The business cycle: dynamical coupling and chaotic fluctuations

de Langen, F.

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CHAPTER 1

GENERAL INTRODUCTION

"The economy is a complicated, dynamic, non-linear high dimensional and evolving entity, so studying it will be difficult. Society and its social system both alter over time, laws change and technological innovations occur, so establishing invariants of the system will not be easy" (D. F. Hendry (1995), 5)

1 Introduction

The main subject of this thesis is economic fluctuations. Both in the short run and in the long run, economies have always displayed booms and depressions. Prosperity and depression have alternated. Fortunes are made and lost. Unemployment and poverty as well as high employment and abundance occur in successive periods. Examples of these successions of down- and upswings over the past century are given in figure 1.1 (Netherlands, 1901-2001) and in figure 1.2 (USA, 1873-1985).

Business cycle theories and research are part of the macroeconomic research tradition. Boehm, in *Understanding business cycles* (Klein(1990)), identifies two kinds of business cycles. The classical business cycle, which is defined as recurring expansions and contractions in the absolute level of aggregate economic activity and growth cycles, which consist of fluctuations in the rate of growth of economic activity (Klein(1990), 28). Figures 1.1 and 1.2 are examples of the second definition.

An historical approach to the business cycle
Economists have analysed time series and developed different theories to explain the succession of prosperity and depression. Controversies between different business cycle theories stimulated further research. The second chapter of this thesis shall answer the question: Which theories have been put forward to explain economic fluctuations?

The description of business cycle theories follows the approach of Haberler(1937). This historical method can be criticised because it gives an interpretation of historical theories in a modern language\(^1\). Yet, many insights from the ‘older’ theories can be and are used to analyse the modern economy. As in Haberler(1937), the business cycle theories are classified using the distinction between impulse and propagation mechanism (Frisch(1933)). Here, an analogy with a rocking chair is often used. Picture a chair in rest, which is given a push (the impulse). Depending on the presumptions with respect to the character of the chair (the propagation mechanism) and the force of the initial push different kinds of movement

\(^1\)Blaug(1998, 7/8) calls this method “rational reconstruction” or “absolutism”. He concludes that rational reconstruction is acceptable, when the historical context is accepted.
can result. If it is an ordinary chair, it only moves in one direction, immediately resuming its initial position when the pushing force ceases. If the chair is a rocking chair, it can show declining movements (dampened fluctuations), ongoing rocking (continuous fluctuations) or even fall over (become unstable).

Some approaches assume the economy to exhibit a strong tendency towards equilibrium. In this case, both the impulse and the propagation mechanism matter. Fluctuations do occur either as a dampened adjustment after an external shock or because of continuous exogenous disturbances. These kinds of theories are labelled the exogenous approach.

Other approaches see fluctuations as the endogenous result of the structure of the economy. The propagation mechanism ensures continuous fluctuations: each expansion carries the seeds of the following depression. This approach is labelled the endogenous approach.

This distinction is important as it determines the methods used to analyse economic time series. The extreme variant of the exogenous approach tries to identify the succession of exogenous shocks, responsible for the ongoing fluctuations. This approach is often augmented by a propagation mechanism, which explains the occurrence of dampened fluctuations after the initial shock. The endogenous approach concentrates on the propagation mechanism: ongoing fluctuations are inherent to economic life. These different kinds of analyses also influence the possibilities and the methods to reduce economic fluctuations. When the economy is inherently stable (exogenous approach), fluctuations are caused by misinterpretations or misinformation. To reduce fluctuations, the government should provide a stable environment and perfect information. Discrete policy should counter incidental shocks. Independent government action is often seen as one of the major sources of fluctuations. If, however, the economy is inherently unstable, fluctuations are the result of endogenous mechanisms. In this case it is both possible and desirable for the government to intervene in economic life.

At the beginning of the 20th century, mathematics were introduced in economics. The former verbal business cycle theories were rewritten by economists such as Frisch and Tinbergen, who used explicit mathematical models. These models mainly showed dampened dynamics. Fluctuations will only appear for special parameter constellations or are absent. This added an additional dimension to the controversy over the occurrence of economic fluctuations. Or, as stated by Frisch(1933, 197): "The examples [..] show that when an economic system gives rise to oscillations, these will most frequently be damped. .. Have these dynamics laws deduced from theory and showing damped oscillations no value in explaining the real phenomena, or in what respect do the dynamic laws need to be completed in order to explain the real happenings? .. They only form one element of the explanation: they solve the propagation problem. But the impulse
problem remains”. According to Frisch (1933, 203) the explanation lies in “the elucidation of the general laws governing the effect produced by linear operations performed on erratic shocks”. Or, as Yorke, quoted by Gleick (1987, 68), remarks “When they [investors] see a complicated pattern of prices, they look for some periodicity wrapped in a little random noise”.

Chaos and economics
The conclusion that explicit mathematical descriptions of the economy generated only dampened fluctuations casts doubt on the validity of the endogenous approach to the business cycle. If it is not possible to derive a mathematical model that could generate realistic cycles, how useful is the endogenous approach?
In 1960, according to Gleick (1987, 83), Mandelbrot was surprised to recognise his chaotic diagrams in time series on cotton prices. As mathematicians became interested in economic time series, chaos was introduced in economics. Chaotical mathematics makes it possible to describe a seemingly erratic phenomenon using a deterministic model. Even in the absence of exogenous disturbances, continuous fluctuations occur ‘as if’ the system is disturbed by continuous shocks. As stated by Pohjola(1981, 37): “Chaotic solutions of deterministic difference systems offer an alternative explanation: non-linearity combined with discrete adjustment mechanisms can generate the irregularities.” The second part of this thesis, chapter three and four, concentrates on the application of ‘chaos theory’ in economics. The question to be answered is: Is it possible to use mathematical methods to build explicit economic models generating endogenous and persistent irregular fluctuations?

Different kinds of models are analysed. A drawback of the usage of chaos is the complexity of the mathematics. To avoid this drawback, all models are rewritten. Using the original behavioural assumptions, a logistic equation is used to prove the possible occurrence of chaos in these business cycle models. The economic analytical question is: Which (behavioural) assumptions are responsible for the occurrence of fluctuations?

The models in the second part of the thesis focus on the behaviour that is responsible for the occurrence of chaotic fluctuations, such as consumption behaviour, investment or the setting of the interest rate. In terms of Vercelli and Dimitri(1992, xv) this behaviour concerns the co-ordination of individual economic choices and activities. Or, as Leijonhufvud (in Vercelli and Dimitri(1992), 29) asks: “Will the market mechanism work “automatically” even if people are not so smart?”

Coupling and fluctuations
Another approach states that “each market is an efficient allocative device within its own boundaries, but this does not rule out the possibility of co-ordination failures across markets” (Vercelli and Dimitri(1992), xvi). Given
the complexity of the aggregate economy, it may deviate from the Walrasian equilibrium, whereas partial markets are adjusting optimally. The third part (chapter five and six) concentrates on the coupling of markets and the influence of the coupling on the occurrence of economic fluctuations. Building on the conclusions of the former parts, different models are developed and the influence of several behavioural assumptions analysed. It will be shown that even when the partial markets are stable, the aggregate economy can display continuous (chaotic) fluctuations. This raises the economic analytical question: Which is the influence of interdependency between different sectors on the dynamics of the aggregate economy?

2 Empirical work and stylised facts

In this introduction, data on the Dutch business cycle are surveyed. Broader econometric surveys on the business cycle can be found in several publications. For a comparison of the German and USA-economies, see Reiter(1995), the French and the USA-economy, see Henin(1995), for the USA-economy, see Blanchard and Fischer(1989) and Klein(1990). Barro and Sala-i-Martin(1995) give a review on earlier empirical work on growth and new empirical analyses for several groups of countries.

The business cycle consists of four periods. Expansion or upswing (Haberler(1937) labels it the period of prosperity) is the period in which the economy recovers from the downswing (depression). The upper turning point, the crisis, is the point in the economic development between (relative) growth and (relative) decline. The revival is the lower turning point. Different types of economic cycles are distinguished and are named after the person first known to have given a full description of the cycle

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Period (years)</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kondratief</td>
<td>40-60</td>
<td>Technological innovations, which change the structure of production</td>
</tr>
<tr>
<td>Kuznetts</td>
<td>15-35</td>
<td>Fluctuations in the construction and sales of major building projects</td>
</tr>
<tr>
<td>Juglar</td>
<td>7-11</td>
<td>Technological neutral changes in the capital stock</td>
</tr>
<tr>
<td>Kitchin</td>
<td>4-5</td>
<td>Differences between the desired and actual investment in stocks</td>
</tr>
</tbody>
</table>

Table 1.1: Different economic cycles.

The fact that the different cycles coincide, brought Schumpeter to the following calculation\(^3\): 1 Kondratieff = 6 Juglars = 12 Kitchens. The coexistence

\(^2\)See for example Kondratieff(1926, 1935).

\(^3\)Schumpeter(1982, 216). Schumpeter did not take the Kuznets in account, noting: "...the three-cycle schema may be looked on as a convenient descriptive device".
of different cycles, with different periods and amplitude, is an additional
difficulty for empirical research.

The growth in GNP in the post war years is undisputed. This growth takes
the form of fluctuations. Whether these fluctuations are less or similar in
periodicity and amplitude compared to pre-war periods is still an open
question, which is not answered here. Despite the difficulties in defining
and measuring the business cycle, some agreement is reached on the stylised
facts of the business cycle (see Blanchard and Fischer(1989); Dore(1993);
Gabisch and Lorenz(1989); Lucas(1985); Danthine in Newman(1992, 409-
410)). The reference cycle, against which all observations are placed, is the
development of (gross) national production. The following list of stylised
facts is derived from empirical work on the business cycle and confronted
with Dutch data (for the cycles in the growth rate: see figure 1.1). The stylised
facts are divided into four categories:

1. Spending
2. Wages and prices
3. Monetary factors
4. Foreign relations

1. Spending
-all components of domestic spending coincide with the cycle in GNP;
-fluctuations in investment are larger compared to fluctuations in
consumption.

This is confirmed by the data taken from the Netherlands. The correlation
coefficient of changes in consumption and changes in production equals 0.8
and the correlation coefficient of (changes in) investment and production is
0.6 (see table 1.2).

2. Wages and prices
-there is little correlation between GNP and aggregate wages, but a positive
correlation can be found between GNP and manufacturing wages, especially
when measured in consumption prices;
-labour productivity moves with GNP;
-the variance of fluctuations in price and output in agriculture is larger than
the variance of other products;
-the amplitude of the fluctuations in profits is larger than the amplitude of
the fluctuations in other variables.

Statistics for the growth rates of GDP (as a proxy for GNP), consumption,
investment, labour costs, productivity and profits are given in table 1.2.

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4See Langen(2000b) for arguments pro and contra.
The correlation coefficient between growth in GDP and labour costs is positive, as was stated by the stylised facts. The variance in the profit rate and in growth in investment is larger than the variance in consumption and labour productivity. The stylised facts on spending and wages are confirmed by the Dutch data.

3. Monetary factors
- correlation between inflation and GNP is small;
- wage inflation has a strong correlation with GNP;
- money growth and GNP are strongly correlated;
- nominal interest rates are pro-cyclical, real interest rates only slightly so.

Table 1.3 gives several statistics for the monetary sector. The expected small positive correlation between inflation (CPI = consumer price index) and GDP (GNP) is found in the data. The wage inflation is represented by changes in unit labour costs. There is only a small positive correlation with GDP. The relationship between money growth (ΔM3) and GDP is also less strong than believed. The short-term nominal interest rate is negatively correlated with growth in GDP, contrary to the stylised facts. Dividing the total period in two gives the following correlation coefficients: 0.16 for 1947-1970 and -0.36 for 1974-2001. On average, the stylised facts on monetary factors are less evident in the data than the stylised facts on the real variables.

4. Foreign relations
Business cycles are international. Fluctuations in small countries depend largely on the fluctuations in international trade, although cycles in larger countries do deviate from the international business cycle. The cycles are asymmetric: the expansion is slower than the depression. Artis, Koutolemis and Osborn(1995, 24) conclude: “with the possible exception once again for

The Business Cycle
Concerning the relation between the domestic and foreign fluctuations, the correlation coefficient between the growth rate of world trade and Dutch GDP is 0.73, whereas the variability in foreign fluctuations (12.4) is higher than the variability of Dutch GDP (2.6) over the same period (1970-2001; see figure 1.3).

The international dependency of a small open economy, like the Dutch economy, led the commission of economic experts of the social-economic counsel of the Dutch government (Commissie Economische Deskundigen van de Sociaal Economische Raad (Social Economic Counsel(1984)), 45 [translation from Dutch]) to the conclusion: “From the research it can be concluded that the domestic business cycle is dominated by foreign business cycles. In relation to the foreign influences the Dutch stabilisation policy ‘s influence is small’. Or, as stated by the so-called ‘Law of Driehuis’ (Sterken(2001), 199) the growth in Dutch GDP is about 40% of the growth in the relevant world trade.
3. Some other relationships

In the third part of this thesis, chapter five and six, two sectors are distinguished: the labour- and the money market. The central relationships are those between the interest rate and the savings rate on one side and the wage share versus production, on the other side. The link between the two sectors is the profit rate. As seen in chapter two, other theories also stress these relationships as major causes of fluctuations. According to these theories both relationships will show a clockwise movement. The next figures give those relationships based on data for the Netherlands.

![Figure 1.4: The relationship between the savings rate and the interest rate, 1953-1999. Central Economic Plan 1972/2001, (CPB, www.cpb.nl)](image)

Looking at figure 1.4, there is a small positive correlation between the interest rate and the savings rate. If the development of the variables over time is taken in account, there is some evidence for a clockwise non-linear relationship.

Furthermore, the wage share-production relationship is approximated by the relationship between changes in the share of labour income in total income \((dAIQ)\) and changes in production \((dY)\), as shown in figure 1.5. Again, taking in account the development in time, an irregular circular movement can be observed.

Although these analyses are only scant, there is some evidence that these relationships are non-linear and can result in cyclical dynamics. In chapter two, the theoretical basis for this relationship will be analysed and this
analysis will be used in chapter five and six to develop a model generating (chaotic) fluctuations.

Figure 1.5: The relationship between the wage share and production, approximated by (changes in) the share of labour income \(dAIQ\) and (changes in) production \(dY\), 1953-1999. Central Economic Plan 1972/2001, (CPB, www.cpb.nl)

Lastly, the time path of changes in the profit share \(dP\) and changes in the level of investment \(I\) are shown in figure 1.6. The relationship is not evident, whereas the correlation coefficient equals 0.5, indicating a positive connection.

Figure 1.6: The time path of changes in the profit share \(dP\) and changes in investment \(I\), 1970-2000. Central Economic Plan 1972/2001, (CPB, www.cpb.nl)
4 Concluding comments

Insight in the causes of short-term fluctuations is relevant even today. The rise of the ‘New Economy’, as the information-based economy is labelled, has changed the way business is conducted today. Yet, production still takes place by combining labour and capital. Labour relations have become more civilised, compared to those in the Industrial Revolution, but the distribution of income over the different macroeconomic categories still causes many disputes and conflicts.

Money has become ‘plastic money’, so the relevance of the old monetary aggregates becomes less. Yet, banks still largely determine the amount of credit available for firms to finance investments and working capital. Because of the internationalisation, competition is larger than before. More data are available on more variables, but the problem to distract relevant information for firms has become more severe. Altogether, the increased demands of consumers, increased government regulations and the increased number of competitors have augmented the complexity of the economy.

‘Old’ mechanisms such as the psychological state of bankers and entrepreneurs and the struggle over income still influence the state of the economy. As Blaug(1998) stated, uncritical adoption of the ‘old’ theories would lead to a misinterpretation of these theories. Yet, analyses of the underlying economic mechanisms are still relevant.

Chapter two gives a review of the different approaches to the business cycle, with an emphasis on the economic relationships causing the fluctuations. Part two (chapter three and four) concentrates on the mathematics of chaos and its application to economics. The same economic relationships as in chapter two will be encountered.

Two of these relationships are central to part three: the wage share-production relationship and the interest rate-savings rate relationship. The first chapter in part three (chapter five) assumes the labour and the money market to exhibit fluctuations because of the ‘predator-prey’ behaviour in each market. In the terminology of Vercelli and Dimitri(1992), the lack of coordination within the market causes these markets to fluctuate. Because the markets influence one another through the profit rate, the aggregate economy will also exhibit fluctuations and may even become unstable.

Chapter six presumes the behaviour of the economic subjects to be such that each market moves towards its equilibrium position. However, because of the mutual interdependency, the aggregate economy will exhibit chaotic fluctuations. The stronger the local tendency towards partial equilibrium on each market is, the larger the chance of the appearance of chaos in the economy.
aggregate economy. The lack of co-ordination between markets causes the economy to fluctuate against the wishes of the participants of each market.

The acceptance of this proposition has many implications. The more complex an economy is, the bigger the chance that - because of the lack of co-ordination - the aggregate economy fluctuates in a chaotic way. Interventions, which enforce local stability (on each market), enlarge the possibility of chaotic fluctuations.

In terms of the 'New Economy': when markets become more transparent, the tendency towards partial market equilibrium will become stronger, stimulated also by the higher competition. Because of specialisation, more markets emerge, increasing complexity and co-ordination failures. The characteristics of the 'New Economy' will lead to large irregular fluctuations when the traditional economical mechanisms take the place of the present optimism.

The structure of this thesis can be summarised as follows. Part one concentrates on the traditional view of the business cycle. The subject of this chapter were the major stylised facts. Empirical economic fluctuations exist, so in the remainder of this part, chapter two, the question is: Which theories have been put forward to explain fluctuations?

In this introduction, it was concluded that a problem of the mathematical translation of the verbal business cycles is either the regularity of the mathematical cycles, or the dampened character of the models, in contrast to the persistent irregular empirical cycles. Part two focuses on the properties of chaos and its applications in economics. This chapter answers the following questions:

Is it possible to use mathematical methods to model economic theories containing continuous irregular fluctuations?
Which assumptions are responsible for the occurrence of fluctuations in these models?

In part three, two different models are developed building on the theoretical foundations in chapter two and the techniques of part two. Purpose is to analyse the effects of the interaction between fluctuating and non-fluctuating markets on the dynamics of the aggregate economy, answering the question: What is the influence of interdependency between different sectors on the dynamics of the aggregate economy?

Chapter seven summarises the main conclusions in this theses and draws some final conclusions on the outcomes.