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Austrian Business Cycle Theory
Examination of Theory and Evidence

Economics

Master's thesis

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Abstract of master's thesis

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Abstract

The purpose of this study is to examine the Austrian Business Cycle theory and the state of empirical evidence for it.

In the theoretical part of the study, the Austrian theory of the business cycle based on the neo-Austrian diagrammatical synthesis was compared to New Keynesian short-run IS-LM and medium-run AS-AD models by studying policy responses. The policy responses to an increase in saving rate and increase in government deficit spending were similar. The policy response to monetary expansion was different between the theories. In New Keynesian theory, monetary expansion can be used as a stabilization instrument. In Austrian theory, it causes an unsustainable investment that is the cause of the business cycle.

The result of literature study on the previous empirical studies on Austrian business cycle theory was that there has not been a hypothesis that could be used to statistically test distinctively the Austrian business cycle theory. Currently there is no credible empirical evidence for the theory.

In the empirical part of the thesis, the relationship between consumption, investment and monetary policy was studied using Vector Error Correction Model (VECM). Spread between short and long term interest rates was used as a proxy for the monetary policy. The model was estimated using U.S. data from 1963 to 2014. The impulse-response functions of the VECM model indicated that a monetary policy shock causes an economic stimulus that peaks after 20 quarters for consumption and after 16 quarters for investment. The results of the empirical study are consistent with both Austrian and New Keynesian theory.

Keywords Austrian school of economics, Austrian business cycle theory, capital, VECM

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1 Introduction

Business cycles, or large fluctuations in macroeconomic aggregates, are an important area of study in macroeconomics, because large economic fluctuations have significant negative consequences for the well-being of individuals.

Starting from the 1960s, the volatility of the output fluctuations in the U.S. have decreased during a period that is called the Great Moderation (Stock & Watson, 2002). Because of the success of economic policy in regulating the variance in output, the mainstream macroeconomic theory was widely accepted and the problem of regulating business cycles was considered to be largely solved.

Following the global Great Recession of 2008-2009, there has been a resurge in research in macroeconomic theory of business cycles. Reasons for this are two-fold. First, the recession cycle was of great intensity and caused significant economic fluctuations, and secondly because of the challenges of the macroeconomists to predict and explain the cause of the crisis.

Austrian School of Economics is a heterodox economic school of thought that has not received much attention within the mainstream economic research, partly because of differences in definitions of key economic concepts, and aversion to use statistical methods to test theory.

Austrian School of Economics has its own theory for the business cycles. The core of the theory was introduced by Ludwig von Mises in 1912 and it was later popularized and further developed by Friedrich Hayek, who was awarded Sveriges Riksbank Prize in Economic Sciences in 1974 for his contributions in the theory of business cycles. Roger Garrison has developed a diagrammatical exposition for the theory that has been labeled as neo-Austrian synthesis. Proponents of the Austrian school of economics claim that the Austrian explanation for business cycles fits well to the recent financial crisis (Tempelman, 2010).

The objective of this thesis is to study the Austrian business cycle theory, how it differs from the mainstream New Keynesian view of the business cycle and to explore empirical evidence for the theory.

1.1 Research questions

The objective of this study is to investigate the current theoretical status of the Austrian business cycle theory, and to examine if there exists empirical support for the theory.

The research questions of this thesis are:

Part 1: Theory

> **1A**: How does Austrian Business Cycle theory explain the economic cycles?
>
> **1B:** What are the main differences between the mainstream New Keynesian theory and the Austrian business cycle theory?

Part 2: Empirical evidence

> **2A:** Are there previous empirical studies to support the theory?
>
> **2B:** Trying to reproduce an empirical study.

1.2 Results

This chapter summarizes the main results of the study.

The Austrian Business Cycle Theory explains the economic cycle by credit expansion that is not supported by an increase in voluntary saving.

The main difference between the Austrian business cycle theory and the mainstream New Keynesian theory is that the Austrian business cycle theory includes the aggregate duration of the capital stock in the model, from which the adverse effects of credit expansion follow. The policy responses of the Austrian and New Keynesian theories to an increase in saving rate and government deficit spending are consistent. However, the policy responses to monetary expansion are different, in Austrian theory it initiates unsustainable growth that is the beginning of a business cycle.

Based on literature study there is no statistically testable hypothesis to empirically assess the validity of the theory. Currently there are no credible econometric studies to support the theory.

In the empirical part of this study a vector error correction model was constructed to study the relationship between consumption, investment and monetary policy.

1.3 Thesis structure

Chapter 2 introduces the Austrian school of economics and Austrian business cycle theory. Chapter 3 compares the Austrian theory to the New Keynesian macroeconomic theory.

The results of a literature study of previous empirical studies in presented in chapter 4. The econometric model used in this thesis is presented in chapter 5, data in chapter 6 and the results of empirical study in chapter 7. Chapter 8 contains the conclusions of the study, main findings, theoretical contributions and ideas for future research.

2 Austrian business cycle theory

This chapter introduces the Austrian school of economics and the Austrian business cycle theory.

2.1 Austrian School of Economics

Austrian school of economics originated from late 19th and early 20th century Vienna. Some of the notable scholars were Carl Menger, Friedrich von Wieser and Eugen von Böhm-Bawerk. The early work focused on subjective theory of value, interest and capital. Later important theorists were Ludwig von Mises and Friedrich Hayek, who shaped the Austrian theory of the business cycles (Taylor, 1990). Hayek was awarded Sveriges Riksbank Prize in Economic Sciences in 1974 for his contributions in the theory of business cycles.

The methodology of Austrian school has traditionally been based on theoretical and deductive reasoning and has opposed using mathematics in economic analysis. In Austrian school, conceptual understanding, and not quantitative relations, is seen as the only meaningful basis for economic analysis (Taylor, 1990).

The rejection of mathematical analysis is first reason why Austrian economists have been mostly absent from the contemporary mainstream economic debate. Second reason are differences in some fundamental macroeconomic concepts, as described below.

Austrian school defines inflation as a general increase in the money supply (von Mises, 1979), and sees general rise in prices as a consequence of that. The mainstream macroeconomic definition of inflation is a general rise in consumer prices. Von Mises (1979) emphasizes that the mainstream definition blurs the causal relationship between the concepts.

GDP is an often used variable to measure the economic output of a national economy. However, as with other aggregates, Austrian school sees multiple problems with using GDP as a comparison between countries. First, not all of the constituents of GDP are market priced. Significant part of economics of the so called welfare societies are public consumption that does not have a fair market price. The resources of an economy might be fully utilized, and GDP reflected that, but simply wrong things might be produced with the resources (Horwitz, 2000, p. 41).

2.2 Austrian business cycle theory

This chapter introduces the concepts of Austrian business cycle theory. Chapter 2.2.1 introduces the Hayekian triangle that is a central concept in the theory, chapter 0 describes the model for the market of loanable funds and chapter 2.2.3 introduces the sustainable production possibilities frontier.

2.2.1 Hayekian Triangle

For Austrian business cycle theory, a central concept is capital, and the Austrian concept of capital is illustrated by a Hayekian triangle, named according to Hayek (1931). It gives capital two-dimensions: The first dimension is value that can be expressed in monetary terms, and the second dimension is time, which denotes the time that elapses between the applying the production process to input and eventual emergence of the consumption good associated with them.

The Austrian view of capital differs from classical and neoclassical approaches to capital, which is, according to Horwitz (2000, p. 42), that capital is seen as a homogenous entity that semi-automatically generates value. The details of the process of the value creation are not taken into account.

Austrian capital theory takes account the intertemporal structure of the capital in producing goods. The entrepreneur constructs a plan to meet consumer demand, and with this plan the entrepreneur gives value to capital goods. Including the structure of the capital into consideration explains why Austrian school distinguishes between overinvestment and malinvestment (Horwitz, 2000).

The process where capital goods are produced, and then utilizing the capital goods, final consumption goods are produced, is called roundabout methods of production or *roundaboutness* in the Austrian school.

In the original definition of Hayekian triangle (Hayek, 1931) multiplying each portion of capital invested at any moment by the length of time for which it remains invested leads to *aggregate production time (APT)*. The dimension of this variable is a monetary unit multiplied by time. As with all macroeconomic aggregates, there are problems in aggregating, even conceptually, the production time associated with different pieces of capital. However, this conception that connects capital and time will reveal useful insights into the workings of the economy.

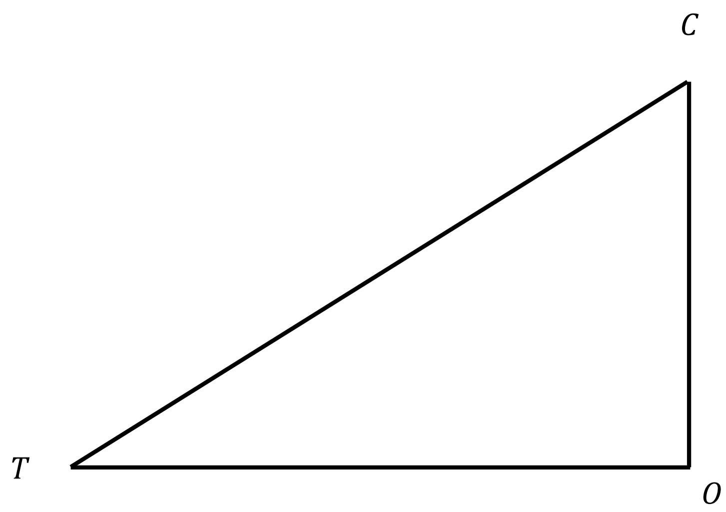


Figure 1: Hayekian triangle

Figure 1 shows the Hayekian triangle. Line OC shows the value of consumer goods that is produced. Line OT shows the amount of time that is used for the production. The slope of line TC represents the rate of increase in value per unit of time per unit of currency that has been invested at T with realized return C. Thus, the slope of TC is the simple rate of interest of investing in production.

The Hayekian trinagle can be used to represent variety of capital goods. There can be fixed and circulating capital goods. Examples of fixed capital goods are factories, machinery and other fixed capital that is used in the production. Examples of circulating capital goods are half-manufactured goods and inventories. This conception does not differentiate between the two, because form the perspective of human action, which aims at consumer goods, the difference is not relevant (de Soto, 2009).

Durable consumer goods, that satisfy consumer needs over a long period of time, can be thought as being in several stages at once: The final stage that is currently being consumed and various intermediate stages according to their duration that will be consumed in the future. (de Soto, 2009).

This triangular model is a very simplified representation of production that occurs in the real world. The changes in the shape of the triangle gives an indication of the type of changes that happen in real world.

An important economic concept is illustrated by the straight hypotenuse of the triangle: The rate of profit in the different stages of economic activity have tendency to equalize through arbitrage: If a certain kind of production provides excessive profits, entrepreneurs will invest their efforts to those activities that generate relatively higher profits in the expense of activities that generate lower profits. This mechanism works to equalize the profits of different type of production. (de Soto, 2009).

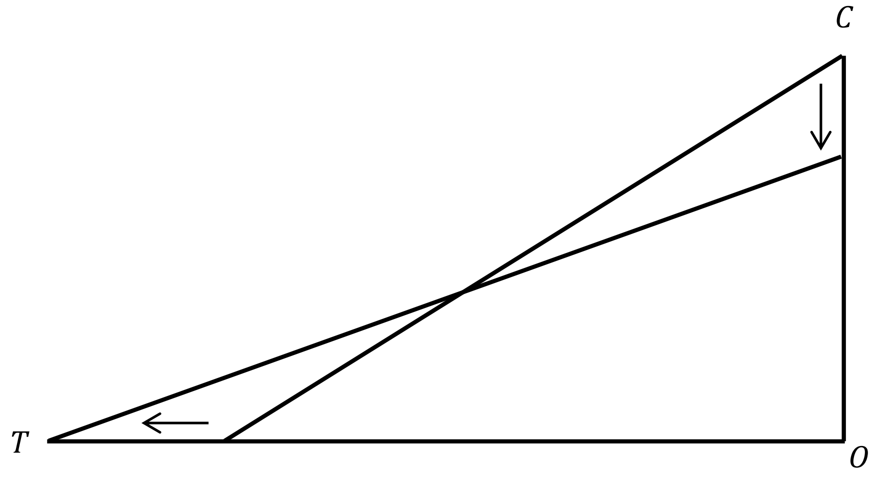


Figure 2: Change in the capital structure.

Figure 2 shows the effect of change in the capital structure caused by increased saving. The effects on the Hayekian triangle are the following:

1. The slope of the triangle (line TC) is less steep
2. The aggregate production time (T) of capital increases
3. The monetary value of consumption (C) decreases

The changed triangle represents changed capital structure that is based on the changed time preferences of the individuals. It is important to note that the decreased value of the consumption does not mean that the consumers would receive less utility, because the new production structure enables increasing the quality of consumption goods.

The Hayekian triangle has been a fundamental concept of the Austrian business cycle theory. However, Cachanosky & Lewin (2014) criticize the aggregate production time in the Hayekian triangle on the following grounds:

1. Economic activities can be present in different stages at the same time, for example energy or financial services that contribute to the whole production process.
2. Looping phenomenon, which means that two industries supply inputs to each other. For example, the energy industry and the financial services industry supply to each other.
3. It is possible that particular industry may change its relative position over the course of the business cycle.
4. A stage of production can grow vertically (increase its value added) but also horizontally.

Cachanosky & Lewin conclude that thinking the terms of production in Hayekian triangle is an oversimplification, and claim that duration is much more practical concept for capturing the same idea. The calculation of aggregate duration for an economy is explained below.

The value of a single investment project (V_p) is

$$V_p = \sum_{t=1}^{T} \frac{(ROIC_t - c_t) * K_{t-1}}{(1 + c_t)^t}$$

where T is the investment horizon of the project, $ROIC$ is the return over invested capital in period t, c_t is the weighted average cost of capital in period t and K is the financial invested capital.

The Macaulay duration (D_p) of the project can be calculated by multiplying each term by time (t) and dividing the sum by the total value (V_p) of the project:

$$D_p = \frac{\sum_{t=1}^{T} \frac{(ROIC_t - c_t) * K_{t-1} * t}{(1 + c_t)^t}}{V_p}$$

The aggregate duration of the whole economy is defined as the weighted sum of durations of individual investment projects, the weight being the fraction of a project of the total value of all projects $V = \sum_p V_p$. The aggregate duration of the whole economy is

$$D = \sum_p D_p * \frac{V_p}{V}$$

Cachanosky & Lewin argue that the complex Hayekian concepts of roundaboutness and aggregate production time can be simply replaced with the aggregate duration of capital of the economy, and that duration is more flexible concept that better corresponds to the real world complexity of capital. In their view the Hayekian triangle is an approximation of a simple special case where the production process is flow input – point output and accumulating value according to non-exponential growth.

In this study we follow the proposition of Cachanosky & Lewin and use the aggregate duration instead of aggregate production time.

2.2.2 Market for loanable funds

The neo-Austrian theory of business cycles is based on a simplified model of loanable funds market.

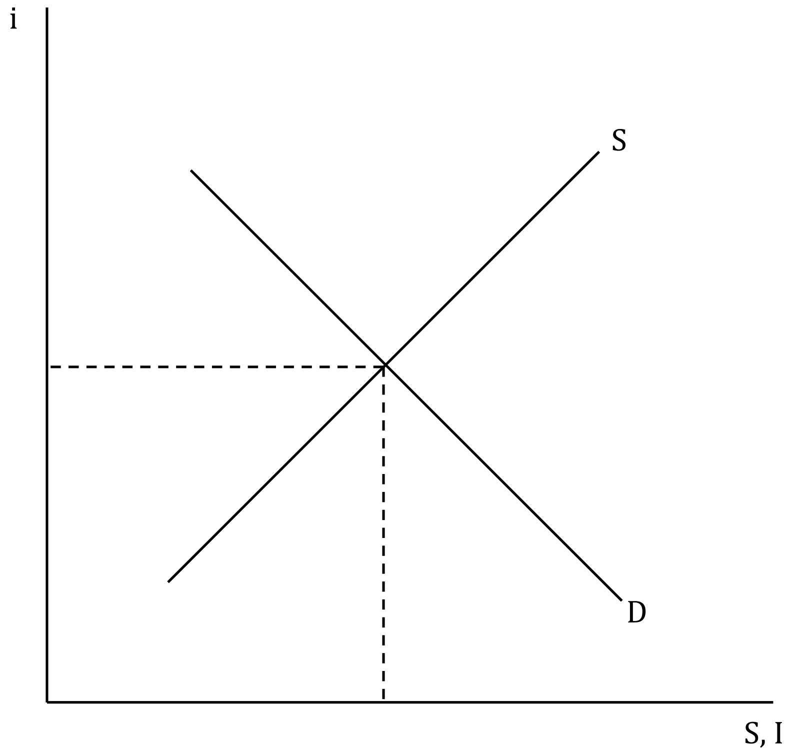


Figure 3: Market for loanable funds.

The market of loanable funds is formed by lenders and borrowers of funds, and the market is brought into balance by movements of the interest rate.

In the horizontal exis, variables S and I represent saving and investment in monetary terms. The vertical axis is the interest rate (i). The supply curve (S) of loanable funds represents the eagerness to borrow the funds, which is increasing with interest rate. Demand (D) reflects the willingness of individuals in the business to pay input prices now in order to sell output at some expected price in the future. Demand naturally decreases with interest rate.

For macroeconomic purposes, the following assumptions are made about the content of the concept of loanable funds (Garrison, 2001):

1. The consumer lending is removed from the supply side of the market. This is because a consumer lending to another consumer results in zero net saving, and in this context we are more interested in net saving.
2. The supply and demand include retained earnings and saving in the form of purchasing equity shares. While the distinction between debt and equity is important in corporate

finance, macroeconomically they have a strong resemblance. Retained earnings can be understood as funds that a firm lends to itself.

3. Amount of money that is kept liquid, i.e. is neither consumed nor invested, is ignored, because it is not a primary focus of this analysis.

The market of loanable funds facilitates the coordination of production plans with individual preferences. With the help of the loanable funds market, the intertemporal consumption preferences of income earners are transferred into intertemporal production plans of the entrepreneurs.

2.2.3 Sustainable production possibilities frontier

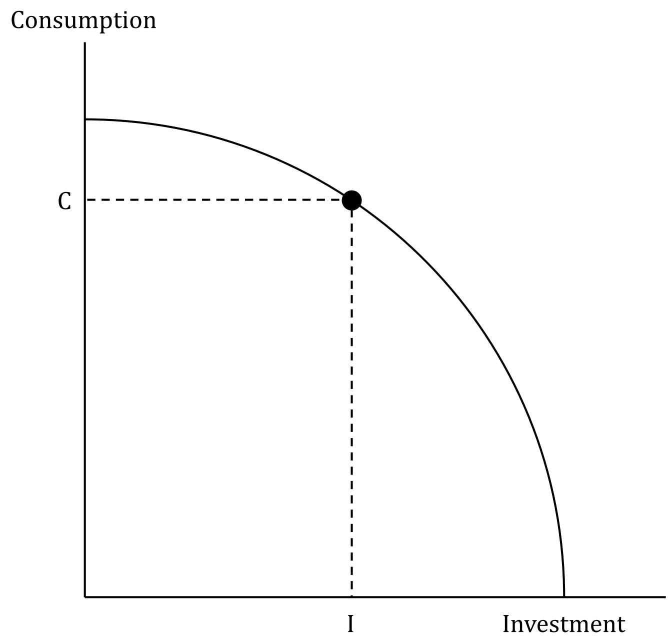


Figure 4: Sustainable production possibilities frontier.

There exists a fundamental trade-off between in the use of income; it can be used for either consumption or investment. This trade-off is presented as sustainable production possibilities frontier in Figure 4. The frontier represents what is sustainable level of output. It is possible for the economy to temporally be outside of the sustainable frontier by utilizing temporary measures, e.g. reducing inventories and working overtime.

Investment is gross investment, which includes replacing capital deprecation. If investment equals deprecation, net investment is zero and the economy does not grow. Positive net investment results in growth of the economy and total income in next periods, which can be depicted by a movement of the whole frontier away from the origin. Negative net investment moves the frontier closer to the origin, respectively.

This drawing describes only the actions of the private-sector of mixed economy. The government spending is assumed to be wholly unrelated to private sector activities.

2.3 Stable growth

In this chapter we link together the diagrams introduced in the preceding chapters to construct what is called the neo-Austrian diagrammatical synthesis, developed by Roger Garrison. The model in this chapter describes a stable growth situation where the rate of saving and investment exceeds the rate of capital deprecation. Without externalities, this leads to a growth where investment is used to build more efficient production equipment, which increases the aggregate duration of the economy, defined in chapter 2.2.1.

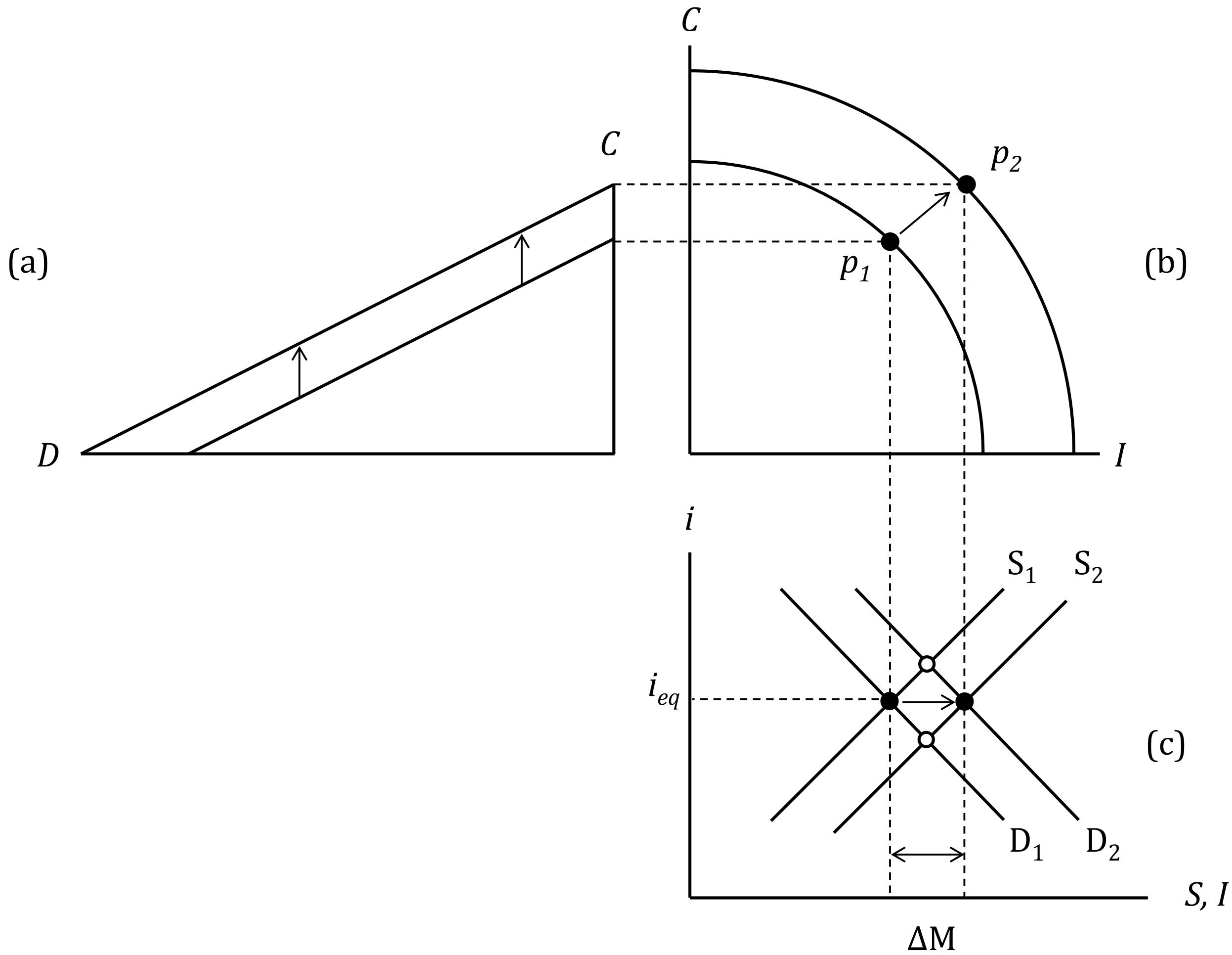


Figure 5: Stable growth in Austrian model (Garrison, 2010)

Figure 5 shows the presentation of stable growing economy using the three interlinked diagrams. The figure shows the changes that are taking place in the economy during normal growth.

In Figure 5a, the capital stock of the economy increases. The aggregate duration of the capital stock increases. The shape of the Hayekian triangle does not change, as the time preferences of the individuals do not change. Also the interest rate is unchanged.

In Figure 5b, the sustainable production possibilities expands because the aggregate duration of the capital stock increases, enabling the use of more efficient production methods. Because of the added income, consumption increases at the same rate. The economy moves from p_1 to p_2.

In Figure 5c, as the economy grows, the supply curve of loanable funds moves from S_1 to S_2. The demand for loanable funds increases also from D_1 to D_2. The interest rate stays in the equilibrium rate i_{eq}, that represents the time preferences of the individuals. The interest rate ensures that the supply and demand of loanable funds are kept equal.

This simplified model assumes that there is no change in technology or individual time preferences. This situation represents a basic model for stable growth of an economy. The next chapter will present the model of unsustainable growth of the economy using the same diagrams.

2.4 Theory of the business cycle

The previous chapter presented the model for stable growth of an economy. This chapter presents Austrian business cycle theory, where the unsustainable growth phase of the business cycle is initiated by a credit expansion in the loanable funds market.

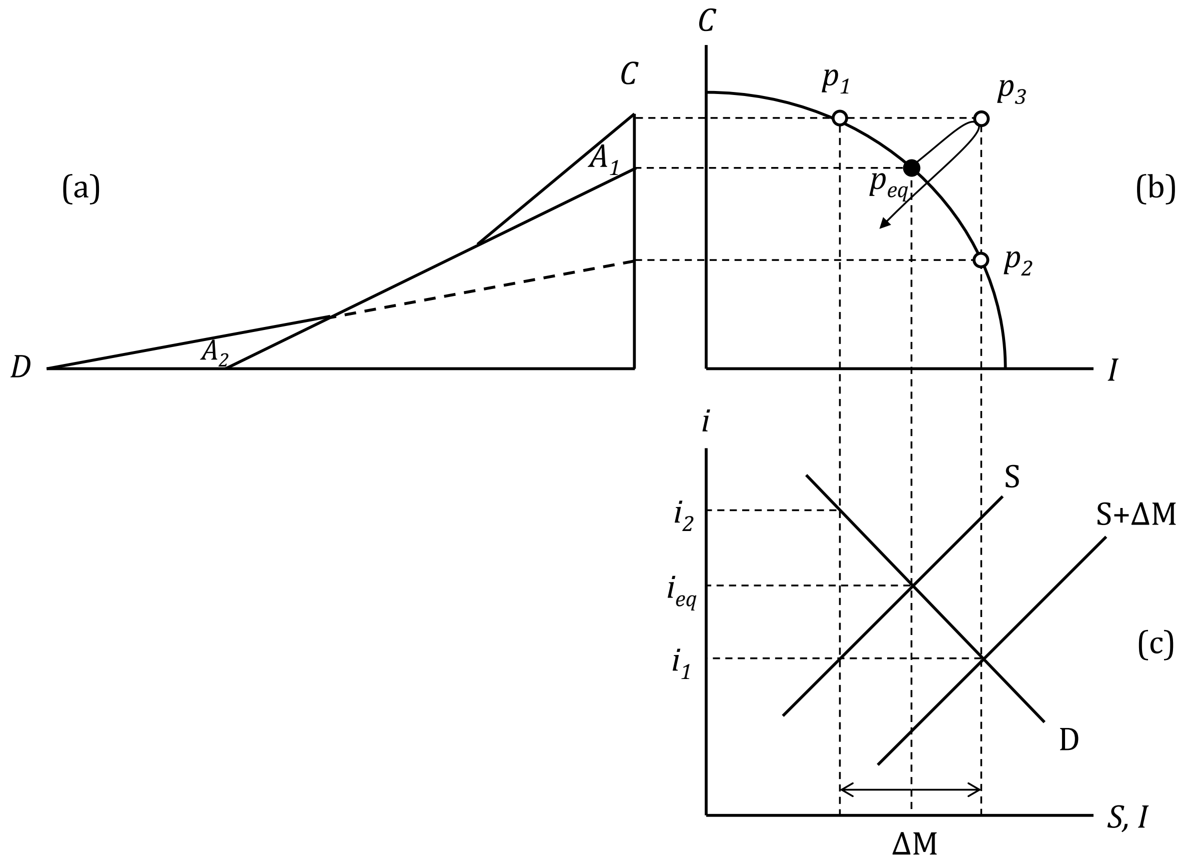


Figure 6: Austrian business cycle (Garrison, 2001)

The cycle begins the loanable funds market where credit expansion ΔM takes place. The effect in loanable funds market is shown in Figure 6c. The supply curve of the loanable funds shifts to right by ΔM while the demand of the loanable funds stays unchanged.

The individuals save less because the interest rate is lower. The individuals consume as if the economy was in point p_1 on the sustainable production possibilities frontier in Figure 6b.

The entrepreneurs see a reduction in the interest rate identical with increased saving level in the economy. The business decision makers see the economy being in point p_2 on sustainable production possibilities frontier in Figure 6b. The entrepreneurs start investing and adapting the production structure to reflect the new time preferences of the consumers.

In reality, the time preferences of individuals have not changed because the decline in interest rate has been caused by credit expansion, and not by increase in saving.

The consumers pulling the economy towards more consumption and the entrepreneurs pulling towards more investment, the combined effect these forces is that the economy starts moving towards point p_3 in Figure 6b. The economy is overheating, i.e. it is operating beyond the sustainable production possibilities boundary.

Figure 6a depicts how the investors and consumers are pulling the Hayekian triangle in two directions. The area A_1 illustrates the overconsumption of consumers. The area A_2 illustrates the malinvestment of capital.

The malinvestment happens, because in the micro level the entrepreneurs evaluate the profitability of investment projects by looking at the net present value (NPV) of cash flows:

$$NPV = \sum_{t=0}^{T} \frac{R_t}{(1+i)^t}$$

where R_t is the net cash flow in period t, i is the interest rate used to finance the project and T is the investment horizon. Because the lower interest reduces the saving and increased consumption, the net cash flows R_t appear larger than their sustainable level because of the increased consumer demand. Similarly, because of the monetary injection the interest rate i is lower than the long term equilibrium interest rate, which also contributes to the higher NPV of the investment.

The expansionary phase of the cycle could only be sustained by accelerating credit expansion. When the credit expansion stops there is an escalation of interest rates, because the entrepreneurs need additional financing to complete the investment projects that they have started (de Soto, 2009).

As a result of the distortion in the investment NPV calculation, entrepreneurs have invested in productive capital with shorter duration. Because low interest rate cannot be sustained, the value of the investments will decline when interest rates increase and lower consumer decreases. It is assumed that at least part of the investments are no longer profitable. The unsustainable investments is called *malinvestments* in the Austrian school. Malinvestment is investment in production capabilities that is not sustainable. Malinvestment eventually causes welfare loss, because after the unprofitability of the investment is realized, not all production investments can be liquidated and used elsewhere.

The economy cannot stay beyond the sustainable production possibilities frontier indefinitely. The scarcity of resources and the continuing high demand for consumption eventually cause the business cycle to turn. The production of the economy starts to fall, and the negative expectations of individuals caused by the rapidly shrinking economy lead the output to fall under the original level of output.

The time it takes for the business cycle to turn depends of the pattern that newly created money is injected into the economy. When the rate of the money creation starts to decline, it depends on the time-horizon of the investments how long it takes before the unprofitability of the investments becomes apparent.

If the monetary authority tries to stimulate the economy by increasing the money supply when the malinvestments are realized and the economy is in recession, the business cycle begins again.

3 Comparison of Austrian and New Keynesian theories

In this chapter we compare the Austrian economic theory to the New Keynesian short-run IS-LM model and medium-run AS-AD model using policy responses to increase in saving rate, increase in government deficit spending and monetary expansion.

The main source for the Austrian macroeconomic theory is Garrison (2010) that contains the neo-Austrian diagrammatical model of Austrian business cycle theory.

It is difficult to define what exactly constitutes the mainstream economic theory, however in the basic policy responses that are discussed in this chapter there is a good consensus about the New Keynesian theory. Blanchard (2010) is used a source for New Keynesian theory.

The mainstream economic theory has multiple explanations for the business cycles, most notably real business cycle theory, credit/debit cycle and financial instability hypothesis. In this analysis we limit the analysis to the policy responses, and do not consider the alternative explanations for the business cycle.

3.1 Increase in saving rate

In this chapter we investigate responses of the models to change in the intertemporal preferences of the individuals, so that the individuals value current consumption less than before and increase their saving rate. Such a change can be caused e.g. by a demographic or cultural change.

3.1.1 Short term IS-LM model

The IS curve is given by $Y = C(Y - T) + I(Y, i) + G$ where Y is the economic output (GDP), C is the consumption function, I is the investment function and G is the government expenditure.

The LM curve is given by $\frac{M}{P} = L(Y, i)$ where M is the money stock, P is the price level and L is the function of real demand for money.

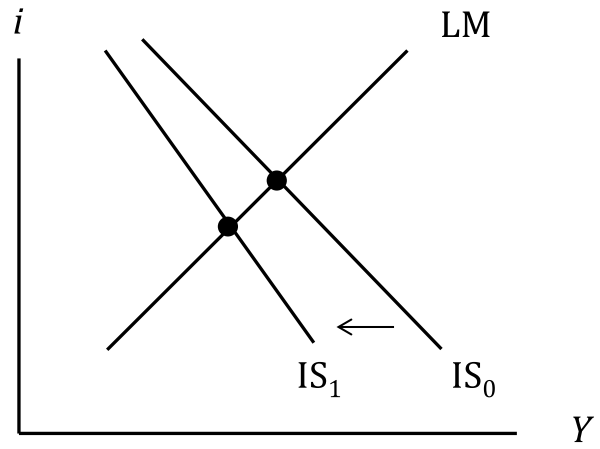


Figure 7: Increased saving in the IS-LM diagram.

The increase is saving decreases the C in the IS-equation so that for each level of Y-T, less of the income is consumed. The IS-curve becomes steeper. This is shown in Figure 7 by changing the IS curve from IS_0 to IS_1, which moves the equilibrium to lower level of income.

The lower income and interest rate also have effect on investment, which depends on term $I(Y, i)$. However, the Y and i have opposing signs in function I. The decrease of Y causes investments to decrease, but decrease in i causes investments to increase.

Thus, in the IS-LM model, the total effect of increased saving is indeterminate, because it depends on the magnitude of the two effects with opposite signs.

3.1.2 Medium-run AS-AD model

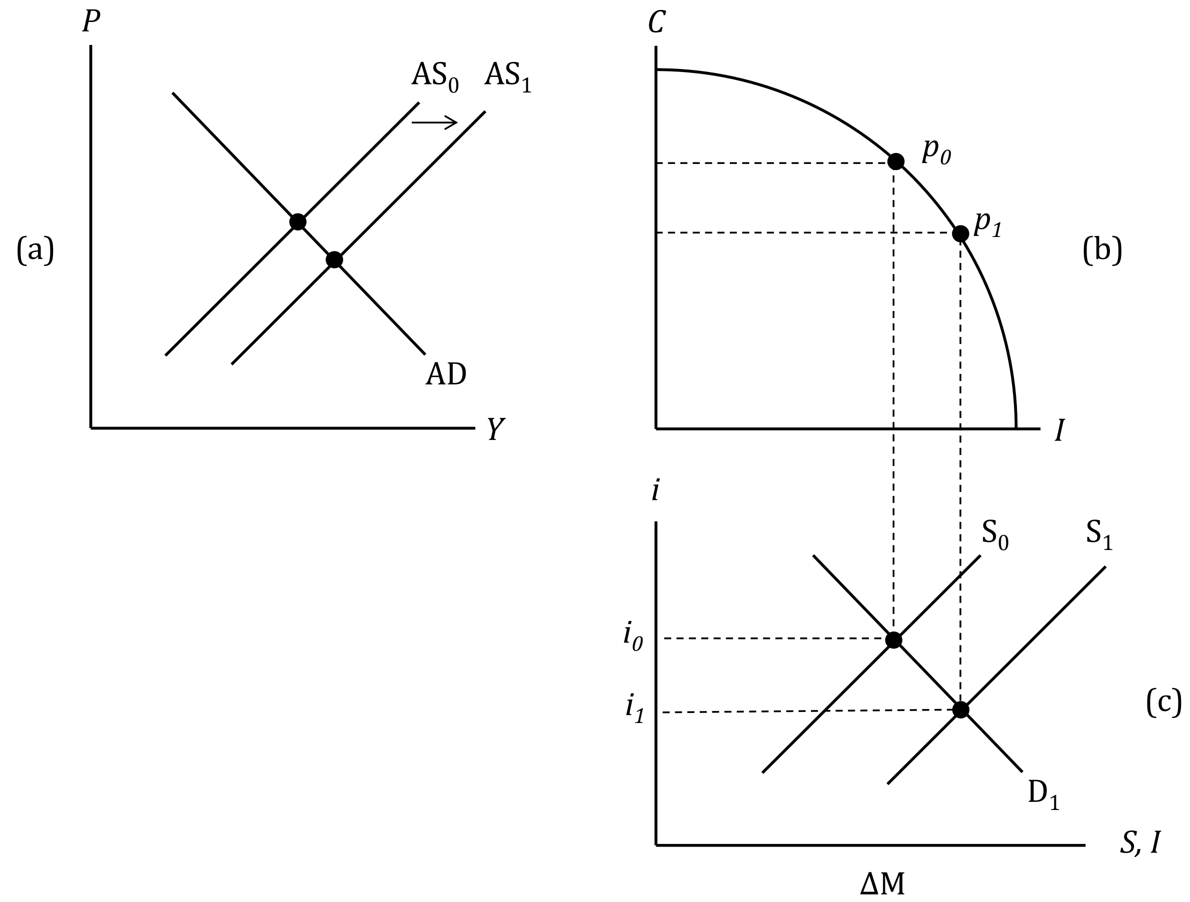


Figure 8: Increase in savings rate in medium run AS-AD model

Compared to the IS-LM model, in AS-AD model the price level is allowed to adjust, and the interest rate is allowed to adjust to the increased saving.

In response to increase of the money supply from S_0 to S_1 the interest rate in the loanable funds market decreases from i_0 to i_1 in Figure 8c. This causes the production mix of the economy to move from p_0 to p_1 in Figure 8b, resulting in less consumption to more investment.

It is assumed that the decrease in consumption is matched by an equal increase in investment, which results that the aggregate demand (AD) curve in AS-AD diagram in Figure 8a stays the same. Because of increased investment, the capital stock of the economy increases and the production is more capital intensive. This shifts the aggregate supply (AS) curve to the right in Figure 8a, changing the AS-AD equilibrium from p_0 to p_1.

The outcome of the higher savings rate in AS-AD model is permanently higher level of output and lower price level.

3.1.3 Austrian model

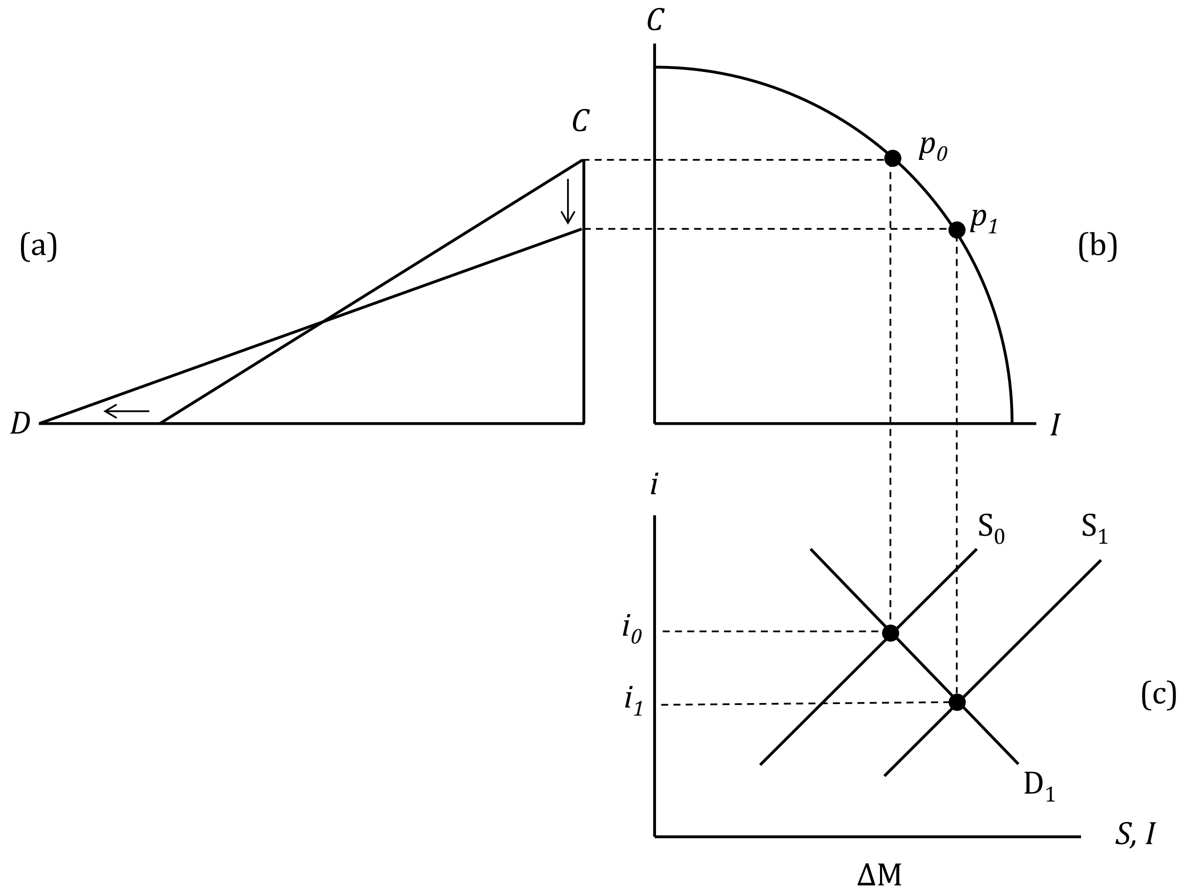


Figure 9: Increase in savings rate in Austrian model

We begin with an economy in equilibrium, with production mix in Figure 9b being at point p_0, and the loanable funds market in Figure 9c having money supply curve S_0 and interest rate i_0.

Because of the increased saving rate, the consumption decreases and the supply of loanable funds curve in Figure 9c shifts right from S_0 to S_1.

Because of increased savings rate, consumption decreases and the availability of loanable funds increases. The loanable funds supply curve shifts from S_0 to S_1. The production mix changes from p_0 to p_1 along the sustainable production possibilities frontier. The Hayekian triangle in Figure 9a changes to more flat shape; because of reduced consumption it has shorter height, and the increased investment causes the aggregate duration to increase which is depicted by a longer base of the triangle.

The result is that the changed intertemporal preferences of the individuals are channeled through the lowered interest rate to the entrepreneurs making investment decisions, and the increased investment increases the aggregate duration of the economy. The production structure of the economy changes to reflect the aggregate time preferences of the individuals. The interest rate is the main channel that the changed preferences are propagated to the economy.

The outcome of increased savings rate is compatible with the outcome of the AS-AD model, although the perspective is different. In AS-AD model the increase in the capital stock shifts the AS curve to right. The Austrian model also considers the change in the content of the capital stock, which changes to have longer aggregate duration. This enables more developed production processes and increases the quality of consumer goods.

3.2 Government deficit spending

The government has two main sources to fund its increase in spending (Garrison, 2001):

1. Taxation. Taxation is a forced transfer of private wealth to the taxation authority. This decreases the supply of loanable funds, which increases the interest rate. From the aggregate investment and consumption, taxation effectively takes the decision making away from the individuals to the taxation authority. The outcome of taxation depends on whether the tax is used.
2. Raising debt means that the government creates debt that is sold in the loanable funds market. This increases the demand for loanable funds, which increases the interest rate.

In this chapter we assume that the source of the funds is raising debt.

The theorem known as Ricardian Equivalence (Ricardo, 1820) assumes that individuals react to the increased government borrowing with increased saving, because they know that government has to raise the tax rate in the future to pay back the debt. This effect would negate some or all of the intended consequences of government deficit spending. In this analysis we assume that the Ricardian Equivalence does not hold, i.e. the individuals do not adjust their saving behavior as a result of the government borrowing.

The government can use the funds in two principal ways:

1. Consumption, by for example in welfare or provision of public services.
2. Investment in common infrastructure, in which the goods are expected to become part of the productive capital structure.

In the Austrian we consider both of these uses separately as they have different effect on the aggregate duration of the capital stock.

3.2.1 Short-term IS-LM model

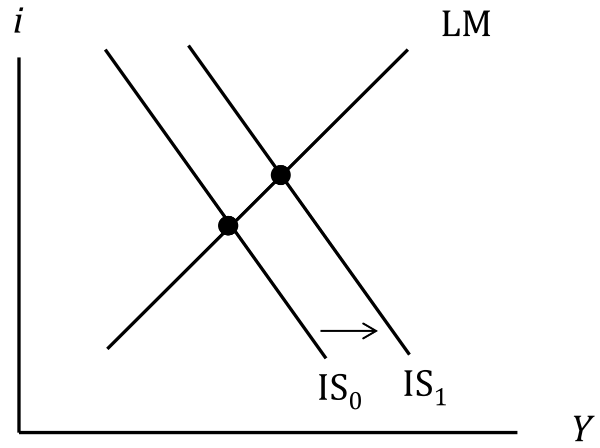


Figure 10: Increase in government spending in IS-LM model.

The IS curve $Y = C(Y - T) + I(Y, i) + G$ shifts to right, because there is an increase in government spending (G).

The LM curve $\frac{M}{P} = L(Y, i)$ is unchanged because M, P and L do not change. We have made an assumption that money supply M does not increase as a result of government deficit, i.e. the central bank is independent and does not directly finance the government deficit, which is the case in modern economies.

The result is a new equilibrium with higher interest rate and higher output.

3.2.2 Medium-term AS-AD model

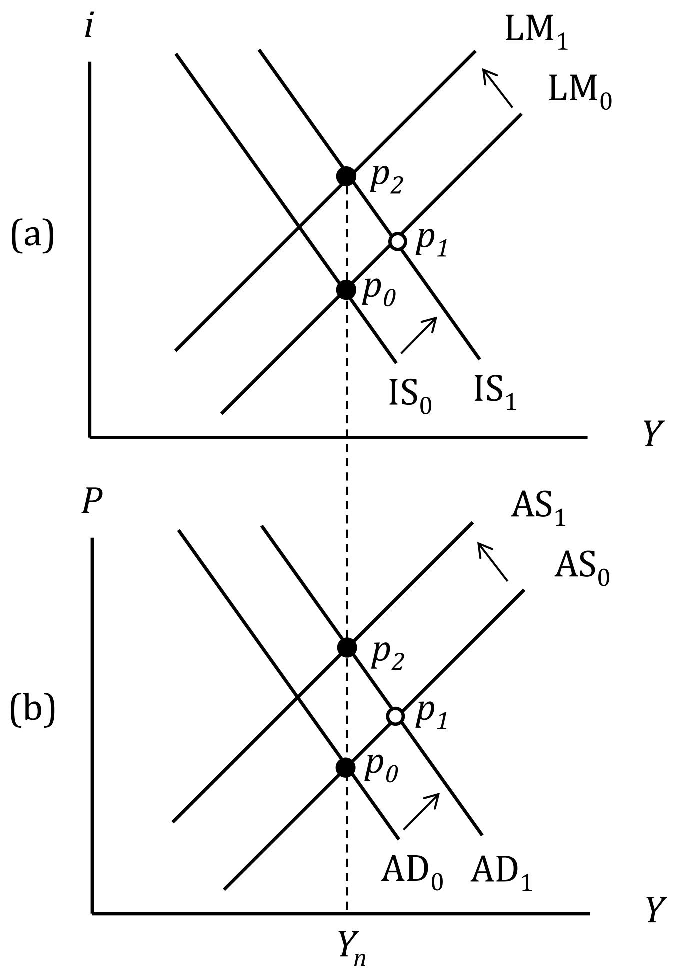


Figure 11: Increase in government deficit in the AS-AD model

Figure 11 shows the IS-LM diagram and AS-AD diagram. In AS-AD model the initial adjustment is the same as in IS-LM model: The IS-curve in Figure 11a shifts to right, because there is an increase in government spending (G). The aggregate demand also equation shifts to the right, from AD_0 to AD_1 in Figure 11b. After the initial adjustment the economy is in point p_1.

The economy being in point p_1, the price level in economy has increased as shown in the AS-AD diagram in Figure 11b. The increased price level causes the LM curve $\frac{M}{P} = L(Y, i)$ to shift to the left from LM_0 to LM_1, because P has increased. The result is the same level of output (Y) with higher interest rate (i).

As a result of the higher interest rate, the private investment $I(Y, i)$ decreases. This is called "crowding out" effect of government spending. The result of reduced private investment is that the capital stock of the economy decreases, which causes the aggregate supply curve to shift from AS_0 to AS_1 Figure 11b.

The result of the medium run AS-AD is that the economy returns to its natural level of output Y_n with higher price level and higher interest rate.

3.2.3 Austrian model

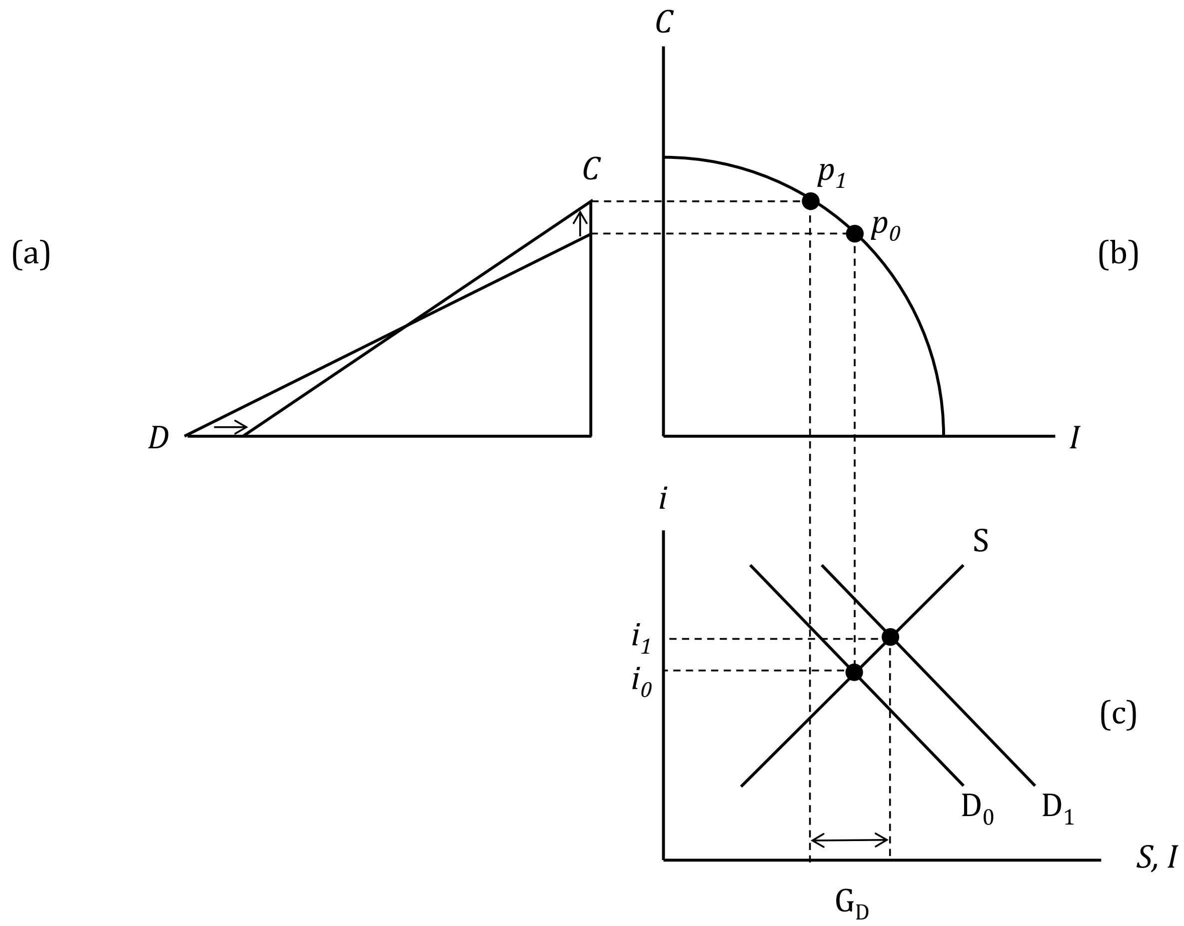


Figure 12: Government borrowing (Garrison, 2001)

When government issues new debt, the demand for loanable funds increases, which increases the interest rate.

Figure 12 shows the effect of government borrowing on the structure of production. Government takes amount G_D of new debt to finance its spending. The demand curve of loanable funds market shifts from D_0 to D_1. The interest rate rises from i_0 to i_1, which causes the production structure to move along to the production possibilities frontier from p_0 to p_1 with more consumption and less investment.

The change to the capital structure is shown in the Hayekian triangle in Figure 12a. The aggregate duration shortens. Because of the reduced rate of investment the growth rate of the economy decreases.

So far in this chapter we have assumed that government spending is consumption, i.e. services or welfare, and it does not result in growth of the productive capital stock. The intention of governments is often to invest so that the goods become part of the productive capital structure of the economy and the production capabilities of the economy are increased.

In Figure 13 we assume that the government invests in commonly used infrastructure. The effect of the government investment on the production structure is presented in Figure 13, assuming that the government spending is fully used in the productive capital stock.

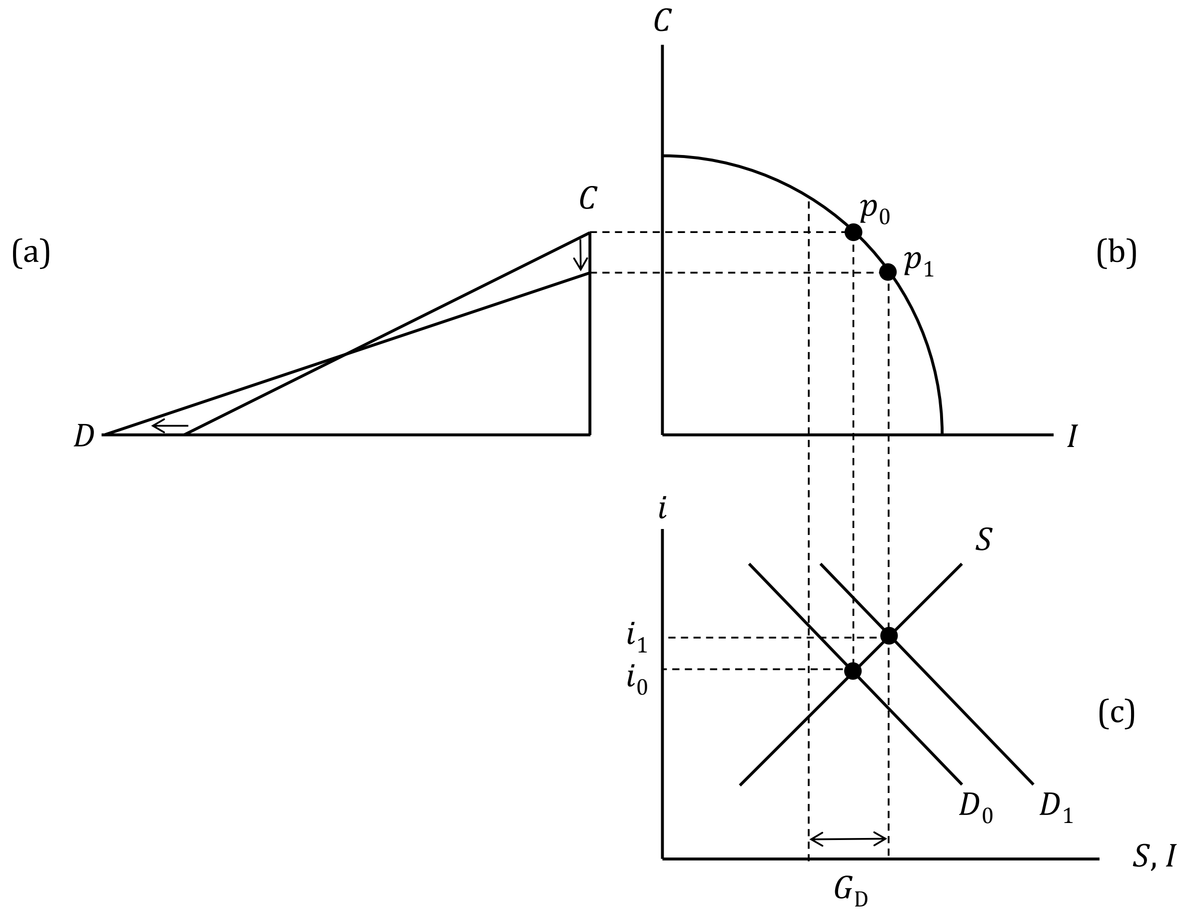


Figure 13: Government deficit spending on infrastructure

As a result of government borrowing, the demand of loanable funds shifts from D_0 to D_1. We assume that the saving remains the same, thus there is no change in the supply of loanable funds, and the interest rate rises from i_0 to i_1. The economy moves on the production possibilities frontier from p_0 to p_1 with less consumption and more investment.

The capital structure of the economy in Figure 13a changes towards increased duration. The privately funded capital from early stage decreases and publicly funded early stage capital increases.

The overall growth rate of the economy increases along with increased investment.

3.3 Monetary expansion

In this chapter we study the responses to an expansionary monetary policy of the monetary authority. The monetary authority has several mechanisms that can cause an increase in the money supply, such as changing the required reserve ratio, changing the interest rate of lending to commercial banks and different types of open-market operations. It does not matter which instrument the monetary authority uses, because they can all be used to increase the money supply.

This policy response is especially important for the Austrian theory, because it forms core of the Austrian explanation of the business cycle.

3.3.1 Short-term IS-LM model

In the IS-LM model a monetary expansion affects the LM-equation $\frac{M}{P} = L(Y, i)$ by increasing the money supply M, which shifts the LM curve downwards. In Figure 14 the LM-curve moves from LM_0 to LM_1.

The IS-curve $Y = C(Y - T) + I(Y, i) + G$ is unchanged.

As shown in Figure 14, the result is a new equilibrium with lower interest rate and higher output.

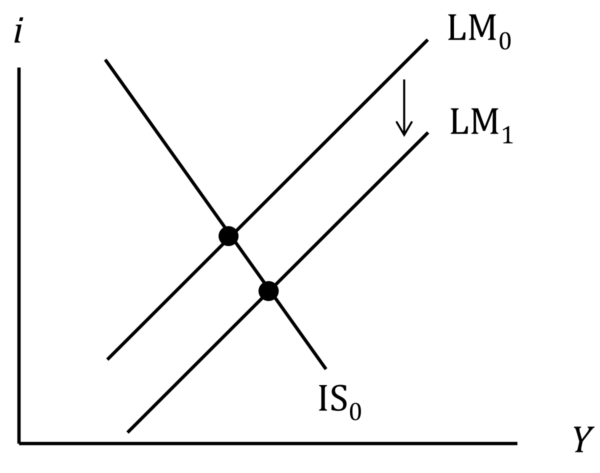


Figure 14: Monetary expansion in IS-LM model.

3.3.2 Medium-term AS-AD model

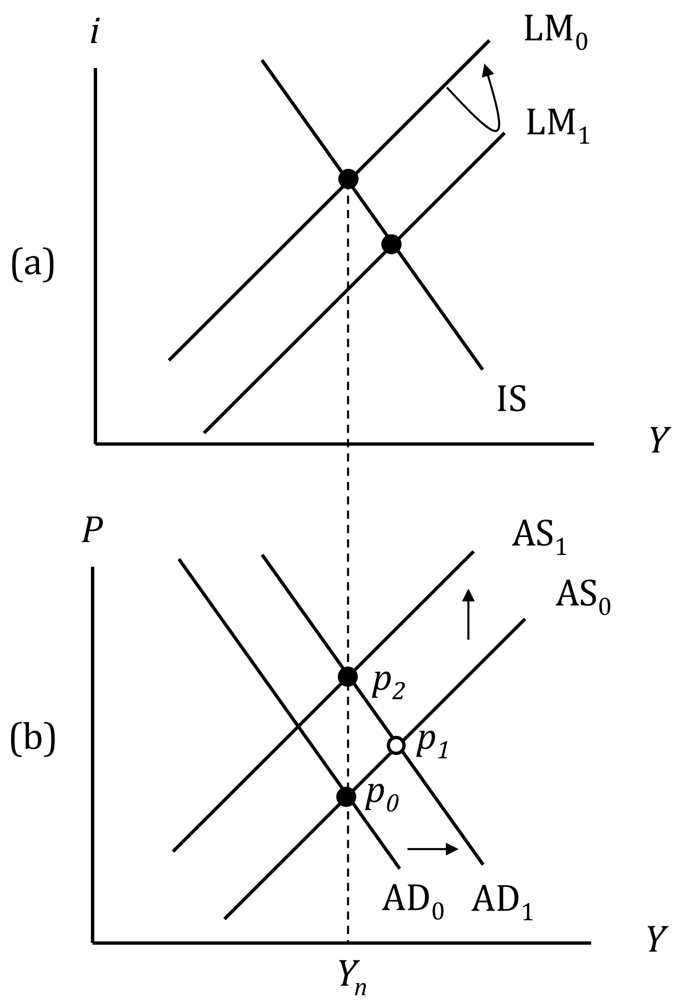


Figure 15: Monetary expansion in the AS-AD model.

Figure 15 shows the effects of monetary expansion in IS-LM and AS-AD diagrams. In the AS-AD model the initial adjustment is the same in the IS-LM: The shift of the LM-curve increases aggregate demand and the AD curve shifts to right, resulting in a new state p_1 with higher price level *P* and higher output *Y*.

The output *Y* is now higher than the natural level of output Y_n, which causes the expected price level P^e to increase. The increase in the expected level of wages causes the aggregate supply curve to shift up from AS_0 to AS_1, until the output has returned to the natural level of output Y_n.. The medium term equilibrium is thus in p_1, same level of output but increased price level.

In the LM equation $\frac{M}{P} = L(Y, i)$ the initial increase in the money supply *M* is followed by a proportionally equivalent increase in the price level *P* in the medium run, which shifts the LM upwards back to its original position (LM_0). The effect in the medium run is thus that there is no change in the IS-LM equilibrium, the result is unchanged level of output and unchanged interest rate.

3.3.3 Austrian model

The effects of monetary expansion in the Austrian model have been presented in more detail in chapter 2.4, and the main effects are repeated in this chapter. Figure 16 shows the effect of a policy-induced positive shock in the money supply is increased by the amount ΔM by the monetary authority.

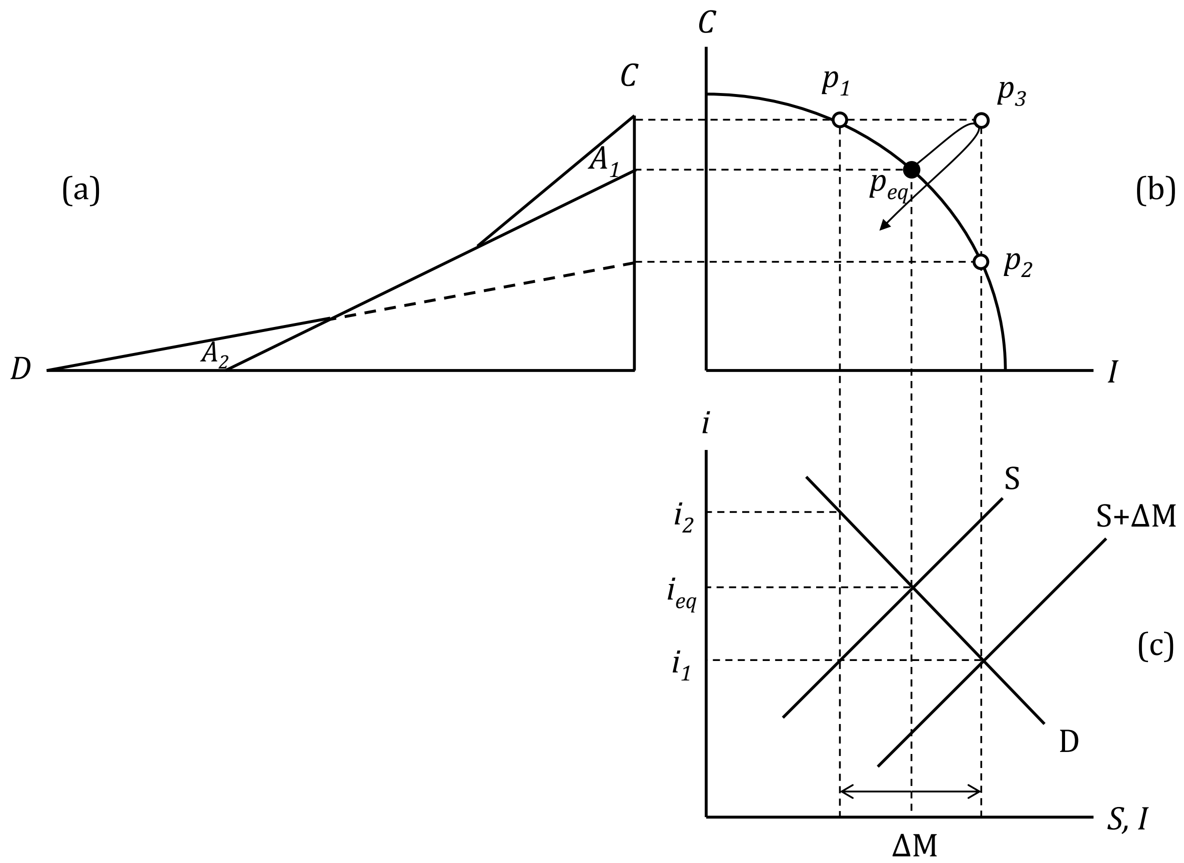


Figure 16: Monetary expansion in the Austrian model (Garrison, 2001)

The direct effect of the money supply shock is visible in Figure 16c. The loanable funds supply curve shifts to right, and the interest rate decreases from i_{eq} to i_1. The lowered interest rate discourages saving, and results in reduced savings. The reduced savings are offset by the monetary shock and new investment rate is higher: $I = S + \Delta M$.

The reduced interest rate leads the economy to an incoherent state. The consumers save less and consume more, acting as if the economy was in point p_1 on the production possibilities frontier in Figure 16b. On the other hand, the entrepreneurs invest more, acting as if the economy was in the point p_2 on the production possibilities frontier.

3.3.4 Synthesis: AS-AD model with Austrian extensions

In order to incorporate the Austrian malinvestment into the AS-AD model, the AS-AD model is extended by adding bank lending marginal and taking account the productive capital stock in aggregate supply.

To add the bank spread into the aggregate demand equation, we use the investment demand model with banks as intermediaries (Blanchard, 2010; p. 424): The banks earn money by charging a spread between the deposit rate and the lending rate. We set the deposit rate to be i, the spread is x, the lending rate is $i + x$ and the IS equation becomes

$$Y = C(Y - T) + I(Y, i + x) + G$$

When malinvestments made in the expansionary part of the cycle turn out not to be profitable, the accounting value of the investments decrease, which creates accounting losses in the balance sheets of the banks that financed the investments. In order to cover the losses, the banks have to increase the spread x between deposits and lending. This assumption is based on a simple model of baking system where the only possible source of funding is increasing the interest rate. We ignore the competitive dynamics between banks. The consequence of the increased spread is that the investments decrease and the aggregate demand decreases.

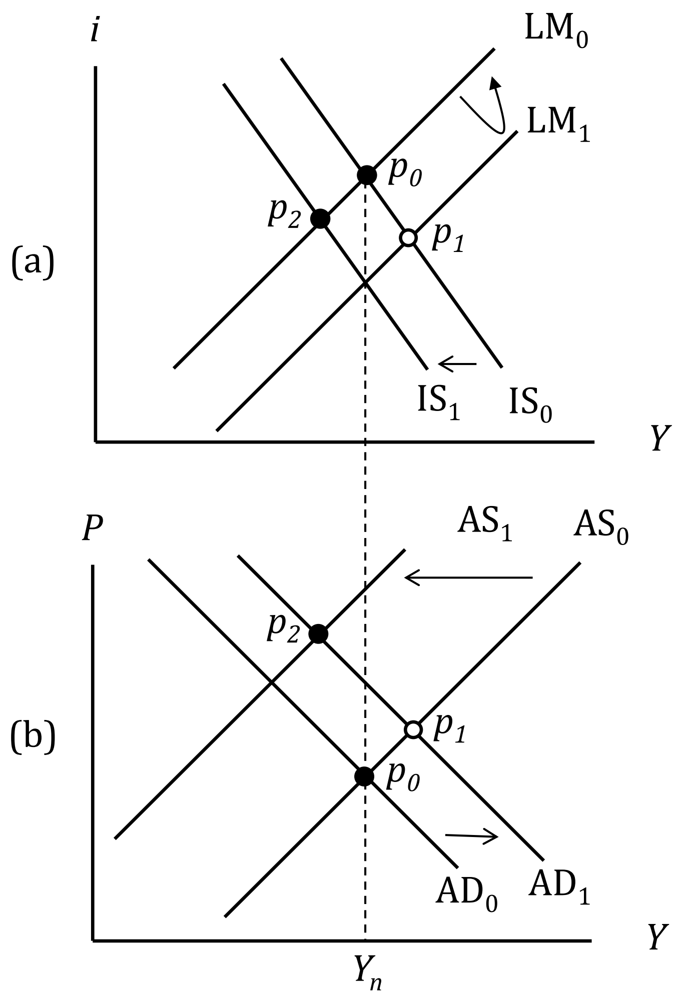


Figure 17: Monetary expansion in AS-AD model with Austrian extensions

The effects of monetary expansion in AS-AD with Austrian extensions are presented in Figure 17. In the expansionary phase the LM-curve shifts down from LM_0 to LM_1 as a result of increase in the money supply. Similarly the AD curve shifts right from AD_0 to AD_1. In this expansionary phase the economy is in state p_1 with decreased interest rate, increased price level and increased output.

The Austrian extensions causes the IS curve to shift to the left, because of the reduced investment demand. As with the basic AS-AD model, the AS curve shifts left because the economy is operating at a higher level of output than the natural level of output.

Because the malinvested capital cannot be fully used in the productive structure of the economy, the productive capital stock is reduced, which causes an additional shift of AS curve to the left, from AS_0 to AS_1 in Figure 17b.

The result of the contractionary part of the business cycle is that the economy is in state p_2 with higher price level, lower output and lower interest rate than in the initial state p_0.

3.4 Taxonomies of Business Cycle Theories

This chapter presents two proposed taxonomies of business cycle theories and places the Austrian and New Keynesian theories within them. In this chapter we assume that the cause of the downturn of the business cycle is an external shock, which is compatible with the real business cycle theory.

In the early work of Ragnar Frisch (1933) on economic cycles, the theory of business cycle was analyzed in two parts: The impulse that triggers the cycle and the propagation mechanism that allows the cycle to proceed throughout the economy.

Leijonhufvud (1984) presents a similar classification of business cycle theories based on two factors:

1. The nature of the of the disturbance
2. The nature of the economy to adjust to the disturbance

This classification leads to four different classes of theories, shown in Table 1.

Table 1: Taxonomy of macroeconomic maladies by Leijonhufvud (1984)

		Nature of the disturbance	
		Nominal (n)	**Real (r)**
Nature of adjustment	**Nominal (n)**	n/n Monetarist	r/n New Keynesian
	Real (r)	n/r Austrian	r/r New Keynesian

Table 2: Taxonomy of business cycle theories by Hansen (1951)

		Lower turning point (upturn)	
		Exogenous	**Endogenous**
Upper turning point (downturn)	**Exogenous**	X/X	N/X
	Endogenous	X/N Austrian, New Keynesian	N/N

Hansen (1951) has proposed a different taxonomy of the theories of the business cycle, where classification is based on whether the lower turning point and upper turning point are exogenous (X) or endogenous (N) in nature.

The Austrian theory of the business cycle belongs to the X/N category, because according to the theory the upturn is caused by an exogenous monetary shock, and the downturn is an endogenous adjustment and recovery of the economy.

The New Keynesian theory belongs to the same category, as the downturn is caused by an external shock, and the policy makers then react to it by exogenous actions.

4 Previous empirical studies

This chapter present the results of a literature study about previous empirical studies on Austrian business cycle theory.

The studies have been classified into categories: Econometrical studies that are presented in chapter 4.1, and historical studies that are presented in chapter 4.2.

4.1 Econometric studies

Wainhouse (1984) was the first to attempt to empirically assess the Austrian business cycle theory. Wainhouse presented the flowing six propositions that arose from the theory:

1. Changes in the supply of savings are independent of changes in the supply of bank credit.
2. Changes in the supply of credit lead changes in rates of interest. Furthermore, changes in credit and interest rates are inversely related.
3. Changes in the rate of change of credit lead changes in the output of producer goods.
4. The ratio of producer goods prices to consumer goods prices tends to *rise* after the initiation of a credit expansion.
5. The prices of producer goods closest to final consumption tend to decline relative to the prices of producer goods further away from the consumer good in the production scheme.
6. The prices of consumer goods rise relative to the prices of producer goods, reversing the initial shift in relative prices.

The propositions 1-3 were tested for Granger-causality with U.S. data and passed the statistical test. However, these propositions do not prove the Austrian theory in itself. Propositions 4-6 are not tested by statistical tests, but instead Wainhouse reports that the data seems to correspond to the propositions to the experienced monetary expansions.

Keeler (2001) used Vector Autoregression (VAR) method to empirically evaluate the Austrian business cycle theory. Equation system can be presented as

$$A\begin{bmatrix} Y_t \\ P_t \end{bmatrix} = B(L)\begin{bmatrix} Y_{t-1} \\ P_{t-1} \end{bmatrix} + C\begin{bmatrix} \varepsilon_t^Y \\ \varepsilon_t^P \end{bmatrix}$$

where Y is a vector of endogenous non-policy variables, P is a vector of policy variabes and ε is a vector of structural errors. Matrix A represents the contemporaneous relations between policy and non-policy variables. $B(L)$ is a matrix of lagged endogenous variables and C is a matrix of the effects of shocks on current endogenous variables.

Keeler (2001) used the following four endogenous variables:

y_1: Real income

y_2: Monetary policy target

y_3: Interest rate term term structure (spread)

y_4: Resource allocation (capacity utilization rate or investment flows)

The variance decomposition of Keeler's results indicated that his empirical model was able to account for a substantial proportion of the simulated cyclical behavior of interest rate term structure, resource allocation and aggregate income.

Bismans & Mougeot (2009) estimated the following equation using panel data:

$$\frac{\mathrm{GDP}}{\mathrm{GDP}_{\mathrm{nat}}} = \beta_0 + \beta_1(i_{10\mathrm{Y}} - i_{3\mathrm{m}}) + \beta_2 \frac{\mathrm{C}}{\mathrm{I}} + \beta_3 \Delta\left(\frac{\mathrm{CPI}}{\mathrm{PPI}}\right) \propto_c + u$$

where GDP is the real GDP and $\mathrm{GDP}_{\mathrm{nat}}$ is the natural level of the real GDP, received from a long-time trend. C is consumption, I is investment, and their division is included as an explanatory variable. Consumer price index (CPI) divided by the producer price index (PPI) is the second explanatory variable. The delta of this variable was taken because the time series from original variable was non-stationary. The yield spread between 10-year and 3-month government bonds is the third variable, and $\propto_c$ is a country-specific multiplier that represents the different level of interest rates in the countries.

The equation was estimated on quarterly panel data from France, Germany, United Kingdom and U.S. from 1980 to 2006. First order differential on the price ratio was used because the ratio was not stationary. The result was that β_0 is positive, β_1 and β_2 have negative coefficients and β_3 was not statistically significant. The positive coefficient β_1 shows an association between smaller interest rate spread and increased GDP compared to the natural rate of GDP. Negative β_2 shows an association between increased investment-to-consumption ratio and expansionary business cycle. Bismans & Mougeot state that the insignificance of β_3 supports the Mises's view of abandonment of the hypothesis that pro-cyclical price movements account for the cycle.

However, the model and results of Bismans & Mougeot is fully compatible with the mainstream macroeconomic theory, it does not contain a distinctly Austrian hypothesis and thus does provide evidence for the Austrian theory itself.

Mulligan (2002) used cointegration analysis to study stable long-term relationships between employment rates in different industries and interest rates with U.S. data from 1959-2000. There was strong evidence of increasing employment in mining, transportation and utilities, retail and wholesale industries in response to higher interest rates. Respectively, employment increased in manufacturing, construction, finance, insurance, government and services falls in response to higher interest rates. Mulligan concluded the former industries belonging to early stage and the latter industries to later stages of production in the production structure. However, it is not clear what the basis of the categorization of the industries is, and whether the differences between the industries are because of the capital effects described by Austrian business cycle theory. Thus, the results give no conclusive indication about the validity of Austrian business cycle theory.

Young (2005) approached the cycle from perspective of labor market adjustment. Young estimated a partial-adjustment regression model with quarterly data from U.S. manufacturing industry labor market, which contains number of new jobs, number of terminated jobs, which together total to a job reallocation. Changes in the monetary policy accounts for a statistically significant but economically small portion of variation in job reallocation from 1972 to 1993. A standard deviation change in the federal funds rate was associated with only 11% of a standard deviation change in job reallocation.

Cachanosky & Lewin (2014) argue that the limited explanatory power of Young (2005) stem from the problem that the assignment of industries into stages of production have limited applicability to the complexity of the real world capital. Their arguments are detailed in chapter 2.2.1. Also, The results of Young (2005) related to job reallocation are compatible with the mainstream economic theory and the hypothesis does not examine the Austrian business cycle theory directly.

Lester & Wolff (2013) performed regression analysis to assess the effect of monetary shock on goods that were divided into groups according to stage of production. The groups of industrial production were crude, primary semi-finished and finished goods. The results were mixed: The resource use expanded in response to a monetary shock, but no statistically significant changes were detected in the prices and produced quantities of goods in different stages of production.

Fisher (2013) used vector error correction model (VECM) to study the relationships between a monetary aggregate, interest rates and real consumption using U.S. data from 1963 to 2012. The study found that the central bank intervention in the loanable funds market dislocates the long-run relationship around a central tendency that seeks to match short- and long-term rates. Also this study, although in line with Austrian theory, did not contain a distinctively Austrian hypothesis.

4.2 Historical explanation studies

A historical explanation study is a study where researchers attempt to identify the causes of outcomes in a particular case.

Callahan & Garrison (2003) state that the historical explanation study is well-suited for researching economic cycles, and point out that Austrian business cycle theory is originally not a theory of mathematical aggregates in the first place.

Callahan & Garrison view that Austrian business cycle theory can be validly criticized as an ideal type on two grounds:

1. The ideal type is constructed using unsound economic reasoning, so that it is incoherent.
2. The theory is economically sound but irrelevant, as no actual cycles ever conform to the ideal type it describes.

The historical explanation study type seeks to answer the point 2 and show that there are cycles that correspond to the theory, although the logic is not based on statistical reasoning.

Powell (2002) provides an in-depth exposition of the abrupt faltering of Japan's economy in 1990. Powell explains the Keynesian, monetarist and Austrian explanations and policy recommendations. He makes a qualitative conclusion that the event was an Austrian business cycle, the initial boom being caused by monetary expansion between 1986 and 1990 when Japan expanded the money stock by average 10.5% per year. For other schools of thought, this was not a concern because of price-level stability at the time. The Keynesian interventions to help the economy to recover have included fiscal stimulus packages, increases in government spending despite tax cuts, increases in monetary base, interest-rate cuts, bail-outs and nationalization of banks, direct government lending to businesses. These policies failed to produce significant recovery in the 1990s.

Young (2012) introduces a new empirical measure of the productive structure of an industry: The TIOR (Total Industry Output Requirement) produced by Bureau of Economic Analysis (BEA) of U.S. Department of Commerce. The definition of TIOR is "the output required, both directly and indirectly, by each other industry to deliver a dollar of final demand of industry output to final users". Young argues that TIOR is proportional to the roundaboutness of production. The study analyses U.S. data from 2002 to 2009 during which the aggregate roundaboutness of U.S. economy increased before a drastic drop in 2009. Young argues is result of the expansionary monetary policy of Fed during that time.

The study of Young does not contain statistical examination of the results, and because it focuses only on a single economic cycle (Great Recession) with relatively short period of data, it can be more as an explanatory than statistical study. However, the TIOR measure utilized by Young can serve as a basis for statistical studies in the future.

4.3 Summary

There have been few empirical studies on Austrian business cycle theory. In Austrian school, there has historically been what Carilli & Dempster (2008) call "almost a pathological aversion" to use statistical analysis to test theory.

The previous empirical studies have not presented a hypothesis that would distinctly test the Austrian business cycle theory. The hypothesis and models used in the econometric studies are equally compatible with the mainstream macroeconomic theory.

We conclude that there is currently no credible empirical evidence to support or reject the Austrian business cycle theory.

5 Econometric model

This chapter introduces the econometric model used in the empirical part of this thesis.

5.1 Background

Because in the literature review of previous empirical studies no viable economic hypothesis was fond to empirically test the Austrian business cycle theory, the focus of the empirical part of this study is to assess the relationship of between the interest rate and private sector economic output, a key element of Austrian business cycle theory.

Sims (1980) criticizes that estimating faulty macroeconomic models overestimates the relationships between variables and defends the use of unrestricted form VAR-methodology because no *a priori* relationships between variables are assumed.

To model the relationships, Vector Error Correcting Model (VECM) is used. According to Mulligan (2002), VECM is especially interesting for Austrian school, because it provides estimates of both the equilibrium process (structural process) toward which adjustment is effected and the disequilibrium adjustment (or error-correction) process through which adjustment takes place toward the equilibrium.

According to the Austrian business cycle theory presented in chapter 3.3, the decrease of the interest rate is associated with short-term increase in both consumption and private investment, but the malinvestment of capital leads to negative macroeconomic consequences in the longer term.

The objective of this study is to assess whether there exists a relationship between the monetary policy, consumption and private investment, and the timing and magnitude of the possible effects. The expected result is that expansionary monetary policy causes a stimulating effect that increases both consumption and investment.

Following the concept of Fisher (2013), we use the spread between the long-term interest rate and short-term interest rate as a proxy for the monetary policy, by assuming that the monetary policy primarily affects the short term interest rate and the long-term interest rate is relatively unaffected.

It is important to note that this empirical examination does not seek to test the validity of Austrian and New Keynesian schools of theory, as the model does not contain elements that would be unique to the Austrian school.

5.2 Vector Error Correction Model

Vector Error Correction Model (VECM) offers a convenient way to specify vector processes with variables that have unit root and are cointegrated. The VECM can be used for forecasting, causality analysis and impulse response analysis (Lütkepohl, 2007).

We use three variables for the VECM:

1. Consumption (C)
2. Private investment (I)
3. Spread between long and short term interest rates ($r = r_{long} - r_{short}$)

Variable 3 is used as a proxy for monetary policy: Expansionary policy is assumed to increase the spread, as discovered by Fisher (2013).

VECM is used to estimate vector processes with unit root. If they together in some extent, they are called cointegrated. In general terms, variables of k-dimensional process y_t are called cointegrated, of order (d, b) if all components are $I(d)$ and and there exists a linear combination $z_t = \beta' y_t$, where cointegrating vector β is a nonzero vector of coefficients, so that z_t is $I(d, b)$ (Lütkepohl, 2007).

A vector autoregression model (VAR) is a generalization of autoregressive (AR) processes to vector form. General VAR model with lag order p has the form

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t$$

where c is a constant vector A_i are coefficient matrices for the lagged terms and e_i are error vectors that are assumed to have zero mean $E(e_i) = 0$, have contemporaneous covariance matrix $E(e_i e_i') = \Omega$ and no serial correlation of error terms: $E(e_i e_{i-k}') = 0$.

Applying VAR to integrated series involves a risk of spurious regression. The integrated series can be differenced to obtain a stationary series. However, the differencing might hide valuable information about the cointegration of the variables, and the resulting VAR model would describe only the short-run responses. If the variables are cointegrated, they have a relationship in the long run.

The VAR model

$$y_t = c + \sum_{i=1}^{p} \boldsymbol{A}_i y_{t-i} + \varepsilon_t$$

can be written as a VECM model

$$\Delta y_t = v + \mathbf{\Pi} y_{t-1} + \sum_{i=1}^{p} \mathbf{\Gamma}_{\boldsymbol{i}} \Delta y_{t-i} + \varepsilon_t$$

where $\mathbf{\Pi} = \sum_{j=1}^{j=p} \boldsymbol{A}_j - \boldsymbol{I}_k$ and $\mathbf{\Gamma}_{\boldsymbol{i}} = \sum_{j=1+1}^{j=p} \boldsymbol{A}_j$.

$r = rank(\mathbf{\Pi})$ is the number of linearly independent cointegrating vectors. If $r = 0$, there is no cointegration among the variables and the VAR model in the differences is consistent. If $r > 0$, the coefficient matrix can be expressed as $\mathbf{\Pi} = \boldsymbol{\alpha\beta}'$, where $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are $(K \times r)$ matrices. We can now incorporate a trend in the cointegrating relationship and the equation itself:

$$\Delta y_t = \boldsymbol{\alpha}(\boldsymbol{\beta}' y_{t-1} + \mu + \rho t) + \sum_{i=1}^{p} \mathbf{\Gamma}_{\boldsymbol{i}} \Delta y_{t-i} + \gamma + \tau t + \boldsymbol{\varepsilon}_t$$

Johansen (1995) lists five cases for estimation of VECM:

1. Unrestricted trend: Equation is estimated as shown above.
2. Restircted trend, $\tau = 0$: Cointegrating equations are trend stationary, and trends in levels are linear but not quadratic.
3. Unrestricted constant, $\tau = \rho = 0$: Cointegrating equations are stationary around constant means, linear trend in levels.
4. Restricted constant: $\tau = \rho = \gamma = 0$: Cointegrating equations are stationary around constant means, no linear time trends in the data.
5. No trend: $\tau = \rho = \gamma = \mu = 0$: Cointegrating equations, levels and differences of the data have means of zero.

In this study we assume the cointegrating macroeconomic variables to be trend stationary, and use the restricted trend approach, which is the option 2 in Johansen's classification.

5.3 Pre-estimation

This chapter explains the pre-estimation steps that are performed before estimating the model.

5.3.1 Lag-order selection

The purpose of lag-order selection is to select a suitable number of lags that provide information about the model.

For selecting a lag-order, we use the following process described in (Lütkepohl, 2007): For each lag level p, a likelihood-ratio test is performed to compare the goodness-of-fit of VAR model with p to a model with $p - 1$ lags. The null hypothesis is that the coefficients of the p lag are zero, meaning that the lag level p does not provide statistically significant additional information to the model. The lag orders are tested starting from the highest order towards zero, and the first lag order p that leads to rejection of the null hypothesis is the selected lag order.

This selection procedure ensures that each new lag level adds statistically significant information to the model.

5.3.2 Johansen test for cointegration

The Johansen test (Johansen, 1991) is used to determine the number cointegrating relationships in the time series. The test is performed by estimating the equation:

$$\Delta x_t = \sum_{i=1}^{k-1} \mathbf{\Gamma}_i \Delta x_{t-i} + \mathbf{\Pi} x_{t-1} + \varepsilon_t$$

where vector $\boldsymbol{x}$ is the time series data, $\mathbf{\Gamma}_i$ are parameter matrices for the lagged terms, $\mathbf{\Pi}$ is a parameter matrix for the term x_{t-1} and $\boldsymbol{\varepsilon}_t$ is a vector or normally distributed errors. The rank of matrix $\mathbf{\Pi}$ determines the number of independent rows in $\mathbf{\Pi}$, which is also the number of cointegrating vectors.

5.3.3 Augmented Dickey-Fuller test for unit root

Augmented Dickey-Fuller is a test for the existence of a unit root in a time series data (Said & Dickey, 1984). The test consists of estimating the model

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} y_{t-p+1} + \varepsilon_t$$

where y is the time series, α is constant, β a coefficient of a linear time trend and p is the order of the autoregressive process. The null hypothesis of the model is that $= 0$, meaning that the previous term in the series y_{t-1} would not provide additional information to the lagged changes Δy_{t-k} for estimating the change Δy_t. This is equivalent of the process having unit root. The alternative hypothesis is that $\gamma < 0$ and rejection of a unit root.

In this study we use the number of lags in the test that is discovered in the lag order selection process explained in chapter 5.3.1.

6 Data

This chapter describes the time series data that will be used to estimate the econometric model presented in chapter 5.

6.1 Time series

The time series data used in this study is from the United States, from 1963Q1 to 2014Q1.

Data from United States was selected because it provides a long time period of data without significant changes in political or monetary regime that would interfere with the study.

The data is originally from the National Income and Product Accounts of the United States (NIPA), and gathered from the Federal Reserve Economic Data (FRED) database from the Federal Reserve Bank of St. Louis.

The time series, their description and data series identifier from FRED are listed in Table 3.

Table 3: Time-series data

Time series	Data series description	Data series identifier
Consumption (C)	Personal Consumption Expenditures, Seasonally Adjusted Annual Rate	DPCERX1A020NBEA
Investment (I)	Gross Private Domestic Investment, Seasonally Adjusted Annual Rate	GPDI
Interest rate spread (r)	10 year treasury constant maturity rate (not seasonally adjusted) – 3-month treasury bill secondary market rate (not seasonally adjusted)	GS10 TB3MS

6.2 Pre-processing of data

In order to estimate a VECM, all variables should have the same order of integration.

Based on Fisher (2013), it is assumed that C and I are $I(1)$, and r is $I(0)$. For this reason, we follow the approach of Fisher and generate a cumulative time series R, that is corresponds to the artificial return of investment into the interest rate spread:

$$R_t = \prod_{n=1}^{t} r_t^{\frac{1}{4}}$$

The interest rates are quarterly observations that are presented as annual return, they are raised to the power of $\frac{1}{4}$ in order to get the quarterly return.

The accumulation of the $I(0)$ series means that R_t is $I(1)$ and can be used in the VECM model. In a pre-estimation step described in chapter 5.3.3 we verify with Augmented Dickey-Fuller that each time series is indeed $I(1)$.

The interest rate spread return time series R is multiplied with factor 10^4 so that it is closer to the level of two other data series. This avoids having very small and very large coefficients in the estimation results. The scaling is taken into account when interpreting the results.

6.3 Descriptive statistics

Table 4: Descriptive statistics of time-series data

Time series	Mean	Median	Min	Max
C	4287.7	3359.3	374.9	11669.5
I	1123.8	934.5	99.7	2766.0
R	1424.6	1368.8	1002.3	2187.1

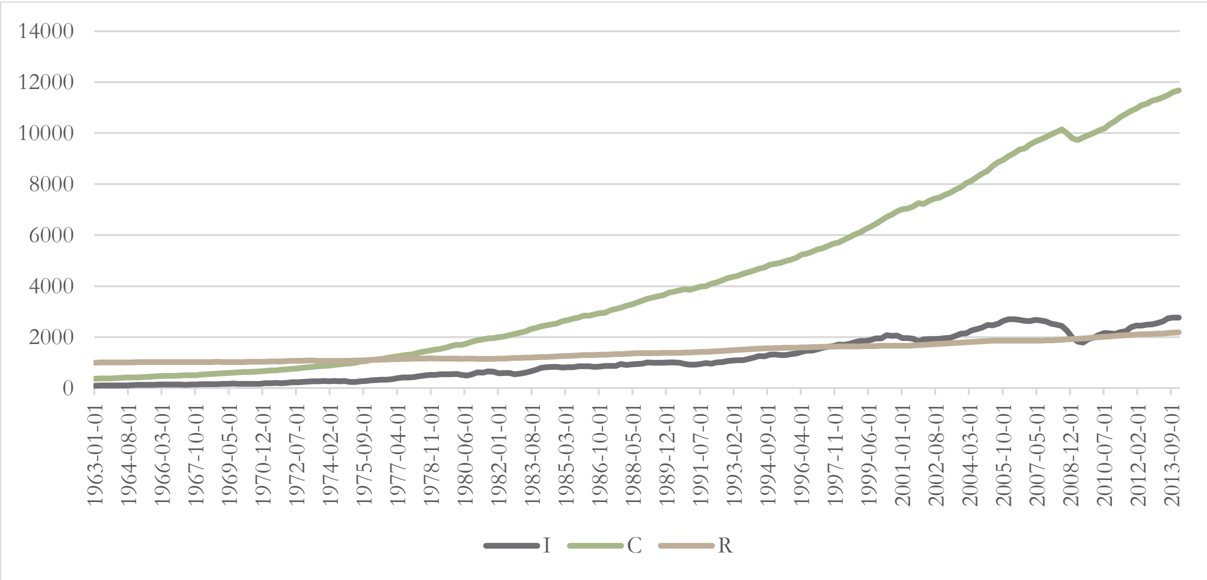


Figure 18: Time series data

7 Results

This chapter presents the results of the statistical analysis of the chapter 5, using the data described in chapter 6.

The results of the pre-estimation procedures are presented, followed by the results of estimating the Vector Error Correction Model.

The statistical results were obtained using Stata software, and the raw output is included in Appendix A.

7.1 Pre-estimation

This chapter presents the results of the pre-estimation tests defined in chapter 5.3.

7.1.1 Lag-order selection

The results of the lag order selection are presented in Table 5. The lag order selected by each method is shown with an asterisk (*). The highest lag order that rejects the null hypothesis of the likelihood ratio test is 2. The lag order 2 is also the minimum value for all of used information criteria: Final Prediction Error (FPE), Akaike's information criterion (AIC), Hannan and Quinn information criterion (HQIC) and Schwarz's Bayesian information criterion (SBIC).

Both the likelihood ratio test and the information criteria report consistently that the estimated lag-order is 2.

Table 5: Results of the lag order selection

Lag	Likelihood ratio	FPE	AIC	HQIC	SBIC
0		$6.2 * 10^8$	28.76	28.78	28.81
1	3399.2 ($p = 0.000$)	30.83	11.94	12.02	12.14
2	**334.88 ($\boldsymbol{p = 0.000}$)***	**6.37***	**10.37***	**10.51***	**10.71***
3	4.808 ($p = 0.851$)	6.81	10.43	10.63	10.92
4	16.421 ($p = 0.059$)	6.86	10.44	10.70	11.08

7.1.2 Johansen test for cointegration

The parameter matrices of Johansen test described in chapter 5.3.2 were estimated using the maximum likelihood estimation. The results of the estimation are presented in Table 6.

Because the trace statistic at $r = 0$ exceeds the critical value, we reject the hypothesis of no cointegrating equations. The trace statistic at $r = 1$ also exceeds the critical value, and thus we reject the null hypothesis that there is one or fewer cointegrating equations. The trace statistic at $r = 2$ is less than its critical value, and thus we cannot reject the null hypothesis that there are two or fewer cointegrating equations. The Johansen's procedure for estimating r is to accept the first r for which the null hypothesis is not rejected, and we conclude that that $r = 2$ is the estimate for number of cointegrating equations.

Table 6: Results of the Johansen test for cointegration

Maximum rank (r)	**Trace statistic**	**5% critical value**
0	57.51	34.55
1	22.82	18.17
2	**1.78***	3.72

7.1.3 Augmented Dickey-Fuller test of unit root

The results of the Augmented Dickey-Fuller test described in chapter 5.3.3 for the time series data are shown in Table 7. The estimation was done with two lags, based on the result of the lag-order selection in chapter 7.1.1.

For each variable, the zero hypothesis of unit root cannot be rejected at the 5% confidence level. The conclusion of the Augmented Dickey-Fuller tests is that all time series have unit root.

Table 7: Results of the Augmented Dickey-Fuller tests for unit root

Time series	**t-statistic**
Consumption	-1.42 ($p = 0.86$)
Investment	-2.94 ($p = 0.15$)
Interest rate spread	-1.22 ($p = 0.91$)

7.2 Vector error correction model estimation

In estimating the Vector error correction model (VECM), we use the lag order 2 that was obtained by the lag order selection in chapter 7.1.1, and 2 as the number of cointegrating equations that was obtained by the Johansen test in chapter 7.1.2.

Cointegrating relationships

The results of the cointegrating part of the VECM estimation are presented in Table 8. The two cointegration relationships are between the consumption and interest rate spread, and between investment and interest rate spread. There is no cointegrating relationship found directly between consumption and investment.

Table 8: Results of estimating the cointegrating equations of the VECM[1]

Equation	C	I	R	Trend (ρ)	Constant (μ)
ce_1	1 (fixed)	0 (omitted)	-12752.59***	7.72	12062.84
ce_2	0 (omitted)	1 (fixed)	-2185.39***	6.14	2137.12

Short term relationships

Table 9 shows the results of estimating the adjustment part of VECM. All three variables have statistically significant coefficient for both cointegrating equations ce_1 and ce_2. The differences in consumption is dependent on the difference in investment in the previous period, and also in the other way, difference in investment is statistically dependent in the difference in consumption in the previous period.

The difference for the interest rate spread ΔR_t has statistically significant coefficients for the cointegrating equations ce_1 and ce_2, for the autoregressive term ΔR_{t-1} and the time trend variable.

Table 9: Results of estimating the adjustment equations of the VECM[1]

	ce_1	ce_2	ΔC_{t-1}	ΔI_{t-1}	ΔR_{t-1}	Trend (τ)	Constant (γ)	R^2
ΔC_t	-0.015**	0.038**	0.127*	0.31***	-0.26	0.0058	0.17	0.80
ΔI_t	-0.17**	-0.053***	0.52***	0.19***	0.79	0.00050	-0.45	0.48
ΔR_t	-0.0018***	-0.0036*	-0.0020	0.00063	0.81*	0.053***	0.46	0.93

[1] *, ** and *** indicate statistical significance at 90%, 95% and 99% level, respectively.

7.3 Impulse-response graphs

An impulse response-graph is a graphical representation how an impulse of one unit in another variable causes a time-variant effect on another variable.

The following nine figures present the impulse-response graphs of the VECM system. Impulse function is defined for each three variable against each variable, totaling to nine graphs.

The steps in the horizontal scale represent quarters. The vertical scale is billions of dollars for consumption and investment, and 0.01 basis points (0.0001 percentage points) for the interest rate spread.

Figure 19 on page 48 shows the responses to a 1 billion USD consumption impulse. A consumption impulses causes a stimulating effect that increases both consumption and investment. Consumption and investment return to their original levels in approximately 20 quarters after the impulse. A consumption impulse causes a lagged upward response to the interest rate spread, which is however so small that we consider it to be statistical noise.

Figure 20 on page 49 shows the responses to 1 billion USD investment impulse. An investment impulse causes a positive stimulating effect to both consumption and investment, similarly to the consumption impulse.

Figure 21 on page 50 shows the impulse-response graphs of a positive 0.01 basis point impulse in the interest rate spread for 40 quarters. As expected, the interest rate impulses causes a stimulating effect to both consumption and investment, and the magnitude of the peak is approximately 16 billion USD for both. The peak of the consumption response is after 20 quarters (5 years) which then slowly levels out. The peak of the investment response is after 14 quarters (3.5 years), after which the response levels out. The response of consumption and is consistent with both Austrian and New Keynesian theory.

The last panel of Figure 21 shows that the interest rate spread causes an accelerating trend to the interest rate spread that is followed by a negative response, and then stabilizes. A possible economic interpretation for this is that after a delay the stimulating effects increase the demand for short-term funds, which lowers the interest rate spread below the original level.

Figure 19: Impulse-response graphs for a consumption impulse

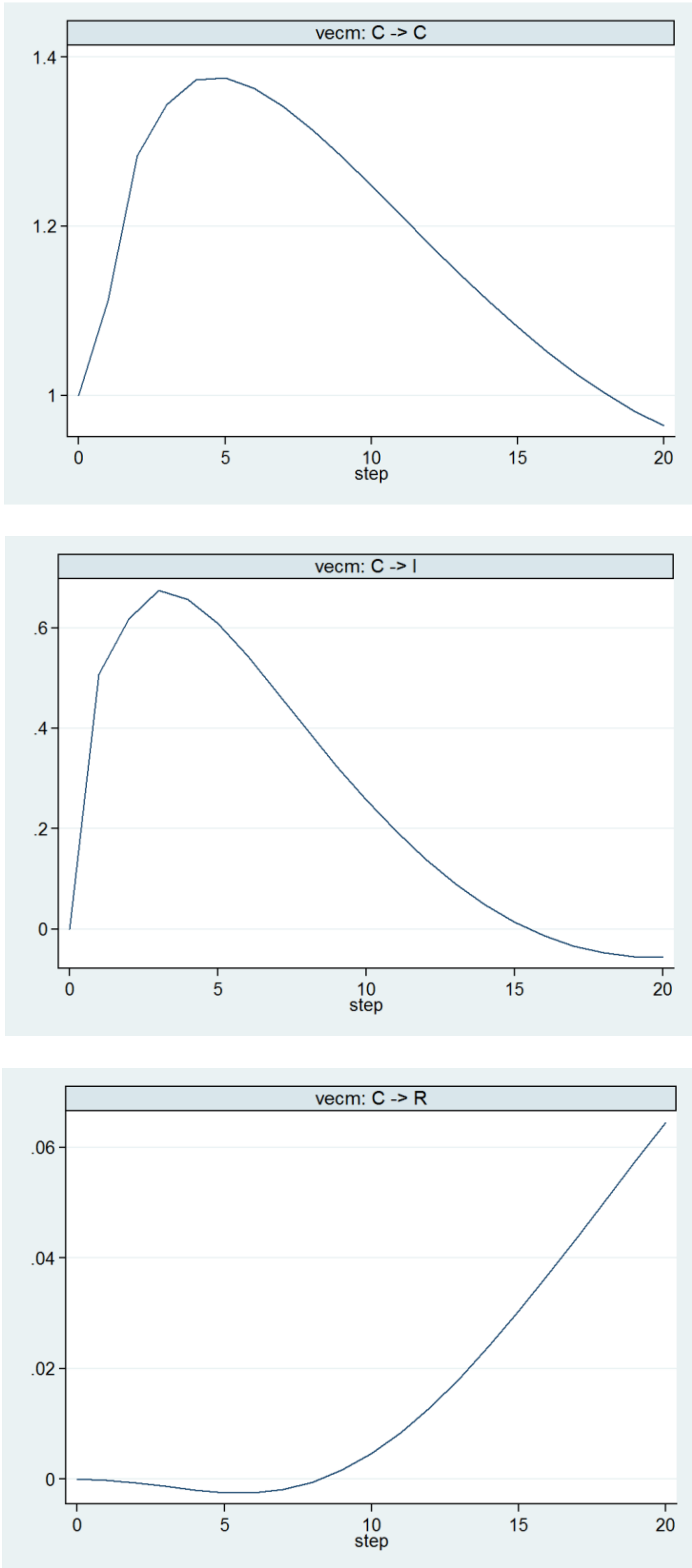


Figure 20: Impulse-response graphs for an investment impulse

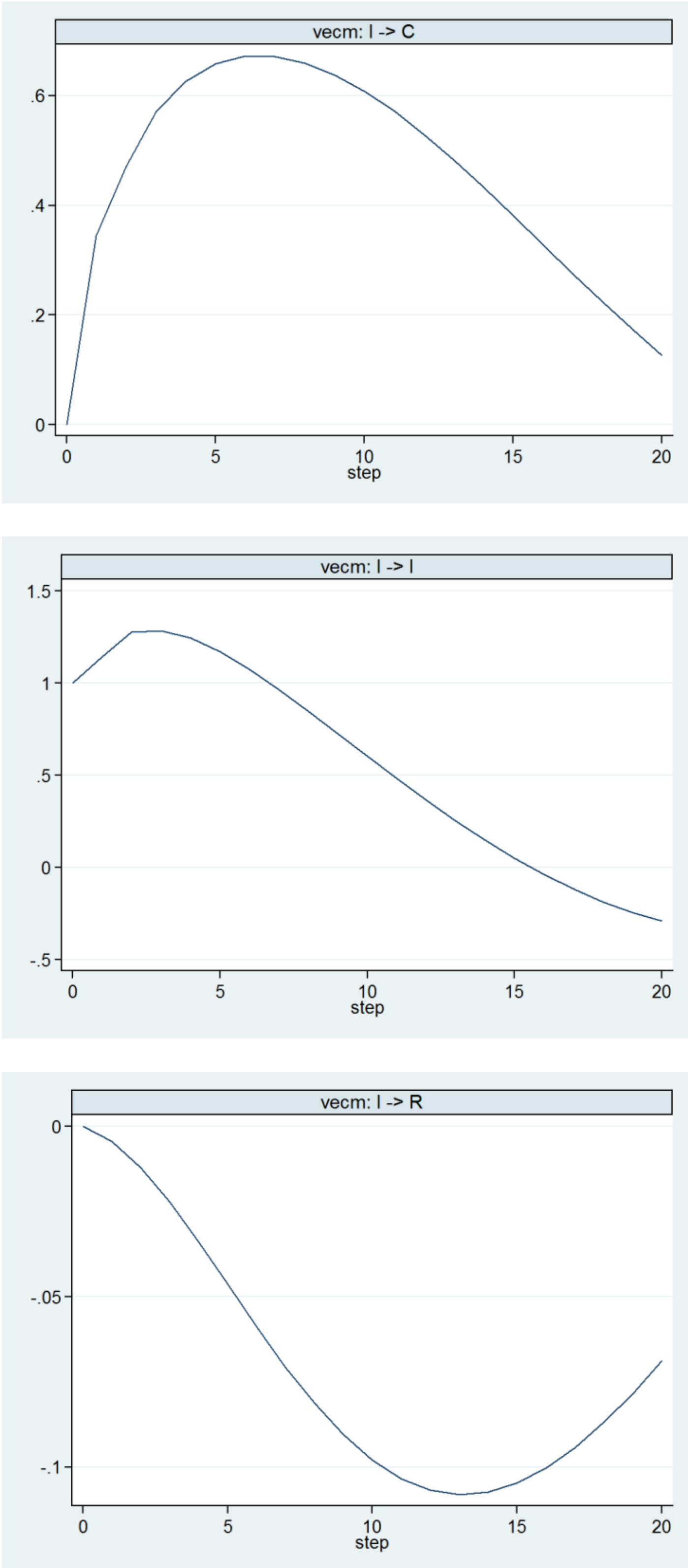
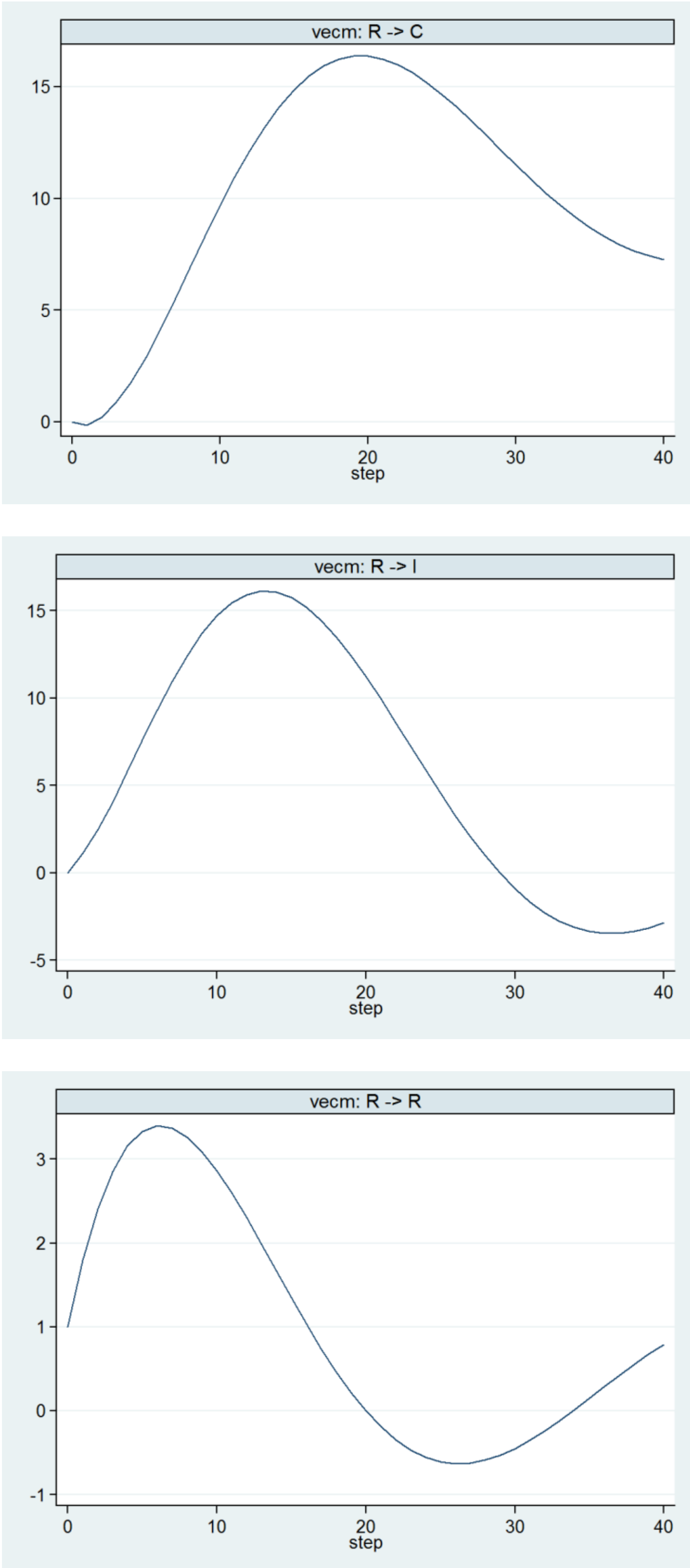


Figure 21: Impulse-response graphs for an interest rate spread impulse



8 Conclusions

This chapter summarizes the study. Chapter 8.1 presents the answers to the research questions that were found in the study. Chapter 8.2 presents the theoretical contributions and chapter 8.3 gives suggestions for future research.

Austrian business cycle theory is a model for the business cycles that includes the structure of the productive capital stock. However, the lack of statistically testable hypothesis and econometric evidence for the theory has excluded it from the mainstream macroeconomic debate.

In Chapter 3 of this thesis the Austrian business cycle theory based on the neo-Austrian diagrammatical presentation of the model was used to compare the theory with the mainstream New Keynesian model using policy responses. The policy responses to increase in saving rate and increase in government deficit spending were similar. The policy response to monetary expansion in chapter 3.3 was different between the theories, and according to Austrian theory the monetary expansion starts unsustainable growth.

Chapter 4 contains a literature study of the previous empirical studies of the Austrian business cycle theory. The previous studies did not contain a hypothesis that could be used to test distinctively the Austrian hypothesis of the business cycle.

In chapter 5 we introduced a VECM model that was used to study the relationship between monetary policy, investment and consumption. Interest rate spread was used as a proxy for monetary policy.

The results of the econometric study are presented in chapter 7. In the analysis of impulse-response functions, expansionary monetary policy was found to be associated with a stimulating effect on both consumption and investment. The results are consistent with both Austrian and mainstream New Keynesian macroeconomic theory.

8.1 Findings

This chapter summarizes the answers to the research questions of the study that were presented in chapter 1.1.

Research question 1a: How does Austrian Business Cycle theory explain the economic cycles?

The Austrian business cycle theory was presented in chapter 2. According to the theory, the initiating cause for the business cycles is credit expansion that is not caused by change in the time preferences of the individuals. The credit expansion causes the interest rate in the loanable funds market to decrease below the time-preference based natural rate of interest, which causes the individuals to save less and the entrepreneurs to invest more.

Entrepreneurs are assumed to evaluate the investments projects by evaluating their net present value $NPV = \sum_{t=0}^{T} R_t/(1+i)^t$. Because the monetary expansion has caused consumer demand R_t to increase and interest rate i to decrease, investment projects with lower return seem profitable. This lowers the aggregate duration of the capital stock of the economy.

As the policy-based lower interest cannot be sustained indefinitely, when the credit expansion decelerates, the consumer demand decreases and the interest rates increase. The investments that are not sustainable are called malinvestments. The malinvestments cause welfare loss because the invested capital was created for certain use, and at least part of the malinvested capital cannot be economically liquidated and used elsewhere.

According to the Austrian business cycle theory, the fundamental cause of the cycle is discoordination between the time preferences of individuals and the structure of the productive capital stock. The discoordination is channeled through the interest rate, which has been altered by credit expansion.

If the monetary authority tries to stimulate the economy by further expanding the money supply when the malinvestments are realized and the economy is in recession, according to the theory, the business cycle begins again.

Research question 1b: What are the main differences between the mainstream New Keynesian theory and the Austrian business cycle theory?

The view of the initiating cause of the cycle is different: In New Keynesian theory the business cycle is caused by an external shock and monetary policy is one stabilization instrument that is used to stimulate the economy after an adverse shock that initiates a downwards business cycle.

In Austrian Business Cycle theory the monetary expansion is the initiating cause of the business cycle, that first causes an expansionary part of the cycle that causes malinvestments which later lead to contractionary part of the cycle when the malinvestments are realized.

From conceptual perspective, Austrian school defines inflation as the increase in the quantity of money, whereas mainstream New Keynesian economics defines it as rise in the general price level. Austrian school considers that the general price level is not a macroeconomically meaningful concept, as the important information about changes in the relative prices is lost in the aggregation.

From theoretical point of view, the main differences are that Austrian business cycle theory includes the aggregate duration of the capital stock in the model. Mainstream New Keynesian short-term and medium-term models do not include the capital stock as part of the model, and particularly not the duration of the capital stock. If the interest rate is pushed away from the time-preference based natural interest rate by credit expansion, the duration of the capital stock of the economy is no longer consistent with the time preferences of individuals. This intertemporal discoordination is the core of Austrian business cycle theory.

The responses to increase in saving rate and to government deficit are consistent between Austrian and New Keynesian theories.

Research question 2a: Are there previous empirical studies to support the theory?

The result of a literature study in chapter 4 was that there is no credible empirical evidence that would prove or disprove the Austrian business cycle theory.

The fundamental problem in the econometric studies is that there is no currently known statistically verifiable hypothesis that could be used to distinctively test the Austrian business cycle theory. The hypotheses that were used in the previous studies were not distinctively Austrian, they were also consistent with mainstream macroeconomic theory, and thus the studies could not be used to make conclusions about the empirical validity of Austrian business cycle theory.

Research question 2b: Trying to reproduce an empirical study.

In chapter 5 we constructed a vector error correcting model to assess the relationship between consumption, investment and monetary policy. The spread between long and short term rates was used as a proxy for monetary policy.

The result of the estimation in chapter 7 was that increase in the interest rate spread are related to a following increase in the consumption and investment. The impulse-response functions showed the peak of the consumption is after 20 quarters after the interest rate spread impulse and then levels out. The peak of the investment response is 16 years after the impulse, after which it reduces below the initial level and then levels out.

The results of the empirical study were consistent with both mainstream New Keynesian and Austrian theory.

8.2 Theoretical contributions

The AS-AD model with Austrian extensions constructed in chapter 3.3.4 is an attempt to bring the Austrian theory into the New Keynesian medium-run AS-AD framework. The model added bank margins into the aggregate demand equation and the consideration of capital stock into the aggregate supply equation.

Although concepts of the AS-AD model are not compatible with Austrian theoretical framework, as the Austrian school rejects the concept of general price level that is present in the AS-AD model and the liquidity preference that is in the LM curve. Despite these limitations, the presented model incorporates the negative aspects of malinvestments to illustrate the consequences malinvestment. The capital stock itself is not part of the combined model.

The presentation is expected to make Austrian business cycle theory more accessible for readers of the mainstream macroeconomic school of thought.

8.3 Suggestions for future research

The principal problem in empirical validation of Austrian business cycle theory lies in the problem of testing the theory using high-level economic aggregates.

In order to empirically evaluate the theory, the examination should be extended to micro-level data that would give insight into the valuation of capital and premature deprecation of capital as an indicator of malinvestment. Balance sheet analysis could offer an interesting path to get more insight into the duration of capital structure in the enterprises.

The TIOR (Total Industry Output Requirement) model introduced by Young (2012) is a new model that might provide interesting results when there is sufficient time series data available for statistically meaningful analysis.

9 Literature

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Appendix A: STATA output

```
. import excel "Data.xls", sheet("Data") firstrow

. gen quarter = qofd(Date)

. tsset quarter, quarterly
        time variable:  quarter, 1963q1 to 2014q1
                delta:  1 quarter

. summarize C I R, detail

                              C
-------------------------------------------------------------
      Percentiles      Smallest
 1%        384.9          374.9
 5%        441.6          376.8
10%        531.5          384.9       Obs                 205
25%       1063.2          386.5       Sum of Wgt.         205

50%       3359.3                      Mean           4287.693
                        Largest       Std. Dev.      3503.688
75%       7041.4        11392.4
90%       9956.4        11498.8       Variance       1.23e+07
95%      10745.3        11612.5       Skewness        .621797
99%      11498.8        11669.5       Kurtosis       2.057243

                              I
-------------------------------------------------------------
      Percentiles      Smallest
 1%        104.6           99.7
 5%        131.2          101.6
10%        152.3          104.6       Obs                 205
25%        281.3          107.2       Sum of Wgt.         205

50%        934.5                      Mean           1123.837
                        Largest       Std. Dev.      849.1779
75%         1928         2699.7
90%       2469.5           2738       Variance       721103.2
95%       2634.2           2766       Skewness       .4574576
99%         2738           2766       Kurtosis       1.834314

                              R
-------------------------------------------------------------
      Percentiles      Smallest
 1%     1007.066       1002.292
 5%     1018.247       1004.963
10%       1026.8       1007.066       Obs                 205
25%     1096.096       1008.724       Sum of Wgt.         205

50%     1368.834                      Mean           1424.648
                        Largest       Std. Dev.      350.6113
75%     1665.931       2144.673
90%     1922.538       2158.163       Variance       122928.3
95%     2078.453       2171.898       Skewness       .4868734
99%     2158.163       2187.051       Kurtosis       1.974209
```

```
. varsoc C I R

   Selection-order criteria
   Sample:  1964q1 - 2014q1                     Number of obs      =       201
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 | -3813.41                      6.2e+12   37.9742   37.9941   38.0235  |
  |  1 | -2113.81  3399.2    9  0.000   308259   21.1523   21.2321   21.3495  |
  |  2 | -1946.37  334.88*   9  0.000  63718.9*  19.5758*  19.7154*  19.9209* |
  |  3 | -1943.96   4.808    9  0.851  68052.2   19.6414   19.8409   20.1344  |
  |  4 | -1935.75  16.421    9  0.059  68609.1   19.6493   19.9086   20.2902  |
  +---------------------------------------------------------------------------+
   Endogenous:  C I R
    Exogenous:  _cons

. vecrank C I R, trend(trend)

                       Johansen tests for cointegration
Trend: trend                                             Number of obs =     203
Sample:  1963q3 - 2014q1                                          Lags =       2
-------------------------------------------------------------------------------
                                                        5%
maximum                                      trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0      15     -1047.7453          .      57.5090    34.55
    1      20     -1030.3995     0.15709     22.8173    18.17
    2      23     -1019.8818     0.09843      1.7819*    3.74
    3      24     -1018.9908     0.00874
-------------------------------------------------------------------------------
```

```
. dfuller C, trend lags(2)

Augmented Dickey-Fuller test for unit root         Number of obs   =       202

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.415            -4.006            -3.436            -3.136
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.8563

. dfuller I, trend lags(2)

Augmented Dickey-Fuller test for unit root         Number of obs   =       202

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.944            -4.006            -3.436            -3.136
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.1484

. dfuller R, trend lags(2)

Augmented Dickey-Fuller test for unit root         Number of obs   =       202

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.215            -4.006            -3.436            -3.136
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9073
```

```
. vec C I R, rank(2) lags(2) trend(trend)

Vector error-correction model

Sample:  1963q3 - 2014q1                           No. of obs      =       203
                                                   AIC             =  24.09021
Log likelihood = -2422.156                         HQIC            =  24.24208
Det(Sigma_ml)  =   4638845                         SBIC            =   24.4656

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_C                  7     34.0825   0.7968   768.4158   0.0000
D_I                  7     35.1904   0.4830   183.1276   0.0000
D_R                  7     2.03682   0.9332   2740.264   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_C          |
        _ce1 |
         L1. |  -.0154106   .0078221    -1.97   0.049    -.0307415   -.0000796
             |
        _ce2 |
         L1. |   .0382665   .0185154     2.07   0.039      .001977     .074556
             |
           C |
         LD. |   .1273127   .0727719     1.75   0.080    -.0153177    .2699431
             |
           I |
         LD. |   .3060381   .0647584     4.73   0.000     .1791139    .4329622
             |
           R |
         LD. |   -.262975   .6935728    -0.38   0.705    -1.622353    1.096403
             |
      _trend |   .0058255   .1986534     0.03   0.977     -.383528     .395179
       _cons |   .1659793   5.024218     0.03   0.974    -9.681307    10.01327
-------------+----------------------------------------------------------------
D_I          |
        _ce1 |
         L1. |   -.017385   .0080763    -2.15   0.031    -.0332143   -.0015557
             |
        _ce2 |
         L1. |  -.0528305   .0191172    -2.76   0.006    -.0902995   -.0153614
             |
           C |
         LD. |   .5244951   .0751373     6.98   0.000     .3772287    .6717616
             |
           I |
         LD. |   .1945621   .0668633     2.91   0.004     .0635124    .3256117
             |
           R |
         LD. |   .7879784   .7161166     1.10   0.271    -.6155843    2.191541
             |
      _trend |   .0005044   .2051104     0.00   0.998    -.4015046    .4025134
       _cons |  -.4540525   5.187525    -0.09   0.930    -10.62141     9.71331
-------------+----------------------------------------------------------------
```

```
D_R          |
        _ce1 |
         L1. |    .001827   .0004675     3.91   0.000     .0009107    .0027432
             |
        _ce2 |
         L1. |  -.0036388   .0011065    -3.29   0.001    -.0058075   -.0014701
             |
           C |
         LD. |  -.0019674    .004349    -0.45   0.651    -.0104912    .0065564
             |
           I |
         LD. |  -.0006394   .0038701    -0.17   0.869    -.0082246    .0069458
             |
           R |
         LD. |   .8098435   .0414489    19.54   0.000     .7286052    .8910818
             |
      _trend |   .0539393   .0118718     4.54   0.000      .030671    .0772076
       _cons |   .4554916   .3002543     1.52   0.129     -.132996    1.043979
------------------------------------------------------------------------------

Cointegrating equations

Equation           Parms    chi2     P>chi2
-------------------------------------------
_ce1                 1   142.3494   0.0000
_ce2                 1   35.53606   0.0000
-------------------------------------------

Identification:  beta is exactly identified

                 Johansen normalization restrictions imposed
------------------------------------------------------------------------------
        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
           C |          1          .        .       .            .           .
           I |          0  (omitted)
           R |  -12.75259    1.06886   -11.93   0.000    -14.84752   -10.65767
      _trend |   7.717994          .        .       .            .           .
       _cons |   12062.84          .        .       .            .           .
-------------+----------------------------------------------------------------
_ce2         |
           C |          0  (omitted)
           I |          1          .        .       .            .           .
           R |  -2.185392   .3666019    -5.96   0.000    -2.903918   -1.466865
      _trend |   6.136829          .        .       .            .           .
       _cons |   2137.116          .        .       .            .           .
------------------------------------------------------------------------------

. irf set vecm
(file vecm.irf now active)

. irf create vecm_20, step(20)
(file vecm.irf updated)

. irf create vecm_40, step(40)
(file vecm.irf updated)
```

```
. irf table irf, impulse(C) irf(vecm_40)

            Results from vecm_40
```

step	(1) irf	(2) irf	(3) irf
0	1	0	0
1	1.1119	.50711	-.00014
2	1.28364	.618187	-.00061
3	1.34342	.674321	-.001295
4	1.37335	.656644	-.001982
5	1.37567	.609124	-.002436
6	1.36337	.543821	-.002443
7	1.34135	.471404	-.001834
8	1.31338	.397401	-.000488
9	1.28173	.325403	.001666
10	1.24799	.257579	.00465
11	1.2133	.195301	.008448
12	1.17856	.13942	.013008
13	1.14448	.090449	.018252
14	1.11166	.048655	.024078
15	1.0806	.014121	.030372
16	1.05174	-.013217	.037009
17	1.02542	-.033551	.04386
18	1.00191	-.047181	.050796
19	.981412	-.054498	.05769
20	.964053	-.055973	.064424
21	.949896	-.05214	.070889
22	.938936	-.043584	.076987
23	.93111	-.030927	.082635
24	.926299	-.014811	.087761
25	.924336	.004108	.092311
26	.925014	.025182	.096244
27	.92809	.047776	.099537
28	.933294	.07128	.102177
29	.940335	.095121	.104167
30	.948914	.118769	.105523
31	.958722	.141744	.106271
32	.969452	.163623	.106448
33	.980806	.184039	.106098
34	.992498	.202688	.105274
35	1.00426	.219331	.104031
36	1.01584	.233786	.102431
37	1.02701	.245935	.100537
38	1.03758	.255716	.098411
39	1.04739	.263123	.096118
40	1.05629	.268196	.093718

```
(1) irfname = vecm_40, impulse = C, and response = C
(2) irfname = vecm_40, impulse = C, and response = I
(3) irfname = vecm_40, impulse = C, and response = R
```

```
. irf table irf, impulse(I) irf(vecm_40)
```

Results from vecm_40

step	(1) irf	(2) irf	(3) irf
0	0	1	0
1	.344305	1.14173	-.004278
2	.47054	1.27878	-.011971
3	.570907	1.28581	-.022146
4	.62642	1.24648	-.033885
5	.658758	1.17053	-.046346
6	.672316	1.07398	-.058798
7	.671865	.96424	-.070624
8	.659905	.846901	-.081328
9	.638344	.725729	-.090525
10	.608648	.603637	-.097939
11	.572115	.482972	-.103389
12	.529962	.36572	-.106778
13	.483375	.253591	-.10809
14	.433525	.148063	-.107369
15	.381557	.050394	-.104719
16	.328579	-.038381	-.100287
17	.275647	-.117445	-.094258
18	.223742	-.186208	-.086844
19	.173762	-.2443	-.078274
20	.126504	-.291569	-.068791
21	.082654	-.328069	-.05864
22	.042783	-.354046	-.048065
23	.007343	-.369924	-.037301
24	-.023339	-.376282	-.026573
25	-.049052	-.373832	-.016086
26	-.069699	-.363399	-.006027
27	-.085292	-.345894	.003441
28	-.095943	-.322289	.012178
29	-.101853	-.293598	.02007
30	-.103299	-.260848	.027029
31	-.100629	-.225061	.032992
32	-.094242	-.187236	.037922
33	-.08458	-.148326	.041805
34	-.072116	-.109227	.044649
35	-.057339	-.070763	.046484
36	-.040745	-.033676	.047355
37	-.022826	.001384	.047326
38	-.00406	.033861	.046471
39	.015098	.063299	.044878
40	.034221	.089343	.042639

(1) irfname = vecm_40, impulse = I, and response = C
(2) irfname = vecm_40, impulse = I, and response = I
(3) irfname = vecm_40, impulse = I, and response = R

```
. irf table irf, impulse(R) irf(vecm_40)

            Results from vecm_40
```

step	(1) irf	(2) irf	(3) irf
0	0	0	1
1	-.150078	1.12514	1.7945
2	.214179	2.43958	2.40558
3	.863759	4.04635	2.85351
4	1.78408	5.78593	3.15702
5	2.90414	7.57397	3.33365
6	4.16894	9.32185	3.39993
7	5.52376	10.9589	3.37152
8	6.91958	12.4274	3.26328
9	8.31249	13.6833	3.08927
10	9.66423	14.6953	2.8628
11	10.9422	15.4435	2.59634
12	12.1194	15.9187	2.30151
13	13.1745	16.1206	1.98901
14	14.0912	16.0569	1.66863
15	14.8583	15.7422	1.34911
16	15.4694	15.1964	1.0382
17	15.9223	14.444	.742593
18	16.2186	13.5127	.467922
19	16.3635	12.4324	.218774
20	16.3652	11.2344	-.001292
21	16.2342	9.9503	-.18971
22	15.9832	8.6114	-.344856
23	15.6266	7.24795	-.465993
24	15.1797	5.88848	-.553195
25	14.6586	4.55937	-.607272
26	14.0798	3.28441	-.629681
27	13.4594	2.08449	-.62244
28	12.8134	.977371	-.588031
29	12.1568	-.022415	-.529309
30	11.5039	-.903653	-.449409
31	10.8674	-1.6584	-.351652
32	10.2591	-2.2819	-.239464
33	9.68885	-2.77242	-.116293
34	9.16522	-3.13106	.014466
35	8.69499	-3.3615	.149535
36	8.28333	-3.46969	.285815
37	7.93382	-3.4636	.420432
38	7.64845	-3.35285	.55078
39	7.42774	-3.1484	.674554
40	7.27087	-2.86222	.789769

```
(1) irfname = vecm_40, impulse = R, and response = C
(2) irfname = vecm_40, impulse = R, and response = I
(3) irfname = vecm_40, impulse = R, and response = R
```