Systemic Insights into Economic Principles

Moscardini A. O. Lawler K and Loutfi M
University of Sunderland UK

Abstract

Economics teaching largely involves the use of comparative static models relying on regression analysis for empirical verification. This paper investigates the pedagogical implications of using the Systems Dynamics methodology. Several established economic principles are considered such as the state of equilibrium and dis-equilibrium within the classic income/expenditure model and unstable or 'razor' edge growth in an economy subject to random exogenous shocks and the qualitative behaviour of a macro-economics system experiencing dynamic upswings and downswings. These well-established principles are contexualised within the framework of an emerging economy typified by Egypt in the 1990's.

In particular, this paper examines the qualitative macro-economics behaviour of the Egyptian economy in periods of dynamic change and shows that without effective government policy initiatives, cobweb style movements in Egyptian labour/goods and money markets are likely. This detailed study of qualitative behaviour of the Egyptian economy shows the power of System Dynamics in presenting the interdependence of the economic variables and its predictive power in recommending effective intervention criteria. The models in the paper are implemented in Powersim.

1. Introduction

The purpose of the paper is not to document new advances in either macroeconomics or system dynamics thinking. It is to show that by using influence diagrams and causal loop simulations, there are definite pedagogical advantages to be gained and it is hoped that more of these methods will be adopted by economics teachers in the future. Some economic reference point is needed to illustrate our points. Because of the research interests of the group, we have chosen the Egyptian economy. This is a perfect representation of an emerging economy teetering between classic Keynesian under-employment equilibrium and Harrodian 'razor' edge growth. Hence, the possibility of chaotic 'cobwebs' developing due to switches in government policy or tiny exogenous or endogenous shocks, provides an excellent backdrop for the application of System Dynamics to tease out critical casual links. Periodic macro-economics instabilities are usually analysed by economists applying Keynesian, Neo-classical or New-classical methodologies, where the mathematical implications quickly become intractable. Moreover, stabilised macro-economics models primarily target advanced economies, where financial intermediation and governments countervail, to a large degree, chaotic swings in markets

This paper therefore uses aspects of the macro-economics behaviour of the Egyptian economy in periods of dynamic change. to show the power of System Dynamics when illustrating economic trends The models in the paper are implemented in Powersim.

2. Pedagogical Issues

A considerable volume of education delivers what could be termed as ‘ laundry list ‘ thinking. By this, it is meant that if one asks ‘ what causes what?’ the likely answer is a (laundry) list of factors. Each is assumed to act independently and the usual way of dealing with them is by fitting a curve or some regression technique. The result will be some form of graphical output.. A major disadvantage of such a methodology is that the results are static. It is difficult to answer questions such as “What if ? “ Much time is spent is analysing past data that may be of no relevance to the present time because of the accelerating nature of change. Dynamic models can reveal much more but have been hampered by the scarcity of good interactive software. The current developments of such modelling tools, especially in the general area of Systems Dynamics, have provided the means to overcome this problem .

According to Richmond (1993), if one switches to Systems Thinking then there are at least seven more fruitful types of thinking available. He classifies these as Dynamic, Closed loop, Generic, Structural,

Operational, Continuum and Scientific Thinking.. Each of these terms has a specific meaning but the common threads are:

i) the notion of modelling structure
ii) the notion that it is the structure that causes behaviour
iii) the ability to observe the effects of changing parameters on behaviour of systems

System Dynamics provides a methodology for doing this and software such as Stella, ithink, Vensim and Powersim offer the perfect platform for posing and answering " what if? " questions.

A second issue is that there has been a revolution in thinking due to the recent advances in Chaos Theory. More and more fields of research are being affected. It is now becoming accepted that we live in a non-linear world and that complicated behaviour can be generated by simple models. There is no need for models with 200 variables and 200 equations which take 24 hours to run and require mountains of precise data. Models using three or four variables with real-time delays can provide similar behavioural output but with the advantage of being able to predict " much from little " (using Friedmans dictum.)

Economics teaching at undergraduate level falls into these difficulties. (Sloman 1997, Parkin 1997) Increasingly the subject is taught not as a way of learning to think about how the world *might* operate but as a set of discovered truths as to how the world *does* operate. (Omerod 1995) The content of degree courses is becoming increasingly standardised. Substantial and impressive textbooks exist, both in micro- and macro-economics, consisting in the main of the mathematical techniques of the differential calculus applied to linear systems. Very little of these text books are true in the sense that statements in a textbook in say engineering are true e.g. formulas exist for strengths of buildings and buildings don't often fall down. The same does not apply in economics. . Economic forecasts have a very poor record and many of the fundamental postulates are being called into question as some of the more imaginative economists seek to restore the link with reality which characterises the work of the classical economists. That this trend is widespread in Anglo-Saxon economics stems from several factors which are summarised as:

- mainstream micro and macro theory still premises largely on the derivation of equilibrium conditions for firms, industries and markets, either within a partial or general equilibrium framework.

- states of equilibrium are examined on a comparative -static basis because of the mathematical convenience of the Marshalian approach,

- the intrinsic belief of most neo-classical theorists that economics, markets and industries always achieve equilibrium in the long run. the economics teaching should focus on the issue of 'training the mind ' of students following Sraffa's famous dictum in 1926 where ironically in this famous paper, Sraffa demonstrates that the Laws of Returns are incompatible with static equilibrium.

- the schizophrenic Keynsian thinking of developing dynamic theories and testing them with static models

- The continued reliance of theorists in developing computable General Equilibrium Models which develop static criteria for the existence of market clearing vectors at micro and macro levels

- an intrinsic fear of developing non-linear models which make prediction hopeless and mark economics as an underdeveloped science.

In this context, economics teaching needs new pedagogies and System Dynamics is being proposed as one that has great potential in this area.

3. The Economic Model Investigated

The choice was to investigate the Accelerator -Multiplier interaction of Samuelson (1960) This is a classic situation where the effects of change in investment spending are initiated by an increase in government expenditure. The effects are straightforward. In the simple equilibrium model an increase in investment leads to a larger increase in aggregate demand and supply in the short run. Larger investment not only adds to aggregate demand directly but by increasing income adds to consumption demand indirectly. This is the causal link between the accelerator and the multiplier. The usual economic reasoning for this is as follows:

If there is an initial change in investment or savings, then this theoretically sets off a chain reaction between the Accelerator and the Multiplier. Hence if there is a rise in government expenditure, this will lead to a multiplied rise in income. However, this rise in aggregate income (demand) kick-starts the Accelerator effect: firms respond to a rise in aggregate demand by raising investment. This rise in investment constitutes a further rise in aggregate demand (income) which leads to a second multiplied rise in aggregate demand. If the incremental rise in aggregate demand is larger than the first, there will be a second rise in investment (the Accelerator) which in turn causes a third rise in aggregate demand (income) via the multiplier. Theoretically, this process could continue indefinitely but it is eventually constrained by ceilings on aggregate supply and the fact that aggregate income cannot continue to rise faster and faster. Once the growth in aggregate demand slows investment will begin to fall and the whole process is reversed. Using J, I and Y to represent Injections, Investment and Aggregate Demand (Income) The Accelerator-Multiplier interaction can be shown formally in Table One.

period t	$J \uparrow \rightarrow Y \uparrow$	(multiplier)
period t+1	$Y \uparrow \rightarrow I \uparrow$	(accelerator)
	$I \uparrow \rightarrow Y \uparrow$	(multiplier)
period t+2	If $\uparrow Y_{t+1} > \uparrow Y$	then $I \uparrow$
	If $\uparrow Y_{t+1} = \uparrow Y$	then I stays same (accelerator)
	If $\uparrow Y_{t+1} < \uparrow Y$	then $I \downarrow$
	This is turn will have a multiplied upward effect no effect or a multiplied downward effect respectively on National Income	
period t+3	this leads to further accelerator effects or otherwise	

Table 1 Accelerator - Multiplier Interaction

Another form is the second order difference equation

$$I = m (y_t - y_{t-1}) + a (y_{t+2} - y_{t+1})$$

which has three main solutions: regular, damped and unstable oscillations depending on the choice of parameters for the multiplier and the accelerator.

What about the cause of a change in investment spending? Firms invest when their existing capital stock is a smaller than their desired amount of capital stock. . When firms are holding an optimal level of capital stock the marginal cost of incremental units equals the marginal benefits, the present value of future profits which it is expected to give rise to over its lifetime. This present value can rise or fall by either a rise or fall in the interest rate at which future profits are discounted. However, in this model the monetary sector has been excluded to allow analysis simply to focus on real capital investment. Other things being equal, higher expected future aggregate demand is likely to raise expected future profits

and increase benefits from marginal additions to the current capital stock. This powerful insight is the major implication of the accelerator-multiplier model of economic cycles [Tvere 1997]

4. System Dynamics Approach

A novel approach in economics teaching is for students to construct their own mental models of the situation using Influence Diagrams. A typical diagram is shown below in figure one.

Valuable insights will be gained by students building such simple representations. It can be seen that there are three positive feedback loops balanced by three negative loops. Depending on the various strengths of these loops classical equilibrium or positive growth /decay can be expected. These are discussed in section 6.

The building of a Causal Model from this loop is often dismissed as routine but it can be difficult even for experienced modellers. A typical model is shown in figure 2. By building such a model, the student gains valuable insight into delays and exponential smoothing. These concepts cease being dry mathematical constructs but take on real meanings and relevance. Change in consumption is usually measured by comparing the quarterly accounts which presents a small problem for the modeller. The pedagogical advantages in this approach is that the students are building their own models, under the guidance of the lecturer. By doing so, they are learning how factors influence each other and about the whole picture. They have abandoned the laundry list and are thinking dynamically - maybe for the first time in their lives!

This is a great advance in the training of economic graduates, because to some extent, it re-locates modern students into insights delivered in Keynes' " General Theory ". This famous text has been criticised over the years for developing a dynamic macro theory linked together with a system of static models. Hence, Keynes famous " Notes on the Trade Cycle" in the " General Theory " are dynamic sets of insights and largely overlooked nowadays by textbook writers and theorists.

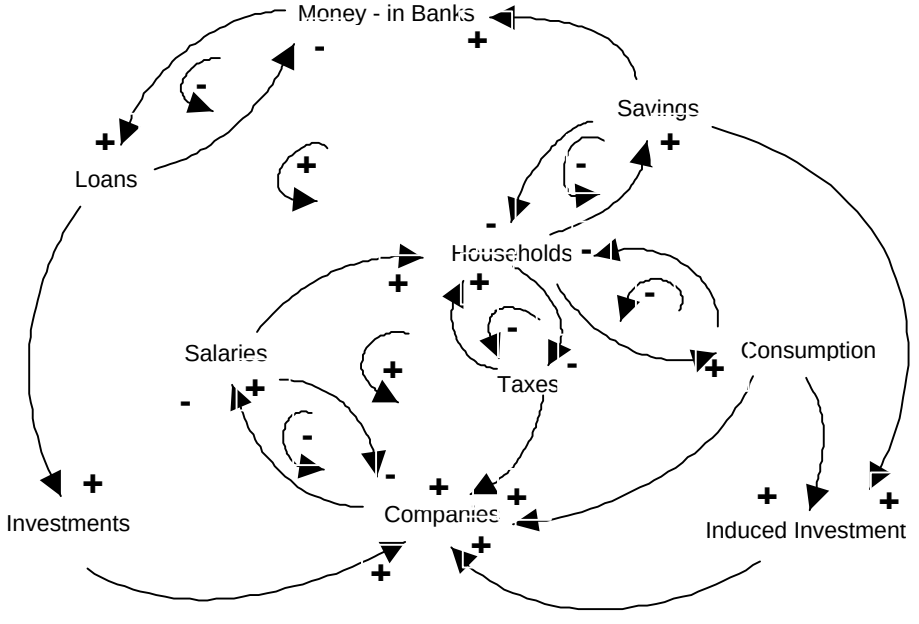

Figure One Typical Influence Diagram

5. Data.

Like many LDCs, Egypt suffers periodically from economic upswings and downswings and sudden changes in employment trends linked to these. In the last 20 years Egypt's working population has increased by around 14% whilst the pound has continued a slight downward trend since 1973. Inflation trends are reasonably stable compared with other LDC's in Africa and Asia. Egypt's 20 year inflation

trend averages around 17-19% p.a.(UN Statistical Year Book 1997). Again compared to many large LDC's, foreign debt is not more than 20% of GNP(IMF-1995) which is sound for a large LDC. This may change if the sudden collapse of the Tourism Industry cannot be halted. [Aghion 1998]

In our model it is assumed that the Capital-Output_ratio (the Accelerator) lies between 0.8 and 1.1 and the marginal-propensity - to - consume is around 0.5 giving a multiplier of 5.. The model assumes that 80% of all savings is deposited into Banks and that the banks loan out 80% of their assets. Both Aggregate demand and Aggregate Supply can be boosted by government expenditure. There are various delays in the system:

i) a four week delay for payments of salaries
ii) a four week delay for consumption to feedback into production
iii) a thirteen week delay for induced investments into production
iv) a twenty-six week delay for investments from loans to feed into production

The models are run over a simulation time of twenty years using weekly intervals and Runge-Kutta fourth order solution techniques. The Powersim model is shown below.

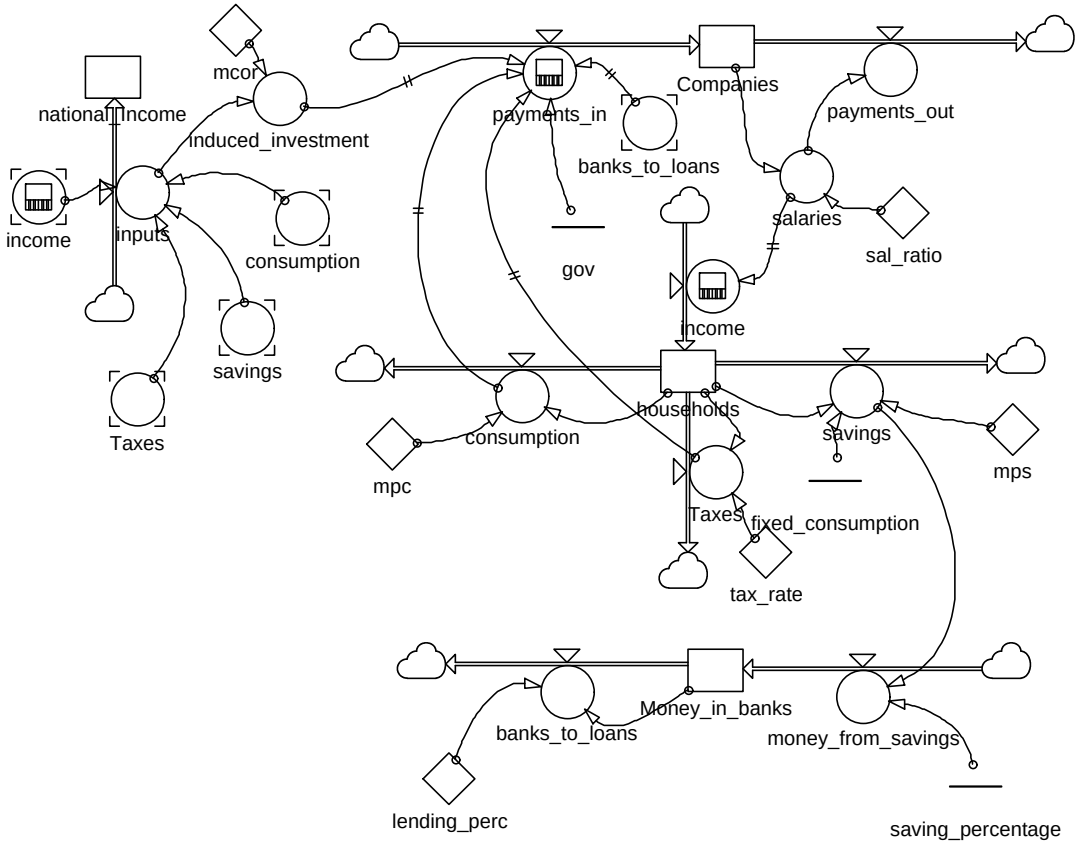

Figure Two System Dynamic Diagram

6. Simulation Runs

The paper presents three simulations for the Egyptian Economy.

1. The first corresponds to a classic textbook equilibrium. There are no delays or leakages in the system. The income circulates around the economy. The positive and negative loops balance each other. The student can experiment with various forms of government interventions and still observe

how the equilibrium holds. Powersim provides tables which gives quantitative results as well as the graphical form. A typical graph is shown in Figure 3.

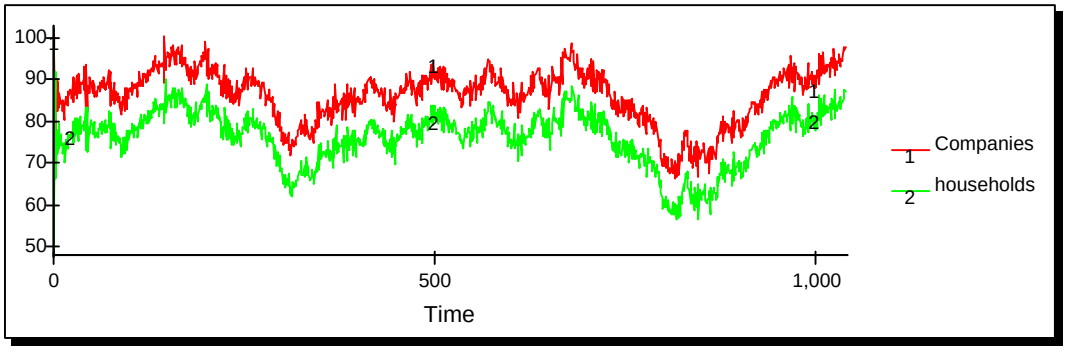

Figure Three Classic Equilibrium

2. The second is modelled using the delays mentioned in section 4 and government boosts to the economy. These boosts are modelled by a normal distribution. The results show the effect of the multiplier.. Aggregate demand growth leads to a rise in the level of investment and thus a rate of growth of the desired capital stock. [Barnet 1997] The major implications of this model are that it takes accelerating demand and output growth to enhance the desired level of investment The marginal propensity to consume is set at 0.6 which is equivalent to a multiplier effect of 2.5. This effect is clearly shown in Figure 4

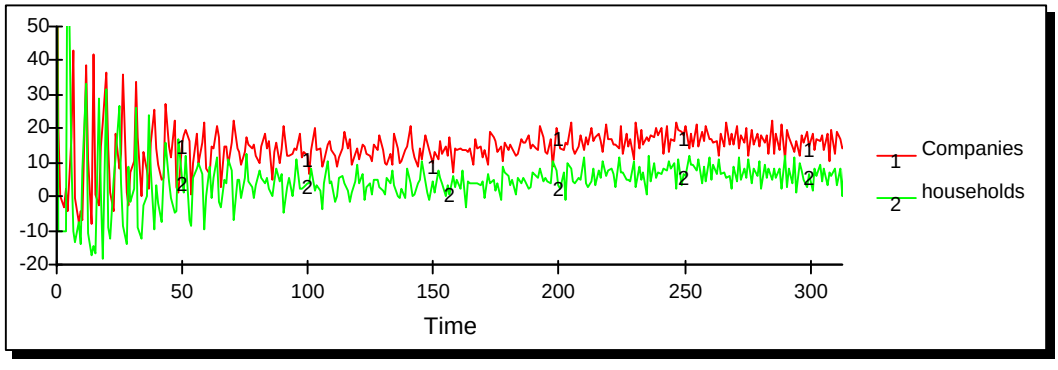

Figure Four Dynamic Equilibrium

3. The third model, the accelerator-principle assumes that firms estimate future aggregate demand and profits by extrapolating past demand growth. This information governs their investment patterns. This induced investment is accelerated by the marginal-capital-output-ratio which is the cost of the extra capital required to produce a 1$ increase in national output. Other things being equal, the accelerator coefficient and the marginal-capital-output-ratio are equal. It can be seen that the behaviour of the economy becomes erratic. The model is extremely sensitive to small changes in the marginal-capital-output-ratio which seems to indicate that Chaos is lurking. This is a valuable experiment for students. One of the runs is shown in Figure 5.

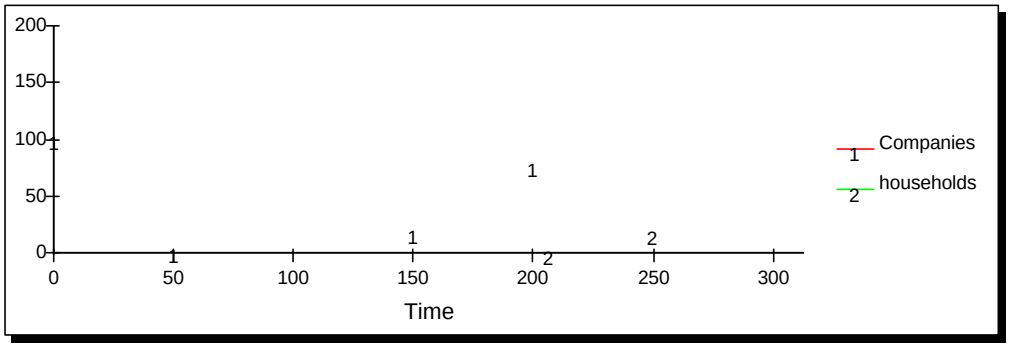

Figure Five Potential Chaos

This acceleration principle captured by this Powersim model is only a useful simplification. A complete model of investment could allow for both the effects of changing aggregate demand on expected profits and the role of interest rate changes in altering present values of expected future profit streams. This model confirms, as in many empirical studies , that the accelerator is a useful simplification of the role of investment in economic cycles. The model here of the accelerator-multiplier interaction can generate cycles without limits and cause swings in aggregate demand/supply. What are the constraints on the extent of the fluctuations shown in figure 5? The cycles become likely when it is realised that aggregate supply/demand have endogenous limits. Hence aggregate supply provides a ceiling in reality. Although it is possible to meet high aggregate demand by overtime working and running down stocks of finished goods aggregate supply cannot expand indefinitely. Indeed aggregate supply slows down as the Egyptian economy reaches the boom. Having overreached itself the economy is likely to bounce back off a ceiling and begin a down turn. Moreover, the model implies a flow or a limit to the extent to which aggregate demand is likely to fall in recession. Gross investment (including replacement investment) cannot actually become negative unless there is capital destruction on a large scale.

Apropos the discussion in section 2, a simple model such as this can have surprisingly powerful economic insights. This model can demonstrate the influence of government in the future Egyptian Economy. The current privatisation programme in Egypt is designed to raise efficiency and cut government debt. However, paradoxically the programme will cause structural unemployment which will mean the government will have to soften the blow to victims. This will raise government spending for the next seven years by as much as 5% for year(IMF-1997). The strategic role of Government in an economy like Egypt is that Government must behave like a Von Stackelberg Leader in an oligopoly game. However, this Von Stackelberg Leadership role must be benign and unchallenged. Thus the model seeks to show that large delays in the implementation of government expenditure can cause severe swings in aggregate supply and demand. The models show that swings in investment and aggregate demand imply that Egypt is normally operating with inflation and unemployment co-existing in the context of steady economic growth. The reason for these paradoxes is that the previous ‘nationalisation’s’, labour practices and legal changes have made the skilled Egyptian labour markets rigid. Labour mobility is weak in Egypt compared to other countries. As privatisation progresses these factors will raise unemployment to levels of 20% in some years. The government should counter this but it could destabilise the Economy. The multiplier-accelerator principle built into the model distinguishes the interplay between these two forces/principles clearly [Medio and Gallo 1995]..

7. Conclusion

There are two major conclusions to be drawn from this paper. One concerns the pedagogical issues and the other is that such models even though they are simple can reveal profound economic insights.

1. Pedagogical Issues

Economics teaching is currently experiencing several difficulties which have been discussed at length. The advantages of introducing this type of methodology into the mainstream economic teaching are obvious. The student is not just regurgitating dry economic theory but is actively building models of the economy and interactively experiencing the surges and booms and collapses that occur. The student is thinking as well as learning. Concepts become meaningful and the students eventually " get a feel " for the subject. It is surprising how little of this type of work is done in the UK undergraduate economics degrees.

2. Economic Insights

The Powersim model shows the key role of Government in Egypt in kick-starting the economy. The Egyptian Government accounts for between 45% to 65% of aggregate demand . As the privatisation process reduces this over the next five years this key component of aggregate demand should fall to around 35% to 45%. However, even in such circumstances, it is appropriate to model the Egyptian Economy on the assumption that the Government is a Von Stackelberg leader even in private markets. Chaotic trends seem to be emerging for the model with long delay lags. This results from the Government's recognition and implementation lags particularly when Government is such a big player in the economy. The Systems Dynamics approach clearly reveals this area of potential chaos. The Egyptian Government relies on official data to operate its fiscal stabilisation programme in conjunction with the I.M.F. Naturally this builds in large information delays, recognition lags and eventual implementation lags. When Government Expenditure is a significant component of aggregate demand, chaotic movements in aggregate supply and demand are likely. The privatisation process too includes a lag vis-à-vis implementation. Hence Government Expenditure in Egypt is likely to exacerbate booms and intensify slumps over the next few years. [Blejar 1997]

These economic insights square with the observations made by famous economists and politicians over the years. Thus in 1958. Harold MacMillan made the famous observation in a Parliamentary debate that " choosing optimal strategies to govern the country is like looking up today's trains in last year's timetable" This observation merely echoed a powerful plea made 150 years ago by the theorist Simonde de Sismondi (1827):

> *Let us beware of the dangerous theory of equilibrium which is supposed to be automatically established. A certain kind of equilibrium, it is true, is re-established in the long run but it is only after a frightful amount of suffering* "

8. References

1. Sloman J Economics 3rd Edition Prentice Hall 1997
2. Parkin D et al. Economics Chapter 3. Longmans 1997
3. Omerod P The Death of Economics. Faber and Faber 1995
4. Richmond B. Systems Thinking: Critical Thinking Skills for the 1990's and beyond. Systems Dynamics Review Vol. 9. Number 2 1993
5. Samuelson 1960
6. Tvede L. Business Cycles: From John Law to Chaos Theory. Gorden and Breach publishers 1997
7. Aghion P. Endogenous Growth Theory MIT Press 1998
8. MedioA. and Gallo G. Chaotic Dynamics Theory and Applications. C.U.P. 1995
9. Barnet W.A. et al. Non-linear Dynamics and Economics C.U.P. 1997
10. Blejar M. and Skreb M. Macroeconomic Stabilisation in Transition Economics. C.U.P 1997
11 Sraffa. P. The Laws of Returns and Competitive Conditions. Economic Journal 1926
12. De Sismondi S. Nouveaux Principlesd'economie Politique. Paris 1827