical basis of computable economics. The role it plays in *Computable Economics* is discussed in Velupillai's *Arne Ryde Lectures*. This may be called the era of ‘Classical’ Computable Economics.

The era of ‘Modern’ Computable Economics, building on the foundations of ‘Classical’ Computable Economics, is circumscribed by issues of *absolutely unsolvable Diophantine problems* and *undecidable dynamics*. The key to the latter are the *Goodstein Sequence* and *Theorem*.

(i). Goodstein's Theorem, referring to the Goodstein Sequence, provides an example of a finite combinatorial result that cannot be proved without an appeal to infinite sets.

(ii). Another perspective on the Theorem is provided by the observation that it is expressible in first-order arithmetic but cannot be proved in *Peano Arithmetic, PA*; i.e., it is (Algorithmically) *Undecidable*.

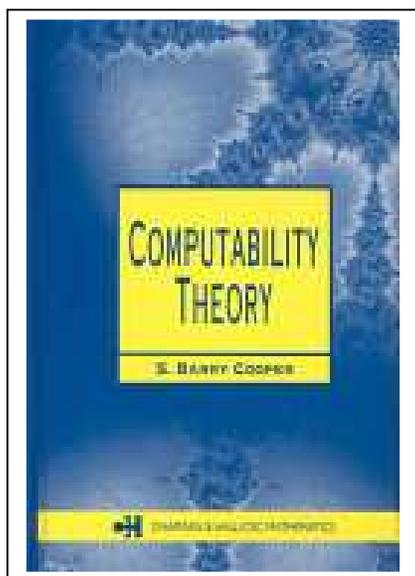
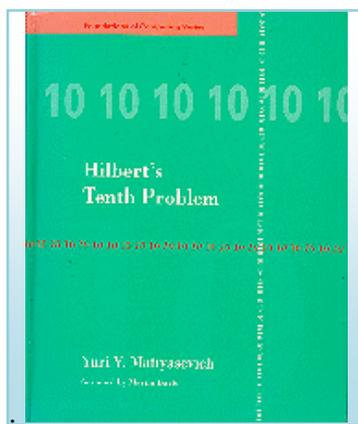
### Goodstein's Theorem

The existence of a trivial attractor, for a dynamical system mapping  $\mathbb{N} \rightarrow \mathbb{N}$  formalised in *PA*, cannot be proved in *PA*.

### Goodstein Sequence

Define  $G_n(m) \in \mathbb{N}$  s.t., if  $m=0$ ,  $G_n(m)=0$ ; if  $m \neq 0$ , set  $G_n(m)$  to be the natural number produced by replacing every  $n$ , in the complete base  $n$  representation of  $m$ , by  $n+1$  and, then, reduce the result by 1. Then the Goodstein Sequence is given by:

$m_0=m, m_1=G_2(m_0), m_2=G_3(m_1), m_3=G_4(m_2), \dots$



## ASSRU Seminars and Organisational Activities



### ASSRU/Department of Economics Seminars

The following ASSRU sponsored seminars, jointly with the Department of Economics, were given during the current academic year:

- I. *The moral for economists of Bourbaki's misconception of logic* by Adrian Mathias, Cambridge University; October 28, 2010.
- II. *Remembering Herbert Simon* by K. Vela Velupillai, February, 9, 2011.
- III. *The Epistemology of Computation in Economics* by K. Vela Velupillai, 23 March, 2011.
- IV. *An Algorithmic Measurement of Technical Progress* by Stefano Zambelli, May 4, 2011.
- V. *Emergence as a Computability Theoretic Phenomenon* by S. Barry Cooper, 11 May, 2011.
- VI. *Agents Learned, but Do We? Knowledge Discovery Using the Agent-Based Double Auction Markets* by Shu-Heng Chen, 18 May, 2011.
- VII. *Nonlinear Dynamics and the Horseshoe* by Allan McRobie, 25 May, 2011.
- VIII. *Sraffa and a Political Prelude to a Critique of Economic Theory* by Guglielmo Chiodi, 1 June, 2011.

### ASSRU Conferences

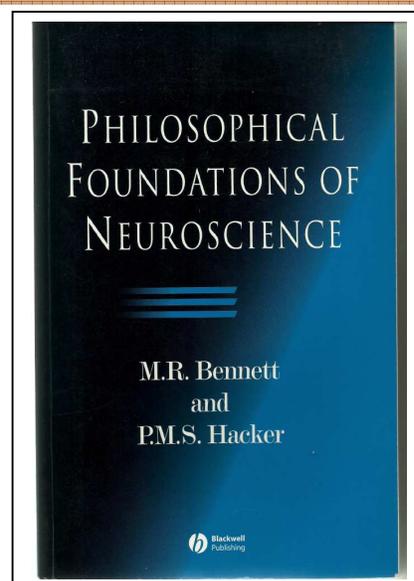
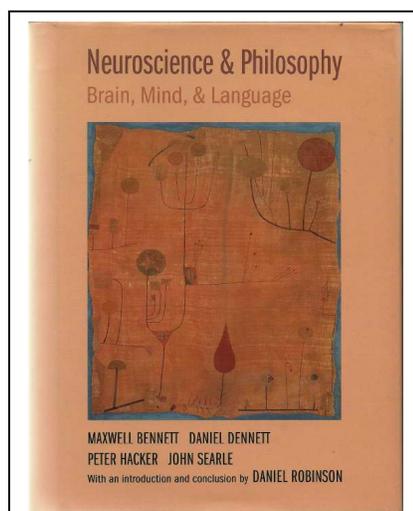
#### **The Economics of Food Security in South Asia**

A 3-day Conference on the above theme will be held in the department of economics, under the sponsorship of ASSRU on 13-17, October 2011. Leading South Asian scholars – academic economists, policy makers and opinion builders – are expected to contribute at the conference. Among other distinguished speakers, the following have agreed to contribute: Professors Jayati Ghosh, C.P. Chandrasekhar and Prabhat Patnaik of JNU, New Delhi; Professor Abhijit Sen, Planning Commission, Government of India; Professor Hema Ramakrishnan of MSE, Chennai and Dr Rammanhar Reddy of EPW, Bombay. It is expected that the proceedings of the conference will be published in a Special Issue of **Global & Local Economic Review**, in early 2012.

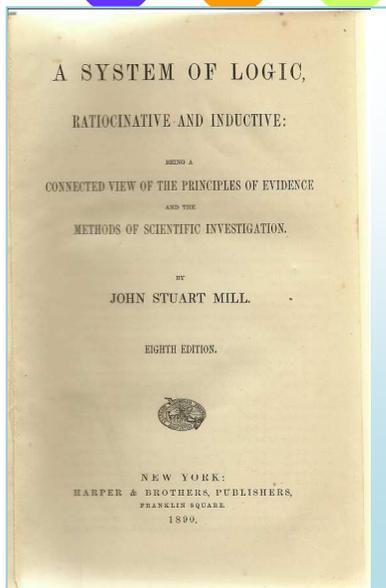
#### **Turing's Economics**

As part of the Turing Birth Centennial Celebrations a two-day conference emphasising the role of computability, solvability and decidability in economic theory and game theory will be held in April/May, 2012 under the auspices of ASSRU. Apart from contributions by resident ASSRU members, it is expected that Barry Cooper, Greg Chaitin, Cristian Calude, Barkley Rosser and Shu-Heng Chen will be invited contributors at this conference.

The next issue of the ASSRU NL (Vol. 2, # 1) will include a review note on *Darwinitis, Neuromania and the Mereological Fallacy*, based on the three interesting and penetrating philosophical & methodological critiques of the *Neurosciences* in the books illustrated here.



## Emergence its Rise, Fall and Rise - again - and its Traditions



The classic works by the trio of John Stuart Mill (1890), George Henry Lewes (1891) and C. Lloyd Morgan (1927), together with C. D. Broad (1929) and Samuel Alexander (1920) made up what has come to be called the '*British Emergentist*' school. The concept of *emergence* came to have its current connotations as a result of these (and a few other) clearly identifiable sequence of classic works by these pioneering British philosophers.

The rise and fall of *British Emergentism* was almost persuasively argued by Brian McLaughlin (1992), basing himself on the emerging (sic!) codification of quantum mechanics in the works of Heisenberg, Schrödinger, Dirac and Pauling, and on the philosophical critiques of the 1920s, launched primarily by Stephen Pepper (1926), W. T. Stace (1939) and Charles Bayliss (1929).

Remarkably, it is possible, to pinpoint the reason for McLaughlin's *premature obituary of British Emergentism* and, at the same time, link that failure with a prescient – and typically penetrating, yet almost playfully formulated – observation by Alan Turing in his last publication before a tragically truncated life came to an end. In what can only be called a moment of weakness, Dirac, one of the great founding fathers of modern quantum mechanics, slipped badly in a pronouncement which was the fulcrum around which the premature obituary of *British Emergentism* was proclaimed:

“The underlying physical laws necessary for the mathematical theory of a large part of physics and *the whole of chemistry are thus completely known*<sup>1</sup>, and the difficulty is only that the exact application of these laws leads to equations much too complicated to be soluble. It therefore becomes desirable that approximate practical methods of applying quantum mechanics should be developed, which can lead to an explanation of the main features of complex atomic systems *without too much computation*.”  
Dirac (1929), p. 714; italics added.

It was little realised, at the time such views were invoked to pronounce the premature death of *British Emergentism*, that Dirac had attended Broad's lectures at Bristol University, before both moved to Cambridge – and, even more importantly, that Dirac had read, with customary care, the whole of Mills' **A System of Logic**.

Turing's remarkably original work on *The Chemical Basis of Morphogenesis* was neither inspired by, nor influenced any later allegiance to the *British Emergentist's* tradition – such as the influential experimental and theoretical neurological and neurophilosophical work of Nobel Laureate, Roger Sperry.

On the other hand, the structure of the experimental framework Turing chose to construct was uncannily similar to the one devised by Fermi, Pasta and Ulam, (1955), although with different purposes in mind. But there was – and there remains – a deeper affinity in that the violation of the equipartition of energy principle that was observed in the *Fermi-Pasta-Ulam* simulation and the symmetry-breaking that is intrinsic to the dynamical system behaviour of Turing's system of reaction-diffusion equations.

Turing's aim was to devise a mechanism by which a spatially homogeneous distribution of chemicals – i.e., formless or patternless structure - could give rise to form or patterns via what has come to be called a Turing Bifurcation. A reaction-diffusion mechanism formalised as a (linear) dynamical system and subject to what I have referred to, in other writings, as the linear mouse theory of self-organisation.

*Unfortunately*, it is the fourth tradition, the von Neumann-Ulam one, based on *Cellular Automatas (CA)*, that seemed to have prevailed, especially in economics.

[The references are given in Velupillai's contribution to the forthcoming **Turing Centennial Volume**, edited by Cooper and Van Leeuwen.]

“..I propose to call the effect *an emergent*. It arises out of the combined agencies, but in a form which does not display the agents in action.”  
George Henry Lewes (1891)

### STUDIES OF NON LINEAR PROBLEMS

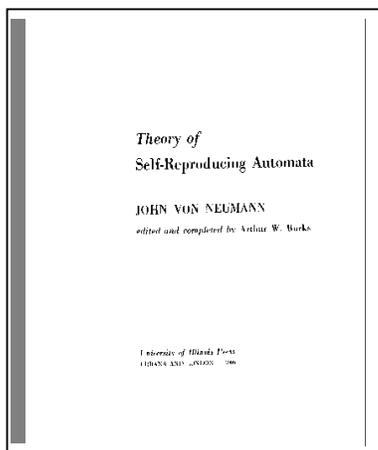
E. FERMI, J. PASTA and S. ULAM  
Document LA – 1940 (May 1955)

#### ABSTRACT

A one-dimensional dynamical system of 64 particles with forces between neighbours containing nonlinear terms has been studied on the Los Alamos computer MANIAC I. The nonlinear terms considered are quadratic, cubic, and broken linear types. The results are analysed into Fourier series components and plotted as a function of time.

The results show very little, if any, tendency toward equipartition of energy among the degrees of freedom.

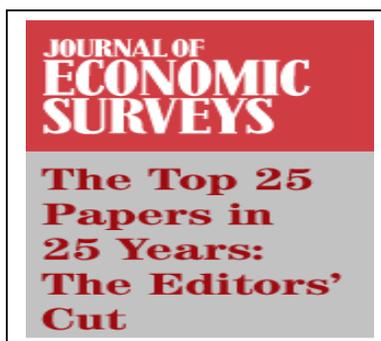
The last few examples were calculated in 1955. After the untimely death of Professor E. Fermi in November, 1954, the calculations were continued at Los Alamos.



## ASSRU Publications and Editorial Activities 2011

Three Special Issues of Journals, on themes central to the research program and methodology of ASSRU were completed during 2011. They are all edited by resident or affiliated members of ASSRU.

- I. A Special Issue of the *Journal of Economic Surveys*, Volume, 25, # 3, 2011, on the interlinked themes of **Nonlinearity, Complexity and Randomness**, edited by Stefano Zambelli, has been published and can be accessed at:  
<http://onlinelibrary.wiley.com/doi/10.1111/joes.2011.25.issue-3/issuetoc>
  - II. A Special Issue of *Economia Politica*, edited by Giovanni Pegoretti, Vela Velupillai and Stefano Zambelli, will be published as Vol. 28, #3, 2011, containing the proceedings of the ASSRU conference on the 60<sup>th</sup> anniversary of the MONIAC (see NL, Vol 1, #1). Access details will be provided in due course.
  - III. The March, 2012, issue of **New Mathematics and Natural Computation**, edited by Shu-Heng Chen, will be in Honour of Vela Velupillai. See:  
<http://www.worldscinet.com/nmnc/mk/archive.shtml?2011&7>
- *Variations on the Theme of Conning in Mathematical Economics*, published in Vol. 21, # 3 (July, 2007) in the *Journal of Economic Surveys*, was selected as one of 'The Top 25 Papers in the 25 years of the Journal'

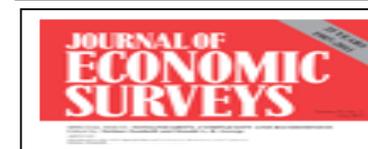
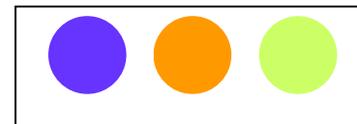


The following articles have been (or will be published) in 2011 by the resident members of ASSRU (in addition to those by Velupillai & Zambelli in *JOES* (Vol. 25, #3) and *Economia Politica* (Vol. 28, #3):

- I. *Technological Progress in Italian Regions: Some Comparisons* by Stefano Zambelli & Matteo Degasperis, **Global & Local Economic Review**, Vol. 14, # 2, 2010.
- II. *Robert Clower: Portrait of an Affectionate Curmudgeon*, **Economic & Political Weekly**, Vol. XLVI, # 24, June 11, 2011 See:
- III. *Computation in Economics*, by K. Vela Velupillai & Stefano Zambelli, forthcoming as Chapter 12 in: **The Elgar Companion to Recent Economic Methodology**, edited by D. Wade Hands & John Davis, Edward Elgar, Cheltenham, Glos., 2011.

The following invited seminar & talk were given by Vela Velupillai:

- a. *Epistemological Aspects of Economic Science*, **Interdepartmental Research Centre in Epistemology and History of Science**, University of Bologna, 31 March, 2011.
- b. *The Pernicious Influence of Mathematical Formalisms in the Development of the Theory of Economic Policy*, Invited lecture at *the Cambridge Journal of Economics Conference in Honour of Geoff Harcourt*, faculty of Economics, Cambridge University, 25/26 June, 2011. See:  
<http://www.assru.economia.unitn.it/external2011.html>



July 2011 Volume 25,  
Issue 3

Special Issue

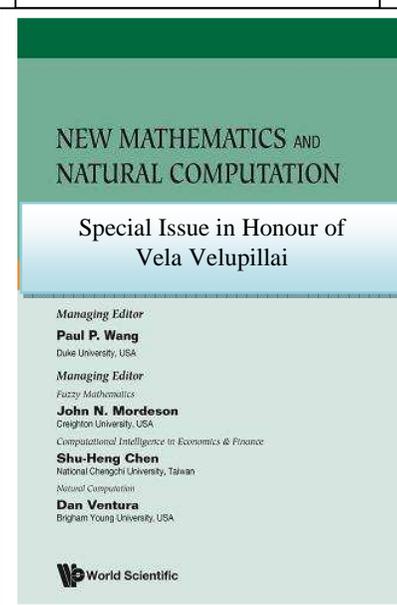
Nonlinearity, Complexity  
& Randomness

Edited by  
Stefano Zambelli



Special Issue  
Celebrating the  
MONIAC  
Edited by

G. Pegoretti, K. Vela  
Velupillai & Stefano  
Zambelli



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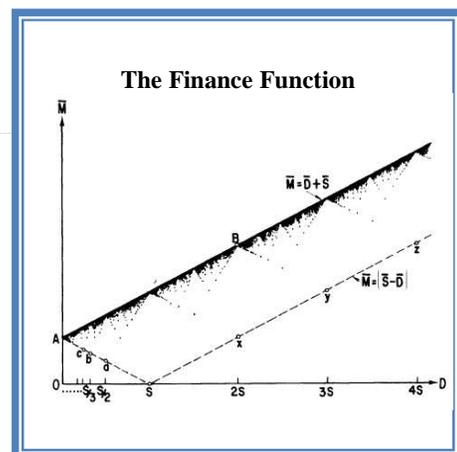
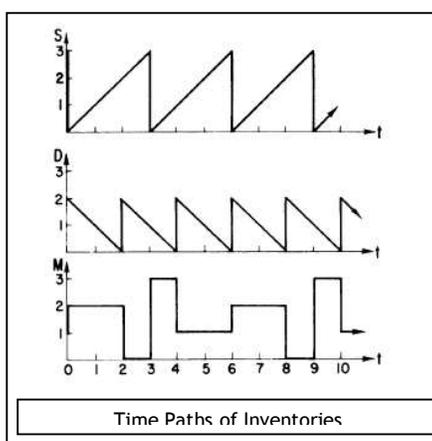
Natural Computation

**Dan Ventura**  
Brigham Young University, USA

 World Scientific



Bob Clower Lecturing at the First  
*Computable Economics Summer  
School, Aalborg, 1992*



## Remembering an Affectionate Curmudgeon Robert W. Clower

13 February 1926 - 2 May 2011

With the death of Robert Clower, on 2 May, 2011, the group of outstanding Monetary Macroeconomists who moulded the subject in terms fashioned by Knut Wicksell, Irving Fisher, Maynard Keynes and Dennis Robertson, has lost its last, enduring, exponent. This set of giants, whether we agreed with their notions and ideologies, their theories or their methods (or lack of method), comprised - apart from Robert Clower - Paul Samuelson, Milton Friedman, Don Patinkin and James Tobin - an all American group. This was in contrast to the pre-War pioneers of Monetary Macroeconomics, all of whom, with the exception of Irving Fisher, were Europeans: Wicksell, Cassel, Keynes, Robertson, Lindahl, Myrdal, Ohlin and Hayek. John Hicks straddled both eras.

A detailed appreciation of Clower's contribution to economic theory in general, monetary and computable economics in particular, by Velupillai can be accessed at: <http://epw.in/epw/uploads/articles/16155.pdf>

Clower and Howitt (ii) imposed **integer constraints** on all economic variables, particularly monetary variables, and on all trading dates. As a result their proofs necessitated (footnote 3, p. 452; italics added):

“...[T]he use of number theory -- *a branch of mathematics unfamiliar to most economists.*”

When it is remembered that:

***“The theory of recursive functions properly belongs to number theory...”*** [Recursive Functions, Rózsa Péter, p. 7],

the relevance of Clower's methodology for ASSRU work becomes clear.

The four most relevant contributions by Clower, for our work at ASSRU are:

- (i). *Price Determination in a Stock-Flow Economy*, **Econometrica**, 1954 (jointly with D. Bushaw)
- (ii). *The Transactions Theory of the Demand for Money – A Reconsideration*, **JPE**, 1978 (jointly with P. Howitt)
- (iii). *Economics as an Inductive Science*, **Southern Economic Journal**, 1994.
- (iv). *Axiomatics in Economics*, **Southern Economic Journal**, 1995

[The two diagrams on the left insets are from (ii), figures 1 & 2, pp. 451-2. The second figure shows the complexity of rational number dynamics]

**“No mathematical method can be useful for any problem if it involves much calculation.”**

Alan Turing: Solvable and Unsolvable Problems

### ASSRU Honorary Patrons

Richard Day  
John McCall  
Björn Thalberg

We can also be found at:

[www.assru.economia.unitn.it](http://www.assru.economia.unitn.it)

### ASSRU Founding Honorary Associates:

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Sami Al-Suwailem (Jeddah)  
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