International Journal of Economics and Finance; Vol. 16, No. 7; 2024
ISSN 1916-971X E-ISSN 1916-9728
Published by Canadian Center of Science and Education

Investments as Business Cycle Trigger - Testing Hicks-Model hypotheses with Demand and Interest Rate Changes: Evidence from Two Behavioral Experiments

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Received: April 18, 2024 Accepted: May 16, 2024 Online Published: June 5, 2024

doi:10.5539/ijef.v16n7p51 URL: https://doi.org/10.5539/ijef.v16n7p51

Abstract

The central Hicks hypotheses were tested using a behavioral science and the model with capacity effects and price changes. In a further step, the model was expanded to include interest-dependent investments. The Hicks hypotheses were confirmed. Demand created demand via induced investment, which led to an upward process, and the mere decline in demand growth already initiated a downward process. Errors by the central bank in controlling interest rates triggered economic fluctuations. Governments and central banks should be careful if they want to stimulate the economy through increased demand and low interest rates. The risk of overstimulation is great.

Keywords: Hicks model, overinvestments, low interest rate policy, monetary business cycles, boom and bust cycles, Wicksell hypothesis, behavioral modeling

1. Introduction

As Scott (2023) points out, business cycles and recurrent crises cannot be explained by purely natural causes. They could be caused by shocks as technology shocks emphasized by real business cycle theory. However, these causes are exogenous in nature and must occur repeatedly and produce sinusoidal oscillations, which is unlikely. The economic system generates endogenous business cycles even when there are no external shocks. These mathematical relationships are at the heart of the theory of endogenous business cycles. Another reason could be human behavior. Furthermore, since economic reality is determined by human behavior, mathematical models should be tested with these actors.

Based on Keynes, for Hicks investments are the central driver of the economic process. In Hicks' supermultiplier (1950), fluctuations in autonomous investments as well as multiplier effects, as increases in demand as a result of increases in demand, and accelerator effects, as investments triggered by increases in demand at full capacity, lead to economic fluctuations. This should be tested using behavioral science. How do managers react to fluctuations in demand with their investments? How does an increase in government spending affect the business cycle? Can a business cycle comparable to the Hicks model be modeled? And how do the central bank's interest rate decisions affect investment behavior and economic fluctuations?

Section 2 provides an overview of the existing literature and compares it with the experiments presented in this study. Section 3 elaborates on the study's experimental design, while the results and conclusions are detailed in sections 4 and 5, respectively.

2. Related Literature

After early contributions by Harrod (1936), Samuelson (1939) was the first to combine the Keynesian demand multiplier and investment accelerator into a model of a demand-dependent investment function, thus generating regular fluctuations in aggregate demand. The disadvantage of Samuelson's economic model, however, is that the fluctuating gross domestic product does not follow a growth trend, but moves around or towards a constant value, depending on the parameter constellation, or moves away from it in the event of explosive fluctuations. Kaldors (1940) mechanism relied on the discrepancies between ex-ante saving and investment to explain the changes in the level of economic activity endogenously. Investment depends on the level of profit. The profit depends on the level

of activity. Nonlinear investment and savings functions and their shift over time lead to a business cycle. Kalecki added the idea of a time lag in the capital accumulation (Krawiec & Szydlowski, 1999; Szydłowski, Marek, & Krawiec, 2001; Szydłowski & Krawiec, 2005). Finally, Hicks (1950) succeeded in explaining the fluctuations in the utilization of a constantly growing production potential that can be observed in reality by taking into account induced and autonomous investments.

Hicks (1950) combined a simple consumption function $C_t = c\ Y_{t-1}$ and an accelerator $I_{ind\,t} = ß \cdot (Y_{t-1} - Y_{t-2})$. By taking into account induced and autonomous investments $I\,aut_t = A_0 * (1 + w)_t$ [A_0: initial value, w: constant growth rate of autonomous investment], HICKs succeeded in explaining cyclical fluctuations in GDP in an upward channel, i.e. fluctuations in the utilization of a steadily growing production potential:

$$Y_t = C_t + I_t^{ind} + I_t^{aut} = c\ Y_{t-1} + ß \cdot (Y_{t-1} - Y_{t-2}) + A_0 \cdot (1 + w)^t$$

Due to the accelerator relationship $I_t^{ind} = ß \cdot (Y_{t-1} - Y_{t-2})$, a constant growth rate is a prerequisite for constant demand. The mere decline in demand growth can thus already initiate a downward process. The upward process is initiated by the investment demand induced as a result of the growth of autonomous investments. As soon as $Y_{t+1} > Y_t$ applies again investments will be induced.

The biggest shortcoming of this model is the neglect of the monetary side (the investments are not interest-dependent). Changes in price levels are excluded as a determinant of the economy. An overdemand does not have any negative consequences. Furthermore, the demand-induced investments have no capacity effect. However, Hicks illustrates the dynamic importance of changes in demand. This explains the sinusoidal fluctuations observed in reality around an ascending gross domestic product growth path. On the other hand, Hicks does not provide an explanation of how the growth rate of autonomous investment that he assumes comes about.

Based on Hicks' model, there have been numerous further developments. Chenery (1952) has designed an investment function that is dependent on both demand and capacity utilization, taking into account the capacity effect of past investments. Goodwin (1951) developed an overall model in which consumer demand consists of an autonomous and an income-dependent part. Goodwin's model results in business cycles with very realistic characteristics, with each cycle initiating the next. The cycles do not expire, nor do – in contrast to Hicks' model – explosive vibrations occur, which would make the introduction of ceilings necessary. In addition, the type of oscillation does not depend on the initial conditions or the model coefficients (Assenmacher, 1998). Goodwin used a reduced-form real-wage Phillips curve. Chiraella a.o. (2000, 2005) took separate equations for wage and price inflation to determine the evolution of the wage share, with the explicit equations for inflation (Scott, 2023).

The missing endogenization of the money market was provided by Phillips (1961) and that of the labor market by Bergstrom (1982). With his model, Phillips succeeds in demonstrating the cyclical stabilizing influence of utilization-dependent price changes triggered by wage reactions. Based on the Philipps model, Bergstrom endogenizes the labor market by means of a production function. In accordance with the conditions of profit maximization in perfect competition, the marginal productivity of capital determines the demand for capital, and the marginal productivity of labor determines the demand for labor, which also determines the level of interest and wages. Ceteris paribus, wage increases cause an increase in labor supply, but also a decline in labor demand and thus a decline in gross domestic product. The decline in income has an effect via the multiplier (Teichmann, 1997; Assenmacher, 1998). Later Samuelson (1988) introduced self-sustained fluctuations by under Goodwin's influence (Assous, Boianovsky, & Davila-Fernandez, 2024).

Wicksell addressed the connection between the central bank's interest rate control and economic fluctuations. Knut Wicksell attributes the responsibility for economic boom and bust cycles to the actions of monetary policy decision-makers and their inappropriate handling of interest rate controls. During the boom phase, interest rates are maintained at excessively low levels, resulting in an accumulation of overinvestments due to a collective error in judgment. The central bank's response, when it eventually comes, is both delayed and severe, not only exacerbating the boom but also inadvertently precipitating the subsequent bust, as posited by the Wicksell hypothesis (Wicksell, 1922; Wicksell, 1968; Grosskettler, 1989).

Conrad, on the other hand, conducted an analysis of the underlying causes of overinvestment and, consequently, investment cycles through two behavioral experiments. In these experimental simulations, increases in demand and reductions in interest rates were found to boost unit profits, resulting in uncoordinated and collectively excessive investments, thereby highlighting the occurrence of collective errors. These errors ultimately contributed to the phenomenon of overinvestment and the subsequent occurrence of investment cycles, often referred to as boom and bust cycles (Conrad, 2022).

Gallegati et al. (2003) mathematically revised the Hicks model, as did Puua et al. (2005). However, the Hicks

model has not yet been tested or explained by behavioral science. It is a purely mathematical model.

This paper delves into an examination of the central Hicks hypotheses by employing a model to elucidate the behavior of individuals within group dynamics. Behavioral modeling, as discussed in Conrad's works (2015, 2019, 2021, 2022), aims to delineate the economic framework governing behavior in various scenarios, although it does not assert an exact representation of reality. In contrast to traditional economic modeling, which uses mathematics, we do not assume rational behavior. Instead, we study behavior with experiments so that we can get closer to reality. These models are designed to encompass only the factors relevant to decision-making and subsequently explore the sociological interactions among multiple actors. Behavioral hypotheses are formulated within the models and then subjected to testing using human subjects within the model's framework. The experimental design is elucidated in detail to enable other researchers to replicate it. In line with Popper's philosophy (1958), these hypotheses remain applicable until they are contradicted by experiments yielding contrasting outcomes. The behavioral tendencies thus ascertained can, in turn, serve as foundations for new theories and strategies in economic policy.

3. Experimental Design

Our behavioral science model is intended to test the central Hicks hypotheses using behavioral science and to make the model more realistic with capacity effects and price changes. Statements for economic policy should be derived from this (experiment A).

In a further step, the model will be expanded to include interest-dependent investments. The effects of monetary policy as interest rate policy are to be examined in the behavioral science Hicks model (experiment B).

Hicks hypotheses experiment A

- Induced investments are the central driver of the economic process.

- Existence of a demand accelerator: demand creates demand via induced investments, which leads to an upward process

- The mere decline in demand growth can therefore already initiate a downward process.

Hicks hypotheses experiment B

- Interest rate cuts induce investments and thus an economic upswing in a Hicks model

- Likewise, interest rate increases initiate a downturn process

This results in the Wicksell hypothesis: errors by the central bank in controlling interest rates can trigger economic fluctuations.

Experiments A and B were carried out during the winter semesters of 2021/22 and 2023/24, as well as in the summer semesters of 2022 and 2023, utilizing MS Teams and Excel as tools. The study involved a total of 142 participants, organized into ten groups, consisting of different students from various Business Bachelor programs such as macroeconomics and political economy at the University of Applied Sciences HTW in Saarbrücken, Germany. A simplified company served as a model for the experiment, and the students were tasked with managing capital investment, much like a company manager. Their primary objective was to maximize profits, an objective of a manager acting on behalf of a company owner or shareholder. Achieving maximum profit within the group resulted in a variable compensation of 10€ in real money. The rules governing the experiment were thoroughly explained to the participants prior to its commencement.

Managers (students) should vary investments to maximize profits. Interest rates are an influencing factor of the P&L and the investments are made with borrowed capital. The interest payments reduced the company's equity, while profits had the opposite effect of increasing it. The investment changes of all players change the demand in percentage terms (50%). The price of products factored in both demand and production capacities. The price for the current period (P_t) was determined by multiplying the ratio of demand to capacity by the price from the previous period ($P_t = D/PC\ P_{t-1}$). The game started with a demand equal to the supply. In addition, capacities per round are reduced by 40% due to depreciation.

Each company had to make profit maximizing decisions regarding its investments (I). Thus, investments will probably depend on profits as assumed by Kaldor (1940). In reality, there are delays in the expansion of production capacities, which was also an assumption of Kalecki's model (1935). Managers are responsible for procuring production equipment and integrating it into the manufacturing process. In our simulation, investments totaling 2.5 million euros (spanning two game rounds) resulted in a 50,000-unit increase in production capacity over a two-year period. This increase equated to an additional 1 million euros in sales revenue at a price of 20 euros per

unit (representing a 40% increase in the price of 50 euros per unit of production capacity, calculated as $PC_{t+2} = PC_t + I_t/50$). Once production facilities were installed, they became permanent fixtures, making the capacity increase irreversible.

The test subjects started with a turnover of 10 million euros (sales) and an equity (EQ) of 10 million. At a price of €20 (P) and production costs of €15 (PC), they sold their production capacity of 500,000 goods (PCap), i.e. they made a profit (PR) of 1.9 million euros (PR) (PR = S - PC - CC) minus the 600,000 euros borrowing costs at an interest rate of 3% (Capital Costs, CC).

4. Results

4.1 Game A: The Effects of Increases of Demand on Investments and Business Cycles

The interest rate remained constant at 3%. Demand was changed in the first game (see Fig. 1) by a positive demand shock of 30% in the 3rd round. This is equivalent to an exogenous increase in autonomous investment in the Hicks model or an increase in autonomous government spending. Due to the accelerator effects in the Hicks model, this leads to an economic upswing as the increase in demand stimulated further investment. The increase in demand first caused a price increase (see Fig. 2). This caused an increase in unit profits for companies (see Fig. 3). Managers responded to this by increasing investments (see Fig. 4). Only the delayed capacity expansions (see Fig. 5) led to an oversupply from the 6th round onwards and thus to a price collapse (see Fig. 2), which made the investments unprofitable due to the falling unit profits (see Fig. 3). Investments collapsed (see Fig. 4). The winners were the players who had invested prudently and not the most.

The problem also emerged that increases in demand can cause overinvestment crises. Companies only see their own earnings figures. The increase in demand leads to price increases with initially constant capacities. Corporate profits rose. From an economic point of view, the manager decided to increase capacities in order to increase sales and thus profits. Investments increased and demand continues to rise. The maturity period of the investments refers to the time that is necessary from the raising of capital to the implementation of the new systems in production. So, capacities only increased two rounds later in order to adapt supply to demand. Therefore, the price and with it the profit continued to rise and the managers invested even more. The managers were not able to optimally control the capacities for the overall economy. In addition to the wrong price signal, they also lack information about how much their competitors have invested. Two rounds later, the new, far too high supply came onto the market and the price collapsed. The result was bankruptcies, which was reflected in the negative equity (see Fig. 6). As a result, the market equilibrium would have been restored due to the reduced supply with the exiting companies.

All in all, behavioral evidence for Hicks` demand-induced investments was provided. Demand created demand and a growth process emerged (see Fig. 7). The accelerator effect described by Hicks was observed in investments; increases in demand increased the price and thus the profit margin. This led to further investments, which drove the price further up and thus stimulated new investments. Ascending sinusoidal oscillations of the GDP emerged (see Fig. 7).

In addition, with 62 participants as a reference game in various groups, the reaction in the base model was tested at an interest rate of 3% with no changes. Overall, the 30% increase in demand resulted in a 15.5% higher maximum price and a 5.8% higher maximum GDP compared to the reference game without demand increase.

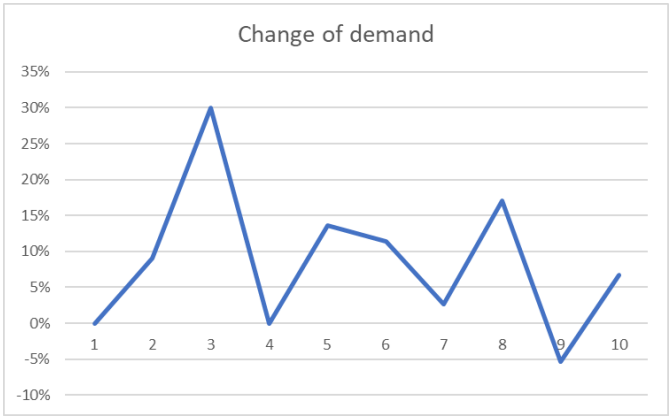

Figure 1. Change of demand

Figure 2. Price

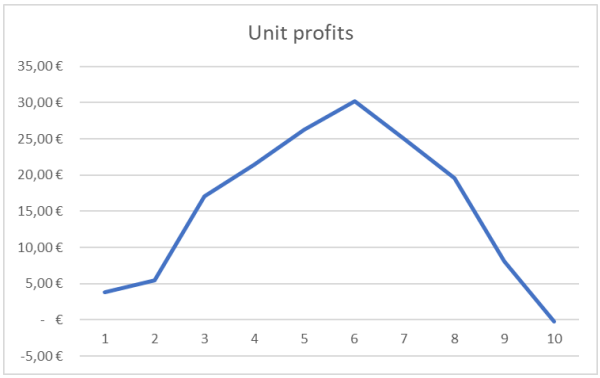

Figure 3. Unit profits

Figure 4. Investments

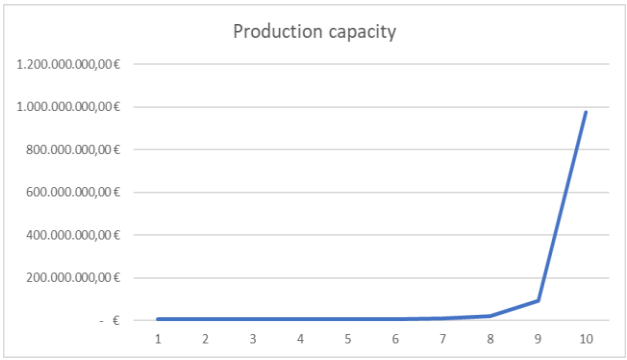

Figure 5. Production capacity

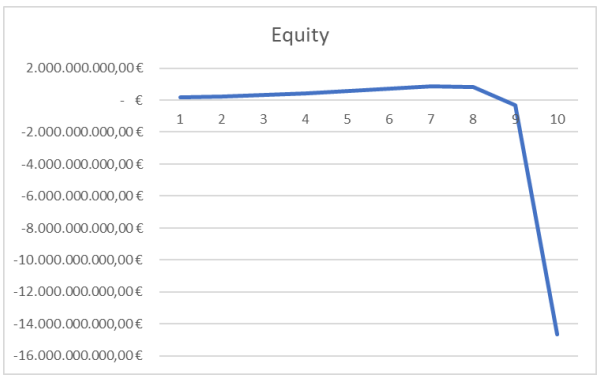

Figure 6. Equity

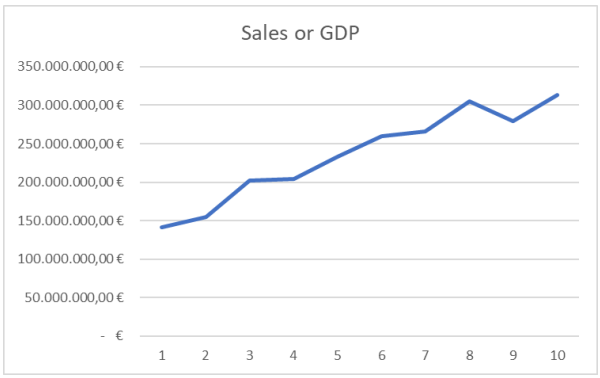

Figure 7. Sales or GDP

4.2 Game B: The Effects of Interest Rate Changes on Investments and Business Cycles

In a second experiment, an expansionary zero interest rate policy of the central bank was simulated. The central bank wanted to stimulate the economy and in the third round reduced the interest rate to zero, which triggered massive investments (see Fig. 11) and thus increased demand (see Fig. 8) and caused a price increase (see Fig. 9). Companies' unit profits (see Fig. 10) increased due to zero interest rates and increased prices, which stimulated new investments (see Fig. 11 and Fig. 14 for the cost of capital per unit). Due to the accelerator effects in the Hicks model, this led to an economic upturn as the investments stimulated further demand.

Due to the price increase (inflation) (see Fig. 9), the central bank increased interest rates in the 5th and 6th rounds and thus choked off investments, as unit profits collapsed (see Fig. 10) due to the high borrowing costs (see Fig 14).

Only the delayed capacity expansions (see Fig. 12) then led to an oversupply and thus to a collapse in prices (see Fig. 9), which made the investments unprofitable, which subsequently collapsed (see Fig. 11). The lack of investment depressed general demand and prices continued to fall (see Fig. 9). From round 7 onwards, the

central bank tried to counteract this with a zero interest rate policy. Investments (see Fig. 11) and thus demand (see Fig. 8) increased again, but they were unable to reverse the negative price trend (see Fig. 9). Investments collapsed again as production capacities led to an increasing oversupply after two rounds of delay due to the previous high investments. The price collapsed (see Fig. 9) and unit profits fell (see Fig. 10). Bankruptcies occurred, which is shown by the average negative equity (see Fig. 13). As a result of the bankruptcies, supply will adjust to demand again, meaning overinvestment will be reduced.

The winners were the players who invested prudently and not the most. Players reported a strong incentive to invest when the interest rate fell to zero, meaning the loans were free.

Interest rate changes had a strong impact due to the accelerator effects of investments. Figure 15 shows how the central bank's interest rate cuts triggered the upturn and the subsequent increase in response to inflation caused the downturn. This results in the sinusoidal economic fluctuations described by Hicks with a growth trend. As a result, the central bank's interest rate control triggered economic fluctuations. The Wicksell hypothesis was confirmed. The model also showed that once the economy has left the growth process, it is difficult for the central bank to regain it by cutting interest rates.

In addition, the reaction in the basic model with an interest rate of 3% and no changes was tested with 62 participants as a reference game in different groups. Overall, the interest rate policy resulted in a 42.9% higher maximum price and a 57.7% higher maximum GDP than in the comparison game without an interest rate increase.

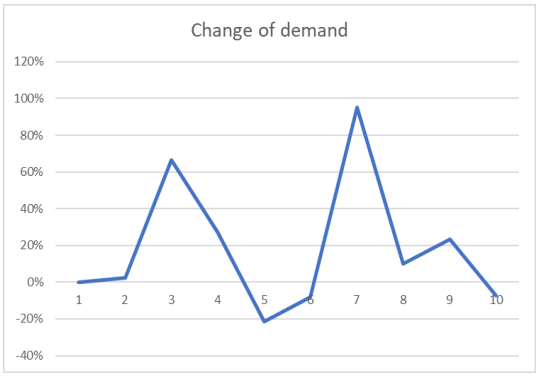

Figure 8. Change of demand

Figure 9. Price

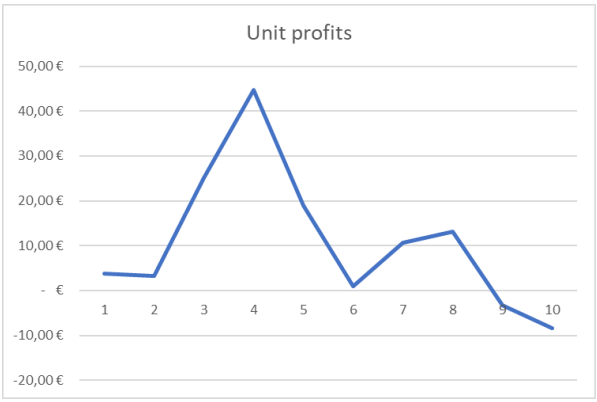

Figure 10. Unit profits

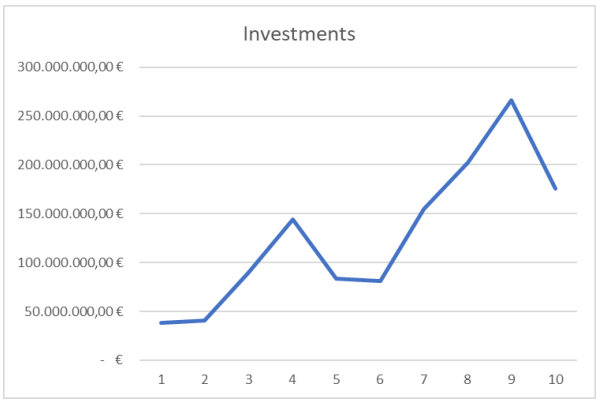

Figure 11. Investments

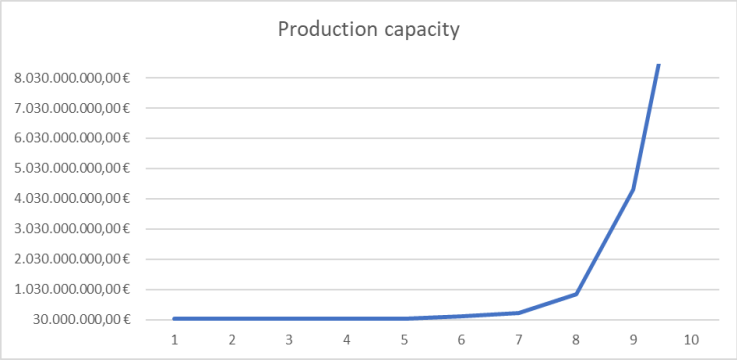

Figure 12. Production capacity

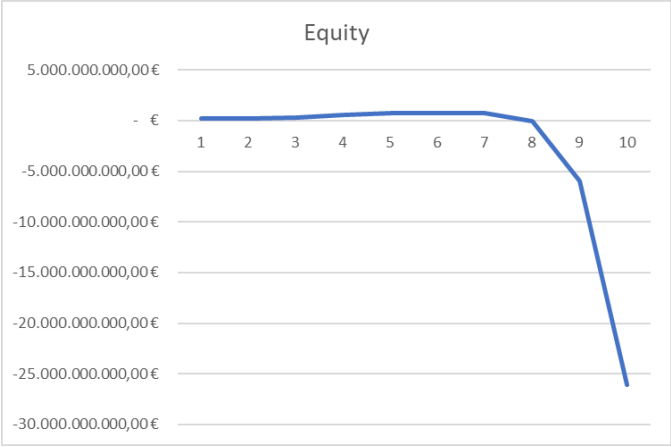

Figure 13. Equity

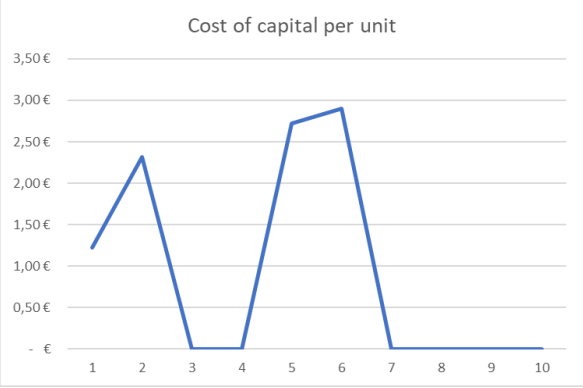

Figure 14. Cost of capital per unit

Figure 15. Sales or GDP

5. Conclusion

It has been shown with the behavioral experiments that, as in Hicks' supermultiplier (1950), fluctuations in autonomous investments and accelerator effects (induced investments) lead to economic fluctuations with an increasing trend.

The Hicks hypotheses from experiment A were confirmed using behavioral science: induced investments are the central driver of the economic process in the simulations. The existence of a demand accelerator could be proven using behavioral science. Demand created demand via induced investment, which led to an upward process, and the mere decline in demand growth already initiated a downward process. The Hicks hypothesis from experiment B was also confirmed using behavioral science. The central bank's interest rate cuts induced investments and thus an economic upswing, while interest rate increased also initiate a downturn. The Wicksell hypothesis was

confirmed by behavioral science. Errors by the central bank in controlling interest rates triggered economic fluctuations in the games.

The economic policy conclusions that can be drawn from this model correspond to those of Keynes' further developed theory. The state should compensate for fluctuations in demand through autonomous demand impulses (discretionary countercyclical fiscal policy). However, Hicks' model also shows the sensitivity with which the economy reacts to changes in demand over the course of dynamics. Taking into account the now well-known practical problems of recognizing and implementing state demand management, a warning against discretionary economic policy can also be derived from this. The inclusion of the capacity effects of the induced investments led to massive price effects. An increase in government demand or a reduction in interest rates by the central bank therefore leads to significantly higher prices and thus to a loss of competitiveness in an open economy. Furthermore, a one-off (one-period) increase in demand by the state in the Hicks model in the following period (c.p.) corresponds to a decline in demand for the economy as a whole and thus initiates a downward process. Therefore, the Hicks model showed also the dangers of discretionary economic policy management.

These conclusions were confirmed and strengthened by the two behavioral science experiments presented. Experiment A simulated a one-time but sustained increase in general demand, comparable to an increase in autonomous government spending. And in experiment B, a sharp interest rate cut by the central bank was simulated. Both times there were economic boom and bust cycles. Due to the delayed price reactions to capacity expansion and the high incentives of rising unit profits, companies tend to make wrong decisions as a result of price increases or interest rate cuts, which can lead to overinvestment with a subsequent crash.

The experiments showed the catastrophic effects of a collapse in investment. If profit expectations turn out to be wrong due to overinvestment as a result of the price collapse, companies will stop investing and demand will collapse. The result is a collapse of the market until supply has adjusted to the reduced demand due to company bankruptcies. Governments and central banks should be careful if they want to stimulate the economy through increased demand and low interest rates. The risk of overstimulation is great. Inflation occurs and the central bank has to counteract this by raising interest rates, which can result in a crash and a monetary policy recession. There are boom and bust cycles generated by monetary policy. The alternative would be to accept inflation over a long period of time. But then the excess capacity would remain in the market for longer and the economic costs and distribution effects would be even higher. Stagflation would occur.

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