



# Corporate governance, taxes and real investment in non- financial firms

An agent-based approach  
N.C.T. van Berkel



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by

N.C.T. van Berkel

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Thesis committee:	Dr. H. H. Hansen, TU Delft, First Supervisor Dr. S. T. H. Storm, TU Delft, Second Supervisor Dr. M. E. Warnier, TU Delft, Chairman

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# Preface

The Master thesis that lies before you is a compilation of hard work, setbacks and my interests in economics finance. After a lot of rejections from other supervisors when desperately wanting to finish my Masters, Servaas Storm was able to brainstorm with me for a potential subject for my thesis. However, he did not have enough time to intensively supervise my thesis. Luckily, Helle Hansen and Martijn Wanier wanted to help me as first supervisor and chairman of the committee.

I want to thank Servaas Storm and Martijn Wanier for the guidance, feedback and support in my graduation. Specifically, I want to thank Helle Hansen for the feedback and meetings week after week. I learned a lot from you about writing coherent and structural text and how to write a convincing literature review. And I hope you learned something about economics and finance too through supervising me in my graduation project. I am sorry for all the late-night emails with my work due to my sometimes not logical study schedules.

Lastly, I want to thank my girlfriend Melissa and my family for the unconditional support during my thesis. Could not have done it without you, guys.

Enjoy reading my thesis.

*N.C.T. van Berkel*  
*Delft, 18 November 2019*



# Executive summary

Real investment within corporations has been steadily decreasing in the last fifty years. [9, 20]. Real investment or physical investment is a collective name for investment in tangible assets, in contrast with financial investments in securities or options. Real investment and capital accumulation is essential for firm growth, and hence economic growth [11, 63], especially for non-financial corporations (NFCs) that have their primary income in the real economy [18, 52].

A decrease in real investment in NFCs in the last 40 years has led economists to believe that increased payouts to financial markets from the non-financial firms have crowded out funds available for investment. The average payout relative to cash flow in US NFCs has increased from 8 percent in 1976 to 49 percent in 2010 [48]. These payouts come in the form of dividend payouts and share repurchases. Dividend payout is the distribution of profits to the shareholder of a company, which is mostly distributed with a yearly schedule. On the other hand, share repurchases are the re-obtainment of stock from shareholders to distribute cash among shareholders or obtain shares for executive payments. On both forms of payout, shareholders have to pay taxes in the form of a dividend payout tax and a capital gain tax. Shareholders can sell or buy shares (or "stock") of a particular firm from the stock exchange the firm is listed on.

The system of practices and rules that a corporation follows in their decision-making processes is known as *corporate governance*. A change in corporate governance from retaining and reinvesting profits to distributing profits to shareholders has been found to be a primary cause of these increased payouts. This change in corporate governance have been labeled mostly as a shift towards *maximizing shareholder value* in public firms. This corporate governance strategy has been prevalent in US board rooms ever since the 1980s [62].

A second reason for increased payouts from the early 2000s was the 2003 dividend and capital gain tax cut. It showed that US non-financial firms increased their payouts relative to the tax cut [15]. However, there are large differences between NFCs in their corporate governance and their decision making regarding payout policy and investment. The work of Chetty and Saez [15] showed that not all firms responded to the 2003 US tax cut. The way firms decide on their payout policy and real investment differ for alternate types of corporate governance NFCs operate with. It is currently unknown which types of corporate governance can explain the effect of taxes on the real investment rate in NFCs. From this knowledge gap, the following research question has been formulated:

*"What kind of corporate governance of NFCs can explain the effects of taxes on the real investment rate in NFCs in a stock market?"*

To answer the research question, an agent-based modelling approach was used. A stock model was built with investors and NFCs, who interact with each other through the buying and selling of stock. The investors in the model were able to have one of two investing strategies, which decided their forecast price and the amount of stock they would want to sell or buy. These two investing strategies were a chartist strategy, which based its forecast on the historical share price, and a fundamentalist strategy, which based its forecast on a *true* value the investor believes the stock is worth. Three tax rates were included in the model: the tax on corporate profits, the tax on dividend payout and the tax on capital gain. Three types of NFCs were implemented, based on different types of corporate governance. These types were:

- *Maximizing shareholder value (MSV)*: NFCs of the MSV type base their dividend rate on the return on investment of their shareholders and base its share repurchasing target on the EPS of the firm.
- *Minimizing interest payments (MIP)*: NFCs of the MIP type base both their dividend rate and share repurchasing target on the change in net income of the firm.
- *Minimum payout and investment (MPI)*: NFCs of the MPI type base both their real investment rate and total payout (dividend payout and share repurchases) on a minimum percentage of earnings that has to be spent on both expenses.

The results showed that there is a strong correlation between taxes and the real investment rate for the MSV and MIP types of NFCs. The MPI type of NFCs had a far lower correlation between the tax rates and the real investment rate due to the minimum investment rate that kept the real investment rate mostly constant.

Especially the tax on corporate profits was a limiting factor on the funds available for real investment in the NFCs. The results indicate that although the share price has no significant effect on the real investment rate, the conditions of the investors and market likely explain the amount of share repurchases of the NFCs.

The answer on the research question is that the MSV and MIP types of corporate governance can explain the effect of taxes on the real investment rate. This answer indicates that corporate governance does affect how firms respond to different tax rates in the area of payout and investment. The investment rate of firms that have a corporate governance focused on maximizing their shareholder value will not differ much from firms that have a corporate governance focused on minimizing shareholder value. In line with Stockhammer [62] and Orhangazi [52], dividend payout and share repurchases will decline the funds available for net income. The condition of the investors and market likely have a large affect on the share repurchasing rate of the NFCs.

This thesis filled the knowledge gap of the unknown influence of corporate governance on the effect taxes has on investment in firms by suggesting that corporate governance does matter in the tax-investment-payout puzzle in NFCs. Moreover, the conclusion that corporate governance does influence the real investment rate in NFCs can help policy makers in understanding how firms can be stimulated in investing more and paying out less of their earnings. The main recommendation for future research is to research what kind of effect changes in tax rates have on the payout and investment rates in NFCs.



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# Introduction

## 1.1. Real investment in non-financial corporations and the growth of the financial sector

Real investment within corporations has been steadily decreasing in the last fifty years [9, 20]. Real investment or physical investment is a collective name for investment in tangible assets, in contrast to financial investments in securities or options. These tangible assets can be related to investment in machines, factories or offices, but also research & development (R&D) and new projects [47]. The increase in capital from these investments is known as *capital accumulation* [62]. Real investment and capital accumulation are essential for firm growth, and hence economic growth [11, 63], especially for non-financial corporations (NFCs) that have their primary income in the real economy [18, 52].

Systemic low investment in corporations can have negative effects on the real economy. Investment is key to economic development and innovation in both developed and in developing countries [66]. The lower real investment shows a larger trend in a shift from firms reinvesting profits to grow their businesses and create innovation within their company, to distribute profits to shareholders. If this happens on a systemic level in the economy, this could damage the health of corporations, which could ultimately lead to bankruptcy and a standstill of the economy [48].

## 1.2. Financialization and increased payouts of non-financial firms

Research suggests the increasing influence of the financial sector on the real economy is a major factor in the decreasing real investment of NFCs since the 1980s [52, 62]. The financial sector has expanded its share in the United States economy from 3.6 percent in 1960 to 8.4 percent in 2014 [48]. Along with the rise of stock and capital markets, this expansion had led to the financial sector exerting a strong influence on the decision-making of public corporations through their role as shareholders and as debtors. These type of shareholders is commonly known as *Institutional investors*, investors that pool capital with the goal to get the highest possible return on this capital [67].

The increasing importance of the financial sector in NFCs is one of the characteristics of *financialization*, which refers to the growing size and magnitude of the financial sector in national economies, as well as the world economy. Financialization shifts income from the real economy to the financial sector [18, 53, 62]. Financialization manifests itself in firms with three different aspects: increased financial investment, increased indebtedness of firms and increased payout to shareholders. The first aspect of financialization is the investment in financial products. Due to the high return of these products, investments in financial assets, derivatives and options crowd out the rate of real investment and growth of their own business [1].

Secondly, firms have increased their debt ratio to decrease paid taxes and increase the company's value. This decrease in paid taxes is the result of the *interest tax shield*, which allows firms to deduct interest payments from their taxable income. This allows firms to borrow more capital to increase their operations, which increases the total value of the company. The increased debt also increased the payout to the debtholders in the financial sector in the form of interest payments.

Lastly, payout of public, non-financial firms to their shareholders have increase drastically, from an average of 8 percent of cash flow in 1976 to an average of 49 percent of cash flow in 2010 [48]. This is shown in

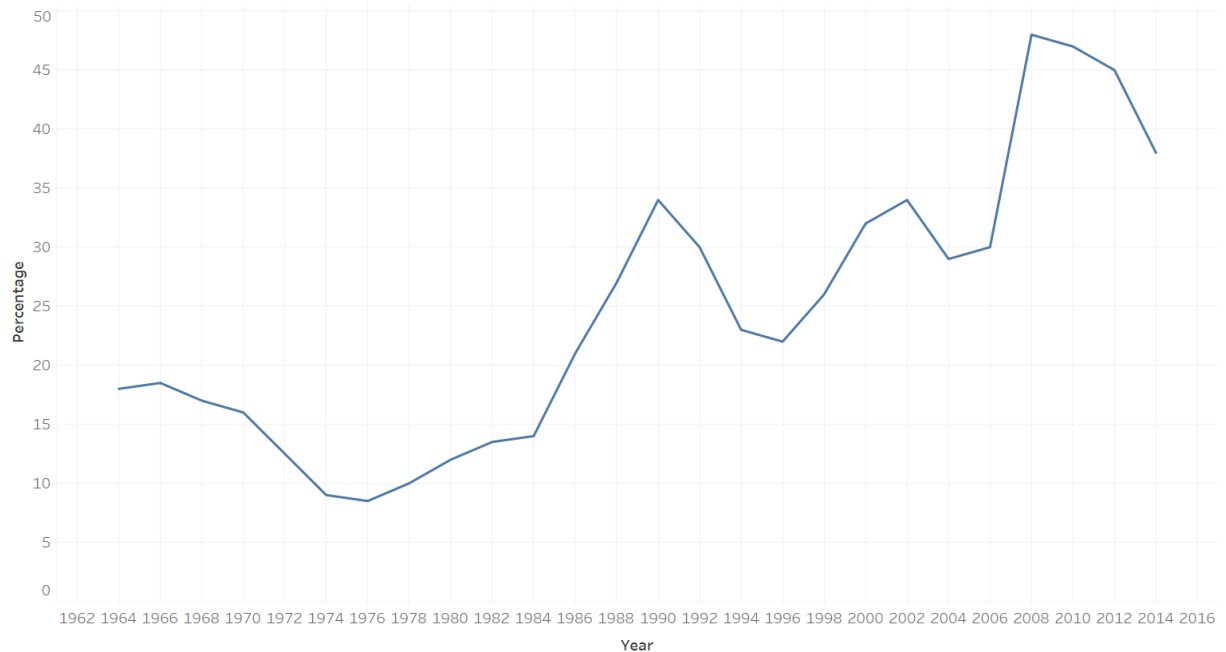


Figure 1.1: Percentage of cash flow returned to shareholders by non-financial firms from 1964 to 2014. Data acquired from the Mazzucato [48]

figure 1.1. The increasing payouts of firms have a large influence over the available funds that are present for real investment, and research suggests that this crowds out the available funds [21].

### 1.3. Corporate governance and payout policy

Public firms have strong connections with their shareholders and the market their shares are traded in. But how they make decisions on the amount of payout to investors, the amount of debt they take on or the capital that is investment is different for every business. The system of practices and rules that a corporation follows in their decision-making processes is also known as *corporate governance*. Corporate governance includes the processes on how the board of the firm is chosen and how shareholders hold power over the firm. Additionally, it also dictates how value is distributed to the shareholders of the firm, how investment decisions are made and how much leverage, the amount of debt in a firm, the corporation is willing to take [37, 61]. Corporate governance is different for every firm, but firms show similarities between countries and operating sectors [54].

This section discusses what the types of payout are, how they are determined and how they influence the shareholders and the financial market. Payout is the primary capital transfer method of corporations to their shareholders, and can come in both the form of dividend payments and share repurchases. The amount of payout is mostly measured in percentage of free cash flow (FCF), the cash available in a firm after the cash outflows to operations and capital assets. FCF is a determination of the amount of cash flow that is available for all stakeholders in the company [14]. Early research from Modigliani and Miller [50] and Miller and Modigliani [49] argued that payout policy does not change the value of a corporation and its shareholders. However, Brennan [13], Rubinstein [58] and DeAngelo et al. [21], amongst others, have disproven this idea over the last few decades and argue that a balanced investment-payout ratio can increase the return of their shareholders.

#### 1.3.1. Paying dividend and the 'dividend puzzle'

Dividend is a payment to shareholders of a firm, and is commonly categorized as a payment of profit that has been made by the firm. The dividend is usually a fixed amount per share, and the dividend rate is calculated as the dividend paid divided by the price per share [34]. In most countries, shareholders have to pay a tax over the amount of dividend they receive from the share equity they own [4]. Public corporations mostly have a yearly schedule for paying dividends, but they are sometimes declared with prior notice in the form of special

dividends. Dividends are usually paid as cash, but are sometimes paid as extra shares on top of the owned shares of the shareholders.

The 'dividend puzzle' of corporations is a widely investigated research subject from the last 60 years, where it has been analysed using both statistical analyses [22, 23, 60] and surveys [6, 7, 43]. The dividend puzzle describes the situation in which firms that payout dividend are valued higher, while in theory, it should not matter whether the income is spent elsewhere in the company or to dividend for the shareholder. One of the most notable factors, first found by Lintner [43], is the interest in keeping a smooth dividend rate without big drops or spikes. Fluctuating dividend rates create a risk for shareholders and also put up a barrier for firms to start paying dividend to their shareholders, as they have to have a stable cash flow to payout the yearly dividend. More factors influencing the dividend rate is the firm size, current and expected profit rate and growth opportunities [6, 22]. However, there is no complete mathematical explanation for dividend rates in firms, as it is not only determined quantitative, but also qualitative.

### 1.3.2. Share repurchasing programs as the preferred payout

Share repurchases or stock buybacks is the re-obtainment of stock by the firm of the stock. Part of the stock of shareholders is bought back with cash of the firm and the shares are either held in storage for payment packages of employees or for re-issuance. As with dividends, shareholders that are targeted by the stock buybacks have to pay taxes over the cash received through the selling of stock in the form of capital gain tax [55]. Public corporations with open-market stock buyback programs have a target for the amount of shares they want to repurchase every year or every quarter [16]. Achieving the share repurchasing goal depends on the demand of shareholders to sell their stock.

Massive share repurchasing programs have been a common payout practice since the mid-1980s and have even become a competitor to cash dividends in the distribution of cash flow to shareholders in corporations [8]. With these programs, corporations try to buy back shares from markets to decrease the supply of shares, hence increase the price of the stock, as well as distribute capital to shareholders and access share packages for employees [3]. *Earnings per share* or EPS management have been strongly linked to share repurchasing programs in NFCs [3, 12, 30]. The earnings per share is the profit of a corporation divided by the number of their outstanding shares. Management of corporations set EPS forecasts and buy back shares during the year to either try to reach the EPS target or surpass the target.

## 1.4. Maximizing shareholder value: from 'retain and reinvest' to 'downsize and distribute'

One of the causes for the increased payouts to the financial sector is the increasing importance of *maximizing shareholder value* in corporations. The notion of maximizing shareholder value is the result of the so-called shareholder revolution of the 1980s and 1990s, in which investors gained more power over management of firms [44]. Maximizing shareholder value was thought to increase the firm value in the long term, as the cash flow of large NFCs was previously invested in projects that were not even profitable [37, 68]. However, the last decade has shown that this ideology has resulted in a preference towards *value extraction* from these firms and a more short-term view for financial decision-making in these firms [18, 52]. This section discusses why and how public corporations have adopted the goal of maximizing shareholder value in the last fifty years.

### 1.4.1. History of maximizing shareholder value

Since the 1970s, the idea of *maximizing shareholder value* has been a substantial part of the corporate governance in the United States and Britain. This maximization of shareholder value signifies the incentive to put the shareholder first when management makes decisions regarding their internal organization, investments and payouts. Before the 1970s, businesses were careful with taking on debt and mostly reinvested their profit in new ventures and projects ("retain and reinvest"). Lazonick and O'Sullivan [36] suggest that the focus on the maximization of shareholder value is a product of mismanagement of the unseen growth of corporations. Due to mergers and acquisitions of successful corporations, the departments and divisions had stakes in different sectors and the central management had a too large distance to the production processes that created a positive return. This disconnect resulted in managers of divisions investing their budget in ventures that were not profitable, while shareholders were left in the dark about how the budget was spent. This led to economists (see, for example, Baker et al. [5], Jensen [31]) arguing that the free cash flow (FCF) of the businesses could be better spent on the compensation of shareholders and thus increasing the market value of the corporation.

At the same time, institutional investors and savings loans institutions (S&L) started to concentrate shares of corporations and gained more influence over the stock markets and their firms. Due to deregulation of the financing sector in the US in the 1970s, the banking sector created a market for previously worthless *junk bonds*, risky bonds with a low yield. This market led to institutional investors and S&Ls having access to large sums of capital, which they used to finance the *takeover movement* of the 1980s and 1990s. The idea behind this movement was that takeovers of firms were necessary to correct the distribution of free cash flow and maximize the shareholder value. Additionally, shareholders chose board members of firms that agreed with the view of shareholder value maximization and would rather sell assets or lay off employees than decrease the shareholder value [36].

#### **1.4.2. Difference in corporate governance in public firms**

The corporate governance strategy of maximizing shareholder value is still the prominent strategy for public firms and is seen as the "new normal" in public firms [35]. The strategy quickly spread through the 1980s and 1990s, and led to a decrease in labour force in corporations and increasing payouts to shareholders ("down-size and distribute") [37]. However, not all public firms execute the characteristics of maximizing shareholder value, as a substantial part of public corporations do not payout dividend or repurchase shares regularly or in large quantities. Aguilera and Jackson [2] found that not all firms focus on maximizing shareholder value in corporate governance, in a survey of public corporations. This depends on region, past management-shareholder relations and the percentage of institutional shareholder in the firm. The increased payout of NFCs that have been found to decrease real investment in these firms gives an indication of a relation between corporate governance and the real investment rate in these firms.

### **1.5. Modigliani-Miller and Post-Keynesian theory of the firm**

In economics, there are several theories on how public firms grow and how they finance their expenses and activities. Two of these theories are the Modigliani-Miller theorem (or MM) of capital structure and the Post-Keynesian theory of the firm. Both theories have been used extensively in economics to explain the growth and behavior of businesses and the constraints on growth and profits of firms. This section will explain both theories and why this study will use the Post-Keynesian theory of the firm.

MM assumes that when a firm operates in a market with perfect information and in the absence of taxes, the value of the firm is unaffected by how the firm finances its operations. This also indicates that the payout of dividend, share repurchases and the selling of new stock do not affect the value of the firm. The idea behind this theory is that investors only want a return on their investment, and do not care from which cash streams that return comes from. If the dividend of a stock does not meet the return criteria of an investor, the investor can sell shares to create that return for themselves. This results in a stable share price, which also keeps the value of the firm stable. In a world with taxes, the choice of cash streams does matter because of differences in dividend payout and capital gain taxes [50].

The main assumption in the Post-Keynesian theory of the firm is that there is a finance constraint for firms to grow due to their inability to fully finance their own expansion. This is also known as the *finance frontier*, which limits the profit rate due to the necessity of external financing. Firms that try to fund their investment with more retained profits are able to have a higher profit rate when expanding their business. However, they are not able to fully retain their profits due to their shareholders wanting a return on their investment, hence this theory assumes that shareholder payout does affect the financing frontier and therefore the value of the firm [19].

This study will mainly use the Post-Keynesian theory of the firm in its research for two reasons. First, the real world of stock markets and public firms do involve taxes, which have a considerable impact on the decision making in the actors involved in the stock market. Neglecting taxes would decrease the relevance for this study in the real world. Secondly, the influence of payout on debt in non-financial firms indicates that there is a relationship between the payout policy of firms and the capital structure of the firms, which supports a Post-Keynesian view of the firm.

### **1.6. Research objective: determining the effect of corporate governance on the real investment rate in NFCs**

As will be further discussed in the following chapters, the research objective of this thesis is to explore the effect of corporate governance on the real investment rate in NFCs. Few attempts have been made to analyse

what specific behavior and decision-making processes of NFCs increase or decrease the real investment rate in non-financial corporations. This thesis is not focused on predicting the payout rates or investment rates for public firms for certain tax rates. As will be further discussed in chapter 2, data for the payout and investment rates is already hardly available and has to be estimated from other data.

This study does not aim to replicate business cycles or corporate structures, but rather aims to analyse generalised types of decision-making rules of NFCs that could explain the larger affect of tax rates on the real investment rate in NFCs. Every corporation is its own entity, and behaves differently based on sector, liquidity, corporate structure and corporate culture, amongst other things, which is often not public knowledge.

## **1.7. Thesis overview**

Chapter 2 contains a detailed discussion of the impact of financialization and payout policy on the real investment rate in NFCs and a literature review on the behavior of investors and NFCs in stock markets, the chapter concludes with the research gap and research question that is present. Chapter 3 states the research formulation and explains the method of approach of this thesis that is chosen to answer the research question. Chapter 4 contains the system identification and decomposition of the stock market and its actors. Chapter 5 discusses the conceptual formalisation and formal model of the stock market, including the system diagram and the formal notations of the relations in the model. Chapter 6 discusses the model implementation in NetLogo and the parameterisation of the model. Chapter 7 discusses the model verification and validation. Chapter 8 shows the results and analysis of the experiments conducted with the model. The thesis closes with a conclusion, the social relevance and scientific contributions of the study and recommendations for further research.



## Literature review and knowledge gap

This chapter contains the literature review that serves as a critical review of the existing literature on how corporate governance affect the real investment in non-financial firms through its effect on payout policy and to identify knowledge gaps that are present in the literature. Both the effect of a change in corporate governance on increased payouts, and the negative effect of increased payouts on the real investment rate have been researched extensively in the last twenty years.

In this chapter, *firm*, *corporation* and *business* will be interchangeably used to refer to a public-traded company. In the same manner, *corporate investment*, *real investment* and *investment* are also interchangeably used to refer to the allocation of capital into non-financial assets.

### 2.1. Stockhammer: crowding out of investment funds due to payouts

In the last two decades, the negative effect of payouts on the real investment in firms have been established in financial literature. Stockhammer [62] was one of the first to find a significant role for payouts in the slow-down of real investment in non-financial corporations. He found a strong correlation through econometric tests between increased payouts in US and UK public firms and the decline in real investment in the period 1963 and 1997. He argues that the increased dividend payouts and increased share repurchases of NFCs has crowded out the funds that are available for investment within the company. In his research, he also views the NFCs with the post-Keynesian theory of the firm, which makes a distinction between workers, management and rentiers (shareholders). This was in contrast to the more influential neoclassical theory of the firm, which views firms as one entity that maximizes profits [50]

The main theory, he argues, behind the decrease in real investment is the effect of the shareholder revolution of the 1980s, from which management has increased its obedience to their share- and debtholders. Stockhammer theorized that businesses have to make a trade-off between profits and growth when allocating cash flow. Managers have the incentive to maximize both profits and growth, whereas shareholders have a strong incentive towards more profits.

Stockhammer used aggregated country-level data for his research. Because the data for the capital spent on real investment is often not available, Stockhammer used the growth of the capital stock, the profit rate and rentiers' share in the firm to calculate the investment rate. He assumed homogeneous firms that always base their investment on these variables. Stockhammer found a strong relationship in the U.S. and France, but had little evidence for this relation in the U.K. and Germany. For the U.K., slowdown of capital accumulation was already in progress in the empirical data. For Germany, Stockhammer found that *rentier shareholders*, shareholders that earn their income from being shareholders, was still a new concept in the researched time period. In the US, the shareholder revolution was more prevalent and had more of an impact from public firms in the 1980s and 1990s.

On a critical note, Stockhammer assumed homogeneous firms when executing his econometric tests. This meant that he assumed that every firm makes decisions on payout and investment based on the same criteria as every other firm. In addition to homogeneous firms, he did not look at the relationship on a firm-level, but used macroeconomic data from the respective countries for his research. His reason for this assumption was to look at larger trends within public companies and compare this trend within the different countries. This raises the question how the differences between firms affect this relationship.

## 2.2. Orhangazi: further evidence with US firm-level data

Orhangazi [52] further elaborated on the work of Stockhammer and found empirical, negative correlations between financialization and real investment in US NFCs between 1973 and the 2nd quarter of 2004, especially for larger firms. He argues that not only the increased payouts of non-financial firms has crowded out funds for real investment, but also included the crowding out of real investment due to financial investment as potential explanation for the slowdown of accumulations in US non-financial firms. He found strong evidence for a negative correlation between financialization and real investment for US firms, but also concluded that there are no simple policy conclusions to mitigate this effect, and that this relationship will heavily affect developing countries. Developing countries are adopting the US-styled financial systems and corporate governance, which will hurt the economic growth of these countries due to low investment.

He found that the negative effect of financial payouts on the investment rate is prevalent in all NFCs, while the negative effect of profit from financial assets on the investment in firms is only significant for larger firms. He argued that this could be the result of a higher interaction with financial markets for larger, more established companies. As with the research of Stockhammer, these statistical finding of Orhangazi are in sharp contrast with the neoclassical view of the firm, in which funds for investment project should not be crowded out by any other form of cash flow expenses like payout. The neoclassical view argues that if there is an investment opportunity that has a positive effect on the value of the firm, there should always be funding to invest, no matter the dividend payout.

In contrast to the work of Stockhammer, Orhangazi used firm-level data from US non-financial public firms to his research. His primary goal was to identify whether there are differences between different sized and different non-financial sector firms in the effect of the aspects of financialization on the real investment rate in NFCs. However, in line with the work of Stockhammer, Orhangazi also assumed homogeneous public firms for the calculation of the amount of investments. This data was also not available for the US NFCs and was calculated from the long-term debt, profit rate and financial payments.

## 2.3. Chetty & Saez: how the 2003 US tax cut impacted payout policies

Stockhammer (2004) and Orhangazi (2008) both found strong evidence for correlation of increased payouts on the declining investment rate in non-financial firms. As stated in section 1.1, due to the importance of investment for economic growth, governments have an incentive to increase investment. Taxes can be viable policies for this, as literature has argued that taxes on dividend and capital gain have an effect on payout policies. Chetty and Saez [15] found that the US tax cut on dividend and capital gain from 2003 correlated with increased payouts in public firms, using data from 1980 to the 2nd quarter of 2004.

The effect of the dividend and capital gain tax cut was strongest in public firms with large taxable, rentier shareholders. These shareholders have the largest benefit from the tax cut, and would execute their power in the public corporation to adjust the payout to give them an optimised return. In addition to this finding, the increase in payout was higher for companies with high stock ownership among top executives in management. They argue that these statistical findings show that shareholder expectations and power in deciding financial corporate governance play a central role in corporate responses to taxation.

On a critical note, Chetty and Saez focused their research on the quantitative differences between firms that reflect possible differences in corporate governance, as they examined the impact of differences in rentier investors in stock ownership and stock ownership of upper management. The actual decisions on different payout levels of these firms were not taken into account, and would also be hard to acquire. Chetty & Saez calculated the dividend rate of the firms homogeneously, as the full data per firm was not available.

## 2.4. Knowledge gap and conclusion

The literature highlighted in this chapter have helped to identify the effects of corporate governance on the payout policy and investment. However, there are still uncertain aspects in the knowledge about corporate governance and its influence on payout policy and investment. This section identifies the most important assumption in the current literature, following the impact of these assumptions and flaws on the results from the literature and ending with the knowledge gap that arises from them.

The idea of maximizing shareholder value is not present in all public non-financial firms. Aguilera and Jackson [2] debated that not all public firms focus on maximizing shareholder value in corporate governance. This was found in a survey of public corporations in advanced capitalist economies they conducted. Aguilera & Jackson also used the post-Keynesian theory of the firm, in which management, labor and capital (share-



holders) interact with each other to form the corporate governance of firms. They argued that the type of corporate governance strongly depends on region, past management-shareholder relations and the rate of institutional shareholders in the firm.

John and Knyazeva [32] found that the corporate governance of firms indeed influence the dividend payout and share repurchases of public firms in their empirical study of US firms between 1993 and 2003. They debated that a poor relationship between executives and shareholders result in higher dividend payouts, as well as higher share repurchases when takeover threats were present. Firms with a stronger relationship between managers and shareholders had more freedom in deviating from existing payout policies.

The most crucial assumption that limits the results of the previous described literature is the homogeneity of the firms that the researchers have assumed. The choice for Stockhammer Orhangazi and Chetty & Saez to assume homogeneous firms have been made to identify a broader trend in US NFCs from the available data they had, as it was not the focus of their research to explain the relationship between payout and investment on a firm level. However, the choice to assume homogeneous firms could have had an effect on the conclusions of both the works of Stockhammer & Orhangazi and Chetty & Saez. Firms base their payout policy and investment on different criteria and have different decision-making processes that are not tied to quantitative results of the firm, like profitability and firm value [28]. Due to the fact that all three studies have used one formula for the calculation of the investment and dividend payout, the results from Stockhammer, Orhangazi and Chetty & Saez are biased towards one type of corporate governance. The use of different formulas, thus different types of corporate governance, for investment and dividend payout could lead to a lesser effect, or even no effect, to the questions if taxes influence investment in firms.

To conclude this chapter, the knowledge gap identified from the literature review is the unknown influence of corporate governance on the effect taxes has on investment in firms. To fill in this knowledge gap, different types of corporate governance has to be defined that represent trends and decision-making in non-financial public firms.



# 3

## Research formulation

The knowledge gap that has been identified is the uncertainty of corporate governance affect the effect of taxes on payout policy and real investment in NFCs. This chapter formulates the research scope and the main research question, as well as the subquestions and the methods used to answer them.

### 3.1. Research scope and main research question

To successfully formulate a research question, the scope of the research has to be defined. This thesis explores the effect of different corporate governance of NFCs on the impact of taxes on NFCs in the context of payout policy and real investment. To determine the effect of taxes on dividend and capital gain, a stock market is used, in which investors can interact and trade shares. The stock market in this thesis will be based on the characteristics of the US stock market, due to the available data and prior research on the topic. The proposed study is limited to the system of the stock market with investors and NFCs and does not cover full endogenous business cycles with households, banks or government bodies. Based on the research scope, the following research question has been developed:

*"What kind of corporate governance of NFCs can explain the effects of taxes on the real investment rate in NFCs in a US-based stock market?"*

Figure 3.1 gives a visual representation of the research question. As stated in the literature review, the effect of taxes on the real investment rate is a known fact and has been argued in several academic papers. This research tries to explain the effect of corporate governance on this relation between taxes and the real investment rate in NFCs. To answer the research question, the main research question is split into two sub-questions.

### 3.2. Sub-questions and respective methodologies

This section discusses the two sub-questions that are answered to give an answer to the main research question. The corresponding research methods that are necessary to answer the sub-questions are also addressed.

#### 3.2.1. Sub-question 1: *How can a stock market of investors and non-financial corporations be conceptualized and formalised?*

The first sub-question addresses the concepts and relations that are necessary to model a stock market. These concepts include the investing strategies of investors, the balancing of demand and supply in the stock market and determining sets of decision rules for NFCs regarding their payout policy and real investment decisions.

#### 3.2.2. Method for answering sub-question 1: *Agent-based modelling*

The method that is used to answer the first sub-question is *agent-based modelling* or ABM. Agent-based modelling is a modelling technique that is used for simulating complex, adaptive systems, in which the behavior of agents is the central part of the system. Stock markets can be classified as complex, adaptive systems, as the interaction between thousands of investors affect the prices of shares and the investors adapt their behavior with the newly composed prices. This creates a feedback loop with returns of investors and price

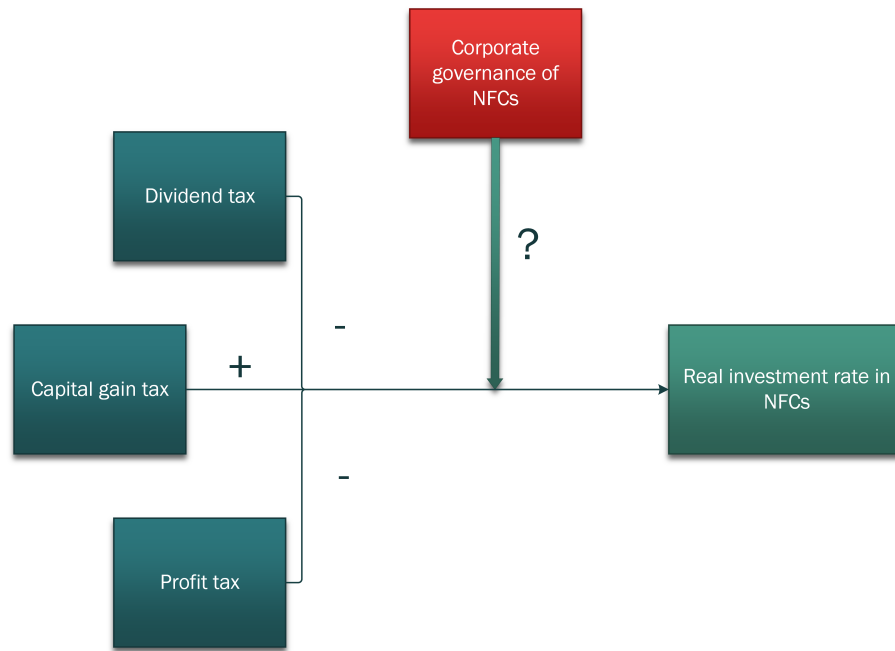


Figure 3.1: Visual representation of the research question. A minus sign indicates a negative relationship between the variables, while a plus sign indicates a positive relationship. Determining the question mark in this diagram is the goal of this thesis.

changes that can not be explained through the sum of the individual behavior of investors. This is known as *emergent behavior*, and is a key feature of agent-based models. Because of the evaluation of behavioral rules, agent-based modelling can be a proper choice as modelling technique.

Agent-based modelling have been widely used to simulate financial and stock markets. Agent-based financial markets started in the 1980s to explore the nature of crashes and bubbles in financial markets and the relation to the behaviour of investors [59]. Financial markets are suitable for ABMs as they involve a large quantity of agents with different and complex decision rules and involve the balancing between demand and supply [38]. In comparison with traditional financial models, agent-based financial markets are able to replicate several empirical features of markets, such as dynamic trading volumes and fluctuating price volatilities [40]. Agent-based financial models can also be integrated in larger and more complex macroeconomic models, as seen in Lengnick [41].

However, agent-based financial markets do not typically include the active involvement of firms whose shares are traded. This involvement can be easily added, as the only involvement firms have in the stock market is the payout of cash as dividend and the repurchasing of shares from investors. This creates two parts of the system, with the stock market and behavior of shareholders on one side and the NFCs and their corporate governance on the other side.

The first sub-question will also be answered following the modelling cycle of agent-based models, as stated in Van Dam et al. [65]. The modelling cycle is a structural tool in helping to create agent-based models and executing the steps that are necessary to give an answer to the main research question. The steps of the modelling cycle include the system decomposition, conceptualisation of the model, formalisation of the model, model implementation, model verification and model experimentation. The steps of the modelling cycle will be further explained when these steps are executed in the following chapter.

### 3.2.3. Sub-question 2: *What kind of corporate governance in NFCs can explain the effect of taxes on the real investment rate in NFCs in a stock model?*

The agent-based model that is created by answering the first sub-question is used to create data from experiments with different values for tax variables in the model. Different sets of corporate governance are varied in NFCs to obtain the data for their real investment rate, as well as other states of the NFCs like the dividend payout rate and the share price of the NFCs. Through analysing the outcomes, a conclusion can be made which type(s) of corporate governance explain the effect of taxes on the real investment rate in NFCs. This conclusion can be extended to answer the main research question through making a comparison to real-world

activities and trends regarding payout and real investment.

#### **3.2.4. Method for answering sub-question 2: Statistical analysis**

The data generated by the model will be analysed with statistical analyses. Calculating the correlation coefficient between the tax rates and the real investment rate will be used to investigate whether the different corporate governance types can explain the effect of taxes on the real investment rate. These correlation coefficients are compared to search for differences between the corporate governance types.

### **3.3. Conclusion**

This chapter discussed the main research question that addressed the identified knowledge gap, the respective research methodology and the sub-questions that will help to answer the research question. Important to take away from this chapter is that the agent-based, behavioral approach is a different approach to model and study the corporate governance of firms than the empirical analyses of the literature from the literature review in chapter 2. As stated in section 2.4, corporate governance is a term that is difficult to make tangible. The agent-based modeling approach helps to study the causal effects of certain types of NFCs on their investment rate, dividend payout and share repurchases.



# 4

## System identification and decomposition

The first step in the modelling cyclus of Van Dam et al. [65] has been executed in the first three chapters by formulating the problem and identifying the actors of the problem. The second step of the cyclus is the system identification and decomposition. This consists of setting the boundaries of the system and the behavior of the agents and environment in the system. Besides the outline and behavior of investors and NFCs, the allocation mechanism and the tax payments are discussed.

### 4.1. Outline and behavior of investors

This section describes the outline and behavior of investors that will be used for the conceptualisation of the stock model. First, the literature on which the investors are based is discussed. Secondly, the final behavior of the investors in the stock model of this thesis is described and explained.

#### 4.1.1. Investors in the stock models of Lux Marchesi and LeBaron

LeBaron [39] and Lux and Marchesi [45] created two of the first agent-based financial markets that could emulate statistics of real-world stock markets. These models introduced two types of investors: a *chartist* or a *fundamentalist*. A chartist investor bases their demand for a particular stock ("excess demand") on the historical data of the share price. A fundamentalist investor base their excess demand for stock on the current difference between the share price and the *floor level* of the stock. The floor level is the price the investor thinks the stock is worth. The agent-based financial markets of LeBaron [39] and Lux and Marchesi [45] function as an Over-the-counter (OTC) market, in which no central stock exchange sets the price and investors trade assets directly with each other.

They implemented the social aspect of *herding* of investing that was not present in past stock models. The flowchart of the model is shown in figure 4.1. The investors re-evaluate their investing strategy based on the pay-offs of the other investors in the model. This social dynamic in this artificial financial market proved to explain the heterogeneity and leptokurtosis of returns of investors. Furthermore, LeBaron [39] defined a learning score for investors that determine the final predicted price of a stock. This learning score "tries to capture possible nonstationarities in the series while maintaining an accurate estimate of forecast prices" [39, p.8]. If one of the investing strategies structurally predicts a higher price than the actual future price, the learning score lowers the future predicted prices of that strategy, and vice versa.

In theory, a semi-realistic market environment can be created, using the behavioral rules of the investors from the LeBaron and Lux-Marchesi stock models. A model validation after the implementation of the model will validate whether the used concepts have created a semi-realistic market environment.

#### 4.1.2. Behavior of investors

Investors are the shareholders of the NFCs in the model. They have a portfolio, which contains the shares they own. Figure A.4 presents a flowchart of the forecasting behavior of investors. Every month, they make a prediction for the future price of their stock in the next month, based on either a *fundamentalist* or *chartist* strategy, as described in subsection 4.1.1. Based on whether the predicted price for the stock is lower or higher than the current price, the investors decides to, respectively, sell or buy shares of that stock. This is also stated as excess supply and excess demand, respectively.

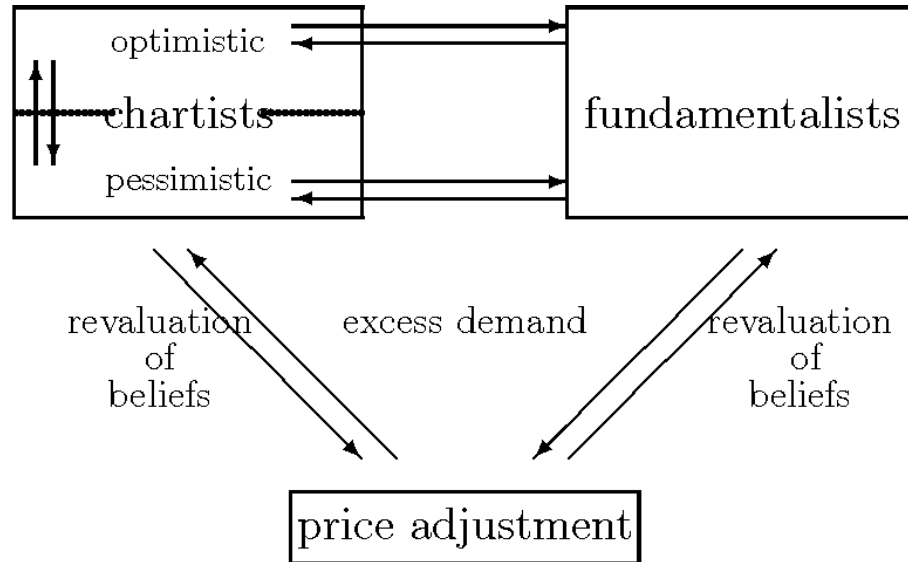


Figure 4.1: Conceptual representation of the Lux-Marchesi financial model, in which fundamentalists and chartists re-evaluate their beliefs based on the price adjustments in the model.

Adopted from Lux and Marchesi [45], the investors have a social learning algorithm, that look at which strategies and investors are the most successful in their network. Figure A.5 shows a flowchart of the social learning behavior of investors. The network consists of investors in a certain area around the investor. There are three outcomes of the social learning algorithm. The social adaption function either looks at the strategy of the most successful investor, the most successful strategy in their network or do not look at any strategy at all. The outcome is chosen randomly every timestep to prohibit the investor to change every timestep. If the investor does not have the strategy of the first two options currently, they will change to that particular strategy.

At the end of each month, the investors determine the amount of liquidity they are willing to spend on new stock based on the liquidity demand they have. Each year, investors have to pay taxes on the dividend payments they received and the capital gain from sold shares.

## 4.2. Outline and behavior of NFCs

NFCs are public, non-financial corporations in the model. The shares of the NFCs are owned by the investors in the model. The NFCs have a yearly net income that they spend on dividend payout, share repurchases and investment, as well as leverage they can take on. NFCs can have three types of corporate governance that determine how they spent their net income and take on debt. These are *Maximizing shareholder value*, *Maximizing net income* or *Minimum payout and investment rate*. These types of corporate governance are based on the different theories and empirical characteristics described in section 1.3 on how payout policy and investment are determined in firms.

*Maximizing shareholder value (MSV)*: This type of NFCs prioritizes the maximization of their shareholder value (*maximizing shareholder value*). Figure A.1 in appendix A presents a flowchart of the decision making of this type of NFC. Every year, a target for the EPS of the firm is set for the next year. If the target is not reached in the next year, the firm will order a share repurchasing program. Their share repurchasing target is equal to the difference in outstanding shares between the real EPS and the target EPS. Furthermore, the first type of NFCs increases their dividend rate if the average return of their shareholders has decreased in comparison to the year before the re-evaluation. The share repurchasing target and the dividend rate of NFCs are calculated every year, as well as their net income and earnings per share.

*Minimizing interest payments (MIP)*: This type of NFCs bases their payout policy on the change in net income of the NFC (*maximizing net income*), as they try to not acquire debt and to maximize their future net income. Figure A.2 in appendix A presents a flowchart of the decision making of this type of NFC. When the net income of the NFC is increasing, the NFC tries to buy back an amount of shares back from investors that is consistent with the net income of the NFC. However, when their net income decreases, the NFC will cut back on their share buyback program. The dividend rate is not affected by the decline in income. They only



## Expenses of the earnings of an NFC

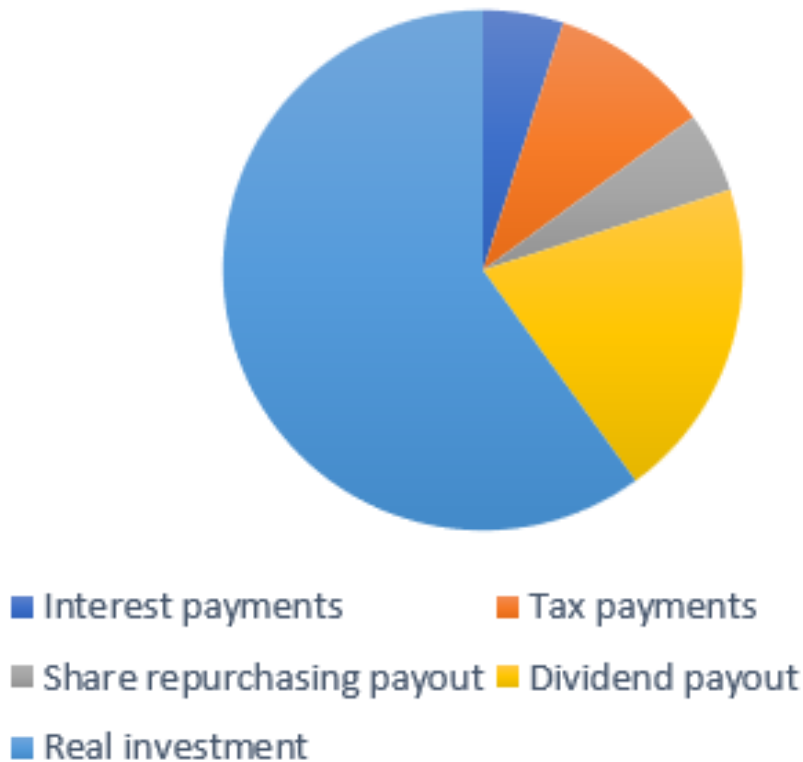


Figure 4.2: Piechart of the expenses of the earnings of NFCs. The size of the expenses is merely an indication of the percentages the expenses could have.

change their dividend rate when their net income has increased with at least 10 percent.

*Minimum payout and investment (MPI):* The last type of NFC tries to have a minimum payout rate to investors and a minimum real investment rate (*Minimum payout and investment*). Figure A.3 in appendix A presents a flowchart of the decision making of this type of NFC. The dividend rate is affected in the same way as the *maximizing net income* NFCs, as they want to increase the dividend rate when their net income is growing to increase the minimum payout to investors. The share repurchasing target is determined by the net income subtracted by the future dividend payout at the end of the year and the percentage of the net income is reserved for real investment.

At the end of the year, the final payout, investment and potential debt are determined for that year. Based on the corporate governance of the firm, the new net income, new dividend rate and share repurchasing target are determined at the beginning of the year. Taxes on the earnings of NFCs are also paid at this time. Every month, NFCs are able to buy shares from investors willing to sell shares through the stock market. If NFCs reach the share repurchasing target depends on the willingness of investors to sell their shares to NFCs. The NFCs issue dividend once a year, 2 months before the year ends, and pays out the dividend at the end of the year. If more capital is spent at the end of the year than the NFC has net income, the difference is added to the debt of the NFC.

Figure 4.2 gives an indication about how the earnings of an NFC are spent. First, the NFC has to pay interest on the debt they currently have. This interest payment is allowed to be subtracted from the taxable income, from which a part has to be paid as taxes on corporate profits. The earnings that are left can be considered to be the net income of the NFC. The net income is spent throughout the year to pay for share repurchases. At the end of the year, the dividend payout is subtracted from the net income. The net income that is left over will be considered to be retained earnings that will be put into real investment.

### 4.3. Allocation mechanism and price setting of the stock model

To balance the excess supply and demand of shares of investors, an allocation mechanism is used. The behavior of the investors are largely based on the work of Lux Marchesi. The agent-based stock market of Lux Marchesi is based on an OTC market, as there is no central market that facilitates the trading between investors. The allocation mechanism will replicate an over-the-counter (OTC) market, as the investors trade their shares directly without a central market. The new price of the share is determined outside the allocation mechanism. The calculation of the new share price is derived from the Santa Fe artificial stock market [39]. The share price increases when there is more demand than supply, and decreases when there is more supply than demand. The price adjustment is further explained in subsection 5.3.2.

Both investors with an excess supply for shares and traders (investors and NFCs) with an excess demand for shares are present in the allocation mechanism to balance the market. For all investors with an excess supply of a stock, a set of potential transaction partners will be made that have an excess demand for that same stock. The forecast price of the potential transaction partners is assumed to be their maximum bidding price. The investors with excess supply sell their shares to the trader(s) with the highest bidding price(s) there are currently available in the model, regardless of the amount of excess demand or spendable liquidity the auction winner has. The amount of shares that are actually sold is determined by the minimum of what the excess supply, excess demand of the auction winner or amount of shares the spendable liquidity of the auction winner allows. The price per share is the bidding price of the auction winner. However, the selling investors that sell their shares last, will have to accept the lower bidding prices of investors and maybe not even sell stock at all if there are no investors with excess demand for that stock left. The order in which investors are able to sell their shares is therefore randomly determined every timestep to give investors no permanent advantage.

### 4.4. Economic uncertainties

The investors and NFCs are subject to exogenous economic circumstances. These economic circumstances manifest itself in the capital and decisions of these agents. First, the interest rate on the debt of NFCs generally depends on the economic situation of the environment of the NFC. In economic prosperity, the interest rate is normally higher than in an economic depression. Secondly, NFCs take less risks when re-evaluating their payout with low economic stability, as there is a high uncertainty if they can sustain this payout. In the same way, investors take less risks when deciding on how much capital they want to spend on their portfolio with low economic stability. These uncertainties will be further discussed in detail in the formalisation in section 5.3.

### 4.5. Conclusion

This chapter has identified the most important features of the stock system that will be modelled and identified the behavior of the investors and NFCs in the stock system. Important to take away from this chapter is that there are three main parts of the system that interact with each other: the investors, the allocation mechanism and the NFCs. The allocation mechanism is the main part of the system from which the investors and NFCs can have interactions due to the repurchasing of shares.

## Formalisation of the financial market

This chapter describes how the concepts and relations from the previous chapter can be formed into a formal model. The formal model forms the main foundation for the agent-based stock market that is built in the chapter 6. This chapter carries out the concept formalisation and model formalisation from the *modelling cycle* of Van Dam et al. [65]. The concept formalisation consists of the properties of the agents and environment, the system diagram of the stock model and an ontology of the hierarchies and relations. The model formalisation include the formulations of the behavior of agents.

### 5.1. Concept formalisation

The first step is to formalise the concepts identified in chapter 4 for the stock market and their actors. In the modelling cycle, this is the *concept formalisation* of the stock model. The first step is to identify the state variables of the investors, NFCs and the environment, along with their units. These state variables are the initial variables from which other states and behaviors are calculated. Based on the state variables from the agents and environment, a system diagram is made to describe the relations between the variables in the diagram. Three different sections are placed in the system diagram that visualize the relationship the specific type of corporate governance creates in the stock model. Lastly, an ontology of the financial model is created that represent the hierarchies and relations between classes in the model. The ontology is created with the semantic software Protégé.

#### 5.1.1. State variables, units and formal notations of investors, NFCs and environment

This subsection show the state variables of investors, NFCs and environment in text boxes. Every box of state variables have a small explanation for the state variables of the agents. Figure 5.1, 5.2 and 5.3 describe the state variables of the investors, NFCs and the environment. The units of the variables are shown between brackets, the formal notation is shown in the brackets after the unit and the descriptions of the variables are also discussed. Some of the state variables are notated as static variables, which do not change during the model run. The state variables of the environment in box 5.3 are all static during the model run.

#### 5.1.2. System diagrams of real investment, payout and the stock market

Because of the different decision-rules in the NFCs, the system diagram for the three types of NFCs are all different. For this reason, one overarching system diagram is made, with the type of corporate governance in the NFC as subsystem within the diagram, which can be seen in figure 5.4. The left side of the diagram shows the three tax policies that are incorporated in the model: dividend and capital gain taxes for investors and a profit tax for NFCs. The top side shows the uncertainties that have an effect on the system: the liquidity demand of investors, the percentile increase of dividend of NFCs when dividend is allowed to increase, the minimum and maximum interest rate on the debt of NFCs, and the growth rate of earnings of NFCs.

The right side displays the subsystem of the type of corporate governance of the NFC. Because the outputs relate to each other, I decided to put the outcomes within the subsystem, as the subsystems would not be clear without these relations. For spacing purposes, the diagrams of the subsystems have been moved to appendix A. The subsystems also show several similarities. As seen in all three subsystems, the outcomes of the dividend rate and share repurchasing target have a negative effect on the real investment rate, as it

- **Portfolio wealth** (USD)/( $wth_{port}$ ): The current wealth of the portfolio of an investor.
- **Liquid wealth** (USD)/( $wth_{liq}$ ): The current amount of cash of an investor.
- **Liquidity demand** (%)/(LD): The percentage of an investor's total capital that the investor wants to have as liquid wealth.
- **Investing strategy** (*chartist* or *fundamentalist*)/( $i$ ): Current investing strategy of an investor.
- **Return on investment of investor** ( $ROI(x)$ ) (%): Return of the shares in the portfolio of an investor.
- **Fundamentalist equilibrium level (static)** ( $\lambda_{fund}$ ) (Probability between 0 and 1): Probability of the fundamentalists' forecast converging to the floor level. This state does not change during the model.
- **Chartist trend level (static)** ( $\lambda_{char}$ ) (Probability between 0 and 1): Probability of the chartists' forecast converging to calculated trend. This state does not change during the model.
- **Floor level (static)** (USD/share)/( $flr$ ): Belief of the investor on the true price of a stock.
- **Neighbours in network (static)** (Set of investors)/(NGHBRS): Investors in the surrounding area of the investor that have a connection with the investor.

Figure 5.1: State variables of investors, along with their units, formal notations and their description.

- **Price per share** (USD/share)/( $pct$ ): The price of one share of an NFC.
- **Number of outstanding shares**/( $n$ ) (Amount of shares): The number of shares owned by investors.
- **Debt** (USD)/( $d$ ): Total amount of outstanding debt of an NFC. Also called leverage.
- **Earnings** (USD/year)/(EBIT): Earnings of an NFC before interest and taxes.
- **Dividend rate** (%)/(div): Percentage of the price per share that is paid out as dividend.
- **Share repurchasing target** (Amount of shares/year)/( $r$ ): Number of shares an NFC wants to repurchase within a year at the beginning of that year.
- **Capital spent on share repurchases** (USD)/( $pay_{rps}$ ): Amount of capital spent on the repurchasing of shares at the end of the year.
- **Earnings per share (EPS) target** (USD/share)/( $EPS_{y+1}$ ): Target for the EPS for next year.
- **Real investment rate** (%)/(invrate): Percentage of net income that is spent on real investment.
- **Corporate governance (static)** (*Maximizing shareholder value* (MSV), *minimizing interest payments* (MIP) or *minimum payout investment* (MIP))/(CG): The type of corporate governance in the NFC regarding their payout and real investment.

Figure 5.2: State variables of non-financial corporations, along with their units, formal notations and their description.

- **Tax on profits**  $(\%)/(tx_{inc})$ : Percentage of earnings that NFCs has to pay as taxes.
- **Tax on dividend**  $(\%)/(tx_{div})$ : Percentage of the received dividend by investors that has to be paid as taxes.
- **Tax on capital gain**  $(\%)/(tx_{cap})$ : Percentage of the capital gain received through the selling of shares that has to be paid as taxes.
- **Excess demand factor** (no unit)  $(EFX)$ : Factor that converts the difference in the forecast price and the current price into an excess demand for the investors.
- **Price adjustment factor**  $(\%)/(\lambda_{pa})$ : Factor that determines the influence of the difference in excess demand and supply on the stock price of NFCs.
- **Minimum liquidity demand of investors**  $(\%)/(LD_{min})$ : Minimum percentage of an investor's total capital that an investors wants to keep as liquid capital.
- **Maximum liquidity demand of investors**  $(\%)/(LD_{max})$ : Maximum percentage of an investor's total capital that an investors wants to keep as liquid capital.
- **Minimum interest rate**  $(\%)/(int_{min})$ : Minimum interest rate on the debt of NFCs.
- **Maximum interest rate**  $(\%)/(int_{max})$ : Maximum interest rate on the debt of NFCs.
- **Dividend increase for NFCs**  $(\%)/(\lambda_{div})$ : Percentage that the dividend rate is increased when NFCs decide to increase their dividend.
- **Average return on investment of NFCs**  $(\%) (ROI_{NFC})$ : Average annual return on the real investment the NFCs make.

Figure 5.3: Properties of the environment, along with their units, formal notations and their description.

crowds out the funds available for investment. These three outcomes then have a positive effect on the debt, as the increase in all these variables would increase the debt of the NFC, if the net income would not change. Furthermore, the debt has a negative effect on the net income, as the debt affects the interest that has to be paid from the earnings. The net income is determined through calculating the new earnings of the NFC through the earnings growth rate and subtracting the paid interest and paid taxes. Lastly, the dividend is always increased with the same percentage of dividend increase when a certain threshold is met, which is further explained in the formalisation in subsection 5.3.6.

The variables in the system diagram explain how the investors alter their excess demand of shares based on their spendable liquidity and the return on investment of the shares. The combined excess demand of investors and NFCs change the price per share of the stock, which affects the worth of the portfolio of investors, and hence change the spendable liquidity of the investor. The price change also affects the return on investment of investors, which also affects the choice to buy or sell shares of a particular share.

Figure B.1 in appendix B shows the subsystem of the MSV type of corporate governance. As stated in section 4.2, the EPS of the NFC determines the target for share repurchasing in the company, which increases the excess demand for shares of the NFC. This is calculated from a EPS growth target that is set at the beginning of every year. At the same time, the shares that are repurchased decreases the available public shares of the NFC, which increases the EPS of the NFC. NFCs have to compete with investors to bid for shares, as the excess supply of shares is limited. Furthermore, NFCs increase their dividend rate based on the year-to-year return of investors on the stock of the NFC. If the average return on their shares decreases, they increase their dividend rate.

Figure B.2 in appendix B shows the subsystem of the MIP type of corporate governance. Compared to the calculation of the dividend rate with the MSV type of corporate governance, the dividend rate is increased with the percentage of dividend increase if there is an increase in net income of the NFC compared to the previous year. The share repurchasing rate is also affected by the net income of the NFC, as the share repurchasing target is cut in half from the previous year if the net income of the NFC has decreased in that year.

Figure B.3 in appendix B shows the subsystem of the MPI type of corporate governance. The dividend rate is also determined through an increase in net income, in the same way as the dividend increase from the MIP type of corporate governance. However, the real investment rate and share repurchasing target dictate a preset minimum payout and investment rate. The share repurchasing target is determined by the net income reserved for payout subtracted by a reserved part for dividend payout. The actual real investment rate and shares repurchased can differ from the preset minimum rates, as the stock buyback programs can fail, stock buybacks can overrun on budget due to an increase price and dividend can alter due to price changes. This can potentially free funds for a higher real investment rate.

To conclude, the system diagram shows how the properties of the agents relate to each other and how the tax policies change the system and influence the outcomes. Factors relating to the forecasting mechanism and the herding behavior of investors are not present in the system diagram due to the purpose of making the diagram clear and understandable. However, the feedback of these mechanisms are present in the influence of the return on investment of investors on the excess demand of investors.

### 5.1.3. Ontology of the financial model

An ontology is a visual way to represent the hierarchies and relations between entities in a model and is used to create a more clear overview of these entities. Figure 5.5 shows the ontology of the financial model that is described in the previous sections. The ontology is made in the semantics software Protégé, that uses the XML and OWL semantic language to generate ontologies. The full ontology can be found through the Protégé application with the following link: [http://www.semanticweb.org/nick/ontologies/2019/3/financial\\_model\\_ABM\\_NCT](http://www.semanticweb.org/nick/ontologies/2019/3/financial_model_ABM_NCT)

The blue arrows in the visual indicates a hierarchical relationship between the entities. For example, a *fundamentalist investor* is an *investor*, which is an *agent* in the model, which is a *thing*. The orange arrows from *share* to *portfolio* and from *portfolio* to *investor* indicates a *isOwnedBy* relation. The shares are 'owned' or stored in the portfolio, which is owned by the investor. This results in the yellow arrow indicating that the shares are also owned by the investor. The light brown arrow from shares indicates a *isPartOf* relation. The shares are owned by the investor, but are a part of the NFC, from which the investor owns a part of it. Furthermore, the two different investing strategies of investors create two different entities of investors of *FundamentalistInvestor* and *ChartistInvestor*. The *CorporateGovernance* class is owned by the NFCs and is split into the three possible corporate governance types that have been identified earlier.

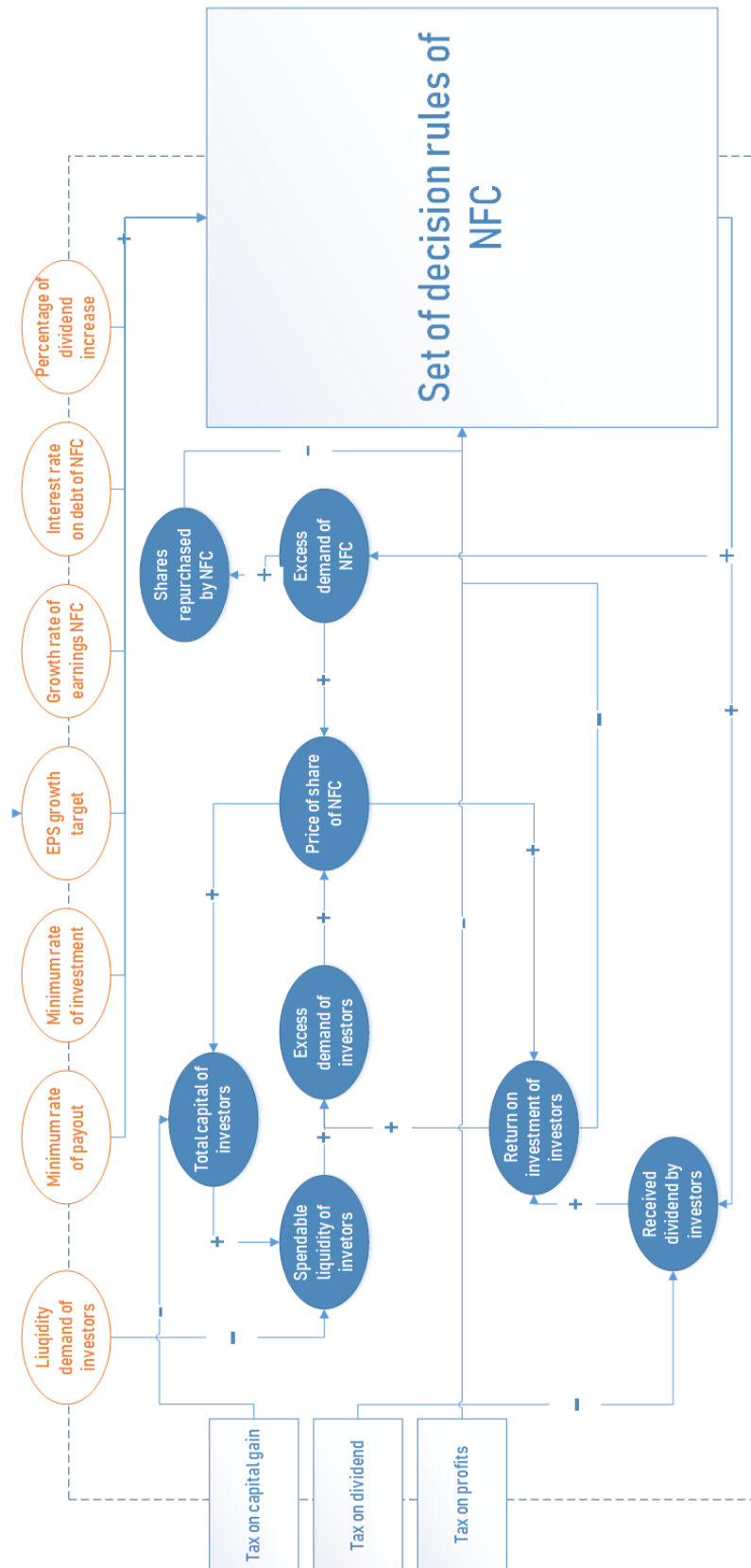


Figure 5.4: Overarching system diagram of the effect of tax rates on the real investment rate in NFCs

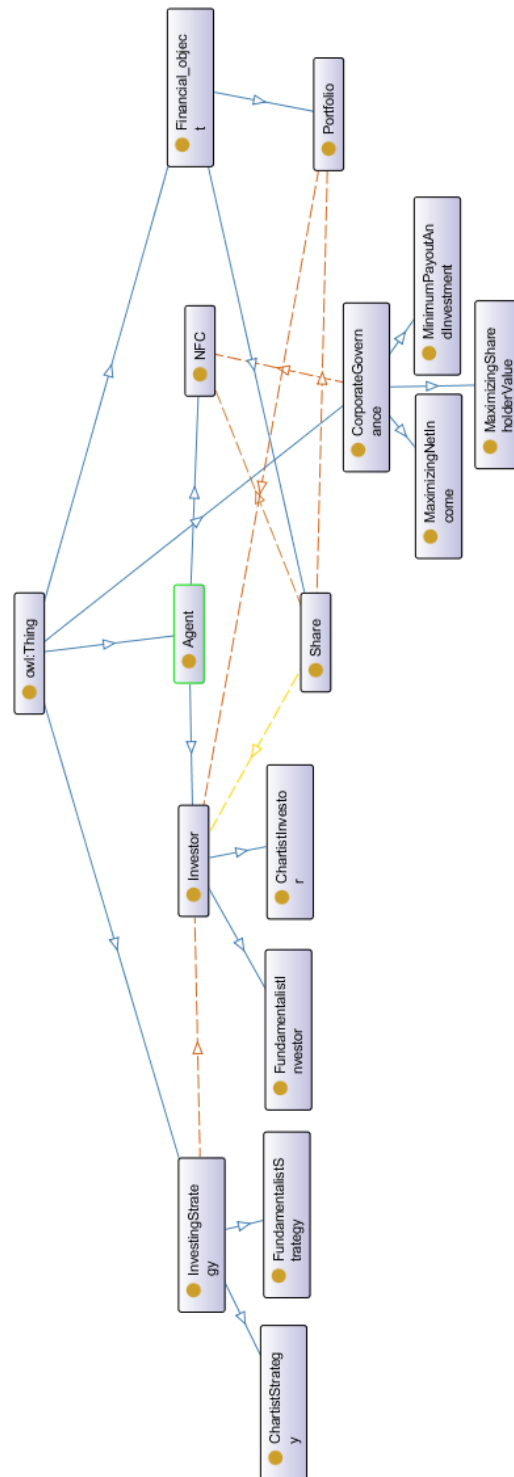


Figure 5.5: Ontology of the financial model, made in Protégé.



## 5.2. Model narrative

First, investors will calculate the forecast prices of the shares they own in their portfolio every timestep or 1 month. The forecast is based on the current investing strategy of the investors. This forecast price is used to calculate whether the investors want to buy or sell shares. The investors with excess supply further place orders in the financial market for that stock. In the financial market, the investors with an excess demand and NFCs with a share repurchasing target for own stock will bid on the orders that are placed. After either no excess demand, excess supply or spendable liquidity is left in the traders, the market will be in balance and quits.

Afterwards the investors will calculate their current return on their portfolio. The new price of the share of the NFCs are then calculated afterwards. Based on the new price of the shares, the investors will then calculate a learning score for the strategy they applied to calculate a forecast. Based on the herding strategies, the investors will change or keep their current investing strategy. After the investors update their new portfolio capital, liquid capital and spendable liquidity, a new month will start again with calculating the forecast prices of shares.

At the end of every 12 months or 1 year, the NFCs will payout dividend and determine how much net income is left, how much more leverage has to be taken on and how much is spent on real investment from that year. Based on the growth rate, interest rate and tax rate on profits, the new net income for the next year is calculated. Based on which corporate governance type relating to payouts and real investment the NFCs have, the NFCs calculate a new dividend rate and a new share repurchasing target.

## 5.3. Model formalisation

The model formalisation will formalise the variables and relations in the model. This section is divided into three parts. This section focuses on the formal relations of the behavior of the investors and NFCs, as well as the allocation mechanism. This is displayed using formulas that show the exact relations between variables in the model.

The formalisation of relations and behavior will be structured following the model narrative, from the calculation of the forecast prices of investors to the calculation of a new dividend and share repurchasing rate. The goal of this section is to explain the functions and concepts that are used to determine the relations and behavior that have been identified and conceptualised in chapter 4 and section 5.1. This section will go in-depth on how the variables and states in the model are calculated.

Some of the subscripts and arguments of the variables in the formulas are used multiple times throughout the formalisation. Subscript  $t$  is used for the value of the variable on the current timestep on which the formula is executed, while  $t + 1$  is used for a prediction for the next timestep of the variable. Subscript  $t - 1$  is used for the value of the last timestep on which the formula is executed. Subscript  $y$  is used as subscript for variables that have a yearly calculation, which is equal to 12 timesteps. An argument  $f$  is used as an argument to indicate that the variable is related to a firm.

### 5.3.1. Forecast price and excess demand of stock

Chartists determine the forecast price of a stock at  $t + 1$  based on a version of a compounded annual growth rate, or CAGR, which takes annual trends of the price into account. The history of the stock price is used as data to calculate the CAGR and the forecast price of the stock. The CAGR is calculated with the built-in annual growth rate function of the *matrix* extension of NetLogo. The forecast price  $fct_{t+1}(f)$  by chartists is determined by the following equation:

$$fct_{t+1}(f) = prc_t(f) + \lambda_{char} * CAGR(f) * \frac{1}{l_t(char)} \quad (5.1)$$

in which  $prc_t(f)$  is the current price per share of firm  $f$ ,  $\lambda_{char} \in [0, 1]$  is the chartist trend level that represents the belief of a chartist in how fast the stock price will go towards  $CAGR(f)$ ,  $CAGR(f)$  is the calculated compounded growth rate of the stock price of firm  $f$  and  $l_t(f)$  is the learning score of the chartist strategy. The learning score can take on any positive value above 0.

Fundamentalists determine the price of a stock on  $t + 1$  based on a *floor level*. This floor level is the price the fundamentalist believes to be the *real* price of a share of the NFC. The forecast price  $fct_{t+1}$  of the stock of firm  $f$  by fundamentalists is determined by the following equation:

$$fct_{t+1}(f) = prc_t(f) + \lambda_{fund} * (flr(f) - prc_t(f)) * \frac{1}{l_t(fund)} \quad (5.2)$$

in which  $prc_t(f)$  is the current price of stock  $f$ ,  $\lambda_{fund} \in [0, 1]$  is the fundamentalist equilibrium level and represents the believe of a fundamentalist in how fast the current price will go towards the floor level,  $flr(f)$  is the floor level of the stock of firm  $f$  and  $l_t(fund)$  is the learning score of the fundamentalist strategy on time  $t$ . This learning score can also take on any positive value above 0.

Based on the forecast price, both fundamentalists and chartists calculate their excess demand  $ED$  for the stock of firm  $f$  with the following equation, derived from [46]:

$$ED(f) = \frac{fct_{t+1}(f) - prc_t(f)}{prc_t(f)} * EFX \quad (5.3)$$

in which  $fct_{t+1}(f)$  is the forecast price of the stock of firm  $f$ ,  $prc_t(f)$  is the current price of the stock of firm  $f$  and  $EFX$  is the excess demand factor. If  $ED(f)$  is positive, the investor has excess demand and wants to buy more shares of stock  $f$ , based on the amount of shares it already has. If  $ED(f)$  is negative, the investor has excess supply and wants to sell a part of their shares of stock of firm  $f$ .

### 5.3.2. Balancing of excess supply and demand in the allocation mechanism and price adjustment

Figure A.6 in appendix A shows a conceptual visualization of the interaction between traders and the allocation mechanism for a stock. For every stock, the mechanism will create two lists, one with all investors with an excess supply (the *sellers*) and one with all traders with an excess demand (the *buyers*). The list of the sellers are randomly ordered, while the list of the buyers is ordered by the highest forecast price. The mechanism chooses the seller on top of the list of sellers, which will be matched with the buyer on top of the buyer list (the *bid winner*). Before a transaction can be approved, the mechanism looks if the bid winner has enough liquidity to be able to buy at least 1 share. If the bid winner does not have enough liquidity, the bid winner is removed from the buyers' list. If the bid winner has enough liquidity, the mechanism will approve the transaction and the seller and bid winner will exchange shares and liquidity and update their states. The amount of shares in the transaction is determined by the minimum of the excess supply of the seller, excess demand of the bid winner and the minimum amount of shares the liquidity of the investor can buy. This results in either one of those three states being zero after a transaction. If either the excess demand or the liquidity of the bid winner is zero, the bid winner is removed from the buyers' list. The seller is then matched with the next buyer on top of the buyers' list, which goes through the same procedure as the last bid winner. Eventually, when the excess supply of the seller is zero, the seller is removed from the sellers' list and the next seller is chosen, whom is matched with the top buyer from the buyers' list. The mechanism for the stock stops when either the sellers' list is empty or the buyers' list is empty. This mechanism creates a balance in which either the excess supply of the investors, the excess demand of the traders or the liquidity of the traders is (close to) zero.

The formula for the amount of shares of the transaction  $shares_{trans}$  is:

$$shares_{trans} = \min(ED(invstr_{sell}), ED(invstr_{aw}), \frac{spliq(invstr_{aw})}{fct_{t+1}(f)}) \quad (5.4)$$

in which  $ED(invstr_{sell})$  is the excess supply of the selling investor,  $ED(invstr_{aw})$  is the excess demand of the auction winner,  $spliq(invstr_{aw})$  is the spendable liquidity of the auction winner and  $fct_{t+1}(f)$  is the forecast price of the auction winner for the stock.

After the excess demand and supply are balanced, a new price for the stocks is calculated. The price adjustment of the stock of NFCs  $prc_t(f)$  is defined by the following equation:

$$prc_t(f) = prc_{t-1}(f) + \lambda_{pa} * \sum_{x=1}^{|X|} ED(f)_x \quad (5.5)$$

in which  $prc_{t-1}(f)$  is the price of the stock at  $t-1$ ,  $\lambda_{pa} \in [0, 1]$  is the price adjustment level that determines the effect of the excess demand of investors has on the price,  $|X|$  are the amount of investors in the model and  $\sum_{x=1}^{|X|} ED(f)_x$  is the total excess demand of all investors in the model. This also includes the negative values (excess supply) for  $ED(f)$  that the investors has. If there is more excess demand than excess supply, the price of the stock will increase. If there is more excess supply than excess demand, the price of the stock will decrease.

### 5.3.3. Learning score of investing strategy

Two algorithms are used by investors to change their forecasts for the shares in their portfolio: learning scores and herding behavior. Learning scores adjust the forecast of both investing strategies to adjust for structural low or high forecasts for the shares of the investor. The learning score of an investing strategy  $i$  at time  $t$  for investor  $x$ ,  $l_t(x, i)$ , is given by the following equation:

$$l_t(x, i) = l_{t-1}(x, i) * \frac{t(x, i) - 1}{t(x, i)} + err(x, i) * \frac{1}{t(x, i)} \quad (5.6)$$

in which  $l_{t-1}(x, i)$  is the learning score of investing strategy  $i$  on time  $t - 1$ ,  $t(x, i)$  is the number of ticks spent in the model with investing strategy  $i$  and  $err(x, i)$  is the average error of the forecast from the actual new price of the shares, which is explained below. With this formula, each price forecast is equally taken into account in the learning score of the investing strategy. When the forecast of a investing strategy structurally calculates a high price per share, the learning score lowers the future forecasts of the investing strategy.

The average error  $err(x, i)$  of the forecasts of investing strategy  $i$  of investor  $x$  is calculated with the following equation:

$$err(x, i) = \frac{\sum_{f=1}^{|F|} |F| e^{\frac{fct_{t+1}(f) - prc_t(f)}{prc_t(f)}}}{|F|} \quad (5.7)$$

in which  $F$  is the set of NFCs,  $e$  is the natural logarithmic constant and  $|S|$  is the amount of NFCs in  $S$ . If the forecast is equal to the new price, then  $err(i)$  makes sure the added error to the learning score equals 1. If the forecast is higher than the new price, then  $err(x, i)$  is greater than 1, and when the forecast is lower than the actual new price then  $err(x, i)$  is smaller than 1. In the calculation of the forecast price, the inverse of the learning score is taken to correctly adjust the forecast price to the structural bias in the investing strategies.

### 5.3.4. Calculating new net income of NFCs

NFCs determine their net income through a series of subtractions from their income statements. Their Earnings Before Interest and Taxes ( $EBIT_{y+1}$ ) for the next year is calculated with the following equation:

$$EBIT_{y+1} = EBIT_y * (g_y + invrate_y * ROI_{NFC}) \quad (5.8)$$

in which  $EBIT_y$  is the current EBIT of the NFC,  $g_y$  is the growth rate of the NFC,  $invrate_y$  is the real investment rate of the NFC and  $ROI_{NFC}$  is the average return on the real investment of the NFCs. The return from the real investment adds a feedback loop in the model, because the investment rate is partially determined by the amount of earnings. The growth rate is drawn every year from a uniform distribution between -10 percent and 10 percent. This growth rate represents the uncertainty in the earnings of the NFC. Because the model is not a macroeconomic simulation, the growth rate has to be calculated exogenously. This uniform distribution is chosen to let earnings grow most of the time, but also introduce a chance that the earnings can fall. The first operation that is executed is subtracting the paid interest from the EBIT to calculate the Earning Before Taxes ( $EBT$ ) for the next time step, which is executed with the following equation:

$$EBT_{y+1} = EBIT_{y+1} - (d_y) * int_y \quad (5.9)$$

in which  $d_y$  is the debt of the NFC and  $int_y$  is the interest rate that the NFC pays over the debt. The interest rate of the NFC is determined by the debt-to-equity ratio of the NFC,  $der_y(f)$ . When the debt-to-equity ratio is high, banks take more risk with the firm and expect a higher interest rate. The interest rate for an NFC takes values between the minimum ( $int_{min}$ ) and maximum ( $int_{max}$ ) interest rate. The interest rate is a linear function of the debt-to-equity ratio  $der_y(f)$  between 0.1 and 2.0. The interest rate of an NFC  $int_y(f)$  is calculated with the following equation:

$$int_y(f) = \begin{cases} int_{min}, & \text{if } der_y(f) < 0.1 \\ (\frac{int_{max} - int_{min}}{1.9}) * der_y(f) + int_{min}, & \text{if } 0.1 \leq der_y(f) < 2.0 \\ int_{max}, & \text{if } der_y(f) \geq 2.0 \end{cases} \quad (5.10)$$

To derive the net income (also mentioned as profits) of the NFC,  $NI_{y+1}$ , only the taxes have to be subtracted from the EBT with the following equation:

$$NI_{y+1} = EBT_{y+1} * (1 - tx_{inc}) \quad (5.11)$$

in which  $tx_{inc}$  is the tax rate on profits that is active. The net income is used for share repurchases, payout of dividend and real investment. If at the end of the following year more than 100 percent of net income has been spent on these three variables, the difference will be added to the debt of the NFC.

The next paragraphs will go in-depth in the calculation of the payout and investment in NFCs. The evaluation of payout policy of NFCs is determined within different time periods. The dividend rate and the share repurchasing target are reevaluated at the end of every year. A share repurchasing program can succeed or fail, as the NFC is dependent on the excess supply of shares from investors to reach the repurchasing target. For every decision rule, the calculation of the share repurchasing target, dividend rate and real investment rate is different.

The calculations are used from trends that are identified in section 1.3 and are modified to fit in the scope of this research. This had to be done because of the exclusion of business cycles in the model and the limited variables the NFCs in the model have.

### 5.3.5. Calculation of payout of the MSV type of NFC

The NFCs with the MSV type of corporate governance determine their dividend rate based on the return on investment of their shareholders. If the current average return on the shares of an NFC over all investors has decreased in the current year, the NFC increases their dividend rate to compensate for the decreased return. The new dividend rate  $div_{y+1}(f)$  is determined by the following equation:

$$div_{y+1}(f) = div_y(f) * \lambda_{div} \quad (5.12)$$

in which  $div_y(f)$  is the current dividend rate with a range between 0 and 1 and  $\lambda_{div}$  is the dividend increase that the NFC uses with a range between 0 and 1. The new dividend rate is used in the following year for payouts to the shareholders of the firm.

NFCs that maximize their shareholder value will only create a share repurchasing program if their EPS growth target has not been reached from the previous year. The  $EPS_y(f)$  of a firm is calculated with the following equation:

$$EPS_y(f) = \frac{NI_y(f)}{n_y(f)} \quad (5.13)$$

in which  $NI_y(f)$  is the net income and  $n_y(f)$  are the amount of outstanding shares. The target for  $EPS_{y+1}(f)$  is set uniformly between 102 percent and 110 percent of  $EPS_y(f)$ . The 2 percent is the minimum target to account for yearly inflation, while the upper bound of 110 percent is a relative maximum for the growth of the EPS for a year.

The target of the share repurchasing program for the next year is determined by the amount of shares that have to be bought back to balance the current EPS to the EPS target, based on the same earnings. The share repurchasing goal  $r_{y+1}(f)$ , measured in numbers of shares, is calculated with the following equation:

$$r_{y+1}(f) = (NI_y(f) / EPS_{y+1}(f)) - n_y(f) \quad (5.14)$$

in which  $NI_y(f)$  is the net income of the firm,  $n_y(f)$  is the number of outstanding shares and  $EPS_{y+1}(f)$  is the EPS target for the next timestep. When a share repurchasing program is active, NFCs will bid on shares of investors with an excess supply. When the EPS target has been reached in the next year, the share repurchasing program will be stopped and no shares will be purchased by the NFC the following year.

### 5.3.6. Calculation of payout of the MIP type of NFC

The NFCs with the MIP type of corporate governance try to maximize their net income through not acquiring more debt and cut back on share repurchases if there is a decrease in net income. However, they do increase their dividend rate if their net income has increased, as they want to adjust their payout if their net income has grown. They determine their new dividend rate based on the difference of their net income with the net income achieved in the previous year. If their current net income  $NI_y(f)$  has increased above a certain percentage ( $div_{limit}$ ), the NFC will increase their dividend rate. Otherwise the NFC keeps the same dividend rate. The new dividend rate  $div_{y+1}(f)$  is calculated with the following equation:

$$div_{y+1}(f) = \begin{cases} div_y(f) * \lambda_{div}, & \text{if } \frac{NI_y(f) - NI_{y-1}(f)}{NI_{y-1}(f)} \geq div_{limit} \\ div_y(f), & \text{otherwise} \end{cases} \quad (5.15)$$

in which  $div_y(f)$  is the dividend rate of a firm,  $NI_{y-1}(f)$  is their net income from previous year,  $\lambda_{div}$  is the percentile increase of the dividend rate and  $div_{limit}$  is the minimum percentile increase of net income for which the NFC will increase their dividend rate. If the percentile increase target is not met, the firm will keep the same dividend rate.

The share repurchasing target of the NFC is also determined through the difference in net income from the previous year. However, the difference in net income does not have to be above a certain limit. The share repurchasing target for the following year  $r_{y+1}(f)$  is calculated with the following equation:

$$r_{y+1}(f) = \begin{cases} \frac{NI_{y+1}(f) - (div_{y+1}(f) * mc_y(f))}{prc_y(f)}, & \text{if } NI_{y+1}(f) > NI_y(f) \\ \frac{NI_{y+1}(f) - (div_{y+1}(f) * mc_y(f))}{prc_y(f)} * 0.5, & \text{otherwise} \end{cases} \quad (5.16)$$

in which  $div_{y+1}(f)$  is the dividend rate of a firm and  $mc_y(f)$  is the market capitalization of a firm. The share repurchasing target is determined by the net income minus the capital that has to be spent on dividend payments, divided by the current price per share of the NFC. This seems like an extreme high rate, but the market mostly prohibits a high repurchasing rate. The share repurchasing target is cut in half when the net income of the NFC has decreased. This is done to prevent that they take on extra debt that will increase interest payments of the firm.

### 5.3.7. Calculation of payout of the MPI type of NFC

The NFCs with the MPI type of corporate governance have a minimum fraction of net income that has to be spent on both payout ( $pct_{pay}$ ) and investment ( $pct_{inv}$ ). These are set to 40 percent and 60 percent of net income, respectively. For the NFCs with the MPI corporate governance, the dividend rate is calculated in the same way as the MIP type for dividend as in equation (5.15). However, the share repurchasing target is calculated with the percentage that is reserved for the payout to investors. The share repurchasing target  $r_{y+1}(f)$  is calculated with the following equation:

$$r_{y+1}(f) = \frac{0.40 * NI_{y+1}(f) - div_{y+1}(f) * mc_y(f)}{prc_y(f)} \quad (5.17)$$

### 5.3.8. Payment of taxes by investors

At the end of a year, investors have to pay two types of taxes over their capital: taxes on the dividend they received throughout the year and taxes on the capital gain the investor got from selling stock. The dividend tax investor  $x$  has to pay  $tp_{div}$  is calculated with the following formula:

$$tp_{div}(x) = divrecv(x) * tx_{div} \quad (5.18)$$

in which  $divrecv(x)$  is the amount of dividend the investor  $x$  has received through the year and  $tx_{div}$  is the dividend tax rate. The capital gain taxes that the investor has to pay  $tp_{cap}$  is calculated with the following equation:

$$tp_{cap}(x) = \left( \sum_{f=1}^{ssell(x)} prcsell_f(x) - prcbuy_f(x) \right) * tx_{cap} \quad (5.19)$$

in which  $ssell(x)$  is the set of shares of firms that have been sold in a particular year,  $prcsell_f(x)$  is the selling price of the shares of a firm,  $prcbuy_f(x)$  is the average buying price of the stock of a firm and  $tx_{cap}$  is the capital gain tax rate.

### 5.3.9. Deciding the capital spent on real investment and debt in NFCs

The amount of capital that is spent on real investment is determined at the end of the year. For all NFCs, the amount of capital spent on real investment is the net income that is left at the end of the year, after shares have been repurchased and dividend has been paid out. For the MPI type of NFC, the minimum real investment rate is reached through loans if there is not enough net income left. However, other NFCs might also take on more debt. To get, the NFCs decide the capital spent on real investment on year  $y$  by subtracting the dividend payout that should have been paid out with the market capitalization on  $y - 1$  from the net income left after capital has been spent on share repurchases ( $caprps_y(f)$ ). If the share price is higher than the share price on  $y - 1$ , the NFC will acquire more debt as it has to spend more on dividend. If the share price is lower than the share price on  $y - 1$ , the NFC has net income left that is used to pay off debts.

The capital spent on real investment  $capinv_y(f)$  is calculated with the following equation:

$$capinv_y(f) = NI_y(f) - caprps_y(f) - (div_y(f) * mc_{y-1}(f)) \quad (5.20)$$

in which  $div_y(f)$  is the dividend rate of the NFC on year  $y$  and  $mc_{y-1}(f)$  is the market capitalisation of the NFC on time  $y - 1$ . The capital spent on dividend  $capdiv_y(f)$  is calculated with the following equation:

$$capdiv_y(f) = div_y(f) * mc_y(f) \quad (5.21)$$

The change in debt  $\Delta d(f)$  is calculated with the following equation:

$$\Delta d(f) = NI_y(f) - capinv_y(f) - caprps_y(f) - capdiv_y(f) \quad (5.22)$$

If  $\Delta d(f)$  is positive, more debt will be added to  $d(f)$ . If  $\Delta d(f)$  is negative,  $d(f)$  will be reduced and less interest payments have to be paid in the next year.

### 5.3.10. Calculation of the real investment rate, dividend payout rate and share repurchasing rate

In analyzing the ratio of payout and investment in firms, the net income is often used as denominator of the fraction [57]. Because this research includes a focus on the effect of the tax on profits on the real investment rate, the EBIT has been chosen as denominator of the fraction. Because the net income is the profit that is left after the taxes on profits are paid, different taxes on profits will not impact these rates if they were the fractions of net income. The real investment rate ( $invrate_y(f)$ ), dividend payout rate ( $invrate_y(f)$ ) and share repurchasing rate ( $invrate_y(f)$ ) are all calculated through dividing the capital spent on these expenses by the EBIT of the NFC, which are calculated with the following equations:

$$invrate_y(f) = \frac{capinv_y(f)}{EBIT_y(f)} \quad (5.23)$$

$$invrate_y(f) = \frac{capdiv_y(f)}{EBIT_y(f)} \quad (5.24)$$

$$invrate_y(f) = \frac{caprps_y(f)}{EBIT_y(f)} \quad (5.25)$$

## 5.4. Predictions and hypotheses

For the NFCs, predictions can be made based on the equations that determine the real investment rate, dividend payout rate and share repurchasing rate. Because both the final dividend payout rate and the share repurchasing rate are dependent on the share price of the stock of the NFCs, the behavior of the market could have a significant impact on these two variables. A large increase in share price could lower the net income that is available for real investment due to a larger dividend payout and capital spent on share repurchases. The capital spent on share repurchases is also dependent on the overall market conditions. The excess supply of investors determine how much shares NFCs can theoretically buy back and the forecast price of the investors with an excess demand determine the amount of bids they can actually win.

Because the MSV type of NFCs determine their dividend payout on the change in ROI of their shareholders, a hypothesis is that the tax dividend will have a significant impact on the real investment rate for these types of NFCs. The ROI of investors will be lower with a high tax on dividend payout, which will result in the NFCs compensating for this lower ROI with a higher dividend rate. This relationship between the market and the NFCs is not present in the MIP and MPI types.

A second hypothesis is that the minimum investment percentage of the MPI types of NFCs could decrease the impact of the tax rates on the real investment rate. This depends on whether the real investment rate of the NFCs will stay above the minimum investment percentage. The tax rates could diminish a large part of net income intended for investment from the MPI types of NFCs, but the minimum investment percentage would lead to the NFC taking on more debt to pay for investment, which would lead to even less net income.

## 5.5. Conclusion

This chapter presented the formalisation of the stock market for determining real investment in NFCs. This included the state variables of the agents and environments, the system diagram of the stock model and the ontology of the conceptual model. The formalisation presented the choices made for how the investors determine their excess demand and supply, how the allocation mechanism balances excess demand and supply and how different types of NFCs determine their payout decisions and capital that is spent on real investment.





# 6

## Model implementation

The implementation of the formal model into an agent-based model is presented in this chapter. The first section describes the implementation of the model in NetLogo, the user interface (UI) of the agent-based model and the input and output in the model. The full model can be found on Github: <https://github.com/NickVanBerkel/ABM-MasterThesis>.

The formal model is implemented in the agent-based software NetLogo. For the purpose of faster experimentation and analysis, I made two NetLogo models: one model with visualizations and one model without visualizations. The model without visualization only contains an empty graphic user interface (GUI) to speed up the experiments that are performed. The code of the model is not broken down in this section. Rather, the UI, input, output and the sequence of functions is discussed to give a clear view of how the agent-based model works.

Figure 6.1 shows a screenshot of the UI of the visualized NetLogo model. The GUI of the model is a template of the United States (without Alaska and Hawaii), which is only used for visualization purposes and has no further meaning for the research. The human figures in the map represent investors, the links between the investors represent the network of the investors and the buildings in the map represent NFCs. The investors are set on a random place on the map. The investors make links with every other investor within in a 50 patch radius. The sliders and plots are described in the next subsections.

### 6.1. Model input and output

Figure 6.2 shows the input variables with their corresponding mathematical counterparts between brackets.

The output of the model is shown on the right side of the GUI. The plots under OUTPUT OF NFCs monitor the observations of NFCs in the model over the run time of the model. These are the price per share  $prc_t(f)$ , the real investment rate  $inv - rate_y(f)$ , the dividend rate  $div - rate_y(f)$ , the share repurchasing rate  $rps - rate_y(f)$  and the amount of debt  $d_t(f)$  of the NFCs. These variables give a overview of the state of the NFCs in how their payout to investors develops, how much capital is spent in real investment and how much debt they take in the run. The plots under OUTPUT OF INVESTORS display the percentage of fundamentalists, the most successful strategy, the strategy of the most successful investor, the average learning score of fundamentalists and the average learning score of chartists. These variables reflect the state of the investors pool and how much the learning score affects the forecast of the investors. The last section of outputs on the right monitor verification variables, consisting of the amount of shares in the portfolio of investors, the number of outstanding shares of NFCs, the number of investors with a negative liquidity and and the number of NFCs with a negative investment rate.

### 6.2. Parametrisation

The parametrisation of the agent-based model involves the finding of appropriate values for the model variables. These values have been chosen based on data, literature and extensive testing of the model. The initial states of NFCs are derived from data of public firms the Standard & Poor's 500 index. This group of large companies from mostly the NYSE and NASDAQ markets is seen as the leading index for the state of the U.S. stock market. The next list gives an overview of all the parameters:



Figure 6.1: User interface of the NetLogo stock model.

- Initialization inputs (top left corner):
  - Minimum and maximum liquidity demand ( $LD_{min}$  and  $LD_{max}$ )
  - Minimum and maximum interest rate ( $int_{min}$  and  $int_{max}$ )
- Tax inputs (bottom left corner):
  - Tax on dividend payouts ( $tx_{div}$ )
  - Tax on capital gain ( $tx_{cap}$ )
  - Tax on corporate profits ( $tx_{inc}$ )
- NFC inputs (under GUI):
  - Dividend increase ( $\lambda_{div}$ )
  - Return on real investment of NFCs ( $ROI_{NFC}$ )

Figure 6.2: Input variables of the stock model in the UI in NetLogo.

- NFCs:
  - The initial states of NFCs are taken from the mean of the public firms in the S/P 500 index on March 20th 2019. These initial states are equal for every NFC simulated with the model. These initial states and their respective values are:
    - ◊ Share price ( $prc_0(f)$ ): \$107.77
    - ◊ Market capitalization ( $mc_0(f)$ ): \$30 billion
    - ◊ Price-to-earnings ratio ( $pe_0(f)$ ): 0.215
    - ◊ Debt-to-equity ratio ( $der_0(f)$ ): 1.1
    - ◊ Dividend rate ( $div_0(f)$ ): 5%
  - The other variables of the NFCs derived from these initial states are:
    - ◊ Amount of outstanding shares ( $n_0(f)$ ): 278,370,604
    - ◊ EBIT ( $EBIT_0(f)$ ): \$6.45 billion
    - ◊ Debt ( $d_0(f)$ ): \$33 billion
- Investors:
  - The shares of the NFCs are equally distributed over the investors in the model, which will be a minimum 2,783,706 per investor, per firm. The residual shares that are left, are handed to a random investor.
  - The liquidity demand of investors is determined by a uniform distribution. The limits of the distribution are set by the minimum liquidity demand ( $LD_{min}$ ) and maximum liquidity demand  $LD_{max}$ .
  - The investing strategy of investors is chosen randomly between a chartist strategy and a fundamentalist strategy.
  - The fundamentalist equilibrium level and the chartist trend level of investors are chosen with a uniform distribution as a float between 0 and 1.
  - The floor level of fundamentalists is calculated with a uniform distribution between 50 percent and 150 percent of the initial share price and is different for each investor.
- Global variables:
  - The excess demand factor ( $EFX$ ) is permanently set to 5000. This creates an excess demand of 5000 shares with a forecast price increase of 100 percent and an excess supply of 5000 shares when the forecast price falls with 100 percent to 0 USD. The market conditions with this excess demand factor keeps the model in balance.
  - The price adjustment factor ( $\lambda_{pa}$ ) is permanently set to 0.01. This indicates a price increase of 1 USD for every 100 more excess demand of shares of investors. This value is chosen based on the price adjustment factors in the research of [39] and [46].
  - The minimum percentile increase of net income to increase the dividend rate ( $div_{limit}$ ) is set to 10 percent. This limit is chosen to make sure that the NFCs do not increase their dividend rate with every increase in net income, as this could result in a high dividend payout ratio when the share price has increased drastically.
  - The number of investors is permanently set to 100 investors. The value of 100 is chosen to have a diverse group of investors, which form networks with their neighbours in the model.
  - The number of NFCs is permanently set to 2 NFCs to simulate a stock market in which investors have a choice in different stocks they want to purchase or sell.

### 6.3. Conclusion

This chapter presented the implementation of the formal model in a NetLogo model. The model input and output were explained, as well as the sequence of processes that the model executes. The parametrisation of the agents and the model were also explained.



## Model verification and validation

This chapter presents the verification and validation of the implemented agent-based model. After the formal has been implemented in the agent-based model, it is time to confirm whether the formal model was correctly implemented in NetLogo. Furthermore, a validation of the model is necessary to determine whether the implemented agent-based model is capable of creating statistical similarities with real-world stock markets.

### 7.1. Model verification

In the model verification, the model is tested to check if the simulation model is a correct representation of the formal model. This section discusses this model verification, based on the verification process in Van Dam et al. [65]. The verification is comprised of two steps. First, verification functions in the model that display an error if agents does not seem to behave properly are discussed. Secondly, the interactions in a minimal model are tested. These test the behavior of the agents and their logic.

#### 7.1.1. Verification functions in the model

The first verification function in the model verifies every timestep that the amount of outstanding shares of NFCs are equal to the amount of shares in the portfolio of investors. These two values have to be equal, as the model is a closed system. The only way the number of outstanding shares can be altered, is through share repurchases, but these have to be bought from the investors in the model. Throughout the experiments, this error message has not come up in the model.

The latter verification functions involves checking the variables of investors and NFCs at every timestep. As the investors in the model are limited to the amount of cash they have, and are not able to have debt, the cash variables should at all times be equal or greater than zero. The total wealth, portfolio wealth, liquid wealth and spendable liquidity of investors are verified, whereas the net income and spendable liquidity of NFCs are tested. For NFCs, the real investment rate is also checked to make sure the investment rate is not below zero. If one of these variables in any of the agents is below zero, an error message is displayed.

#### 7.1.2. Minimal model testing

Two investors and an NFC are tested to verify if the conceptual and formal model is implemented correctly. The agents are tested by coding an input for the agent, and track the output of the agent to make sure this output can be expected from the conceptual and formal model. For the investors, the excess demand for the share is tracked to verify if the excess demand is in line with the expectations provided by the investing strategy and the price history. For the NFCs, all three types of corporate governance are separately verified. The dividend rate, real investment rate, share repurchasing target and debt are tracked to verify if these variables are in line with the corresponding variables that determine the decision. The plots for the minimal model verification are found in appendix B. In the MSV and MIP plots, investor 1 has the chartist strategy while investor 2 has the fundamentalist strategy. In the MPI plot, investor 1 has a fundamentalist strategy and investor 2 has a chartist strategy.

The fundamentalist and chartist investors both show expected behavior. The forecasts of chartist investor mostly follows the price itself as it is based on the historical data of the share price. The excess demand of

chartist investors also show expected the behavior, as the excess demand is mostly stable. This is the result of the forecast prices not differing much from the share price. The forecasts of fundamentalists show mostly a forecast lower than the share price, as the share price mostly increases which increases the difference with the floor level of the investor. This results in the excess demand having more fluctuations than the chartist investor. The excess demand does correspond to the difference of the forecast price with the current price. The excess demand of 0 in the MPI run after around 15 ticks is the result of the investor running out of shares due to its high excess supply.

## 7.2. Model validation

To validate whether the stock model shows similarities with real-world stock markets and companies, a validation of the results is conceived. The model validation will both focus on determining whether the model is able to create a historical replay and whether the observed results share conclusions from previous research. The validation focuses on the validity of the stock system.

The validation of the model is based on two different hypotheses. First, the return on investment of investors is validated against common metrics in stock returns. A normal distribution of returns of investors is common in stock markets when looking at year-over-year returns [29]. However, the first hypothesis states that after several years since the first observation of returns, the shape of the normal distribution will change towards an asymmetric distribution, with a higher peak around 0 percent return and a longer right tail [17]. To measure this change, the skewness and kurtosis of the distribution is calculated. Skewness is a statistic of a probability function that describes the asymmetry of the distribution, while the kurtosis is a statistic of a probability function that describes the length of the 'tails' of the distribution. The first hypothesis can therefore be stated as saying that a higher, positive skewness and lower, negative kurtosis will form from the distribution of returns after 10 years.

The second hypothesis states that the prices of shares will have a comparable volatility to the S&P 500 volatility. Volatility is a statistic that describes the dispersion of the return on a specific asset or stock, and is a statistic that Lux and Marchesi [45] explained with their agent-based herding model. A common way to measure the volatility of returns is calculating the standard deviation of periodic price changes, and converting them into an annual volatility of returns. The calculated annual volatilities will be compared to the average annual volatility of the S&P 500, as the state variables of the NFCs are also based from this data set of companies. However, the annual volatility of the S&P is calculated with daily price changes, while the annual volatility of the model is calculated with monthly price changes, which leads to a lower annual volatility. I hypothesize that the annual volatility of the model runs will have a lower volatility from the annual volatility of the S&P 500 of 18.1 percent due to the difference in discrete timesteps.

Validation of NFCs would be a hard task and is not preferable in this model. The data from the NFCs are used to investigate differences in variables and depend on the type of corporate governance in NFCs. The properties of these types do show empirical trends in firms, but are impossible to validate as I have combined trends and created these types without empirical data. Additionally, even though the initial states of the NFCs are based on S&P 500 data, the future earnings of the NFCs are exogenous and randomly calculated.

### 7.2.1. Validation through the ROI of investors

Figure 7.1 and 7.2 show the distributions of return of investors after 1 year and after 10 years, respectively. The skewness and kurtosis are calculated with functions from the SciPy Python library for statistics. The distribution of returns of investors after 1 year shows a normal distribution of returns, with its average being slightly less than 0 percent. The distribution of returns after 10 years shows a asymmetrical distribution with a peak at roughly 5 percent, and a fatter tail at the right. The skewness and kurtosis of the distribution of returns after one year are 0.1588 and -0.2918, respectively. The skewness and kurtosis of the distribution of returns after 10 years are 0.7252 and -0.4230, respectively. This is in line with the hypothesis that the skewness increases and the kurtosis decreases of the return distribution changes several years after the first observations of return.

### 7.2.2. Validation through the volatility of stock prices

The volatility of the stock prices are calculated for both NFCs in the model and for all runs in the data of the *corporate governance* results. The monthly volatility of a firm's stock  $vol_{month}(f)$  is calculated with the standard deviation of periodic price changes, derived from Kahl [33]:

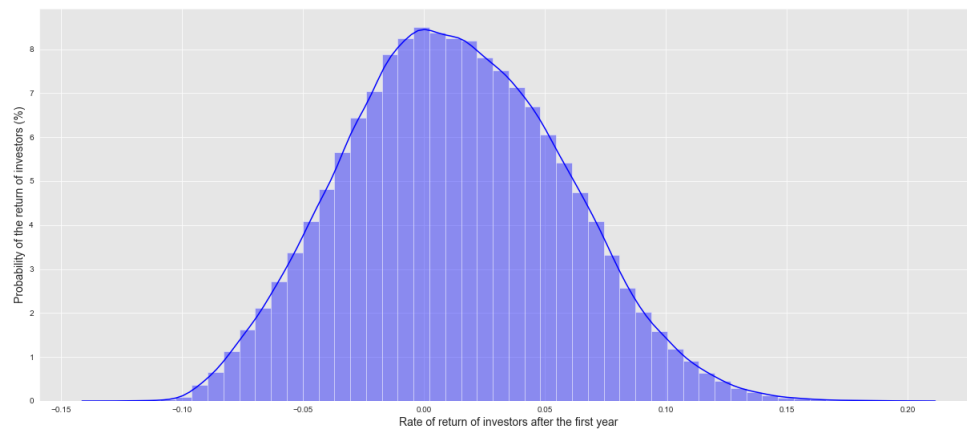


Figure 7.1: Distribution of the returns of investors in the model after 1 year.

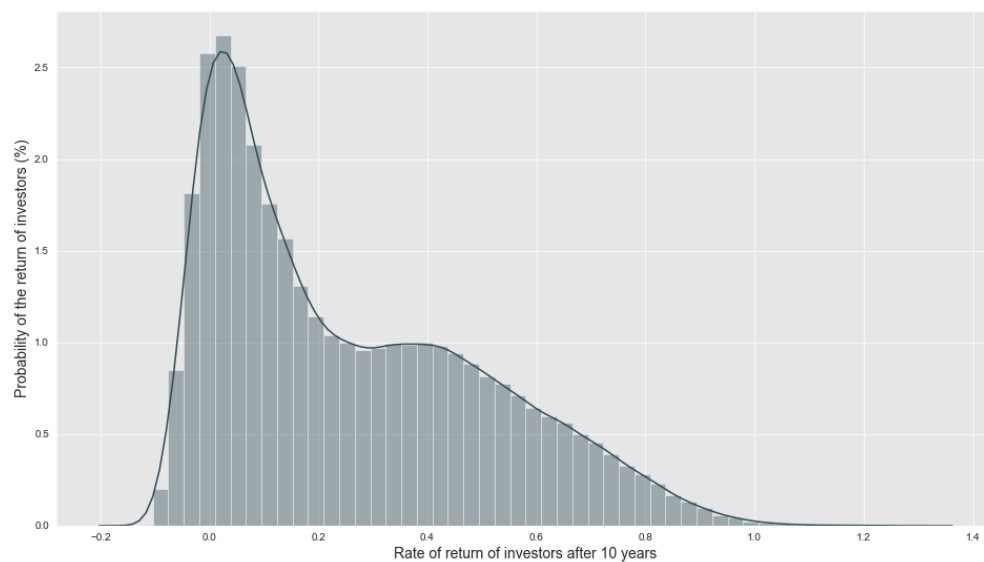


Figure 7.2: Distribution of the returns of investors in the model after 10 years

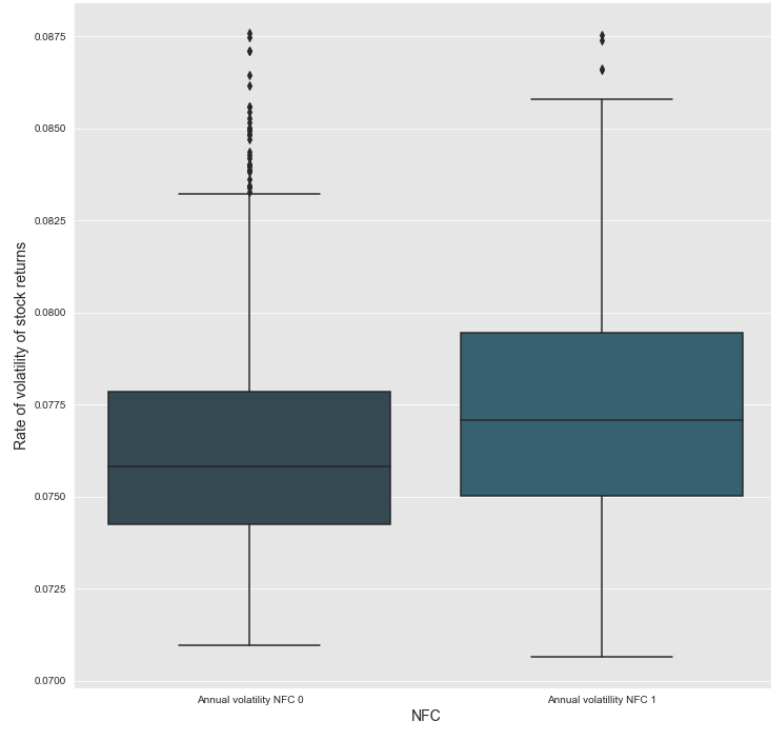


Figure 7.3: Volatility of investors for the both NFCs for the economic scenario experiment.

$$vol_{month}(f) = \sqrt{\frac{\sum_{t \in T} (chg_t - chg_{t-1})^2}{T}} \quad (7.1)$$

in which  $T$  are the time steps in the run and  $chg$  is the percentile change of the stock price compared to the average stock price. The annual volatility of a firm's stock  $vol_{ann}(f)$  is calculated with the following equation, derived from Kahl [33]:

$$vol_{ann}(f) = vol_{month}(f) * \sqrt{12} \quad (7.2)$$

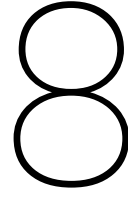
in which  $\sqrt{12}$  is used to adjust the monthly volatility for the 12 months in a year.

Figure 7.3 shows a boxplot of the rate of annual volatility of returns for the two stock prices that are measured from the model runs. The average volatility of the return in the runs is around 7.6 percent for both firms. The difference between the two average is not significant and can be explained by randomisation in the model. The range of volatilities is equal for both the firms with ranges between 7.0 percent and 8.8 percent. This is about half of the average annual volatility of the S&P 500 of 18.1 percent. The volatilities confirm the hypothesis and show that the stock market create semi-realistic market properties.

### 7.3. Conclusion

This chapter presented the verification and validation of the model. The verification shows that no errors are found within the model and the outcomes of the behavior of investors and NFC show no irregularities that are not expected. The model validation showed that the skewness and kurtosis of the distribution of the ROI of investors change into realistic statistics for the distribution after 10 years. The validation also showed that the volatility of the share prices shows a realistic percentage for the timestep in which the share price is measured.





# Experiments, model results and analyses

Together with chapter 6 and 7, this chapter aims to answer the subquestion: *What kind of financial corporate governance in NFCs explain the effect of taxes on the real investment rate in NFCs in a stock model?*. This chapter discusses the results and analyses of the agent-based model from the data of experiments executed with the model. The chapter describes two different experiments with their results and analyses. The first section discusses the experiment with the uncertain variables in the model and their impact on the state variables of NFCs. The second section discusses the experiment with the three different types of NFCs and the results and analyses of this experiment. Each section starts with an experiment setup, followed by the results of the experiment and analyses of the results. The chapter ends with a conclusion of the results and analyses.

## 8.1. Impact of uncertain variables on the output of NFCs

Several variables in the model setup have been implemented that influence the behavior of the agents, and subsequently the model itself, and also reflect economic uncertainties. As an example, the liquidity demand of the investors are determined by a uniform distribution between the minimum and maximum liquidity demand. The range of the liquidity demand is a model input that cannot be determined from literature, but can be classified as an input that is largely subject to the current economic prosperity. If the overall economic prosperity is high, investors perceive less risk and would be more likely to invest with their liquid capital on average. This results in the investors having a lower liquidity demand. Three different scenarios of economic prosperity will be used as input to this experiment.

### 8.1.1. Experiment setup

Table 8.1 shows the uncertain parameters with their corresponding mathematical notations and the values that are varied with three scenarios. These scenarios reflect an *economic recession*, an *average economic situation* and an *economic prosper* situation. These variables show uncertainties for investors and NFCs. These uncertainties can have an effect on the stock market and the decisions made by NFCs regarding their payout policy and investment. The values have been chosen to be on the lower spectrum of percentages, as higher percentages could break the model and create a unsustainable economic environment. The experiment with different values for these uncertainties are separately executed from the experiments that look into the effect of taxes on the real investment. The tax rates for these experiments are set to 0 percent. The three scenarios are replicated 100 times, for all three types of NFCs. For every run, there are two NFCs and 100 investors in the model. These NFCs will each follow one of the three corporate governance types that have been preset. The real investment rate, the dividend payout rate, the share repurchasing rate, the share price and debt of the NFCs are the output variables of the model. All runs in the experiments are run for 120 time steps, or 10 years, from which the first year is not recorded as no payout policy or investment is determined in the first year.

### 8.1.2. Feature scoring of uncertainties

To identify which uncertainties have the highest impact on the model, a feature scoring analysis [10] is performed for the different values for the uncertainties and the corresponding outcomes of the model. Feature

Table 8.1: Experiment setup of the uncertain variables with their mathematical notations and value ranges.

Parameter	Mathematical notation	Economic recession / Average situation / Economic prosperity
Minimum liquidity demand of investors	$LD_{min}$	15% / 5% / 2%
Maximum liquidity demand of investors	$LD_{max}$	50% / 30% / 20%
Minimum interest rate of NFCs	$int_{min}$	0.1% / 1% / 2%
Maximum interest rate of NFCs	$int_{max}$	5% / 7% / 12%
Dividend increase by NFCs	$\lambda_{div}$	2% / 5% / 10%
Return on investment of NFCs	$ROI_{NFC}$	2% / 8% / 10%

scoring is a family of techniques that is used to identify relevant features of the model and is similar to a global sensitivity analysis. The feature scoring analysis is performed with the *feature scoring* tool in the EMA Workbench extension in Python. The feature scores give an indication how much the uncertainties impact a specific output variable. The feature scores are floating values between 0 and 1, and sums up to 1 for every output variable. The feature scores are relative to each other and reflect the difference in impact between the uncertainties. A high feature scores is a sign of high relative impact on the output variable, while a low feature score is a sign of a low relative impact on the output variable. The feature scores do not indicate whether the uncertainties influence the variables negatively or positively. The feature scores are displayed in a *heatmap* to visualize the uncertainties with the highest and lowest impact on the output variables. Due to the data labelling in NetLogo, the variables of the NFCs are separately analysed for the two NFCs in the model. However, the two variables will be similar to each other, as the NFCs will always both follow the same corporate governance strategy in the same run. Due to the randomisation in the model, small differences are expected.

Figure 8.1 shows the heatmap of the feature scores for the uncertainties in the model. The data for the runs are averaged over all runs and all three types of NFCs. The first observation is the high impact of the maximum interest rate on the real investment rate in NFCs with feature scores of 0.48 and 0.39. A high interest rate limits the amount of net income that is available for the real investment rate. This indicates that more capital is available for investment in low economic progression due to a lower average interest rate. The maximum interest rate also has feature scores of 0.23 and 0.24 on the dividend payout rate. This is explained by the decision rules of the MIP and MPI types that increase their dividend rate when their net income increases too, as seen in equation (5.15). The maximum interest rate has a relative low impact on the net income, which is a contradictory feature score due to the fact a high interest rate directly limits the net income. However, the other uncertainties have a higher impact on the net income, as they influence the other variables that contribute to the net income.

A second observation is the relatively high feature scores of 0.28 and 0.38 for the return on real investment of NFCs on the net income of NFCs. This was expected due to the investment feedback loop in equation (5.8) in which the return from real investment feeds back into next year earnings of the NFCs. Due to its influence on the net income and the influence of the net income on the dividend rate and share repurchasing target, the return on real investment in NFCs also has a medium feature score on the dividend payout rate and the share repurchasing rate.

The minimum and maximum liquidity demand have low feature scores between 0.083 and 0.093 for the real investment rate of NFCs and 0.14 and 0.17 for the share repurchasing rate. This indicates that the spendable liquidity of investors is not a limit for the amount of shares NFCs can buy back, and subsequently the real investment rate. A low liquidity demand could result in investors being able to buy more shares, as they have more spendable liquidity, which would lead to NFCs buying back less shares from the investors with an excess supply. The feature scores show that this is not the case. This also hints towards the forecast and investing strategy of the investors having a larger influence on whether the NFCs are able to buy back shares. The dividend increase and minimum interest rate do not specifically affect one of the variables of NFCs.

### 8.1.3. Conclusion uncertainty analysis

The feature score analysis showed that the maximum interest rate and the return on real investment of NFCs have the largest impact on the states of the NFCs and that the low feature scores of the minimum and maximum liquidity demand of investors indicate that the spendable liquidity of investors do not significantly limit the repurchasing power of the NFCs. To conclude, in an economically challenging situation with a low inter-

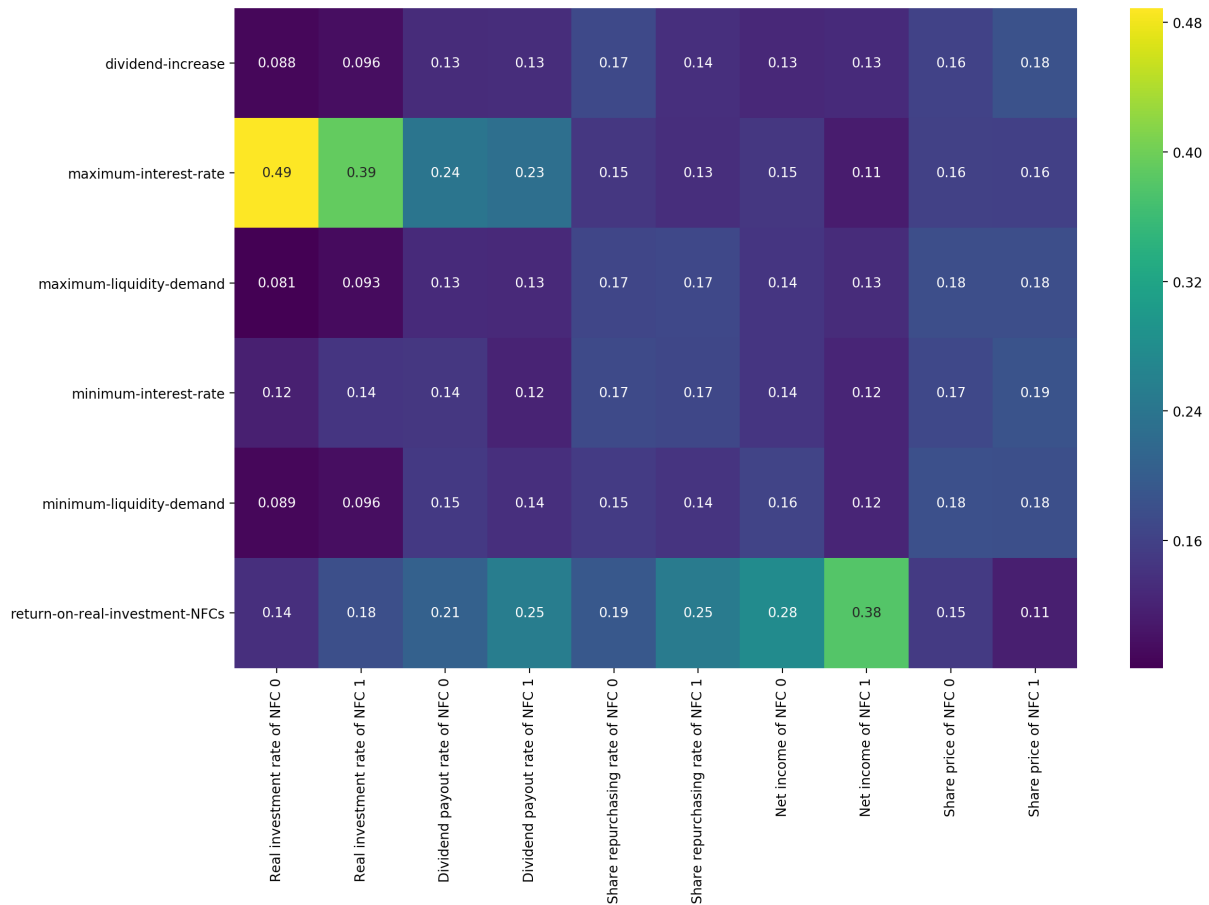


Figure 8.1: The heatmap for the feature scores of uncertainties on the output variables in the stock model. The feature scores indicate the explanatory power of the uncertainties on the output variables in the columns. A distinction is made for NFC 0 and 1 because of the data notation limits in NetLogo.

Table 8.2: Experiment setup of the corporate governance types and tax rates with their mathematical notations and value ranges.

Parameter	Mathematical notation	Range of values
Corporate governance types of NFCs	$CG$	only MSV / only MIP / only MPI / (MSV - MIP) / (MSV - MPI) / (MIP - MPI)
Tax rate for corporate profits	$tx_{inc}$	0% / 10% / 30% / 40% / 50% / 60%
Tax rate for dividend payments	$tx_{div}$	0% / 10% / 30% / 40% / 50% / 60%
Tax rate for capital gain	$tx_{cap}$	0% / 10% / 30% / 40% / 50% / 60%

est rate, more net income is available for the NFCs to put in real investment due to the lower interest rate. At the same time, it can be assumed that the long-term net income will not grow as fast in this situation due to more risk and lower returns on the capital put in real investment. This indicate stagnation in the growth of the firm.

## 8.2. Corporate governance of NFCs and its effect on the tax-investment relationship

The second experiment tries to give a direct answer to the second sub-question: *What kind of corporate governance in NFCs can explain the effect of taxes on the real investment rate in NFCs in a stock model?*. In this experiment, every run in the model will have NFCs with a combination of the three types of CG and a combination of tax rates for dividend payout, capital gain and profits. The results and analyses focus on whether the different NFC types can explain the effect of taxes on the real investment rate and which combination of variables are able to explain the variation in the real investment rate of NFCs.

### 8.2.1. Experiment setup

The goal of the second experiment is to research how different types of corporate governance influence the effect of taxes on the real investment rate. Table 8.2 displays the setup values for the corporate governance experiment, with their respective mathematical notations and value ranges. The types of the two NFCs are varied between six different sets for the corporate governance in NFCs in the model, as there are two NFCs in each run. For the tax rates, higher and unrealistic percentages have been included in the ranges of tax rates to account for relative small changes with lower tax rates. Every possible combination of tax rates and corporate governance in NFCs is replicated 10 times. All runs in the experiments are run for 120 time steps, or 10 years, from which the first year is not recorded as no payout policy or investment is determined in the first year.

### 8.2.2. Correlation coefficients between taxes and outcomes

A correlation coefficient indicates how strong the relationship between two different variables are in a data set. The correlation coefficient is calculated with the *Pearson correlation coefficient* that measures linear correlation between two variables. This correlation coefficient is suitable because it can handle rational variables, which have been used for the tax rates. This section uses a table for every outcome with the correlation coefficients between tax rates and the outcome. The correlation coefficient is separately calculated for the three types of corporate governance that are displayed in the columns, while the three taxes are displayed in the rows.

Table 8.3 shows the correlations of the three tax rates with the real investment rates, dividend rate and share repurchases, respectively. The three different corporate governance of NFCs are displayed in the columns of the table. The investment part of table 8.3 shows a strong negative correlation between the real investment rate and all tax rates for especially the MSV and MIP NFC types. While the correlation of the tax on dividend payouts and capital gain are similar, the tax on corporate profits have the highest correlation with the real investment rate for the two NFC types. This can be explained by the direct effect of the profit tax on the net income of the NFCs and thus the investment rate. The MPI NFC type have significant lower correlations than the other two NFC types for the tax rates. These lower correlations can be explained by the minimum investment rate that does not allow the real investment rate to get lower than 60 percent.

The dividend part of table 8.3 shows similar negative correlations across all three types of NFCs. As with the correlations of the real investment rate, the tax on corporate profits has the highest correlations for the tax rates and the dividend payout rate. This can be explained by higher corporate taxes limit the net income

Table 8.3: The correlations between the tax rates and the real investment rate of the three types of NFCs for the real investment, dividend payout rate and share repurchasing rate, respectively.

<b>Real investment rate</b>	Maximizing shareholder value	Minimizing interest payments	Minimum payout and investment
Taxes on dividend payouts	-0.6927	-0.6393	-0.2993
Taxes on capital gain	-0.6720	-0.6150	-0.3628
Taxes on corporate profits	-0.8746	-0.8975	-0.5318
<b>Dividend payout rate</b>	Maximizing shareholder value	Minimizing interest payments	Minimum payout and investment
Taxes on dividend payouts	-0.6690	-0.6842	-0.6686
Taxes on capital gain	-0.6433	-0.6414	-0.7334
Taxes on corporate profits	-0.8191	-0.8913	-0.8991
<b>Share repurchasing rate</b>	Maximizing shareholder value	Minimizing interest payments	Minimum payout and investment
Taxes on dividend payouts	-0.4794	-0.6157	-0.5526
Taxes on capital gain	-0.4457	-0.5585	-0.5924
Taxes on corporate profits	-0.5223	-0.7015	-0.6731

and also limits higher dividend rates for the MIP and MPI types of NFCs.

The share repurchasing rate of table 8.3 shows lower negative correlations with the tax rates than the real investment rate and dividend payout rate for all three types of NFCs. A high profit tax still limits the net income available for share repurchases and the share repurchasing target. However, the weaker correlation can be explained by the situation of the stock market and does not fully depend on the available net income.

The results agrees with the works of Aguilera and Jackson [2] and John and Knyazeva [32] in that the corporate governance of firms do affect their dividend payout rate, share repurchasing rate and real investment rate. The MPI firms were less affected by the tax rates and made different decisions for their payout and investment. However, the payout and investment rates of the MSV and MIP firms were very similar to each other, even though their decision rules were very different. This similarity is primarily explained by the influence of the stock market and share price on both the payout rates and investment rate. This indicates that the market conditions are the primary driving force of the payout and investment rate. However, the MPI firms showed that the influence of the stock market can be limited by setting goals that are not related to market conditions.

Furthermore, the results from the correlations of taxes and the dividend payout rate and share repurchasing rate in table 8.3 are in line with the findings of Chetty and Saez [15]. Chetty Suez found that the dividend payout and share repurchases in firms increased when the dividend tax and capital gain tax were decreased in the US, which is an indication of a negative correlation. The results from the correlation analysis show a negative correlation between the dividend tax rate and the dividend payout, as well as a negative correlation between the capital gain tax and the share repurchasing rate. However, the correlation analysis showed that the tax on corporate profits is the primary force behind the difference in the payout and investment rates, as this is the biggest influence on the available net income for both investment, dividend payout and share repurchases.

### 8.2.3. Distribution analysis of the effect of payouts on the real investment rate

To further investigate the effect of the minimum investment rate of the MPI type of NFCs and the influence of the stock market, showing the distribution of the real investment rate, the dividend payout rate and the share repurchasing rate can be a helpful tool. Because the dividend payout and the share repurchases can limit the net income available for real investment, the correlations of the dividend payout rate and the share repurchasing rate and the real investment rate is also a good indicator of the effect of payouts on the real investment rate.

To determine the correlation of the dividend payout rate and the share repurchasing rate with the real investment rate, the data is plotted in a scatterplots. The analysis is separately executed for the three types of NFCs (MSV, MIP and MPI) to determine possible differences in the correlation between the types. Due to computational limitations, only the lower three tax rates (0.00, 0.10 and 0.30) are used for this analysis. The higher tax rates show no different outcome, and are very one-sided for the MPI types of NFCs, as the NFCs

rarely pass the 60 percent minimum investment percentage. All data points for every time step have been used for the analysis and a joint plot is shown to also visualise the distribution of the dividend payout rate, the share repurchasing rate and the real investment rates.

The left and top three plots in figure 8.2 visualize the correlations between the dividend payout rate and real investment rate and distributions of both rates in the NFCs for the MSV type, the MIP type and the MPI type. The different colors in the dividend payout-real investment plots mark the three different tax rates on corporate profits used in the experiments. The first observation of the correlation of the dividend payout rate and the real investment rate is the three strokes of data points that are present for the MSV and MIP type. The distribution of the real investment rate also shows these strokes with three spikes that are present in the distribution. The strokes are the result of the different tax rates on profit that are used in the experiment. Due to more income being spent on taxes, there is less income available for both investment and dividend. The correlation for the MPI type of NFCs shows a different picture, mostly because of the high spike at the minimum investment rate of 60 percent. However, the distribution of the dividend payout rate is fairly similar to the other distributions of the other types.

The right and top three plots in figure 8.2 visualize the correlations between the share repurchasing rate and real investment rate and distributions of both rates in the NFCs for the MSV type, the MIP type and the MPI type. The plots show little correlation between the two variables. An explanation of the data can be the result of the power of the financial market, as the amount of shares repurchased by NFCs are dependent on the willingness of investors to sell shares and the forecasts of investors with an excess demand who can outbid the NFCs. Even though the NFCs are able to control the amount of shares they want to repurchase, they cannot control the financial market.

The distribution of the share repurchasing rate for the MSV type and the MPI type are fairly similar. Both have a large peak at 0 percent and a second peak around 0.03 percent of their earnings, for which there is no logical explanation from the formal model. A possible explanation could be the result of the investors in the market having an excess supply of shares that results in NFCs buying back similar amounts of shares. The MIP type of NFCs differs from the other two, as most of the data of the share repurchasing rate is 0 percent, with only a handful of large share repurchases. This difference could be the result of the MIP minimizing their debt and not willing to take on more debt every year. This would result in a share repurchasing target that is regularly cut in half, and in less buybacks.

The bottom three plots in figure 8.2 show the distributions of the share price and the real investment rate for the three types of NFCs. There is little correlation between the share price and the real investment rate for all three types of NFCs. The real investment rate slightly get lower when the share price increases, but not significantly.

To conclude, the distribution and correlation analysis has shown that the dividend payout rate has a strong negative correlation with the real investment rate and the share repurchasing rate has no correlation with the real investment rate. The analysis of the share repurchasing rate also indicates that the stock market has a large influence on how much shares are actually repurchased by NFCs, but that the share price has no significant effect on the real investment rate.

### 8.3. Computational limitations

The experiments had several computational limitations that limited the results of these experiments. The limited amount of investors, NFCs and timesteps in the experiments is a large downscale from the massiveness and on-going trading of shares in stock markets. Prices of shares are updated every second when a trading market is open. While the model validation does show that the investors have statistical similarities with real-world markets, a smaller timestep in the model could impact the final share price of the investors, as chartists base their predictions on the historical data of the share price. Due to the dependence of NFCs on the excess supply of investors, different dynamics in the share price and excess demand and supply in investors could impact the share repurchasing rate of NFCs.

The amount of replications was limited by the run time of the model, which Because of the allocation mechanism in the model, a slight increase in investors causes the model to slow down significantly. In the model without visualisation, a run of 120 ticks with 100 investors and 2 NFCs takes around 5 seconds, while the same run with 150 investors takes around 9 seconds. Three NFCs will slow down the model by more than 50 percent and would not add any more effects into the model.

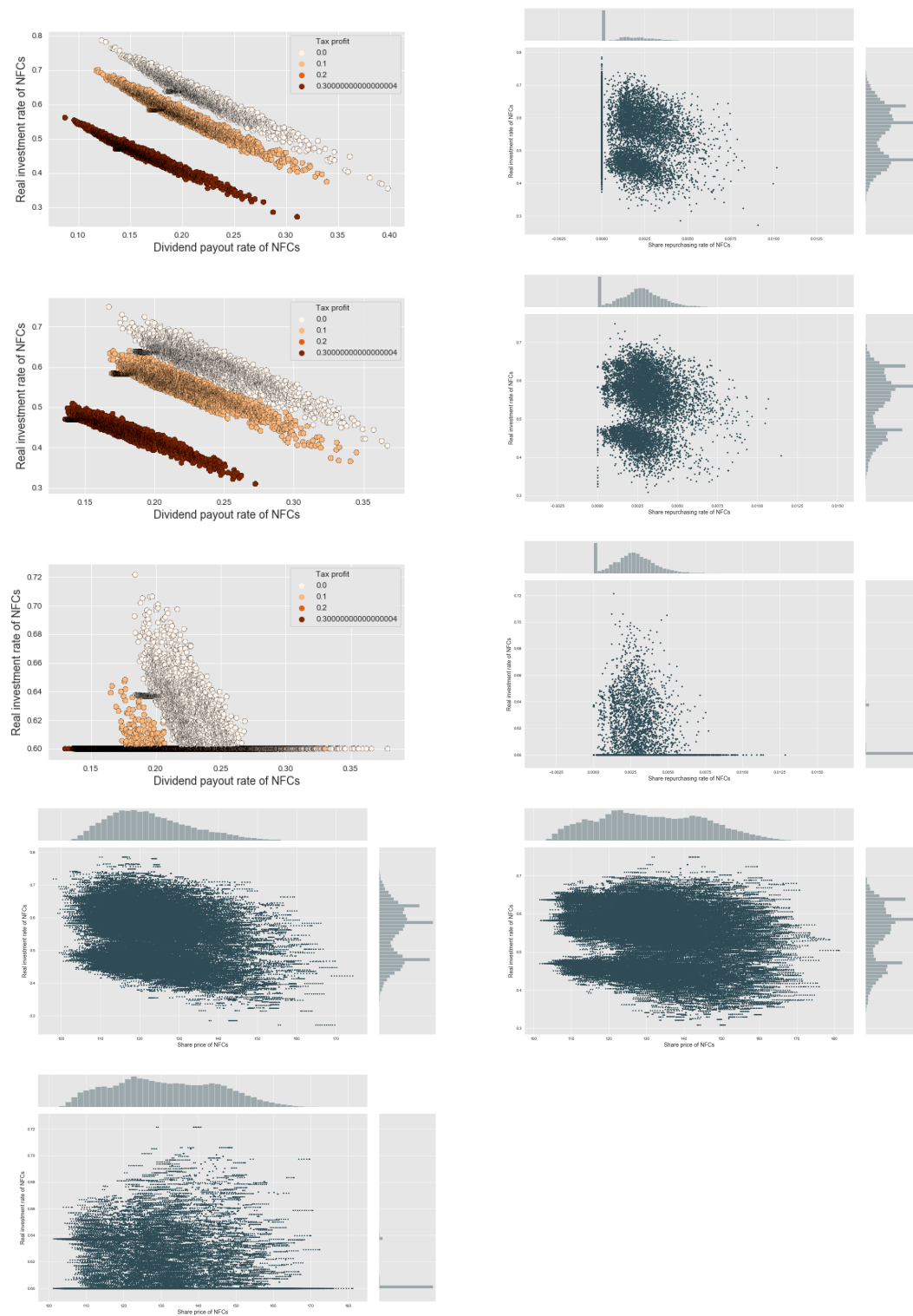


Figure 8.2: Plots of the distributions of the real investment rate, dividend payout rate, share repurchasing rate and share price. The colors in the investment-dividend plots are the tax profit rates of 0.00 (color), 0.10 (color) and 0.30 (color).

## 8.4. Conclusion

Together with chapter 6 and 7, this chapter aimed to answer the second subquestion: *What kind of financial corporate governance in NFCs can explain the effect of taxes on the real investment rate in NFCs in a stock model?*. From the results, the conclusion can be made that the MSV and MNI type of NFCs can explain the effect of taxes on the real investment rate in NFCs. Especially the tax on profits has a large negative effect on the available net income for real investment. Both an increase in the tax rate on dividend payout and capital gain would also decrease the real investment rate. However, NFCs of type MPI are less influenced by the tax rates due to the minimum investment rate they have to accomplish, but also hardly exceed an investment rate above the minimum percentage of 60 percent. The results indicate that although the share price has no significant effect on the real investment rate, the conditions of the investors and market likely explain the amount of share repurchases of the NFCs.



## Conclusion and discussion

This study started with the problem description of the decreasing investment rate in non-financial firms and the influence of increasing dividend payouts and share repurchases on this decreasing investment rate. This study tries to contribute to a solution for the decreasing investment rate by exploring the effects of different corporate governance in NFCs on the effect of taxes and real investment in these firms. This chapter aims to sum up the conclusions from the model, answer the research question and give a summary of the most crucial limitations of the study. The societal relevance and the scientific contribution is also discussed, as well as recommendations for future research.

### 9.1. Model results

This research aimed to identify which types of corporate governance have an effect on the real investment rate. The following research question was formulated, based on the knowledge gap identified by the literature review:

*"What kind of corporate governance of NFCs can explain the effects of taxes on the real investment rate in NFCs in a US-based stock market?"*

To answer the research question, an agent-based stock model was built, which incorporated taxes on profits, dividend payout and capital gain. The real investment rate, dividend payout rate and share repurchasing rate were calculated as part of the earnings of the NFCs. The NFCs in the model had three different types of corporate governance:

- The **maximizing shareholder value** (MSV) firms are defined by their focus on maximizing the value for their shareholders by increasing the dividend rate when their average ROI decreases and increasing the share repurchasing target to increase their EPS.
- The **minimizing interest payments** (MIP) firms are defined by a focus on not increasing their debt by only increasing their dividend rate when their net income increases and decreasing their share repurchasing target when their net income decreases.
- The **minimum payout and investment** (MPI) firms are defined by a minimum investment and payout rate of respectively 60 and 40 percent of earnings that tries to keep the investment rate and payout rates stable.

The data showed that the MSV and MNI type of NFCs can explain the effect of taxes on the real investment rate in NFCs. Especially the tax on profits has a large negative effect on the available net income for real investment. Both an increase in the tax rate on dividend payout and capital gain would also decrease the real investment rate. However, NFCs of type MPI are less influenced by the tax rates due to the minimum investment rate they have to accomplish, but also hardly exceed an investment rate above the minimum percentage of 60 percent. The results indicate that although the share price has no significant effect on the real investment rate, the conditions of the investors and market likely explain the amount of share repurchases of the NFCs.

## 9.2. Answering the main research question

The results showed that both the MSV and MNI types of corporate governance can explain the effect of taxes on the real investment rate. The effect of taxes on the firms with the MPI type of corporate governance is mitigated because of the minimum investment rate they reinforce. This suggests that the corporate governance of a firm does give an indication on how they respond to different tax rates, in the area of payout and investment.

As for tax policies, the results indicate that governments could stimulate real investment in non-financial firms by increasing the dividend and capital gain. This would have a negative effect on the dividend payout and share repurchases, which could free up funds for real investment. However, a sudden change in tax rates could also prompt businesses to increase the dividend rate and share repurchases to compensate for the loss in return for their shareholders. Future research in dynamic tax rates could give an answer to rather higher tax rates would result in a higher real investment rate.

The results from this thesis does have several limitations in giving an explanation in the real-world, which will be discussed in the next section.

## 9.3. Limitations of the study

This section discusses the limitations of the most important assumptions, the method of agent-based modeling. These assumptions are the formulation of the types of NFCs, the formulation of the behavior of investors, the market mechanism and the partly exogenous calculation of net income. The subsections will shortly state the critical assumption, discuss the impact on the model and its behavior and the limitations on the results of the study.

### 9.3.1. Limitations of the behavior of NFCs

The first major assumption is the simplification of decision-making in NFCs. With this study, I wanted to research if corporate governance could explain the effect of taxes on the real investment rate in firms. As stated in the literature review, corporate governance is a difficult term to make concrete for a specific corporation. The types of decision-rules that were used, are simplified and generalised types of rules. The properties of these types separately have empirical validation in corporations [3, 43, 51]. Three different types does not cover the whole spectrum of possible decision-rules that corporations can own. Corporations are also not single entities, as the actual decision-making on investment and payout decisions is done by multiple agents that may or may not have a similar vision for the company.

The most crucial limitation on the results is that the results neglect any behavior of firms that lies between the three extremes of behaviors that have been simulated in this study. Public firms would not neglect either the market conditions, their change in net income or their change in debt, as this would pose serious consequences for any public company. The results only show what the extreme variants would do in these market conditions. A second crucial limitation on the results is that neither of the NFCs make decisions directly based on the tax rates. The tax rates only affect the variables on which the firms make decisions. Public firms are certainly aware of the tax rates governments impose on them, and actively change their strategy when they change, as seen in the 2003 US tax cut. A third limitation on the results is also the neglecting of any tax evasion by firms, which is a major problem for governments. The results of the study only fits within the context of a closed stock market, in which the firms cannot change their corporate structure to have a lower tax rate. However, this would be a very complicated addition and falls without the scope of this research.

### 9.3.2. Limitations of the behavior of investors

The simplification of the behavior of investors also poses limitations for the results of this study. Investors only have a limited amount of spendable liquidity, as well as a limited rationale on their investment decisions. Because of the limited amount of liquid capital investors can spend on new shares, they are sometimes not able to buy shares when they have an incentive to do so, which limits the behavior of the investors. NFCs do have the option to take on more debt. Large shareholders mostly have access to loans when they need liquidity for a profitable business decision. This assumption does balance the model, as investors can not constantly buy new shares with debt when the share price increases for a long period of time. This could have limited the amount of shares these investors can buy, especially for higher tax rates on dividend payout and capital gain. This could have affected the correlations of these tax rates and the share repurchasing rate, as NFCs could buy more shares from investors due to less competition from regular investors.

### 9.3.3. Limitations of the allocation mechanism and price adjustment

The most crucial limitation of the implementation of trading is that the price adjustment of the share price is not affected by the allocation mechanism. The price is calculated outside the model based on the difference in excess demand and supply, derived from the work of LeBaron [39]. This also limits the allocation mechanism in not being a full market mechanism.

Secondly, the allocation mechanism of the model ensures that the highest bidder gets the shares of the investor with excess supply. This indicates that especially the share repurchasing rate is limited by this allocation mechanism. NFCs have a constant bidding price and do not adjust this, even if they are not reaching their share repurchasing target. Firms would definitely pay more for shares if it was crucial to reach their share repurchasing target.

An auction mechanism with a central authority would create different dynamics in the stock market. The lack of the central authority limits the amount of shares the investors with an excess demand can buy, as the central authority would mostly have stock that the investor could buy that has the same price for every investor. With the VCG auction, the investors with an excess demand are limited to their bidding price which determines their rank in the auction. This could create more equal opportunities for the investors in the model.

An open ascending bidding auction would be another alternative for the allocation mechanism. This would have led to more dynamic bidding prices, as the traders would have to bid over each other to get a certain amount of shares. However, the model would be very time intensive due to the amount of bids that would be placed. If the forecast price would be kept as the highest bidding price for the traders, the outcomes of the market will not change much.

### 9.3.4. Limitations of the exogenous net income

The last crucial assumption is the partly exogenous growth of earnings in NFCs. The decline or growth in earnings for NFCs is calculated with a random uniform distribution between -10% and 10% and the return from real investment they receive. Even though the return from investment creates a partly endogenous growth, there is no system in place that determines the earnings of the firms within the model. The earnings and net income is therefore partly random generated by the model and is not based on the performance of the firm. As the payout and investment rates are based on the earnings, the results are therefore also partly random generated. The large ranges in the data and the high percentage of outliers in the data is presumably the result of these randomly generated earnings. This exogenous growth is the result of the choice to make an agent-based stock market instead of an agent-based macroeconomic model. Agent-based macroeconomic models simulate not only businesses and stock markets, but also banks, households (consumer market) and the government [64]. These agent-based models create endogenous business cycles, in which the next state of the business is determined through the combined behavior of the other agents. However, creating agent-based macroeconomic models is very time intensive and was not suitable for the time span of this Master Thesis. As an example, Eurace have been developed and improved for over 11 years with two EU-funded research groups [56]. The scale of agent-based macroeconomic models with complex and heterogeneous agents, as well as multiple markets, has resulted in efforts being made by mostly research groups that started small and built more complex features over the years (as an example, see Dosi et al. [24, 25, 26]).

Although the lack of validation of the payout and investment data from the model limits the generalizability of the results, this study have provided new insights into how corporate governance affects the real investment rate in firms. The investment rate of firms that have a corporate governance focused on maximizing their shareholder value will not differ much from firms that have a corporate governance focused on minimizing shareholder value. In line with Stockhammer [62] and Orhangazi [52], dividend payout and share repurchases will for both types of firms decline the funds available for net income. However, the market conditions seems to have the largest influence on the crowding out of funds due to higher payout rates, and not the possible increase in the dividend rate and share repurchasing programs. This is in contrast to the above mentioned researches, which dedicate the increasing payout rates to the particular focus on increasing the shareholder value of firms.

## 9.4. Limitations of the method of approach

As stated in chapter 3, the argument for choosing agent-based modelling was its suitability to model stock markets due to their complexity and dynamics. Implementing the decision rules of investors and NFCs in an agent-based modelling showed to create a dynamic model in which these agents interact to create a new

state. However, the representativeness of agent-based models are limited. In addition to this, the causal relations in the model are based on several conclusions from empirical data. These causal relations has to be validated in turn with the same empirical data. This is also called 'backward induction' [27]. This means that the data that is used to validate the model is the same data that is also used to create the model.

### **9.5. Scientific contribution**

This thesis filled the knowledge gap of the unknown influence of corporate governance on the effect taxes has on investment in firms by suggesting that corporate governance does matter in the relationship between taxes and investment in NFCs. This study has used an agent-based, behavioral approach in a financial market setting in trying to explain empirical relations found in non-financial firms with different types of corporate governance.

### **9.6. Societal relevance**

This study have contributed to understanding the problem of low investment in the OECD region. The financial crisis of 2008 have left an investment gap in the private sector in the OECD region [42]. Investment is key to economic development and innovation in both developed and in developing countries. However, there is no single answer to why there is low systemic investment. The conclusion that corporate governance does influence the real investment rate in NFCs can help policy makers in understanding how firms can be stimulated in investing more and paying out less of their earnings.

### **9.7. Recommendations for future research**

First, an opportunity for further research can be found in the direction of dynamic tax rates in the model. The tax rates in this study were constant throughout the runs. A shift in tax rates during a run could possibly encourage some NFCs to alter their payout policy, also mentioned in 9.2. The degree in change would likely depend on the type of corporate governance of the NFC. Secondly, the agent-based financial market could be implemented into an agent-based macroeconomic model, or be expended to an agent-based macroeconomic model. This study was limited by time and resources, as agent-based macroeconomic models are mostly made within teams of researchers with several years of development. However, these models could include the full endogenous development of earnings in NFCs and include more relations that were not feasible in this model. This could include the effect of payouts on the earnings of NFCs and the effect of payouts on the purchasing power of investors and economic growth.

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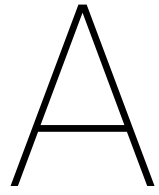
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## Flowcharts of the behavior of NFCs, investors and the allocation mechanism

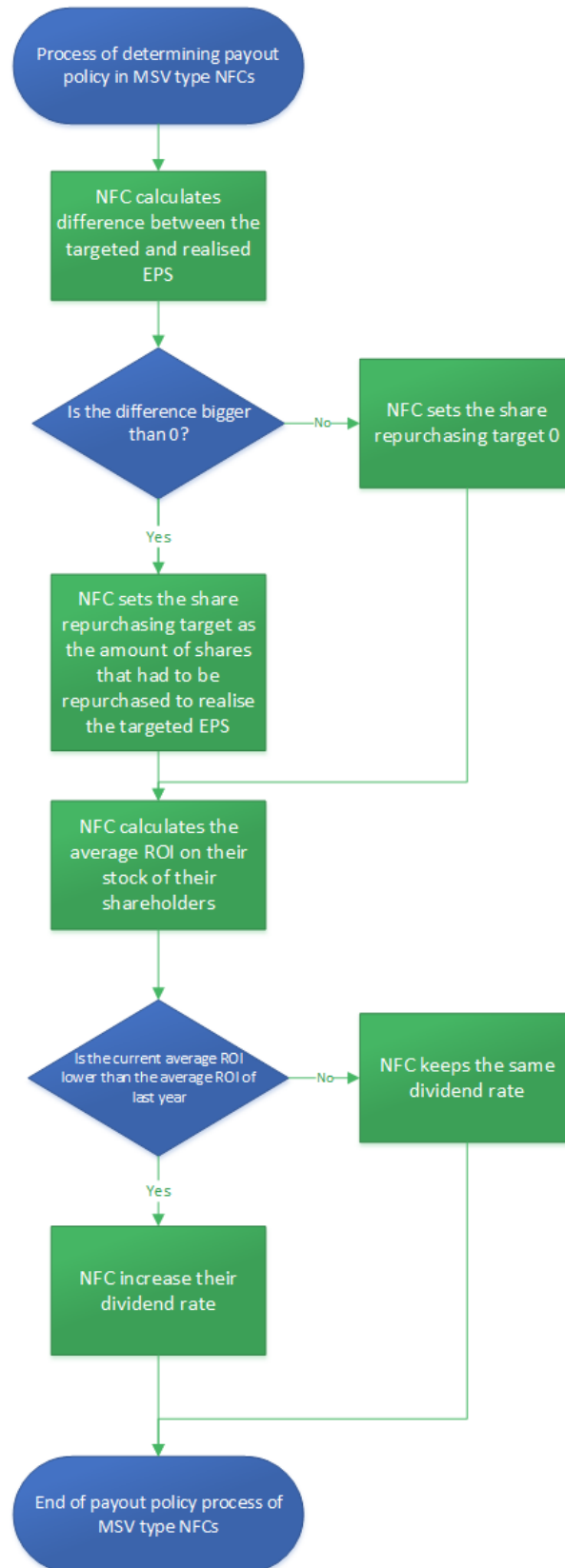


Figure A.1: Flowchart of the decision making process for payouts of the MSV type of NFC.

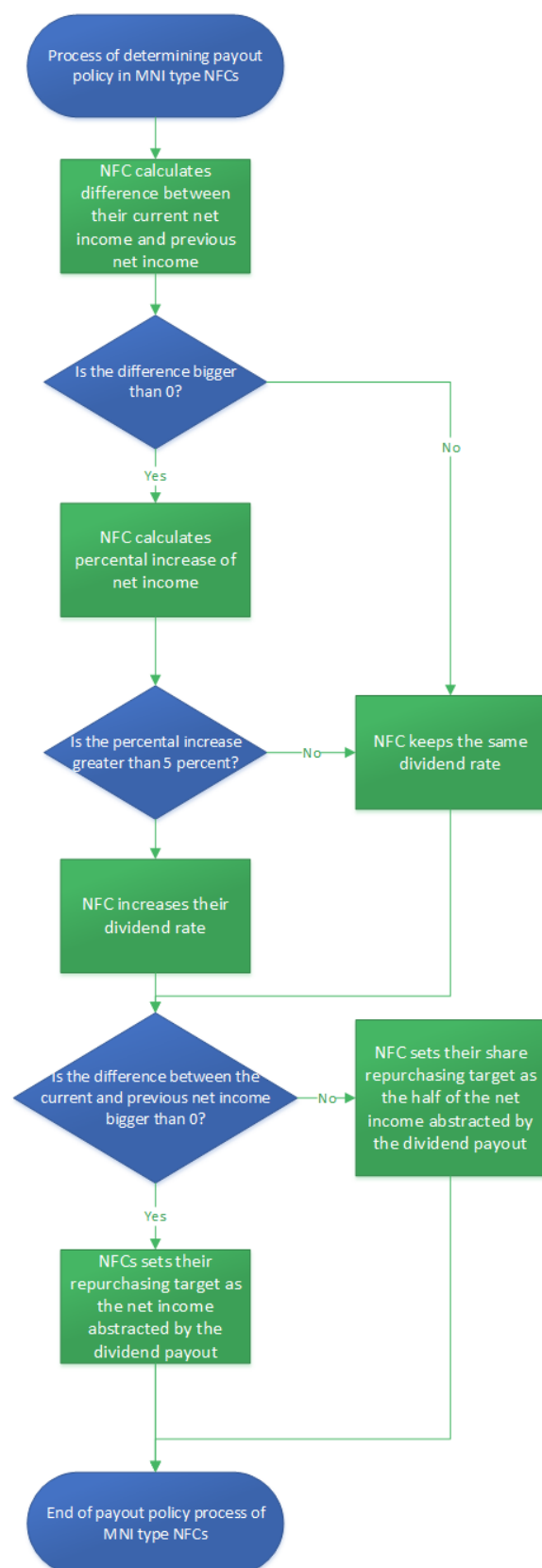


Figure A.2: Flowchart of the decision making process for payouts of the MIP type of NFC.

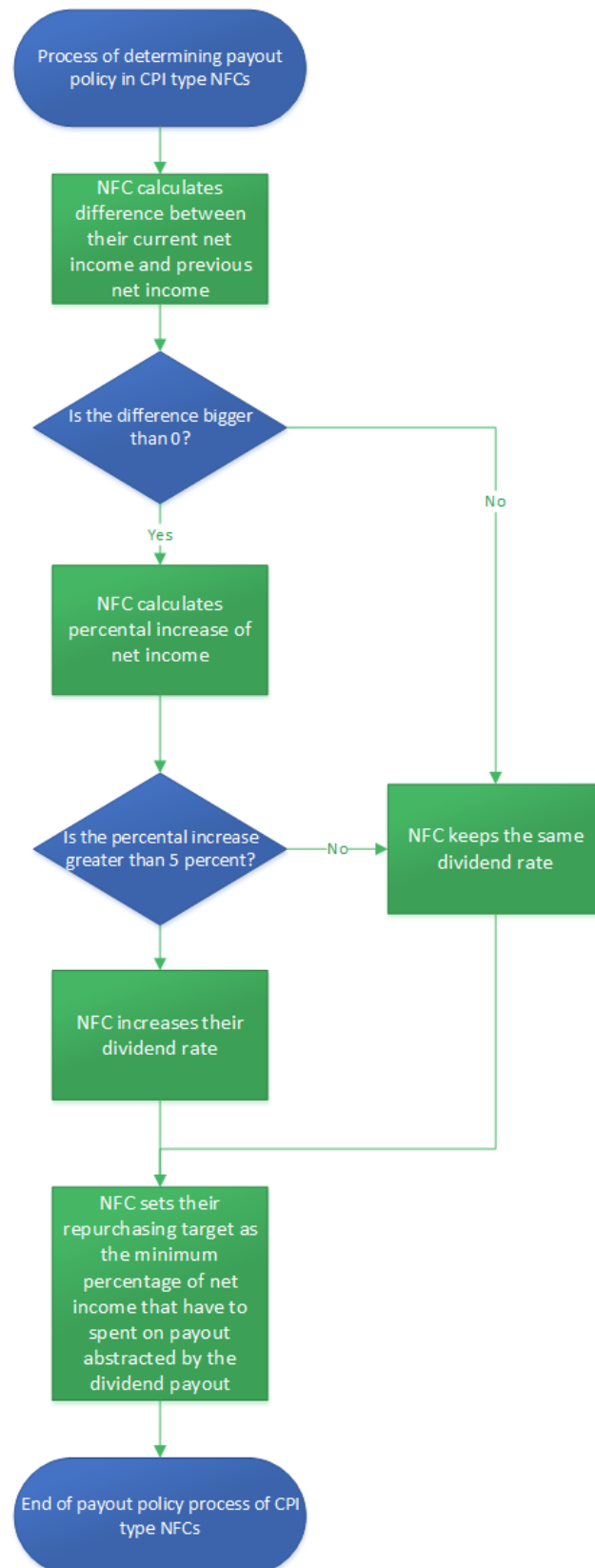


Figure A.3: Flowchart of the decision making process for payouts of the MPI type of NFC.

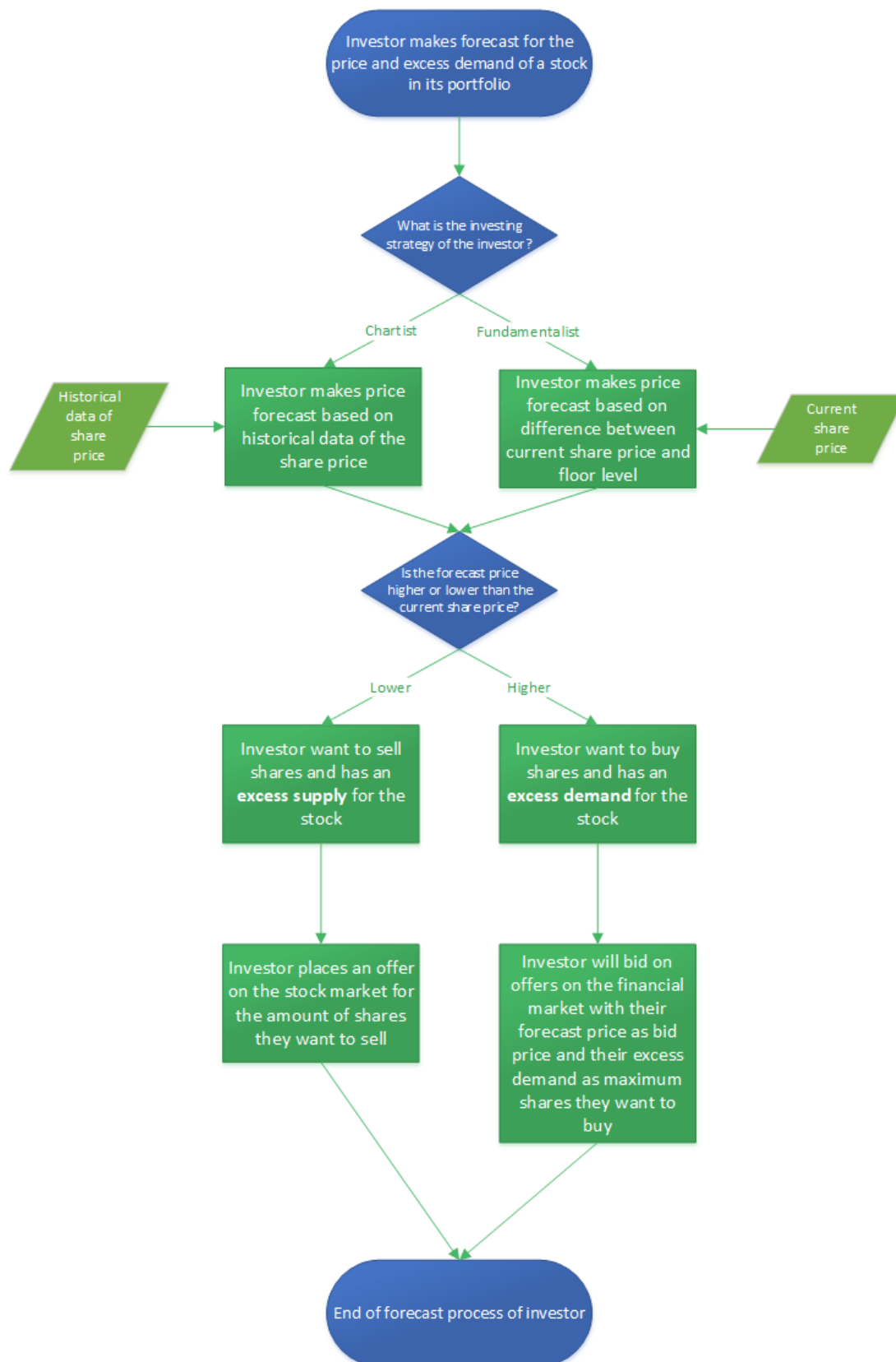


Figure A.4: Flowchart of the forecast process of investors.

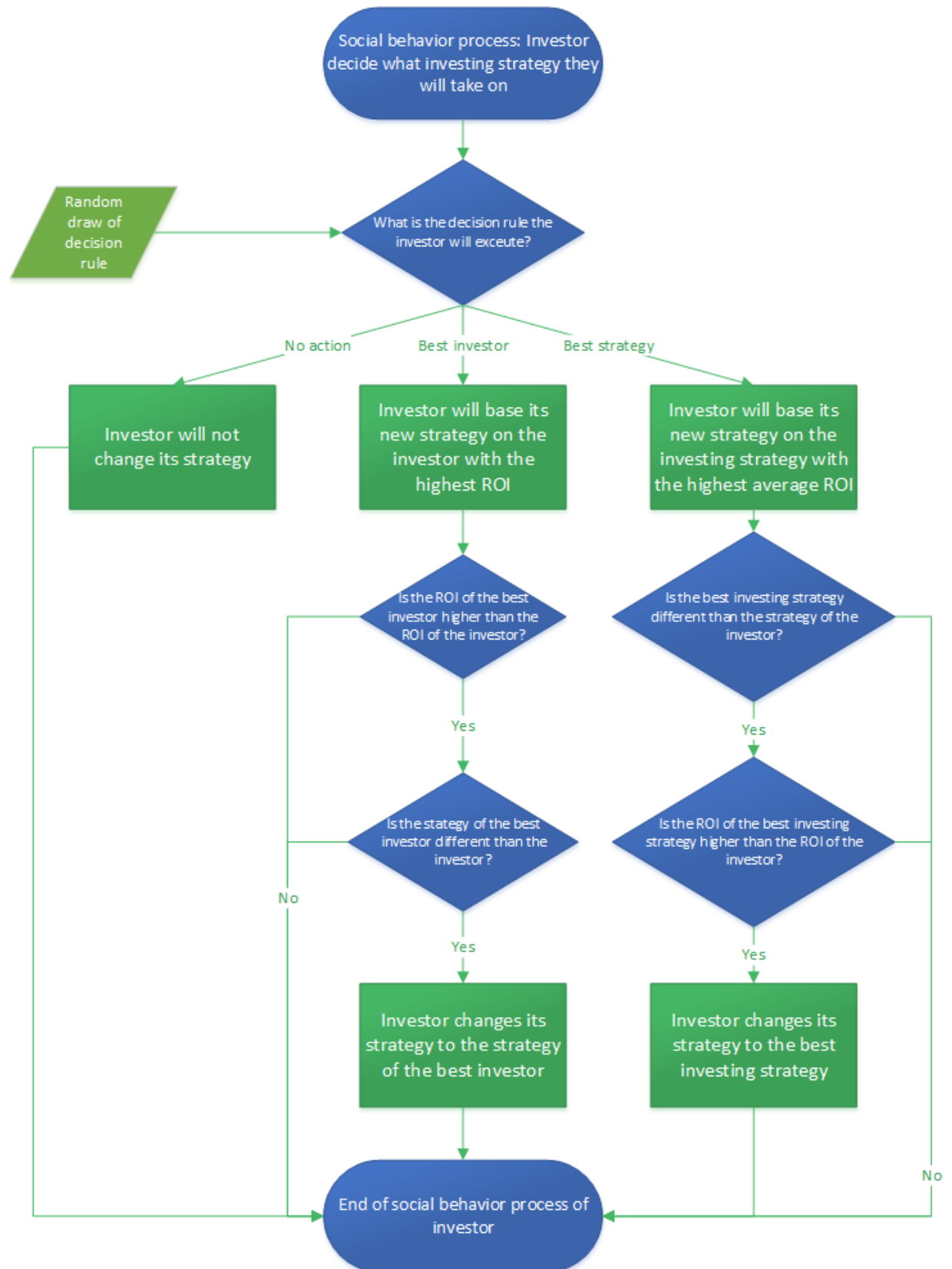


Figure A.5: Flowchart of the social learning process of investors.



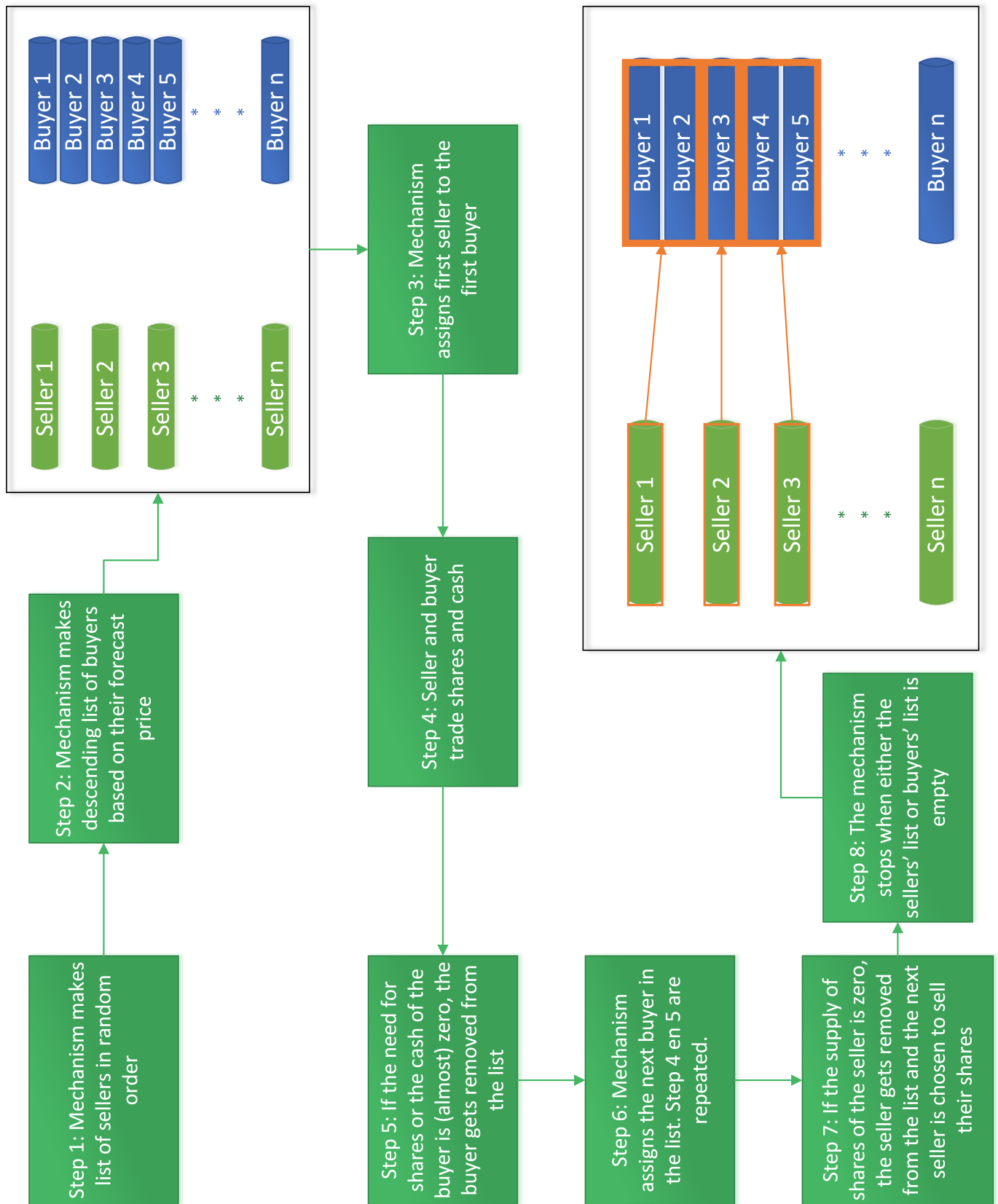


Figure A.6: Flowchart of the market mechanism that balances the excess supply and demand of investors in the model



# B

System diagrams of real investment,  
payout and the stock market

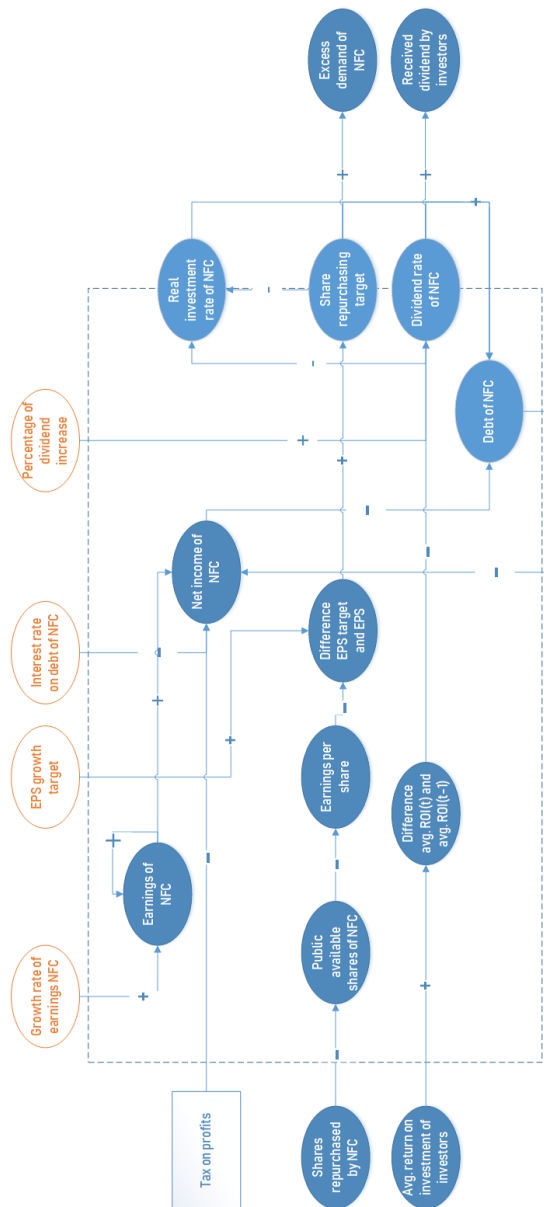


Figure B.1: Subsystem of the *maximizing shareholder value* set of decision rules that fit in the overarching system diagram.

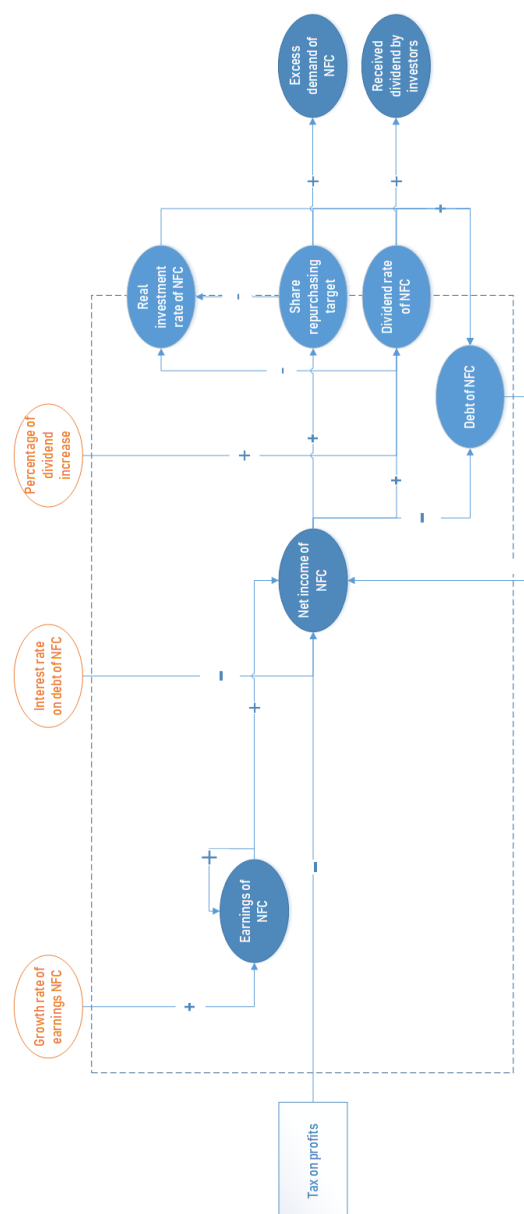


Figure B.2: Subsystem of the *maximizing net income* set of decision rules that fit in the overarching system diagram.

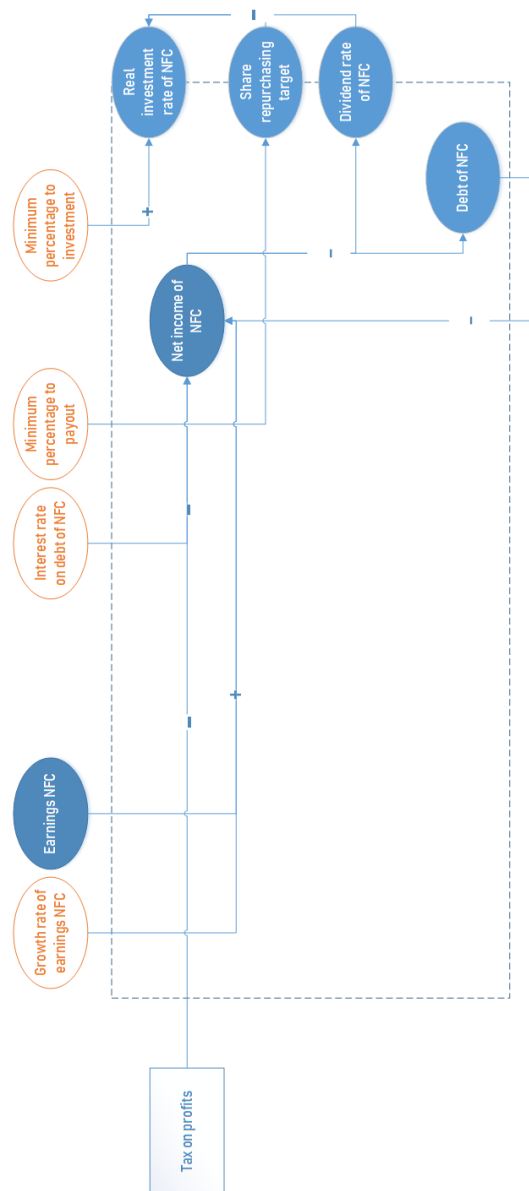


Figure B.3: Subsystem of the *constant payout and investment* set of decision rules tat fit in the overarching system diagram.

C

Minimal model verification plots

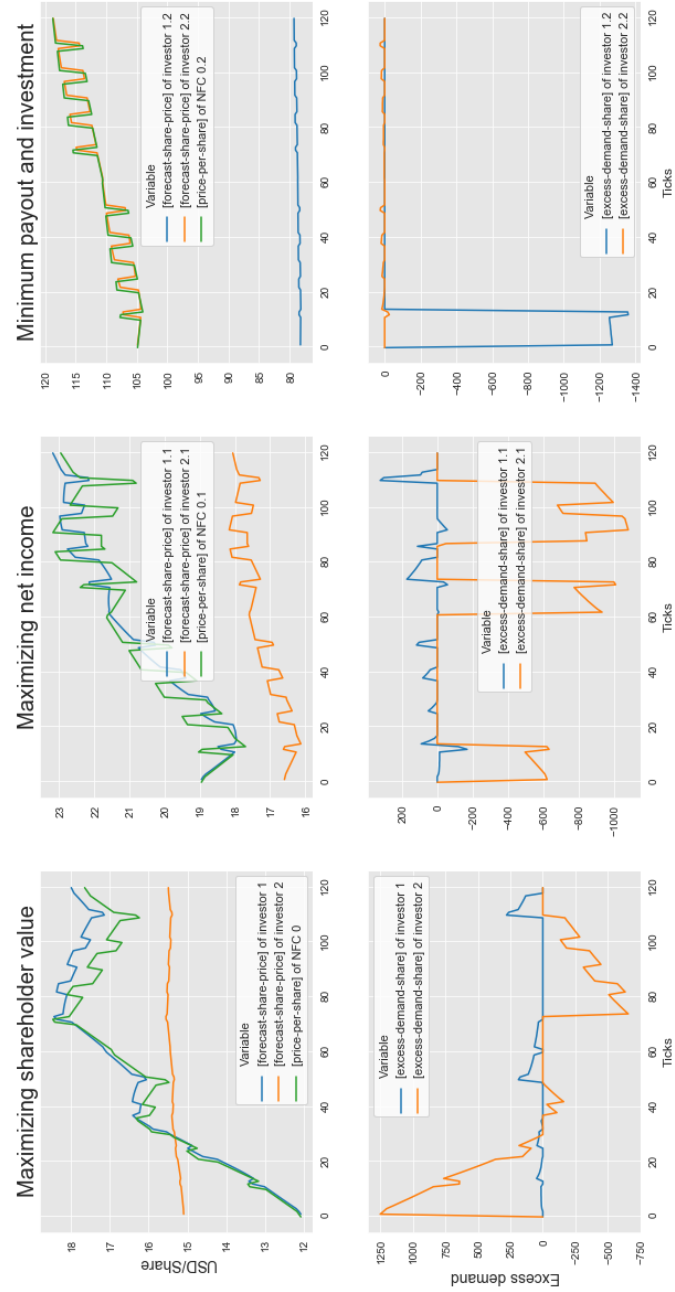


Figure C.1: Verification of the states of two investors in a minimal model.



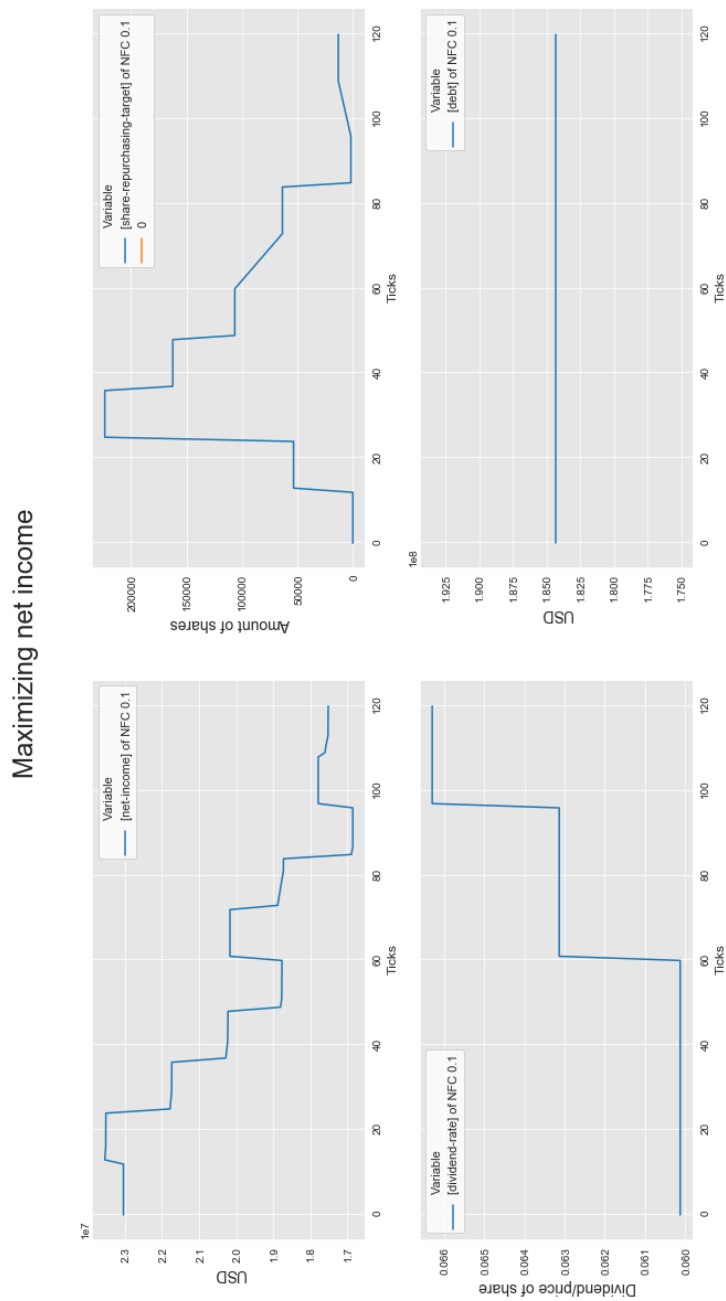


Figure C.2: Verification of the states of an NFC with the *maximizing net income* corporate governance in a minimal model.

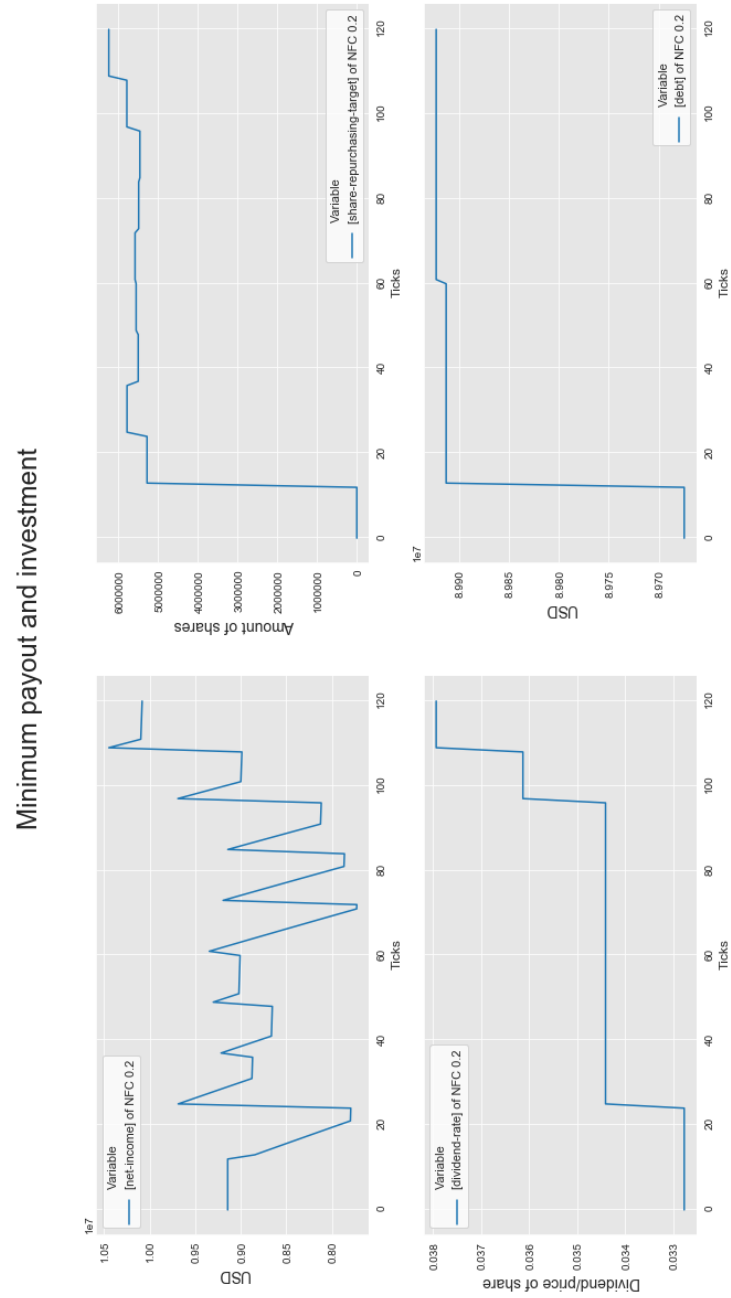


Figure C.3: Verification of the states of an NFC with the *constant payout and investment* corporate governance in a minimal model.

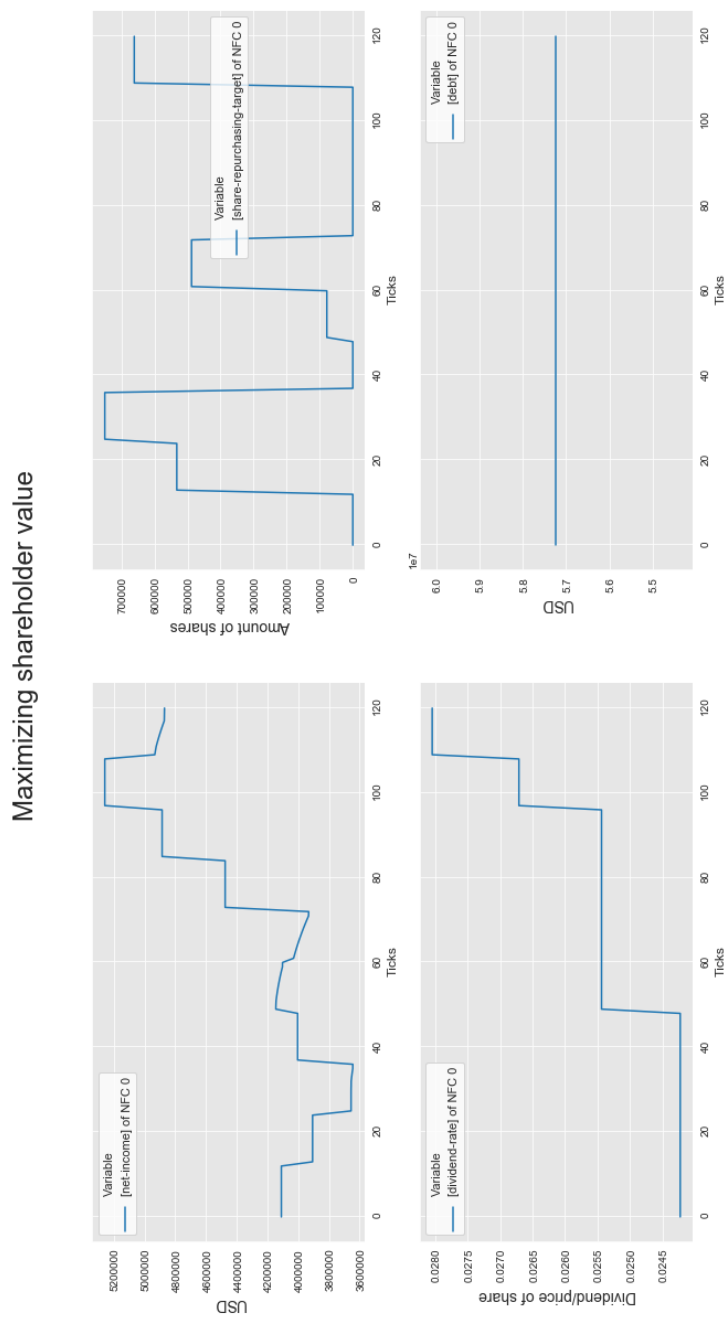


Figure C.4: Verification of the states of an NFC with the *maximizing shareholder value* corporate governance in a minimal model.