The business cycle: dynamical coupling and chaotic fluctuations

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CHAPTER 7

SUMMARY AND CONCLUSIONS

"Even when prosperity is restored, the prospects for poverty-vulnerable workers are not promising. More of them are likely to be unemployed or not in the labour force than was true before 1980s”
Tobin(1996, 247)

1 Introduction

Economic fluctuations do exist, as is seen in chapter one. Not only is there a succession of rising and falling GNP, but the changes in GNP coincide with several real and monetary variables, giving support to the idea that there is a set of economic relationships, which can be called the business cycle.

In the general introduction the following four questions were stated. 
1. Which theories have been put forward to explain fluctuations?
2. Is it possible to use mathematical methods to model economic theories containing persistent irregular fluctuations?
3. Which assumptions are responsible for the occurrence of fluctuations?
4. Which is the influence of interdependency between different sectors on the dynamics of the aggregate economy?
Each part of this study was devoted to answering one or more questions.

In this chapter the answers are summarised and some conclusions are drawn from the former analyses.

2 Which theories are put forward to explain economic fluctuations

Frisch(1933)’s impulse-propagation mechanism was used to divide business cycle theories in:
1. Real versus monetary approaches.
2. Exogenous versus endogenous approaches.

An economy is characterised by a state vector, $x$, and a parameter vector, $\mu$. The dynamics can be described using a general function as in Azariadis(1993):

$$x_{t+1} = f(x_t, \mu_t) + \varepsilon_{t+1}$$

There seems to be a consensus among economists that the impulse ($\varepsilon_{t+1}$), the initial disturbance, can be both monetary and real in nature. A controversy exists over the nature of the propagation mechanism. The
source of instability can be the structure \( f(x_t, \mu_t) \) of the monetary sector or that of the real sector.

Gandalf(1996) reduces this controversy to the amount of variables \( x_t \) and the description of \( \mu_t \) (the size of the model). The larger the model, the fewer exogenous disturbances are observed \( (e_{t+1} \text{ becomes a part of } f(x_t, \mu_t)) \). Yet, even when such a ‘Grand Design’ \( (x_{t+1} = f(x_t, \mu_t), e_{t+1}=0) \) exists, the controversy over the stability of the economy is still relevant. Either the economy moves, directly or in time, towards an equilibrium position after an initial shock or fluctuations are inherent to the structure of the economy. Research in the first strand concentrates on the kind of impulse and the way the impulse temporally disturbs the equilibrium, which is called the exogenous approach. The second approach, called endogenous, ignores the original impulse and concentrates on the structure of the economy as the cause of fluctuations.

Vercelli and Dimitri(1992) distinguish two different approaches. Firstly, endogenous fluctuations can be caused by insufficient co-ordination \textit{within} a market, based on the behaviour and decisions of the individuals acting within this market. The second approach states that even when all markets move towards equilibrium, the aggregate economy can exhibit fluctuations as there is no co-ordination \textit{between} markets (also see Morishima(1992)). A combination is made by Goodwin(1947), who starts with two markets in which a lack of internal co-ordination causes the price and production within each market to fluctuate. He then analyses the effect that two fluctuating markets have on each other and on the economy as an aggregate. His conclusion is that the resulting aggregate fluctuations differ substantially from those in the two markets.

The classical economists assume stable growth to be the ‘normal state’ of the economy. Fluctuations were seen as seasonal phenomena or as adjustments after an exogenous shock that temporarily depresses the natural growth rate. Early Keynesian multiplier-accelerator models were also labelled exogenous, because the occurrence of irregular persistent fluctuations in these models still depends on the appearance of irregular exogenous shocks. The research following the ‘sunspots-approach’ of Cass and Shell(1983), Azariadis and Guesnerie(1986) and Azariadis(1993) concentrates on the impulse and can also be labelled exogenous theories.

The main modern representative of the exogenous business cycle theories is the new classical approach, which can be divided in the imperfect information approach and the real business cycle approach.

Endogenous business cycle theories can be divided in:
1. real cycles, such as:
   a. the maladjustment theories (Haberler(1939), Kalecki(1971))
   b. the predator prey models (Goodwin(1967))
   c. Keynesian cycles (Hicks(1950), Hommes(1991))
The relationship between the business cycle and growth is ambiguous. On one side, growth is seen as a source of exogenous business cycle fluctuations. Innovations cause upward adjustments in production, employment and investment. These adjustments can take the form of dampened or persistent fluctuations, depending on the propagation mechanism. When the fluctuations are dampened, the appearance of persistent fluctuations depends on the re-occurrence of new innovative investment (Aghion and Howitt(1998)). On the other side, short-term fluctuations are seen as a source of long-term growth. The nature of this relationship is not clear. Question is whether upswings further innovations or whether growth is enhanced by depressions? Van Ewijk(1994) takes an intermediary position: growth is slowed down by large depressions, but stimulated by small downturns.

Accepting the diversity of impulses, there are also many endogenous propagation-mechanisms possible. This can be (and often is) seen as the root of the controversies in macroeconomics. Yet, as shown in the conclusions of chapter two, it is possible to derive a business cycle theory that combines most of the endogenous approaches as mentioned above. Psychological and political factors provide stimuli that cause an economy to leave its equilibrium position. In the case of a downward adjustment, savings and investment will decline at different rates, causing horizontal and vertical maladjustments. In the monetary sector, risks are assessed again and credits restricted. Both developments influence the production negatively. The changes in the demand for labour can generate a predator-prey cycle. However, when the interest rate, the wage rate and prices are adjusted, there is reason for the government to intervene, whereas some new investment projects become profitable, creating new optimism. Slowly, the economy will recover until the different variables have risen so much that the deviations between actual and desired levels give reason for the following decline.

The introduction of mathematical and econometric techniques in economics also introduced a systematic way of analysing business cycles. Yet, the need to solve a deterministic model, imposes restrictions on the business cycle which often cause the resulting economic model to exhibit dampened fluctuations. Only a few models generate regular endogenous fluctuations (variations of the multiplier-accelerator model, predator-prey models). These models are criticised because of the small range of parameters for which persistent fluctuations appear. Within this range of parameters, these fluctuations exhibit regularities both in periodicity and
amplitude, which are not observed in empirically observed fluctuations. So, even these models rely on exogenous shocks to account for the observed asymmetry in cycles.

3 Chaos and the business cycle

Part two answers the following questions:

*Is it possible to use mathematical methods to model economic theories containing persistent irregular fluctuations?*

*Which assumptions are responsible for the occurrence of fluctuations?*

In this section the conclusions with respect to chaotic dynamics, econometrics and chaos control from chapter three are given, followed by the conclusions from the models analysed in chapter four.

To explain the erratic endogenous fluctuations, within a deterministic model, chaos was introduced in economics. Chaos is a mathematical concept, used to generate time series which are often difficult to distinguish from time series generated with exogenous irregular disturbances, but the chaotic dynamics are endogenously determined. Chaos is characterised by continuous movements within a stable boundary. The appearance of these fluctuations depends on the occurrence of both repelling and contracting forces.

The models, which are most frequently used in economics, often generate irregular cycles and chaos by using the so-called logistic equation. The characteristics of this logistic equation or logistic map were demonstrated, using a simple tax-production model. The development of the dynamics of such a model (monotone and cyclical movement towards equilibrium, regular cycles, irregular cycles, chaos, instability), depends on the evolution of a crucial parameter or a combination of crucial parameters. The relationship between these parameters and the occurrence of different kinds of dynamics is made visible by the usage of two methods: the bifurcation diagram and Lyapunov characteristic exponents. These methods can be used to prove the existence of chaos, in the absence of thorough mathematical proof.

*Econometrics*

Because of the property of (true) chaos to resemble ‘white noise’ it is difficult to distinguish the cause of the fluctuations: exogenous erratic shocks or endogenous deterministic mechanisms. Several econometric methods are developed to prove the existence of chaos in time series. Large data sets are necessary to distinguish endogenous chaos from exogenous erratic disturbances. An additional problem in empirical work is the disappearance of chaotic behaviour on a macroeconomic level (van Witteloostuijn and van Lier(1990)) and the influence of errors and distortions (van der Ploeg(1986), Kelsey(1988)). Given these problems,
empirical work can not reject, but either can not confirm the existence of chaos in economic data (see for example Scheinkman(1990), Grauwe, Dewachter and Embrechts(1993), Dechert(1996) or Barnett(1996)).

The dependency of the resulting time series on the initial value poses a serious problem for the econometric testing of chaos. Accurate measurement is important: small deviations of the initial value of a variable give large forecasting errors. The right structure can be rejected because of a small estimation error in the initial value. Furthermore, this characteristic makes forecasting in such a model unreliable. It was shown that an estimation error of 0.01 of the initial value of the variable could lead to a totally different time path for a long period, even when the dynamics, in time, reduces to a period-3 cycle.

Chaos and control
When a system behaves in a chaotic way, it can only be controlled if (interpreting Ott, Grebogi and Yorke(1994));
- the structure is known or can be approximated closely;
- there are no external disturbances (influence of noise is low);
- there are only a few variables involved.

Translating these mathematical conclusions in economic terms, a chaotic economic system can be controlled by:
- continuous intervention by discrete policies;
- changing the behaviour of the economic subjects, so the control parameter falls within a stable corridor;
- changing the structure of the economy (removing the non-linearity).

Chaotic economic models
As stated before, chaos was introduced in economics to explain irregular economic fluctuations. Different models were reviewed. By reducing the mathematical properties (using the logistic equation), the behavioural assumptions responsible for the occurrence of chaos were shown for the following models:
1. overlapping generation models,
2. models of imperfect markets ,
3. financial models ,
4. growth models.

1. In the overlapping generation models, chaos occurs because of the interaction between utility and production. Intertemporal equilibrium requires the actual and desired debt position of the successive generations to be in equilibrium. Temporal equilibrium requires that present production is divided over the existing generations. Using the conditions on (inter)temporal equilibrium and the indirect utility function, it was shown that a negative relation between present debt and utility can cause chaotic fluctuations if the reaction of the young generation to (expected)
intertemporal price changes is strong enough. Medio and Negroni(1996) generalised this conclusion with respect to other classes of utility- and production functions. Two points of criticism are relevant for these kinds of models. Firstly, as the conclusions depend strongly on the form of the different functions, these models are criticised because of their ‘ad hoc’ character. Secondly, as each period in these overlapping generation models concerns half a lifetime, a cycle consisting of four periods equals (roughly) 120-160 years in real time.

2. Also in models of imperfect markets, chaos can occur. Using an oligopoly-model of Rand(1978), van Witteloostuijn and van Lier(1990) show chaotic fluctuations to appear for different behaviour of the entering firm. Essential is the ‘sign switching’ of the reaction function: the reaction of the former monopolist depends on the level of supply of the entering firm. The stronger the reaction of the defending firm, the greater the chances of chaos. The existence of more firms makes the analysis too complex. An intuitive conclusion from the ‘van Witteloostuijn-van Lier model’ is that a rise in the number of firms present at the market will lessen the intensity with which the current firms react to a new entrant. Monopoly or co-operation is essential for the occurrence of chaos.

3. In financial models chaos occurred for different reasons. Analyses of the stock markets show the importance of behaviour of different kinds of investors. The formation of expectations towards future stock prices strongly influences the dynamics of these prices.

The interaction between the real and monetary sphere is another cause of fluctuations. Chaos results because of the interaction between confidence (the psychological state of mind of the banks and the producers) and the actual loan-capital stock ratio (Franke and Semmler(1989)). In these kinds of models, the expectations (or confidence) in the financial sphere influences the production. A lack of confidence will act as a self-fulfilling prophecy when this leads to a tightening of credit constraints and so to a decline in production and a depression. Foley(1987) models this relationship in a different way. A rise in profitability will cause a disproportional rise in debt. In turn, the rise in debt and the accompanying rise in the rate of interest brings about a contraction in profitability and a decline in production. Using the logistic equation, it was shown that the interaction between financial factors (such as credit restrictions and the rate of interest) and real factors (such as the rate of profitability and production) can be a source of endogenous irregular and chaotic fluctuations.

4. Lastly, the Goodwin(1990) growth model was presented. Using the technique of the Rössler Band, Goodwin(1990) showed the appearance of chaos in a variation of his 1967-model. Innovation, the impulse, was exogenous in the Goodwin-model. A variant was developed which contained endogenous innovations. Endogenous growth results because of:
1. chaotic investment behaviour;
2. a dependency of the capital stock on the state of the labour market.

Even in simple mathematical models using the logistic map, the different behavioural assumptions, mentioned above, can cause an economy to exhibit chaotic fluctuations. Both the lack of co-ordination within a market or sector of the economy (consumer behaviour, imperfect markets, stock market) and the lack of co-ordination between markets (consumption versus production, financial versus product markets) can be the cause of persistent economic fluctuations. Because of the empirical difficulties, it is troublesome to establish the existence of chaos in actual time series. Although results are mixed, the hypothesis of chaotic fluctuations can not be rejected.

4 Coupling and fluctuations

Part three concentrates on the influence of the interaction between markets on the dynamics of the aggregate economy, to answer the question: Which is the influence of interdependency between different sectors on the dynamics of the aggregate economy?

This part follows Goodwin(1947), who analyses the influence of the price dynamics of two goods: an intermediary good used for the production of the final good. Morishima(1992) analyses the Japanese economy as a system consisting of two sectors. Potentially, the lack of co-ordination between the banking system and the production sector is a source of instability. He sees “a visible collaboration between industrial and banking sectors” (Morishima(1992), 110) as one of the major factors of the post-war growth of Japan and Germany. The models developed in part three contain aspects of Goodwin(1947), Morishima(1992), but also elements of Foley(1987) and of the monetary-real cycle of Hayek (1933), who both identify the relationship between production, the funding of (working) capital and the behaviour of the banks as sources of fluctuations.

Two sectors are distinguished. A financial or monetary sector in which firms demand funds to finance their working capital (the wage funds and the costs of other inputs) and banks provide credits, backed by savings. Within the monetary sector, the rate of interest is determined. Production takes place using capital and labour. Within the second sector, the labour market, the wage rate is determined. Because wages and the rate of interest influence profits and so entry and investment, the two markets interact.

Two situations are analysed. Firstly, the situation in which each market fluctuates. In both markets, the participants exhibit predator-prey behaviour. The fluctuations in wages and the rate of interest cause the aggregate economy to fluctuate. The second situation assumes the economic subjects to strive for equilibrium on each market. Depending on the behavioural
parameters of each market and the coupling between those markets, the aggregate economy will exhibit chaotic fluctuations.

**Predator-prey behaviour**
Modelling the labour and money market as adjusted predator-prey models gives rise to quasi-periodic and periodic cycles, as was shown by the Lyapunov characteristic exponents. The interest rate influences the labour market dynamics through its effect on the rate of profit and so on the rate of utilisation. In turn, the rate of utilisation determines the demand for funds in the credit market. Both markets influence one another. It is not surprising that the coupling of two fluctuating sectors results in a fluctuating economy.

Simulations show fluctuations in the economy, influenced by the two-sided feedback, to be unbounded. The government is assumed to supply bonds at a minimal interest rate, to avoid the savings and the interest rate becoming negative. The aggregate economy displays persistent fluctuations. These fluctuations deviate from those in the partial markets. The amplitude of the fluctuations rises in periods of co-movement of the variables, whereas it is moderated in the following periods of conflicting dynamics in the two sectors.

The periodicity of the cycle in each market plays an important role, as is also shown in simulations. When the deviation between the periodicity of the cycles in the markets is sufficiently large, the observed relationships between the prices of the factors of production (labour, funds) and between savings and the rate of utilisation is the reverse of the theoretically expected correlations.

Short-term government intervention affects only the short-term time path of production and inflation. When the economic system is unstable, the monetary authorities have to intervene, before the interest rate becomes negative. The economy, then, returns to its long run fluctuations. Only by changing the structure of the economy (intervening in the economic behaviour of the market participants), government action is effective.

Three kinds of interventions were analysed.

1. partial policies: intervening in only one market. The interventions, which were analysed, were:
   - a restriction on the level of the desired net credit creation, raising fluctuations in the credit market and so in the aggregate economy.
   - a rise in the bargaining power of labour. This does not influence the equilibrium level of employment. The effect on inflation depends on the periodicity of the cycles in both markets.
- setting the minimum interest rate at the desired interest rate, so the credit market does not fluctuate. The fluctuations in the aggregate economy are equal to those in the labour market.
- a tax policy which reduces labour costs. This increases employment without influencing the fluctuations in the aggregate economy.

When fluctuations in one market become smaller, the influence of this market on the fluctuations in the other market becomes less. The aggregate economy fluctuates less.

2. shifting markets: intervening in one market, but with an effect on the parameters in the other market.
A rise in the equilibrium level of the interest rate, demanded by the savers, raises fluctuations in the credit market, because net credit creation rises. The rise in the level of the interest rate depresses the demand for credit because the costs of production rise. Inflation rises and employment declines, whereas the fluctuations in the aggregate economy rise.

3. integrated policies: changing conditions in both markets.
The government can support the rate of profit by providing a subsidy, which is financed by creating money. This subsidy influences both markets. Firstly, it lowers the desired profit rate, stimulating utilisation. Secondly, the rise in the money supply raises the liquidity of the firms. Because of the rise in liquidity, the demand for funds is reduced, thereby reducing the equilibrium level of savings. Both the desired rate of profit and the interest rate decline. Employment rises and inflation declines.

Theoretically and on average there is a negative correlation between inflation and employment: when utilisation increases, this raises supply. Because demand partly depends on utilisation in the former period, demand rises less than supply. This lowers inflation, whereas the rise in present utilisation raises employment.

When inflation and employment are calculated using simulations, there appears to be a positive relationship, confirming the empirical positive correlation of the Phillips curve. This positive correlation is caused by continuous shifts in the underlying inflation-employment relationship, as the parameters of the inflation-employment relationship depend on the savings rate and the wage share. Only when the cycles in the partial markets are synchronised, the theoretical negative relationship re-appears in the simulations.

The dynamics in inflation and employment have a common cause, but there is no causal relationship between both variables. The government cannot exploit the seeming correlation between inflation and employment. A higher level of inflation will not cause employment to rise. As seen above,
it is possible to raise employment, but the effect on inflation depends on the action chosen and the periodicity of the cycles in each market.

Linear behavior
The assumed non-linear predator-prey behaviour in both markets is responsible for the occurrence of cycles. The appearance of fluctuations in the aggregate economy is, therefore, no surprise.

In chapter six it is assumed that the participants in both markets behave in a ‘linear’ way. Using partial models of the credit market-production economy and the labour market-production economy it was shown that (irregular) fluctuations only appear when there is either a high adjusted capital productivity or a high credit-wage share ratio. When the magnitude of the behavioural parameters is such that irregular and chaotic fluctuations occur in the partial models, either a negative interest rate (in the credit market-production economy) or a negative wage share (in the labour market-production economy) has to be accepted. By choosing intuitive plausible parameters, each partial model will move towards its equilibrium position. The economy does not exhibit fluctuations because of the behaviour on the independent markets, in contrast to the situation in which two predator-prey markets were coupled.

However, the aggregate economy will exhibit persistent irregular fluctuations when the markets interact with each other through the profit rate and capital accumulation. The occurrence of the fluctuations has three sources:

a. the behaviour on partial markets
The first source of chaos originates in the behaviour of the economic subjects. As stated before, the reaction parameters on each market are bounded above to ensure a positive wage share and interest rate. In the case of partial analyses, these parameters are such that they result in a stable market equilibrium (variables return towards their equilibrium value after a distortion).

When the equilibrating forces are strong, the dynamics on the labour market and the money market both push the profit rate towards its equilibrium value. The profit rate will overshoot this equilibrium level, resulting in persistent fluctuations.

b. the coupling between markets
The second factor is concerned with the magnitude of the parameters determining the coupling: the profit-investment ratio and the credit-wage share ratio. Using bifurcation diagrams and simulations, it is shown that the influence of the coupling depends on the behaviour in the partial markets. If the combination of partial behaviour gives rise to fluctuations, a higher coupling parameter enhances the possible occurrence of chaotic fluctuations.
When the behavioural parameters rule out fluctuations, the coupling parameters cannot generate fluctuations.

The coupling of the markets is a necessary, but not sufficient condition for the occurrence of fluctuations.

c. market equilibria
The equilibria in each market (the credit market and the labour-production market) can be characterised by the capital stock necessary for the market to clear. There is no mechanism that guarantees the two markets to clear at the same level of capital stock. The capital stock, necessary for general equilibrium, will be between the two capital stocks necessary for equilibrium on the markets. This potential discrepancy between the capital stocks necessary for the equilibrium on each market and the aggregate equilibrium is another possible source of fluctuations.

Using simulations several situations were analysed. It was shown that when the capital stock required by the money market equilibrium was above the capital stock required by the labour market equilibrium chaos appears for values of the parameters below those parameter values necessary for positive rewards. When the capital stock required by the money market equilibrium was below the capital stock required by the labour market equilibrium, chaos could not appear. This shows that the aggregate dynamics depend on the relative magnitude of both equilibrium levels of the capital stock.

The dynamics of the aggregate economy cannot be derived from research of the behaviour on the independent partial markets. When the coupling is ignored, dynamic analyses of the partial models show, for realistic parameters, a strong movement towards the market-clearing level of the capital stock. Only when the coupling is taken into account, irregular and chaotic fluctuations can occur.

The inflation-employment relation
To derive an inflation-employment relationship for this model, additional assumptions have to be made. The confrontation between nominal demand and real supply is assumed to determine the price level, whereas the labour intensity and the capital stock determine employment.

The reaction of the demand for labour to the nominal wage rate results in fluctuations in the labour market. In turn, the changes in the labour intensity influence the reaction of the capital stock to disequilibrium.

These assumptions will result in a long wave in the labour intensity. This long wave is disturbed by short-term fluctuations, caused by the equilibrium-seeking adjustments in the capital stock.
During the long-term upswing, production is more labour extensive causing the capital stock to move towards its equilibrium value. When the economy approaches its equilibrium position, the labour intensity increases, which causes the labour market to 'overshoot' its real equilibrium wage rate. The labour intensity rises further and the profit share declines drastically.

The recovery in the nominal sector takes more time because of the assumed lag between the capital stock adjustments and the nominal wage rate. The long-term wave moves the capital stock away from its equilibrium position during the downswing and the labour intensity rises, so adjustments become more hectic. The resulting dynamics show an asymmetric cycle: a smooth upswing followed by a distorted downswing: short-term fluctuations are mild during a long-term boom, whereas the fluctuations during the long-term downswing are chaotic.

**Government policies**

Government policy was not treated explicitly because of the complexity of the model. Some intuitive conclusions can be reached when it is assumed that the equilibrium level of the capital stock in the government sector differs from that necessary for equilibrium in the labour and money market. The equilibrium stock of capital for the government sector depends on the objectives of politicians or bureaucrats, for example the level of capital that results in full employment or a minimal level of inflation. The government interventions will add an additional disturbing force to the economy. As the labour and money market move the economy towards their equilibrium level of the capital stock, the government will try to influence the aggregate outcome by their tax policies. This will be even more disturbing when the government behaviour can be described by a Nordhaus(1975)-like political business cycle. As before, the feedback mechanisms can result in persistent (chaotic) fluctuations.

Concluding, it was shown that:
1. even when behaviour on the partial markets can be represented by linear behavioural equations, for which the partial markets move towards a market-clearing equilibrium, the coupling can cause the economy to exhibit persistent (chaotic) fluctuations.
2. the fluctuations in the aggregate economy can deviate substantially from the fluctuations which are expected of analyses of the partial markets.
3. it is not the deliberate usage of market power of one of the economic agents or the lack of information on the part of the market participants which causes the economy to fluctuate. It is the lack of co-ordination, the incompatibility of equilibria on different markets and the equilibrating behaviour that causes the occurrence of chaotic fluctuations.
5 Final conclusions

In this thesis a review was given of theories, giving an explanation for the occurrence of endogenous economic fluctuations. The major causes of these fluctuations were found in:
- the relation between the interest rate, savings/credits and the behaviour of the banks;
- the conflict over income (profits versus wages) between workers and entrepreneurs;
- the decisions on investment and production, within firms, based on prices and costs;
- the behaviour of non-economic groups, such as politicians, who have a stake in the performance of the economy and the possibilities to influence the behaviour of the other stakeholders;
- the psychological factors governing economic behaviour.

Chaos was introduced as a way to model persistent irregular fluctuations. Whether actual economic fluctuations are determined by chaos is still an open question. Due to the empirical problems, this hypothesis can be neither confirmed nor rejected. To control chaotic economic systems, there are three methods:
- a variable is monitored continuously and corrected through discrete actions to keep it within certain stable boundaries;
- the control parameter(s) is (are) adjusted so the model is kept within the stable boundaries, for example by using an automatic stabiliser;
- the crucial non-linearity within the system is removed, by permanently changing the behaviour responsible for the non-linearity.

Generally, in economics, interventions involve interfering in the behaviour of the economic agents, which is subjected to large uncertainties. These methods of control demand a large amount of knowledge of the system, as a chaotic system has its specific empirical problems. The first method requires knowledge of the magnitude of the ‘stable’ boundaries. Corrections that are too small are ineffective, corrections which are too large cause the variable to enter the unstable corridor. For the second method knowledge is required of:
- the parameters which are the control parameters and
- the actual and desired magnitude of these parameters.

Removing non-linearities demands not only a considerable understanding of the structure of the economy, but also a major influence regarding its functioning.

The models developed in the last part are based on the first three causes mentioned above and concentrate on the influence of a coupling between the monetary sector and the labour market on aggregate economic fluctuations. Both models show that the aggregate fluctuations, resulting from the coupling of markets, deviate from the fluctuations in the
independent markets. The synchronisation of cycles in the individual markets was shown to be of major importance.

Given the complexity of the economy, with many markets, each clearing at another level of capital and in the presence of equilibrium searching behaviour, the possibility of chaotic economic fluctuations is evident. Taken the empirical enigmas, information on the actual state and structure of the economy is difficult to reveal. So, fluctuations are inherent to the free market-oriented way of production. Even when the political business cycle is ignored, the potentiality of stabilising policies is only modest. Prosperity and depressions are, and will remain, part of economic life.