TU Delft BK Bouwkunde

9 May, 2022

casa UCL University College

Session 8

Forrester's Urban Dynamics & cities as systems

Michael Batty
Centre for Advanced Spatial Analysis
CASA-UCL

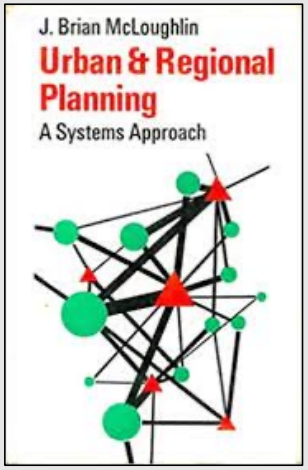
m.batty@ucl.ac.uk @jmichaelbatty

Outline of My Talk

- The Genesis of Urban Models: The JAIP 1965 Special Issue
- Dynamics and Disaggregation: The Lowry Model
- Enter the Maverick in 1969: Jay W Forrester: Urban Dynamics
- America in 1970
- Dynamics into Urban Models: A Long, Difficult Quest
- World Dynamics: The Club of Rome: Our Letter to ***The Guardian 1972***
- The Continuing Path to Dynamics: Aggregate Dynamics in the mid to late 1970s:

- **The Genesis of Urban Models: The JAIP 1965 Special Issue**
  - A little bit about my background in science and arts. Is urban planning a science? is it engineering?
  - In 1965, the JAIP Special Issue. The systems approach: Chadwick (1971) and McLoughlin (1969)

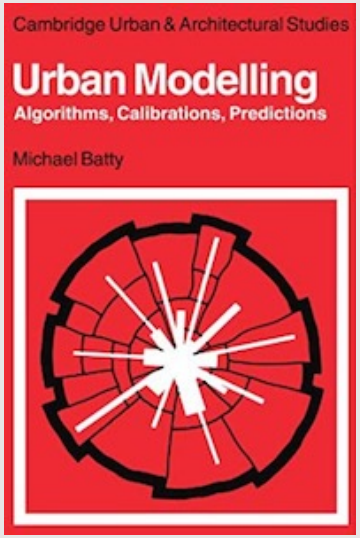


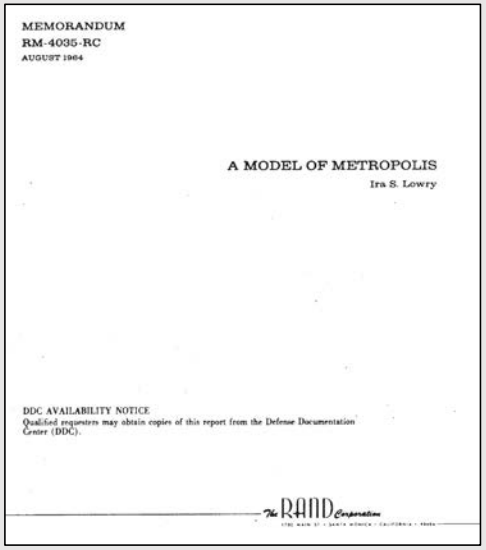


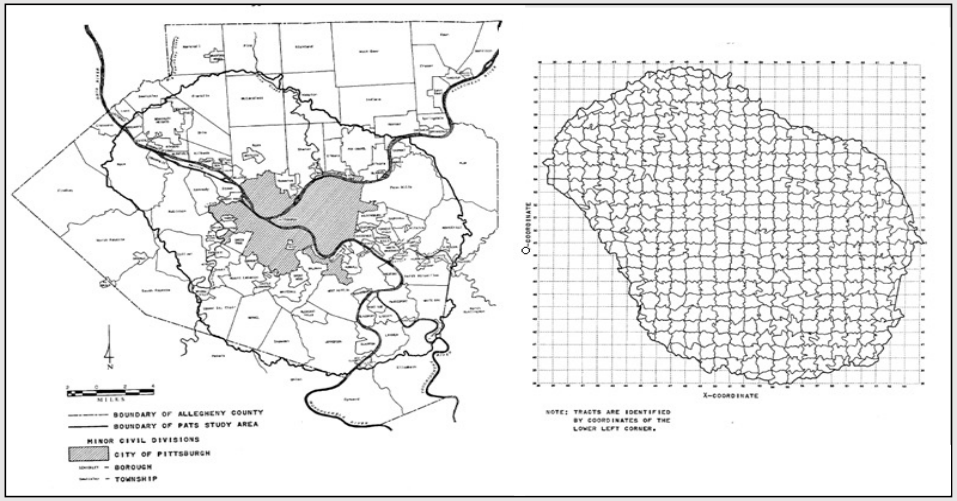
  - Computers and programming at Manchester 1966-69
  - My own research: design methods and then urban models,
  - Quantitative revolution in geography

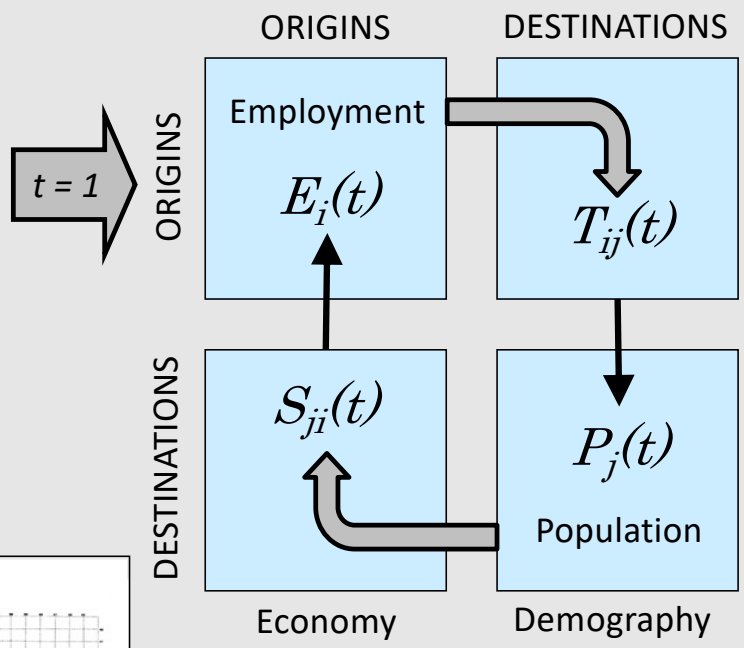
- **Dynamics and Disaggregation: The Lowry Model**
  - Urban models – land use transport models or urban development models – were built from 1955 onwards – There came the fast realisation that one needed to build aggregate static models at one instant of time, as if the city were in equilibrium. This was predominantly due to the fact that disaggregate data was hard to get and temporal data almost impossible.
  - The model built for Pittsburgh by Lowry was perhaps the quintessential variant that was the most complete – it embodied the idea that activities would be generated using economic multipliers and distributed using gravity models

- One absolutely key issue is that the first model builders did not articulate their models in terms of dynamics or disaggregation because they thought static equilibrium models were the best to build – they didn't. It was more because one could not do anything else
- Right from the beginning, we always believed we should aim for disaggregated dynamic models and only now is there any retreat from this idea – and that is largely due to our view of predictability changed – is changing.
- Let me just throw Lowry's model into the table and say something about how it works because as soon as it was developed a dynamic version was suggested by John P. Crecine – The TOMMs model


Cambridge Urban & Architectural Studies
Urban Modelling
Algorithms, Calibrations, Predictions
Michael Batty

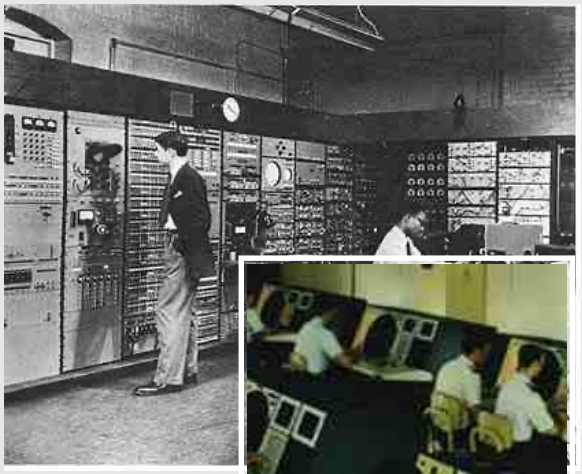

MEMORANDUM
RM-4035-RC
AUGUST 1964
A MODEL OF METROPOLIS
Ira S. Lowry
DDC AVAILABILITY NOTICE
Qualified requesters may obtain copies of this report from the Defense Documentation Center (DDC).
The RAND Corporation


BOUNDARY OF ALLEGHENY COUNTY
BOUNDARY OF PATS STUDY AREA
MINOR CIVIL DIVISIONS
CITY OF PITTSBURGH
BOROUGH
TOWNSHIP
NOTE: TRACTS ARE IDENTIFIED BY COORDINATES OF THE LOWER LEFT CORNER.


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ORIGINS
DESTINATIONS
ORIGINS
DESTINATIONS
Employment
$E_i(t)$
$T_{ij}(t)$
$S_{ji}(t)$
$P_j(t)$
Population
Economy
Demography

- **Enter the Maverick in 1969: Jay W Forrester: Urban Dynamics**
  - Forrester was an electrical engineer, born on a farm in Nebraska in 1918 – but found his way quickly to MIT
  - At the end of the war, he led the Whirlwind computer project at the Lincoln Labs at MIT which was the basis of the 1950s SAGE missile system. This was one of the hot beds of early computing
  - He had many patents for computer hardware such as the magnetic core but he also realized (like Turing, von Neuman and others) that the computer was a universal machine – it could play music, do graphics and so on …

This is what Whirlwind looked like







MIT Whirlwind

close

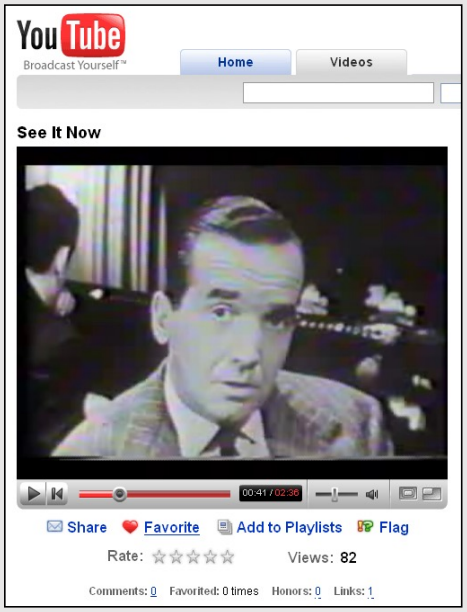
1951

- MIT´s Whirlwind debuted on Edward R. Murrow´s "See It Now" television series. Project director Jay Forrester described the computer as a "reliable operating system," running 35 hours a week at 90-percent utility using an electrostatic tube memory.

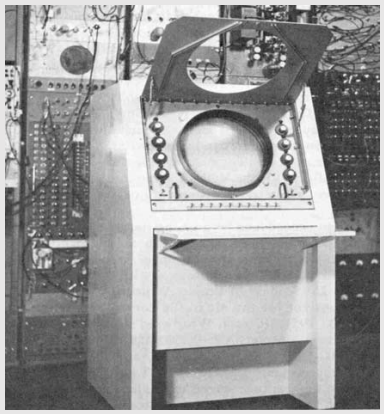
Start of 1945 project:

Completed: 1951

YouTube Broadcast Yourself™



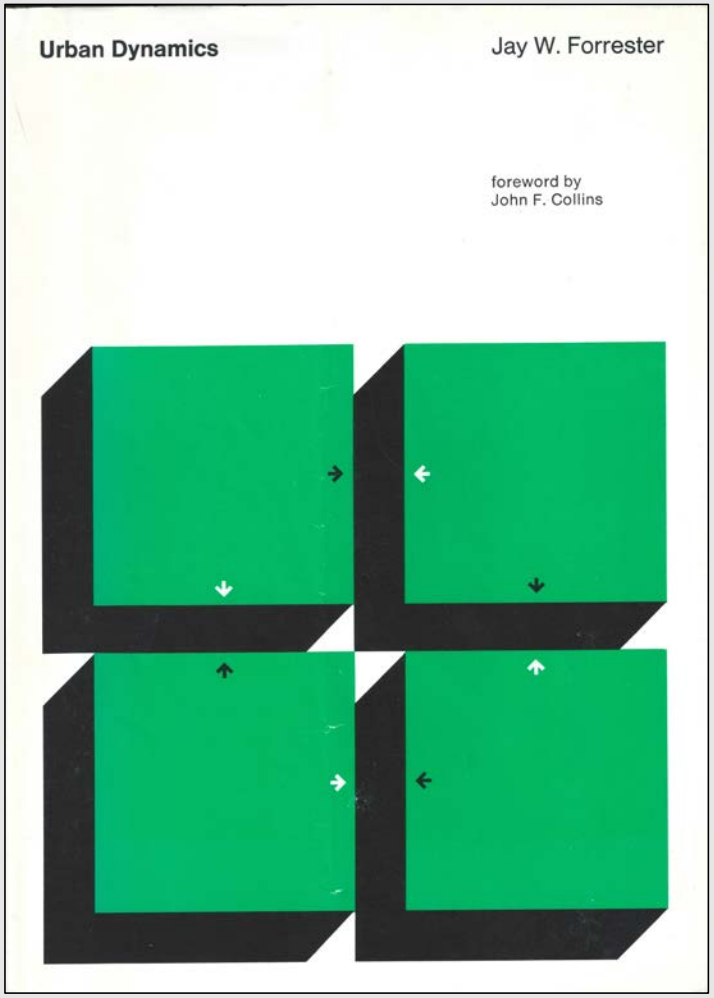






https://www.youtube.com/watch?v=5ZQP4G3Qwb4

- **Jay W Forrester and Urban Dynamics**
  - I had never heard of Jay Forrester in 1969 – he certainly didn't appear in the very small urban modelling literature then: it is just possible I had heard of Systems Dynamics
  - But before I left Manchester for Reading University in 1969, I came across a new book from MIT Press called **Urban Dynamics** by Forrester in the uni bookshop. This is where you saw new books in those days
  - This book was amazing. In those days even as a grad student you knew everyone in the field and all the ideas By the mid 1970s I had met all the pioneers. The field was tiny – you could read everything ever written on it.



- What Forrester did was introduce fully fledged dynamics into modelling system, based not on negative but on positive feedback
- This was not incremental dynamics but long term booms and busts
- It was highly unrealistic in terms of modelling observed systems as the observations were based on stylized facts at best – in his case on Boston or its caricature
- But let me get back to Forrester the man himself

- Forrester, the same as the inventor or Whirlwind was a very influential systems engineer at MIT who had written a book in 1961 called *Industrial Dynamics* all about how one could build models of firms using ideas about positive feedback.
- He was now a professor of management at the Sloan school at MIT. Whirlwind had ended and Forrester was key to MIT that the President had asked him to develop systems ideas in Sloan
- In the late 1960s, he turned to applying this kind of dynamics to cities – but to hypothetical cities –

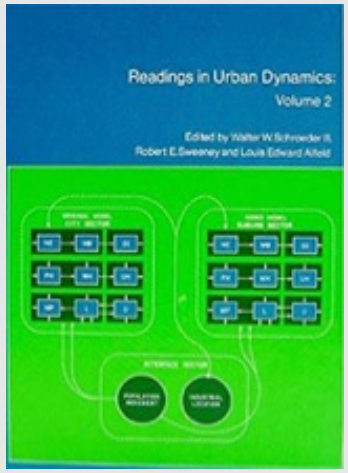
- Let me now crave your indulgence and tell you how I got to work with some of these ideas.
- So I had moved to Reading University from Manchester in 1969 and was a research assistant on a big modelling project to build land use transport models for use in planning.
- Peter Hall was the PI of the project and as part of the grant we had monies to visit the US and talk to the pioneers. Peter was too busy to go so eventually it fell to me to accompany my boss, Eric Cripps, on this incredible trip in May 1970.

- **America in 1970**
  - Let me take time out now to give you a flavour of those times. The Vietnam War was in full swing. Rioting on US university campuses. Tricky Dickie had just become President ! (of Watergate fame)
  - None of us knew how long it would take to fly city to city in the US and our travel agent in Cooks in Reading didn't know – he was younger than us and had never travelled!
  - Coffee in America was largely free, at most 5 cents a cup
  - We had never really flown to speak off and we got all the times wrong and even some of the places !
  - So in May 1970 we flew from Heathrow to NY on BOAC

- I could tell you some stories but basically we flew to NY but then immediately went to Philadelphia to see Brit Harris, Dave Boyce, Walter Isard and so on
- Next day to Boston on the shuttle and so damned tired we missed meeting Forrester himself but did see John Kain
- Then the next day to LA and saw Lowry at RAND – then Systems Development Corporation and so it went on – Berkeley, then North Carolina
- And back to New York – and the whole thing punctuated with visits to friends and family and so on –
- Rioting at Berkely with the National Guard on campus – first time I have ever smelt tear gas

- **Dynamics into Urban Models: A Long, Difficult Quest**
  - Forrester made a big impact on our work largely because he showed what was possible – you could work with aggregate populations and model dynamics – dynamics that invoked positive feedback
  - Forrester's model was heavily critiqued – it did not have location or space or interaction within it – the relations between activities were based on 'plausible' relations not observed data. It was a best based on stylized facts
  - The model produced exponential growth which then collapsed because of capacity constraints. Forrester argued this would happen if you revived the inner city

- Several groups attempted to extend the model and also to ground it in data.
- All failed – the model could not really be generalized spatially to many locations and transport was not part of it. These efforts were not insignificant and were collected into a handful of edited books e.g.



In fact we took inspiration from Forrester to simulate local relationships and the kinds of boom-bust phenomena we hypothesized might be in the local spatial detail – we took our model of Reading and extended it incrementally in many ways …..

NATURE VOL. 231 JUNE 18 1971 425

Modelling Cities as Dynamic Systems

MICHAEL BATTY
Urban Systems Research Unit, University of Reading

Most attempts at building mathematical models of cities treat such systems as if they are in static equilibrium. But models which simulate the dynamics of change in cities seem to be more relevant to urban research and planning. The design and application of such a model are described in this article.

lation and employment and on the interactions between such activities. The technique of modelling interaction using the so-called gravity model, derived by analogy with the Newtonian concept of gravity and, more recently, with the concept of entropy in statistical mechanics[3], was central to much of this research and reflected the concern of the model builders with the interdependencies within the urban system.

Static or Dynamic Models?

In spite of the enthusiasm of social scientists for these systematic approaches to urban research, progress has been extremely slow. The immensity of this kind of research effort was not anticipated by the model builders, who often did not

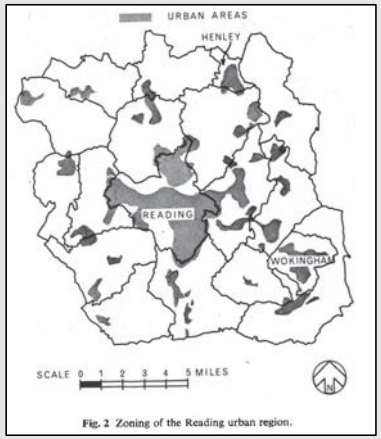


Fig. 2 Zoning of the Reading urban region.

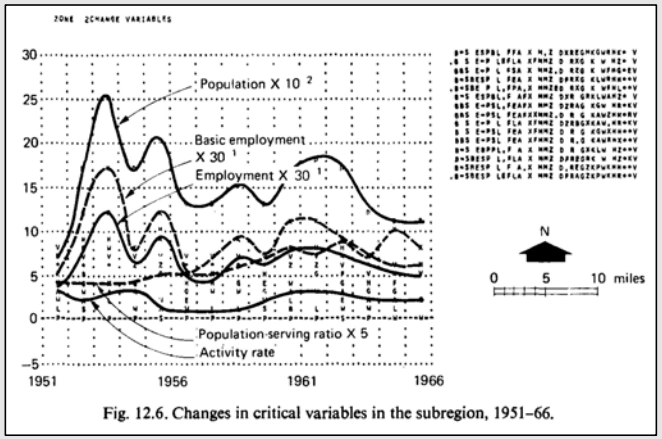


Fig. 12.6. Changes in critical variables in the subregion, 1951–66.

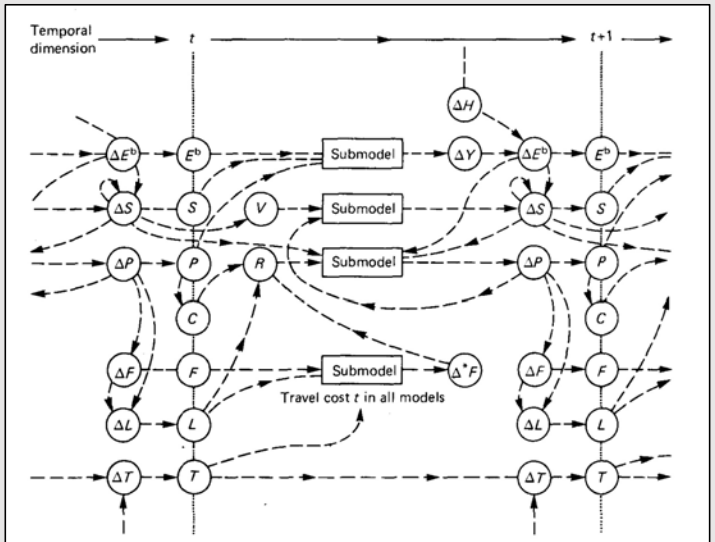


Fig. 12.4. Linkages between model variables in and between time periods.

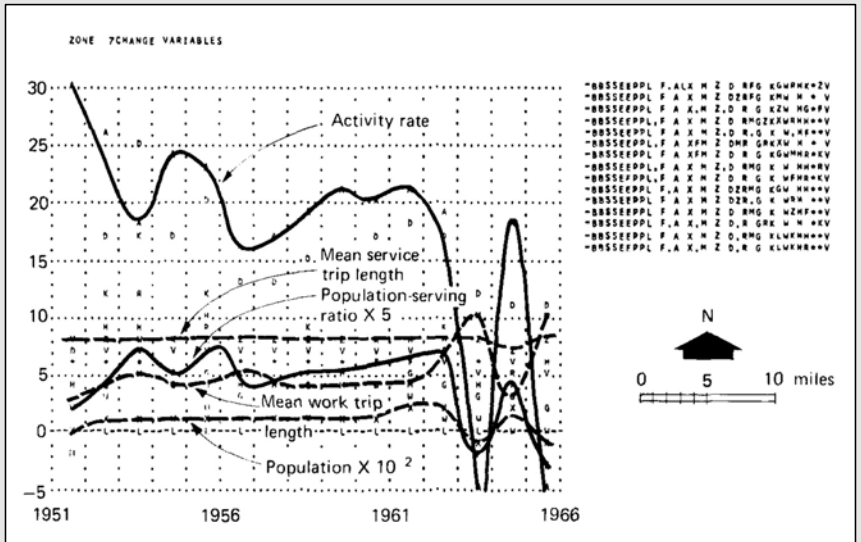
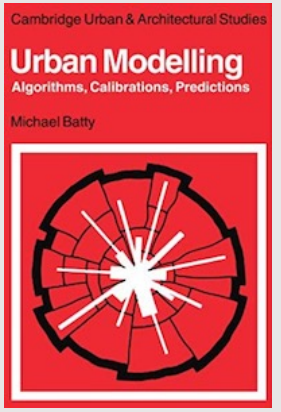


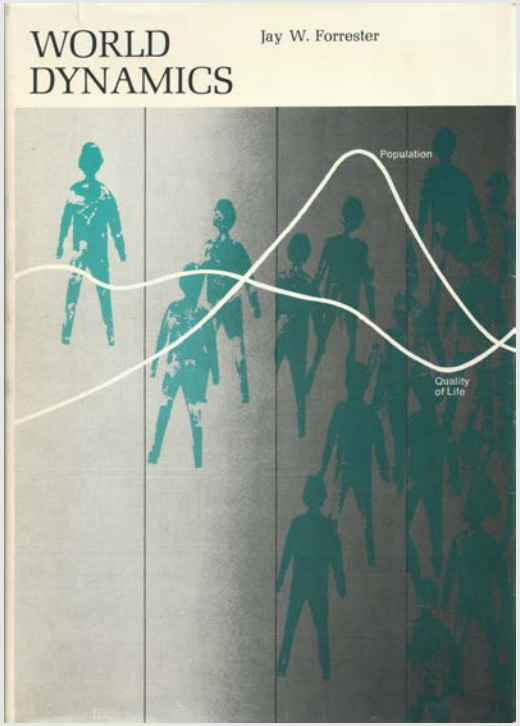
Fig. 12.12. Changes in critical variables in Shiplake zone 7.

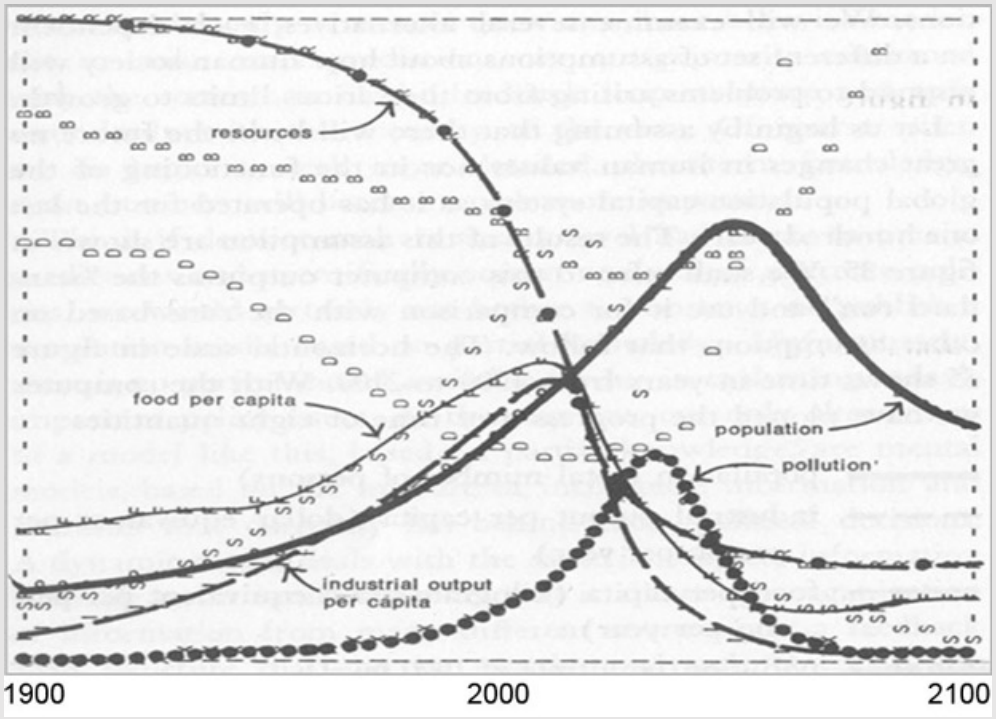
Chapter 12
Batty, 1976



- Forrester with his grad students then convinced the Club of Rome – a group of the great and the good looking at long term world population change – that he could use his SD models to make long term predictions
- This led to the **World Dynamics** book and also this reflected the notion that as the world's resources ran our and ran down, by 2100 we would be in dire straights
- In essence all Forrester's capacitated dynamics led to outcomes like this if a mismatch took place and grew through time. It was a model of what Malthus had predicted. Over-population and then collapse with not enough food to survive

- World Dynamics: Club of Rome: Our Letter to ***The Guardian 1972***





- As World Dynamics was widely publicised in the serious press as a new way of looking at the future, we wrote ***The Guardian*** pointing out the pitfalls in this style of modelling



LETTERS TO THE EDITOR
Bather, Nicholas;Batty, Michael;Cripps, Eric;Gould, Terry;Read, Jane
The Guardian (1959-2003); Mar 15, 1972;
ProQuest Historical Newspapers: The Guardian and The Observer
pg. 14

Flexible approach to work

Sir,—I read with great interest your recently published article on the "Four-day working week." I thought that it might be of interest to your readers to know of another experiment which is being conducted in this country and already proving successful, namely Flexible Working Hours.

In Germany, five million workers employed by more than 1,500 companies will this year, be operating Gleitzeit, or, as we call it, Flexitime. Large companies in Sweden, Switzerland, France, Belgium, Japan, America, and Canada are in the process of adapting to this revolutionary new working concept.

The results to date have been staggering — production up, absenteeism down and a new relationship between employer and employee are but three of the extremely exciting developments. The system is very simply operated and allows employees to arrive at and leave work at times which vary according to their work load, travelling conditions, personal responsibilities, etc., while averaging time towards a given target over a predetermined period.

The fundamental difference is reasonably easy to spot. Freedom of choice. With Flexible Working the individual has the opportunity to provide an harmonious equation of his work- and social life. With the four-day week there is "not much social life four days a week." The results of both systems are beneficial, but the weight of evidence and enthusiasm prove the case for Flexible Working.—Yours faithfully,

G. Reinelt,
Sales Manager.
Hengstler Flextime Ltd.,
Suite B, Abbey Chambers,
Highbridge Street,
Waltham Abbey,
Essex.

Regional answer

Sir,—The recent crises over waste disposal, and the Royal Commission Report point, with an as yet unrecognised logic, to a solution which goes beyond controlling the alarming symptoms of a serious problem, and which offers a comprehensive administrative structure into which fundamental changes might fit.

About a year ago, I raised, through David Steel, MP, with the Ministry of the Environment the possibility of introducing into the structure of local government reform, committees of the environment at regional level.

The simplified structure of local government could be linked into regions based upon the economic planning regions and joint standing committees set up with their function echoing that of the Department of the Environment.

It is becoming increasingly clear in environmental matters that coordination beyond local boundaries is necessary on a host of issues — Green Belt policy, motorway routeing, etc. as well as waste disposal. Such committees would be able to work in a considered and preventive way, not merely reacting in an ad hoc manner as in the recent crises. They could, for example, set up regional tips, carefully supervised, and establish recycling plants to serve an extensive area and varied products. I would urge MPs of all parties to consider promoting such a proposal.

Eric Robinson, Vice-Chairman, West Midlands Liberals.
Rantock,
Wolverhampton.

LETTERS TO THE EDITOR

Rent loophole

Sir,—Your leader on the problems of furnished tenants (March 9) draws timely attention to the insecurity they face. Your readers may be interested to learn of a method of letting that has recently been encountered by students living in furnished tenancies in Liverpool, which removes even the limited protection afforded by Part VI of the Rent Act through the machinery of the rent tribunals. Landlords are able to evade the provisions of Part VI by renting out "places" in a furnished flat rather than granting a tenant exclusive occupancy of the premises.

This means that the tenants are unable to go the rent tribunal to claim that they are being overcharged, and the landlord is free to terminate the tenancy at a moment's notice. The Francis Committee a year ago recommended that this loophole in the law be closed. Ironically, their report's description of this practice served only to inform unscrupulous landlords of a novel means of exploiting their tenants.

The NUS is urging the Government to legislate so that where two or more persons together enjoy exclusive occupation of the same accommodation under two or more contracts, those contracts shall be deemed to constitute a contract to which Part VI applies. The Government has recently demonstrated its ability to rapidly plug a legal loophole when its own interests were threatened. Is it too much to ask that I should now do the same for the furnished tenants?—Yours sincerely,

John Randall, Deputy President, National Union of Students,
London WC1.

Helping out

Sir,—With regard to Jill Knight's allegation (Guardian, March 10), I wish, on behalf of the Warwick Anti-Internment Society, to utterly refute her allegation that we are sending money to the IRA. The money from the raffle of three Long Kesh handkerchiefs and a carved wooden gun, will be sent to the family of the internee whom we have "adopted."

Since last October we have been writing to our adopted internee, and have been supporting his family, who in common with other victims of internment are suffering terrible hardship. The family receive £8 per week from various relief organisations: £8 to feed and clothe seven children, besides providing food for the father in Long Kesh, the food there being so appalling.

Since we "adopted" the family, we have sent them desperately needed blankets, clothing and money, and it is to raise more money for the family that we are holding a raffle. I do not see that this can be regarded in any way as aiding the IRA, and I can only wonder from which source Jill Knight obtained her facts.

As an anti-internment society, we utterly condemn the imprisonment of people without trial, and are committed to aiding the internees and their families who are suffering deprivation and hardship. I fail to see what Jill Knight finds so disturbing in sending blankets and clothing to a family in desperate need. No doubt it is the fact that the family whom we are supporting have been reduced to their present situation by the policies of the Government of which she is a member.

Shelagh Gallagher, secretary
Warwick University, Anti-Internment Society.
Coventry.

Going it alone

Sir,—I take strong exception to your report, "Colliery Deputies get £7 rise" (March 6). May I point out that the National Association of Colliery Overmen, Deputies and Shotfirers:

1. Were not in dispute with the NCB.

2. That it was our duty to see that the pits remained free of water and that proper ventilation was maintained during the period of the strike, so that work could be resumed immediately after the strike was settled, and

3. NACODS negotiate wages and conditions for its members and not the NUM as you seem to infer. We do not ride on the backs of the miners. My union is strong enough to handle its own affairs. Of course my wages are tied up with those of the miners. How can you possibly divorce them when we work so closely together in the same industry? By the way nearly all NACODS members were former miners.

I protest, most strongly, that you saw fit to present this article in the way you did. We want reporters to try to promote a team spirit in the mining industry so that we can get on with the job of producing the nation's coal. You are obviously supposed upon helping the NUM to declare war on NACODS and thus help to destroy the industry.—Yours etc.,

D. H. Johnson, Chairman
NACODS Lodge.
Oakdale Colliery,
Newbridge,
Mon., S. Wales.

Computer role

Sir,—We are all aware of the implications of computers in the so-called "data bank" society, but there is another more subtle and probably more dangerous issue involving use of computers in society which is implied by your lead article (March 6). The computer model built by Professor Dennis Meadows and his team at MIT, which is being used to explore the future of world population and resources, is a laudable and inspired attempt at futurology, but this work must be seen in perspective.

Apart from the criticisms, with which we agree, made by Mr M. Cordey Hayes (March 8) of some of the model's assumptions, we do not regard Meadows's work as any more or less "sober" than the forecasts of other [illegible]. The use of computers does not mean that the forecasts are more valid than other intuitive approaches and the use of an "expert computer team" does not imply the input of correct assumptions to the computer.

We feel that the subtle merging of science with sensationalism in this work is likely to bring computers in analysing social problems into disrepute. The whole of this work appears to have been built around the computer, but we feel that the true role of the computer is [illegible] used to explore, rather than definitively predict, the future. Our major point is, therefore, that it is Dennis Meadows and the Club of Rome, not the computer, which give mankind 100 years.—Yours faithfully,

Nicholas Bather, Michael Batty, Eric Cripps, Terry Gould, Jane Read, Urban Systems Research Unit, Department of Geography, University of Reading.

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Our Major Point

"We feel the subtle merging of sciences with sensationalism in this work is likely to bring computers into analysing social problems into disrepute

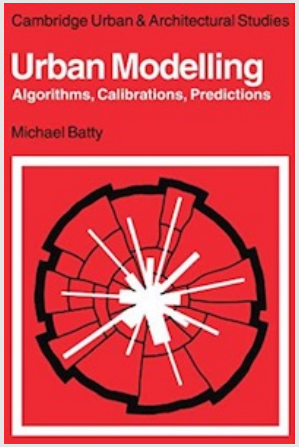
The whole of this work seems to have been built around the computer but we feel that the true role of the computer is that of a tool which be used to explore rather than definitively predict the future.

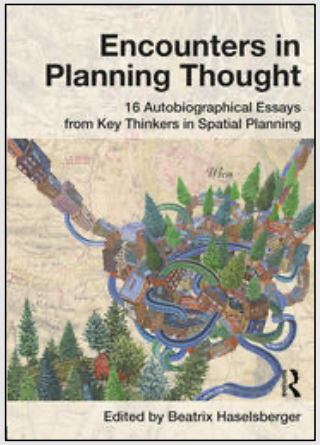
Our major point is, therefore, that it is Dennis Meadows and the Club of Rome, not the computer which give mankind 100 years."

- The Continuing Path to Dynamics: Aggregate Dynamics in the mid- to late-1970s: What Next?
  - Forrester worked away at social systems for another 20 years. He passed away in 2016 aged 98; I nearly went to see one of his last talks when I was at George Mason in 2014 and he was giving a talk in downtown DC and I couldn't factor this into my trip
  - To be honest, aggregate dynamics has never really been broached in equilibrium models and their time is well past.
  - Other models – ABM, CA, Microsimulation, Discrete Choice and even new forms of spatial econometrics – now form a more obvious cutting edge

What Can I Give You to Read and Follow Up

- My 1976 book: Chapter 12: http://www.casa.ucl.ac.uk/urbanmodelling/UrbanModelling.pdf





My semi-autobiographical essay: Batty, M. (2017) A Science of Cities: Prologue to a Science of Planning, in Beatrix Haselsberger (Editor) **Encounters in Planning Thought: 16 Autobiographical Essays from Key Thinkers in Spatial Planning**, Routledge, London

- Batty, M. (1971)Modelling Cities as Dynamic Systems, ***Nature***, ***231***, 425-428, And all of Jay Forrester's Books from MIT and the Wright-Allen Press, and the special issue of ***IEEE Transactions on Systems, Man, and Cybernetics,*** Volume: ***SMC-2*** , Issue: 2 , April 1972