Economics
The Open-Access, Open-Assessment E-Journal

Vol. 14, 2020-10 | March 26, 2020 | http://dx.doi.org/10.5018/economics-ejournal.ja.2020-10

Stock price related financial fragility and growth patterns

Pascal Aßmuth

Abstract

The total output of an economy usually follows cyclical movements which are accompanied by similar movements in stock prices. The common explanation relies on the demand side. It points out that stock market wealth drives consumption which triggers production afterwards. This paper focuses on influences via the supply side of the economy. The aim of the paper is to explore channels where stock price patterns influence the amount of credit taken by firms. The author examines trend and volatility cycles on the stock market. There are three channels addressed: the stock market valuation as piece of information for the assessment of a firm's creditworthiness, the influence on restructuring prospects in times of financial distress and the stock market related remuneration of the top management affecting capital demand. The author ask to which extent a channel may contribute to the stock price - output relation when there is mutual feedback. A model à la Delli Gatti et al. (*A new approach to business fluctuations: heterogeneous interacting agents, scaling laws and financial fragility*, 2005) drives the results. Firms take credit to finance their production which determines their financial fragility. If their stochastic revenue is too low, they are bankrupt and leave the economy. The capital loss hurts the bank's equity base and future credit supply is diminished. This causes business cycles. Results show that if the bank assesses creditworthiness according to the stock price then idiosyncratic stock price fluctuations have only a slight effect as they disturb selection and hinder growth. If stock market optimism matters for bankruptcy ruling the level of stock owners' influence does not matter. If optimism is wide spread among stock investors however, investment behaviour is also correlated through the stock prices and this results in huge real economy cycles without any long-term growth. If volatility is considered in the decision of managers they act more prudently and this fosters growth.

JEL E32 G30 C63
Keywords Heterogeneous agents models; financial fragility; stock prices; business cycles

Authors
Pascal Aßmuth, University of Bielefeld, pascal.assmuth@uni.bielefeld.de

Citation *Pascal Aßmuth* (2020). Stock price related financial fragility and growth patterns. *Economics: The Open-Access, Open-Assessment E- Journal*, 14 (2020-10): 1–33. http://dx.doi.org/10.5018/economics-ejournal.ja.2020-10

Received November 30, 2017 **Published as Economics Discussion Paper** December 8, 2017 **Revised** July 28, 2019 **Accepted** December 6, 2019 **Published** March 26, 2020

1 Introduction

Economic fluctuations and boom-bust patterns in asset prices occur sometimes in conjunction while crises in financial markets can turn economic contractions into recessions (Minsky, 1970; Kindleberger and Aliber, 2005; Bordo and Lane, 2013). This paper aims to explore the possible causal contributions of asset prices to economic performance by asking which effect do stock prices and their patterns have on output via the supply side? The model focuses on bank credit as the channel that transmits changes in stock prices to the real economy. This focus on bank credit is based on two observations: firms finance a significant part of their business by relying on external sources of funds (Graham and Leary, 2011) and, although financial systems differ around the world, credit is an important external source of funds (Allen and Santomero, 2001).

Stock prices are part of the financial market. Nevertheless, they are likely to affect real market activity. Their impact might be so severe that they cause financial market breakdowns and recessions (Minsky, 1970). "There are four channels through which stock prices can be considered to affect [real] activity: (1) the wealth effect on consumption, (2) the Tobin's Q effect on investment, (3) the balance sheet effect on private spending (via the credit channel) and (4) the confidence effect on private spending." (Altissimo et al., 2005, p. 4.) In academic research, effect (1) has been studied the most while also channel (2) got some distinct attention. The other channels are usually not pointed out separately (Semmler, 2011, p. 79). Many early papers focus on the role of increased (perceived) wealth in times of stock market booms as source of increased consumption which establishes the link between stock markets and the real economy. By this concept, the stock market leads the dynamics of the economy (Semmler, 2011, p. 79). More generally, the distinction between asset prices and the financial market is in order. While it is shown that asset prices indeed contribute to the real economy, for instance via investment in owned houses (Higgins and Osler, 1998; Semmler, 2011), the link between other assets, traded on the financial market like bonds or stocks is less proven. Nevertheless, stock prices are a good indicator for following investment (Barro, 1990). Morck et al. (1990) examine three theoretic transmission channels by econometric analysis. The first one does see the managers responding to the stock price as source of information on future economic fundamentals like aggregate demand. The second theoretical link states that stock prices affect the cost of external funds and the third link is about pressure on managers by stock investors. This pressure leads them to respond for instance to low stock prices which comprises the threat of a hostile take-over. Morck et al. (1990) use idiosyncratic sentiment differences but also focus on market-wide correlated sentiment. They find that idiosyncratic differences across stock prices are not held up by the empirical evidence for all of the three theories. If investors' sentiment is correlated market-wide their evidence is able to support only the first theoretical link.

In this paper stock prices fluctuate due to real activity but also due to exogenous random deviations on top of that. The paper builds upon a model of Delli Gatti et al. (2005) where excessive leverage in credit financed production may cause bankruptcies. The paper shows that collateral based credit granting may contribute to model output dynamics that exhibit features of real world output dynamics. Also, firm sizes and their growth exhibit patterns which match empirical regularities. The model is agent-based and therefore allowing for enough flexibility to incorporate multiple scenarios about stock market changes. In this paper there will be three variations of the model carried out by computer simulation using the software `Wolfram Mathematica`. Two of the three model extensions comply with the original paper as it is a special case of the extended model. Therefore, the original model will serve as a benchmark case. The third variation is only slightly different and exhibits similar dynamics. The baseline model by Delli Gatti et al. (2005) is modified in three different ways where the parametrization allows for maintaining the initial case. First, stock prices are included in the lending decision of the bank as it takes it into account as forecast for the firm's economic situation besides the assets. Second, the bankruptcy condition is altered as the stock price also plays a role. Third, the lending decision of the firm is altered by the stock price as managerial compensation usually does include stock packages.

An agent-based framework is used which allows for capturing the various feedback effects between respective variables. We use computer simulations for carrying out the models since their complexity makes them analytically non-solvable. Bankruptcy is highly idiosyncratic, it does matter who is bankrupt in order to determine the effect on the macro economy. Gabaix (2011) establishes the granular theory and shows that idiosyncratic bankruptcy shocks can trigger business cycles, depending on which company is actually affected by the shock. The fate of any single individual is not the same as that of the entire economy (called emergence) which differs from equilibrium macro models where the inherent complexity of economies is assumed away.

There are some features of economies that ABMs promise to be able to deal with which equilibrium models cannot: emergence, low level of predictability at a point in time, limited cognition of individual agents and multiple possible histories (Ormerod 2009). Emergence deals with differences in single dynamics and aggregate dynamics. Since agents make decisions in situations of genuine uncertainty (Knight, 1921; Keynes, 1921) the path of evolution of their decisions and thus the entire economy is hardly predictable, especially since -due to the behavior- several outcomes are possible. Furthermore, "micro behaviors of individual households and firms are very diverse. Thus, we have *distribution* of responses by microeconomic agents as an equilibrium rather than a unique response by a representative agent." (Aoki and Yoshikawa, 2007). Such distributions, if observed in many empirical data examinations are deemed to be stylized facts. Delli Gatti et al. (2007) summarize 28 (!) stylized facts of economic features. Models can be 'validated' for their ability to replicate those facts.

The first influence introduced is that the way credit is granted is depending on the stock prices. When banks estimate the creditworthiness of borrowers they also refer to the stock price as piece of information. Secondly, firms in financial distress might be subject to restructuring and thus survive in cases where the stock market does evaluate its future prospects rather optimistically. The third influence is that managers may act in response to the stock price if their payment is also dependent on the stock price. This influences risk taking. The question addressed is to what extent stock prices have an impact on firms' dynamic and output via those various channels? The analysis will be based on comparing scenarios with varying levels of crucial behaviour parameter values to the baseline case where stock prices do not play a role.

This paper contributes to the investment literature by dealing with the influence of stock prices on the investment behaviour of firms (see ECB, 2012; Ormerod, 2009; Morck et al., 1990). Due to the agent-based structure it can add further insight to the impact of firm level financing to aggregate growth. It relates to Minsky's (1970) approach of leverage and financial fragility due to credit and investment that causes single failures feeding back to the rest of the economy. This two-sided relationship is not greatly covered in classical macroeconomics: "[m]oreover, it is worth noting that in the stochastic growth model there is only a one-sided relationship. Real shocks affect stock prices and returns but shocks to asset prices - or overreaction of asset prices relative to changes in fundamentals - have no effects on real activity." (Semmler, 2011, p. 82.)

The results show that all channels do have a significant impact on the dynamics of the firms and total output. If banks take the stock price into account for their credit offer, this leads to a more similar evolution across firms because leverage does pay off less for them. Therefore, financial health gains a higher importance and this induces more persistence in firms' differences where the pace of growth is comparatively lower. If stock prices matter for legally declared bankruptcy a high bargaining power of shareholders is of almost no effect if stock prices are uncorrelated. If stock prices have a boom-bust pattern the real economy shows correlating patterns over time because all firms act on those prices simultaneously. In the last scenario, where managers react on the stock price, they behave ambivalent: in highly leveraged companies they increase capital demand due to a lower expected remuneration. This is caused by a high bankruptcy risk that makes payment less likely. In healthy firms managers reduce risk by demanding less capital and acting more prudent. Managers of highly leveraged firms have a small downside risk as their payoff is expected to be less certain in the first place.

In the economic literature formal approaches to the causes of crises in economic activity linked to financial market range from failure propagation approaches in networks (Battiston et al., 2007) to asymmetric information concepts (Stiglitz and Weiss, 1981). The particular mutual dependency of credit obligations between -in general banks and firms, but also among firms and banks themselves - might contribute to an amplification of failures. Not only is the effect of idiosyncratic failure of different effect on an economy as Gabaix (2011) points out in his granular model, but the connectedness of economic agents might lead to contagion. Gabaix (2011) shows that it matters which firm is hit by a shock or a crises for the economy, for instance due to the firm size a shock to major players like General Electric might influence the economy more than foreclosure of the neighborhood grocery store. He shows that the empirically proven power law distribution of firm sizes can propagate idiosyncratic shocks in a way such that business cycles emerge (Gabaix, 2011).

According to the Basel II regulations banks need to have their credit engagements rated. They can do this themselves (internal rating) or hire some rating agency to do it (external rating). Ratings will be done using a mix of information consisting of quantitative and qualitative information (Reichling et al., 2007). To the best of our knowledge, there is no literature that assesses the impact of rating strategies at an economy-wide scale. Literature dealing with rating methods is concerned about the predictive accuracy of the method as this is crucial for practitioners such as banks or rating agencies. For instance, Altman coined the "Z-Score" as a bankruptcy predictor (Altman, 1968). This approach is used in many refined ways so that rating agencies and banks have their own slightly different methods of rating (Altman and Saunders, 1998; Crouhy et al., 2000; Reichling et al., 2007). Our approach deals with the impact of actual customs at financial markets in an economy-wide context. We motivate our analysis with rating methods that comprise stock market valuations as piece of qualitative information (Crouhy et al., 2000; Reichling et al., 2007; Standard and Poor's, 2011).

As the legal processes are a major source of political risk in any country those bankruptcy laws are important for investment decisions. In our model the degree of the transmission of stock price variation is the main mechanism. The impact of bankruptcy law on business cycles is addressed by Suarez and Sussman (2007). They find that more firm friendly laws, that is a higher chance of not being declared bankrupt, has a possible adverse long-term effect. While more firms continue to exist in the short run, lenders may require higher levels of collateral in the long-run which diminishes growth. Their idea of soft laws is based also on shareholders' bargaining power which is the transmission channel of stock prices in our model. In a simpler argument Lee et al. (2007) point out that soft laws may be beneficial as they promote a larger variety of firms. They deem this desirable for the society. In a general equilibrium context, modest levels of bankruptcy punishment can be beneficial because they make both, creditors and lenders better off (Dubey et al., 1989).

Our results indicate that the law is of minor effect if the firms are affected idiosyncratically by stock prices. If there is correlation among stock prices, for instance through boom-bust cycles, a firm friendly ruling would also result in extreme variations and business cycles. Those come however, with no long term growth in the model because there is no further equity injected. Therefore, in the presence of boom-bust cycles at the stock market we would recommend a bankruptcy law that is not too firm friendly.

The compensation of managers can actually consist of several components. Besides from the salary there are performance based payoffs that serve as incentive for the managers. This incentive can differ. Bryan et al. (2000) point out that for instance, granted stocks may lead to more prudent behaviour while stock options might increase the risk taking. This is due to the different payoff structure which is linear in granted stocks but not in stock options where managers do not bear the downside risk.

There is a recent debate as to cap the bonuses of *bank* managers since wrong incentives have been deemed to contribute in the financial crisis of 2007. As a result, the European Union [EU] passed a law with effect of January 1, 2014 that effectively limits the bonus payments of bank managers to 100% of their fixed salary (EU, 2013: Article 94,1,g,(i) and (ii)). Managers in the United Kingdom even face a claw-back rule put into effect from January 2015 on. According to that, they can be forced to pay back bonuses over a period of seven years after their awarding. This is a form of ex post risk adjustment in order to "align better the interests of staff subject to the Remuneration Code with the long -term interests of the firm." (Bank of England, 2014.) In the model the bankruptcy costs are taken into account by the managers since they suffer from the termination of their contracts. If there is only fixed salary, they loose only their salary which matches with the cost concept of Delli Gatti et al. (2005). However, if part of their salary is also granted stocks in a performance based remuneration scheme, there might be also a loss positively related to the current stock price.

Our model results indicate that there is a complex impact of performance based compensation. For low levels (share is below about 1/2) any increase does hardly increase output but causes a higher interest rate. However, for a share above 1/2 a further increase does increase the interest rate only marginally but boosts output. Policy advise is therefore depending on the current level of performance based compensation and on the particular issue that should be promoted. In comparison to the EU law this means that it makes sense to hold the managers accountable since this induces sensitive behaviour. If managers behave sensitive, volatility cycles at the stock market do not harm the economy very much.

The paper is organized as follows: Section 2 gives an overview of the model. Then, the impact of bank policy is introduced in Section 3. The impact of different bankruptcy circumstances is discussed in Section 4 and last the impact of managerial behaviour with respect to stock prices is examined in Section 5. Section 6 discusses the results.

2 The Model

The model is based on work of Greenwald and Stiglitz (1990) and subsequent work of Delli Gatti et al. (2005). A core feature is that firms' managers act in a risk averse manner because bankruptcy of the firm is costly for them personally. Credit financing and leverage exposes the firm to financial fragility. Therefore, they take possible bankruptcy costs into consideration when they use bank loans for financing desired production. The use of credit drives the economy and has an ambivalent impact which induces fluctuations: a higher amount of credit increases leverage which possibly induces higher profits but at the same time also increases financial fragility.

Bankruptcy is costly for the management first of all due to the loss of salary but also the loss of reputation and further reemployment might become more difficult. A further assumption is that the costs of bankruptcy increase in firm size because usually there are more managers involved in large companies (Greenwald and Stiglitz, 1990, p. 17). Greenwald and Stiglitz also point out that financial distress can occur in different ways and does not always lead to bankruptcy (Greenwald and Stiglitz, 1990, p. 17, footnote 5). While for the company financial distress does not automatically mean the end of the firm, usually one of the first measures undertaken in such situations is to replace management. Therefore, as soon as there is financial distress, managers most probably suffer from a monetary loss which is at least foregone salary. The issue of financial distress and bankruptcy is incorporated in the model by Delli Gatti et al. (2005) in the simple way that financial distress automatically leads to the liquidation of the firm.

2.1 Baseline Setup

We first recall the model introduced by Delli Gatti et al. (2005). We add equity and stock prices in Section 2.2. Other extensions are presented in the following sections. Net worth of a firm i at time t, that is in general assets minus liabilities due in t, is denoted A_{it}. This notation refers to the net worth *at the end* of period t. It consists of the net worth at the end of the prior period plus *net* profits from the current period. Often, this net worth is also referred to as "equity". If the firm has not issued any shares, net worth is the same as the sum of all retained profits up to the *end of period* t.

$$A_{it} = A_{it-1} + \pi_{it} \tag{1}$$

Assume that the firms transform financial means into productive capital without any costs. Productive capital K_{it} is then the sum of net worth taken over from the prior period A_{it-1} and credit taken in the current period, L_{it}:

$$K_{it} = A_{it-1} + L_{it} \tag{2}$$

Output Y_{it} is produced by applying constant returns to scale ϕ to productive capital:

$$Y_{it} = \phi K_{it} \tag{3}$$

Profit depends on the price u_{it} that applies to the output and the costs for setting up capital which consists of retooling costs $g > 0$ and rental costs for capital r_{it}. Assume that the costs for credit and the real return to capital are the same and apply hence to the entire stock of productive capital:

$$\pi_{it} = u_{it}\phi K_{it} - gr_{it}K_{it} \tag{4}$$

with u_{it} being random and uniformly distributed with support between zero and two. Therefore, $\mathbb{E}[\pi_{it}] = (\phi - gr_{it})K_{it}$. A firm is bankrupt when its assets are insufficient to repay the debt at the end of a period:

$$A_{it} < 0. \tag{5}$$

This condition states that a firm whose equity (net worth) is below zero will be dissolved and leaves the economy. It is assumed that firms can sell their products at a market isolated from all others ("islands") and that they can sell their entire production. Nevertheless, they face uncertainty in the price u_{it} which is unique on each island and period. This approach is in line with the fact that a lot of financial distress stems from defaulting customers (Reichling et al. (2007), p. 223). Therefore, the random price which yields a random revenue can also be interpreted as the share of sales that is actually paid for. Taking into account the bankruptcy condition and Equations (1) and (4), the price that just sustains a firm is

$$\overline{u}_{it} = \frac{gr_{it}}{\phi} - \frac{A_{it-1}}{K_{it}\phi} \tag{6}$$

Assume that the costs of bankruptcy depend on the size of the enterprise in the form $c^f = cY^2$ with $c > 0$ being a constant. Assume further that managers take into account these costs of bankruptcy when deciding about the demand for capital in each period. They base their decision on the expected profit

$$\Gamma_{it} = (\phi - gr_{it})K_{it} - \mathbb{E}(c^f) \tag{7}$$

while the expected costs of bankruptcy $\mathbb{E}(c^f)$ are determined by the probability of bankruptcy $\mathrm{Prob}(BR) = \mathrm{Prob}(u_{it} < \overline{u}_{it}) = \overline{u}_{it}/2$ for $u \sim \mathrm{Uniform}[0,2]$. Demand for capital is the result of the maximization of expected profit. Using the first order condition and solving for capital yields $K_{it}^d = \frac{\phi - gr_{it}}{c\phi gr_{it}} + \frac{A_{it-1}}{2gr_{it}}$. Credit demand is the difference between demand for capital and retained profits $L_{it}^d = K_{it}^d - A_{it-1}$, yielding

$$L_{it}^d = \frac{1}{c\phi gr_{it}}\left(\frac{c\phi}{2}A_{it-1}(1-2gr_{it}) + \phi - gr_{it}\right). \tag{8}$$

The banks' profit (π_t^B) depends on the revenue from loans granted minus the costs of raising those funds from equity E_t^B and deposits D_t:

$$\pi_t^B = \sum_{i \in N_t} r_{it} L_{it}^s - \overline{r}_t[(1-\omega)D_{t-1} + E_{t-1}^B]. \tag{9}$$

Here, ω describes the degree of competition within the banking sector and is a measure for the mark up the bank can charge on interest above deposits. The interest paid on deposit is $\overline{r}_t(1-\omega)$ where $\overline{r}_t$ is assumed to be the weighted average lending interest rate. When a firm goes bankrupt *at the end of a period*, the banking sector as a whole suffers a loss equal to the difference between the amount of credit supplied in period t and the relative mortgage (value of assets), which is the same as the (negative) amount of net worth: $B_{it} = L_{it} - (K_{it} + \pi_{it}) = -A_{it}$. The banking sector's equity base evolves according to the law of motion:

$$E_t^B = \pi_t^B + E_{t-1}^B - \sum_{i \in \Omega_t} B_{it} \tag{10}$$

Here, Ω_t is the set of all bankrupt firms in period t. The bank lends a multiple of its prior equity base according to some multiplier $L_t^s = \frac{1}{v} E_{t-1}^B$ which is based on regulatory constraints. Credit supply emerges from the banks equity base E_t^B and deposits D_t in the form $L_t^s = E_t^B + D_t$ while deposits are treated as a residual. Write $\alpha_{it} = A_{it} / \sum_i A_{it}$ and $\kappa_{it} = K_{it} / \sum_i K_{it}$. Credit supply is then

$$L_{it}^s = L_t^s[\lambda \kappa_{it-1} + (1-\lambda)\alpha_{it-1}] \tag{11}$$

The interest rate r_{it} for each firm is determined by the equilibrium situation where credit demand matches credit supply. In equilibrium, firms pay less if they have a high value of collateral. From that condition this rate is

$$r_{it} = \frac{1}{2cgL_{it}^s + 2gc(\frac{1}{\phi c} + A_{it-1})}(2 + A_{it-1}) \tag{12}$$

Entry depends on the average interest rate $\overline{r}_t$ which determines the number of possible entrants and the features of the entrant is determined by a random draw. The term is:

$$N_t^{entry} = \overline{N} Prob(entry) = \frac{\overline{N}}{1 + e^{d(\overline{r}_{t-1} - f)}} \tag{13}$$

where $\overline{N} > 1$, d, and f are constants. This assures that the probability of number of entrants is low if the overall interest rate is high. The term is then rounded to an integer.[1] New firms are endowed with capital and net worth randomly. The draw for an entrant's capital endowment is from a uniform distribution with a center at the mode of incumbents' capital. Then, the equity ratio $\alpha_{it} = A_{it} / \sum_i A_{it}$ is determined by the mode of all incumbents' equity base A_{it} and the capital ratio is $\kappa_{it} = K_{it} / \sum_i K_{it}$. Those ratios are needed by the bank in order to determine the credit supply for each new firm. Please note that once a company is started its endowment is either financed with some credit or savings - converted to production means or some machinery, for instance, is brought to the company's use directly. In both cases, the productive capital entering the competitive market is increased. It is assumed, that there are no spin-offs from existing firms which would divert some portion of the initial firm's capital to the new one.

[1] In the original paper, the number of initial firms is 100, $\overline{N} = 180$, $d = 100$ and $f = 0.1$ with 1000 iterations.

2.2 Stock Price

We now include equity and stock prices in the model. If firms have also access to equity markets, they can raise capital by issuing shares. If those are traded at a stock exchange their price can be thought of to consist of a "fair" component, that is the fundamental value F_{it}, and a deviation θ_{it} from that.

$$P_{it} = F_{it} + \theta_{it} \tag{14}$$

The fair stock market value depends on net worth and on the overall equity that a firm has

$$F_{it}E_{it} \equiv E_{it} + \Pi_{it} = A_{it} \tag{15}$$

Here Π_{it} refers to retained profits up to period t. Note that total equity of a firm will consist of the equity raised through issued shares E_{it} and net worth which is accumulated profits Π_{it}. The above specification is based on the assumption that each share has a nominal value of 1 unit of currency, therefore the number of shares equals the nominal value of shareholders' equity, both denoted by E_{it}. Hence there is exactly one share of nominal value 1 for each firm. Furthermore, the fair share price is just the net value over the number of shares issued. In the remainder of the paper we will assume that $E_{it} = 1$ for all i,t, implying that $A_{it} = F_{it}$ and $P_{it} = A_{it} + \theta_{it}$.
The actual stock price P_{it} could deviate from the "fair" price because of the expectations of investors:

1. the future inflow of cash is supposed to be significantly large or small;

2. speculators pay premiums (sell at discounts) in order to benefit from expected even larger (lower) prices in the future.[2]

This specification follows the idea that market valuation on average represents the discounted sum of all expected cash flow, represented by profits in this setup. If these expectations are very optimistic, there can be a mark up which is not justified alone by just the actually observable profit. The relation between the mark up on firm value and the error in profit estimation is

$$\theta_{it} = |\pi_{it}|\varepsilon_{it}.$$

This expresses that the markup on firm value (LHS) is just the markup on expected cash flow, here today's profit (RHS).

This markup *on (fair) market value* is assumed to be a function of profits and a random component. The overall market value of *cash flow* based on profits and the error is supposed to be given by $\pi_{it} + |\pi_{it}|\varepsilon_{it} = \rho(\pi_{it}, \varepsilon_{it})$. This means that a positive error always leads to a more favorable profit estimation, also for negative profits. The sign of the error is preserved in this way. The error might occur for some time span. The persistence in this error can be induced if the error is modeled as a random walk.[3]

$$\varepsilon_{it} = \varepsilon_{it-1} + \eta_{it}\sigma_\eta \tag{16}$$

[2] Note that 1. affects the fair value of shares while 2. may occur due to speculation (exogenous to the firm) .
[3] If there is also a drift in the random walk, then this would represent general phases of optimism or pessimism.

where $\eta \sim \mathcal{N}(0,1)$ and $0 < \sigma_\eta < 1$. Hence, $\mathbb{E}(\varepsilon_{it}) = \varepsilon_{it-1}$.

The complete expression for the stock price is hence

$$P_{it} = A_{it} + |\pi_{it}|(\varepsilon_{it-1} + \eta_{it}\sigma_\eta).$$

3 The Role of the Stock Market Value in Credit Decisions

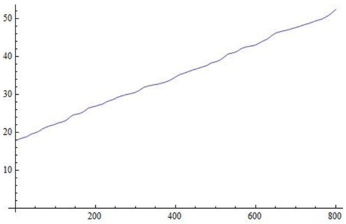
The stock market value of a firm carries information that is valuable for a bank for two reasons. First, the valuation on the stock market might reveal some information about a firm's ability to raise funds from the asset market. Second, it reveals information about the market's estimation of the relative prospect of the firm. The stock market usually indicates changes of firm's prospects earlier than the income statement or the balance sheet (Atiya, 2001; Altman, 1968). Therefore, the stock market value is a piece of forward looking information rather than the backward looking balance sheet analysis. Furthermore, "[s]tock market based information ... has responded more quickly to changing financial conditions than ratings of credit risk agencies." (Bongini et al. (2002), p. 1011.) This is an incentive to free-ride on external information since assessing creditworthiness is costly, as is monitoring.

In order to represent the impact of the stock price on credit supply we shall assume in this setting that credit supply is determined according to:

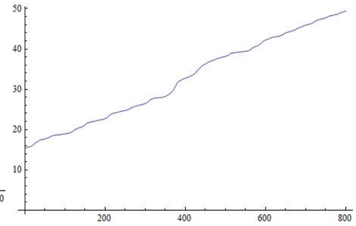
$$L^s_{it} = L^s_t \left[(1-\mu)\lambda \frac{K_{it-1}}{K_{t-1}} + (1-\mu)(1-\lambda)\frac{A_{it-1}}{A_{t-1}} + \mu \frac{P^E_{it} E_{it}}{\sum_i P^E_{it} E_{it}} \right] \tag{11a}$$

where $0 < \lambda < 1$ represents the weight put on relative firm size and $0 < \mu < 1$ stands for the weight put on the relative stock market value. The third piece of information used for the decision is the relative net value. We run simulations for increasing values of μ while for each value there are a number of repetitions. Results are taken from an interval over 51 periods, between $t = 1000$ and $t = 1050$. The average is computed. This is done for each of 100 repetitions for any parameter value and for those 100 results from each parameter value also the average is taken. Note that the simulations for $\mu = 0$ also represent the benchmark case which matches the Delli Gatti et al. (2005) model. The results in our baseline case are in line with the findings of Delli Gatti et al. (2005). While they focus on the distribution of firm sizes and their growth rates we will put emphasis on total output and the average interest rate in our analysis.

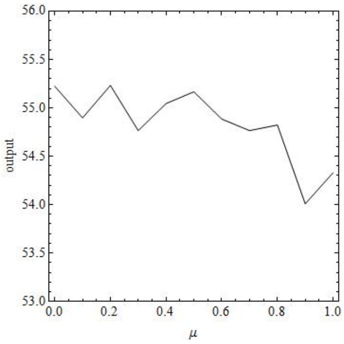
Figure 1 shows the effect of the stock price consideration on output. The baseline case shows that over time output is increasing with phases of faster and phases of slower growth (Figure 1a). This represents business cycles. If the bank would only look at stock prices, those phases would be more intense (Figure 1b). The overall pace of output growth would be similar, however (Figure 1c). As a firm's stock price - for given nominal equity - rises in total equity, a firm that possesses more equity has an increasing advantage if the banking sector refers more to the stock price. The impact of relative capital and thus output is decreasing in μ. Therefore, equity has relatively more weight. That is, less fragile firms get relatively more credit offered because the total assets K_{it} are without effect for large μ. This means that only firms with relatively low leverage get access to



(a) output over time baseline case



(b) output over time $\mu = 1$

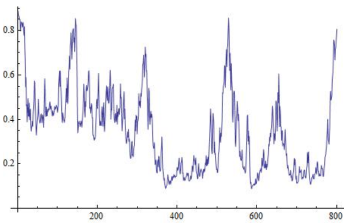


(c) output

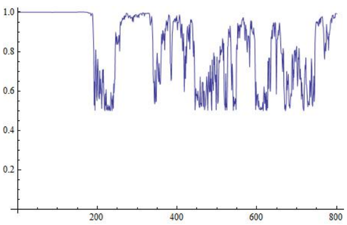
Figure 1: **Impact of μ on output**

credit. The total output in the economy however, is lower because firms that otherwise produce at the brink of bankruptcy have less access to credit. Firms that are less fragile get funded over proportionally compared to the case where $\mu = 0$ but only offer a really low interest rate for that. This dampens the evolution of credit supply and thus total output. This low interest rate is the key for their advantage in growth which is visible in the Herfindahl index (Figure 2c). Comparing representative runs shows that under the stock market relevance regime ($\mu = 1$) there is a fast movement to the dominance of a monopolist (Figure 2b) while in the baseline case ($\mu = 0$) there are only short episodes of market domination (Figure 2a). Furthermore, if credit is offered less strictly, comparatively many firms survive (Figure 3) . This is also a reason why total output is lower in this regime: more firms leave the industry and there are less periods where there is no capital lost due to bankruptcy. Differences in firm size are less decisive for credit due to μ because there is additional noise. Nevertheless, we observe that market power increases in μ (Figure 2c). Concentration therefore stems from *exiting firms*.

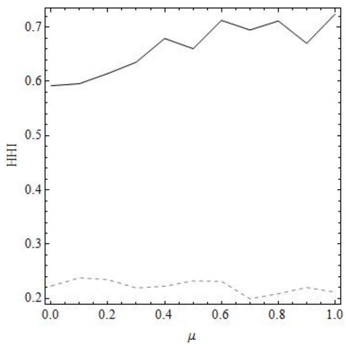
Economically, if some firm faces a markdown $\varepsilon_{it} < 0$, it will be offered less credit in the following period. Nevertheless, as its equity A_{it} is the same, it still demands the same amount of capital. This leads to a higher equilibrium interest rate for that firm in the upcoming period and



(a) Market Power baseline case

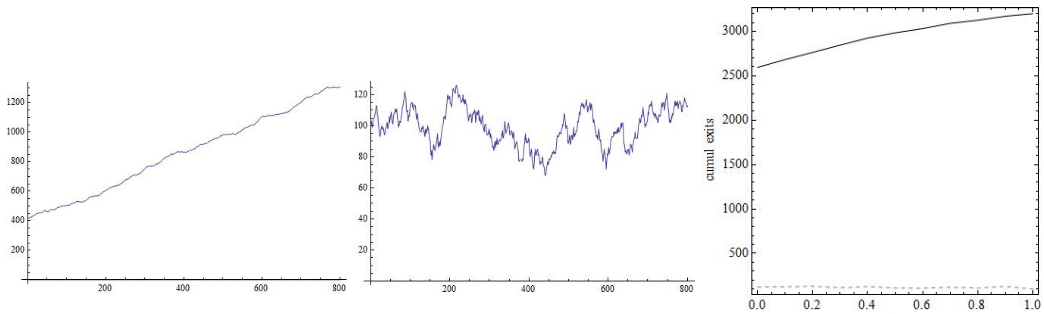


(b) Market Power with $\mu = 1$



(c) Market Power, dashed line: standard deviation

Figure 2: **Impact of μ on market concentration**



(a) numberof firms baseline case (b) number of firms $\mu = 1$ (c) no. of exits, dashed line: standard deviation

Figure 3: **Impact of μ on the no. of firms**

less leverage which will lead to lower profits. This means, that the markdown also leads to lower credit supply in the *following period*. This effect is even more severe since there is persistence in the markup/markdown. Even for a one time markdown, there is a long term effect in diminished credit supply and hence hindered firm growth.

If some firm faces a mark up ($\varepsilon > 0$) it is offered more credit and thus experiences higher growth and lower interest rates in the following period. It is more leveraged and will grow faster. The growth advantage is however, less pronounced if the bank predominantly puts weight on the stock price. Then the advantage from a markup on profit is less than an advantage from size due to the magnitude of the underlying value.

The additional noise disturbs the selection process in that some fragile firms are offered more credit and some robust firms are constrained for reasons other than their financial situation. If we consider only the balance-sheet situation as a benchmark, stock market expectations are exogenous. We cannot verify whether there would actually be reason to grant more credit due to some positive outlook. The only information from the model is the financial situation. A selection process based on this information is disturbed by the additional noise which hurts total output in the long run compared to a situation where only model internal information is used.

4 Firm Distress and Restructuring

In this section we distinguish between insolvency and bankruptcy in order to tackle the question how the stock price can influence the fate of a financially distressed firm in a bankruptcy negotiation. The impact may have implications for designing a favourable institutional framework. Mere financial distress may hurt business, but does not mean that a firm will cease to exist. Whether it can resolve financial distress and sustain as a going concern depends very much on the expectations of its creditors and shareholders - along with its capital structure and the legal framework in each particular country.

Consider that the stock *market* value instead of net worth determines bankruptcy of a firm. Most of the large firms are publicly listed firms whose market value is determined at the stock exchanges. Sabry and Hrycay (2014) provide empirical evidence that shows that when a bankruptcy case is filed courts do take the stock market value into account for their ruling about bankruptcy. Usually, the stock market price serves as source of information complementary to the ability to issue bonds and credit ratings based on cash flow projections. Occasionally however, the stock market price is the major determinant of bankruptcy ruling.

Note that mere insolvency already occurs when net worth is negative: $A_{it} < 0$. Since restructuring could take place, insolvency does not automatically mean that a firm cannot continue to exist. For instance, if a firm has a negative cash amount but the evaluation of its future cash flow is still optimistic it can survive. The initial public offering [IPO] of 'Rocket Internet' which took place on Oct. 2, 2014 may serve as example. The IPO collected 1.5 bn Euros which left the internet company with a total market value of 5.5 bn Euros, about the same value as Lufthansa. This is remarkable since 'Rocket Internet' has low revenues and huge losses. Therefore, the market value is "predominantly based on the hope of a glorious future" (FAZ, 2014). This is also visible in the fact that the shares sold at the top end of the price range but lost more than 20% of their value within the first days of trading. Accordingly, in the model setup, a stock price mark-up θ_{it} would be high because investors think that *in the long run* the firm will recover and be able to repay all of its current debt. A bankruptcy condition based on market value hence takes the expectations into account:

$$A_{it-1} + \rho(\pi_{it}, \varepsilon_{it}) \equiv \underbrace{F_{it} + \theta_{it}}_{\text{stock market value}} < 0.$$

The stock market value consists of inherited net value A_{it-1} and the *market valuation* of current profit $\rho(\pi_{it}, \varepsilon_{it})$ which is equivalent to the end-of-period net value F_{it} and a mark-up θ_{it}.

Whether they can be rescued and go on profitably, depends on *all* of its stakeholders. Many parties are allowed to file for bankruptcy: creditors might try to recover part of their loans to a firm and seek foreclosure in order to rescue as much asset value as possible, owners (shareholders) might not be willing to inject further money into the firm and maybe also to limit losses by liquidating the firm, and at last, the firm itself may file for insolvency. Focusing on the interest of the provider of funds, each group has some bargaining power in the restructuring negotiations. While a bank would be willing to file for bankruptcy, optimistic shareholders, who do not want to lose their investment, could be able to convince the bank to roll over the loan once again. They are more likely to be successful if the stock market value of a firm is high. Assume there is a parameter $n^s \in [0,1]$ representing the shareholders' influence, the firm would be dissolved and leave the economy if

$$A_{it-1} + \pi_{it} + n^s \theta_{it} < 0. \tag{5b}$$

If the shareholders have no influence on the bank's decision, the bankruptcy condition is as in Delli Gatti et al. (2005) and the market markup does not play any role. If they have influence, any markup makes actual bankruptcy less likely. Equation (5b) covers the different interests of stakeholders. The bank would file for the firm to go in formal bankruptcy if $A_{it-1} + \pi_{it}$, the net worth, is not sufficient. The shareholders have a deviating interest which is expressed in θ_{it}. The parameter n^s determines to what extent this deviation is crucial. In conjunction with θ_{it}, $n^s \theta_{it}$ shows how much the hard facts are influenced by stock market expectation and can be understood

as measure for legal circumstances and policies applied in an economy.
Each firm's demand for capital is affected by the new bankruptcy condition. Recall that profit is revenue minus capital costs

$$\pi_{it} = (u_{it}\phi - gr_{it})K_{it}.$$

The new bankruptcy condition is in detail

$$A_{it-1} + (u_{it}\phi - gr_{it})K_{it} + n^s\theta_{it} < 0.$$

This can be solved for

$$\overline{u}_{it} = \frac{1}{K_{it}\phi}\left[K_{it}gr_{it} - (A_{it-1} + \theta_{it}n^s)\right]. \tag{6b}$$

Doing the same steps as in the baseline model, this crucial price $\overline{u}_{it}$ is used in the probability of bankruptcy. Firms do not know the mark up on profit at the end of the period and they form naive expectations in the form

$$\mathbb{E}[\theta_{it}n^s] = \theta_{it-1}n^s \tag{17}$$

It is assumed that the influence of stockholders n^s is known for example due to the legal institutions and that the management does not know how the stock market forms expectation of future profits. Therefore, the firms do not know how the mark up θ_{it} actually comes up. They know, however, the deviation of the prior stock price from the net value and it is assumed that they simply expect this deviation to persist. After maximizing profit, capital demand is determined by

$$K^d_{it} = \frac{\phi - gr_{it}}{c\phi gr_{it}} + \frac{A_{it-1} + \theta_{it-1}n^s}{2gr_{it}}.$$

The banking sector also reacts on a distressed firm. It will not take into account the (negative) net worth of distressed firms. Since the capital ratio of a distressed firm is very low, such a firm will be offered little credit via the market share rule. The bank's rule is now

$$L^s_{it} = \begin{cases} L^s_t\left[\lambda\tilde{\alpha}_{it} + (1-\lambda)\kappa_{it}\right] & \text{for } A_{it-1} > 0, \\ L^s_t\left[(1-\lambda)\kappa_{it}\right] & \text{else.} \end{cases} \tag{11b}$$

Here $\tilde{\alpha}_{it} = \frac{A_{it-1}}{\sum_{i\in\Delta_t} A_{it-1}}$ and Δ_t is the set of all firms that are solvent in period t. This ensures that all individual credit offers sum up to L^s_t again. Compared to a situation where insolvent firms leave the pool of assessment there is less credit supply for the solvent firms. Thus, by construction, if there exist insolvent but not yet bankrupt firms, the solvent ones are comparatively worse off due to a tougher assessment. The equilibrium interest rate is

$$r_{it} = \frac{2 + (A_{it-1} + \theta_{it-1}n^s)c}{2gc\phi(L^s_{it} + A_{it-1} + \frac{1}{c\phi})} \tag{12b}$$

It is easy to see that capital demand and hence equilibrium interest increases in the markup on profit. If the stock market values the firm extremely high, managers can afford to take higher risks as the firm will be less likely to go bankrupt.

It is possible, that the bank credit offer does not suffice to offset the negative net value carried over to the next period. In this case, there would be negative productive capital. This is excluded in the simulation as the productive capital must be at least zero. Therefore,

$$K_{it} = \begin{cases} A_{it-1} + L_{it}, \text{ for } A_{it-1} + L_{it} > 0, \\ 0, \text{ else.} \end{cases} \tag{18}$$

Figure 4 shows that the credit demand curve contingent on the interest rate shifts upwards in θ_{it}. This shift is larger in the influence parameter of the shareholders n^s. If there is a positive stock market influence an actual bankruptcy is less likely. Therefore, the expected costs of bankruptcy are lower which boosts credit demand by firms and vice versa.

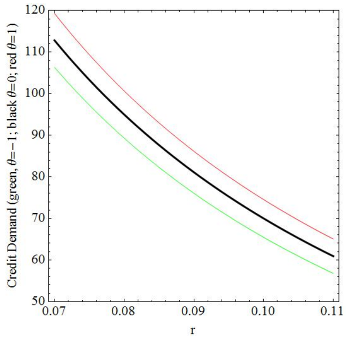
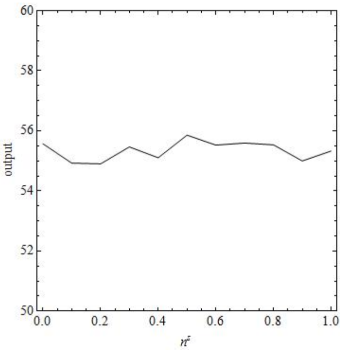


Figure 4: Credit demand $n^s = 1$
(black→ $\varepsilon = 0$, red→ $\varepsilon > 0$, green→ $\varepsilon < 0$)

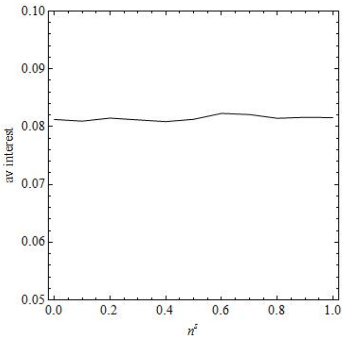
4.1 No Stock Market Mood Swings

As the firms in the model operate on "isolated islands" which makes their product prices independent, the same is true for stock prices in this section. This adds some further noise to the expected costs of bankruptcy. However, the noise is auto correlated in the short run. The question is whether the firms take more or less risk compared to the initial model and whether this influences the output pattern. The comparative analysis is done for different levels of influence of shareholders in restructuring negotiations $n^s \in [0, 1]$. There are 100 repeated simulations for each parameter value while the interval is covered in 10 incremental steps.

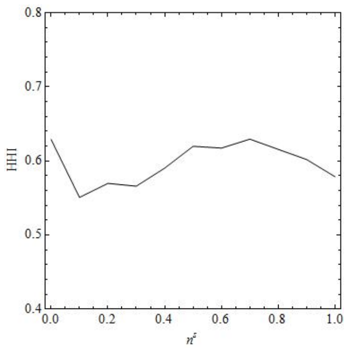
The impact of positive markups is that distressed firms can survive but that might only have a short postponing effect. Figure 5b shows that the bargaining power of shareholders does not have a significant impact on the evolution of the economy. Total output, the interest rate and market power do not change in the bargaining power. The reason is that some firms pay relatively more interest if they face a markup but others pay relatively less. The representative run in Figure 6 reveals that the dynamics over time are distinct. Especially the interest rate fluctuates severely (Figure 6c). The output has a pattern of distinct economic booms and recessions (Figure 6a) while the firm number also is somewhat cyclical (Figure 6b). There seems to be a clear tendency toward



(a) total output (log)

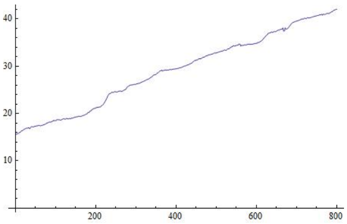


(b) average interest rate

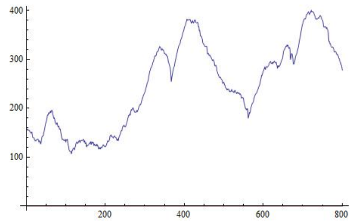


(c) Market Power

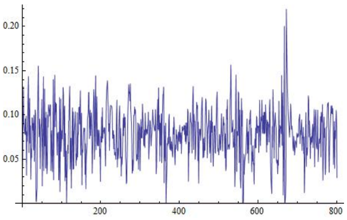
Figure 5: **Impact of bargaining power**



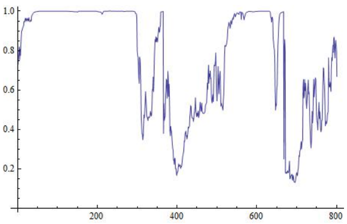
(a) GDP without drift



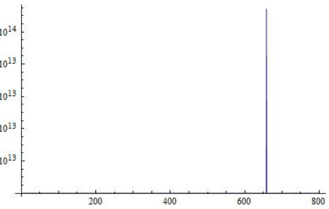
(b) Firm number without drift



(c) Average interest rate, no drift



(d) Market Power without drift



(e) Bad Debt without drift

Figure 6: **Time series for high bargaining power of shareholders**

market concentration while this is frequently disturbed (Figure 6d). This indicates that also large firms are likely to go bankrupt. They could be hit by a severe markdown. On average though, a clear impact of the bargaining power cannot be distinguished.

The legal framework does not seem to have much of an influence if stock prices are not correlated.

4.2 Boom Bust Periods

Stock markets exhibit cycles which can be caused by fundamental changes due to real economic cycles. They can also show booms and busts which are are considered to be overreactions not justified by fundamental data (Shiller, 1981; DeBondt and Thaler, 1985, 1987). Those booms and busts can be driven by herd behaviour, for instance. Market-wide speculation, or manias, means that the expectations and the behaviour of the agents needs to be increasingly homogeneous. Homogeneity in behaviour *due to expectations* has already been introduced by Keynes (1936) who called the entrepreneurial outlook “animal spirits” and later on Minsky (1970) acknowledged that in times of economic flourishing also optimism emerges among the members of both parties, lenders and borrowers. For a survey of the formation of expectations literature in the economic context, please refer to Pesaran and Weale (2006). This kind of speculation is introduced exogenous to the model by adding a drift to the random walk of ε_{it}:

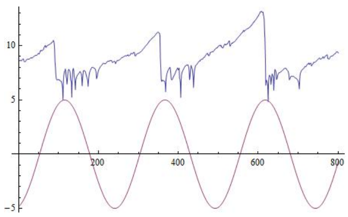
$$\varepsilon_{it} = \varepsilon_{it-1} + \eta_{it}\sigma_\eta + \sin\left(\frac{t}{40}\right).$$

This means that the errors are correlated and the drift lifts all deviations equally or diminishes them by the same amount. If there are phases of booms and busts, as described by the drift in the random walk, the real economy reacts distinctively on stock market mood. Figures 7a to 7e show the extreme situation where shareholders’ bargaining power is $n^s = 1$. The market drift is also depicted, but for graphical reasons amplified in the images.

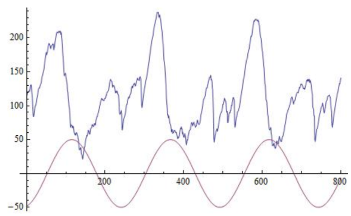
Total output (Figure 7a), the number of firms (Figure 7b) and the average interest rate (Figure 7c) respond to boom-bust cycles of the stock market. For high mark ups many firms go bankrupt. That also causes deep recessions. The average interest is generally high in such phases which causes the large number of bankruptcies and the depression times. Market power varies a lot (Figure 7d) but there is no clear correlation with the stock price swings visible.

If the bargaining power of stock holders is high and there are booms every firm has an increased demand for credit (see also Figure 4), which is the cause of high interest rates. The reason is that the probability of bankruptcy is comparatively low. If the stock price mark ups are uncorrelated the effects on single firms more or less cancel out each other. If there is correlation there is also correlation in credit demand and all firms face higher interest rates.

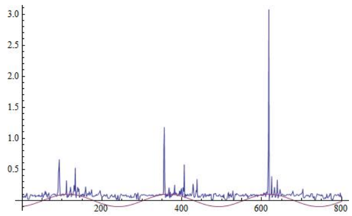
Figure 7 depicts a drastic scenario where the stock holders have maximum bargaining power. Almost all firms are certain that their shareholders would not let them go bankrupt in times of stock market booms. Therefore, they all have low expected bankruptcy costs which causes them to demand high amounts of capital. As long as the markup increases but is not too high yet, firms pay



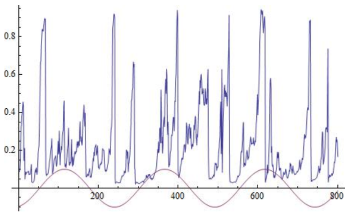
(a) GDP with drift



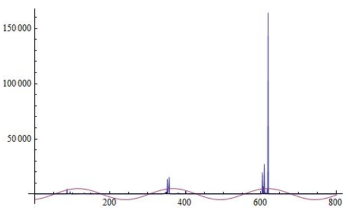
(b) Firm number with drift



(c) Average interest rate, drift



(d) Market Power with drift



(e) Bad Debt with drift

Figure 7: **Time Series for high bargaining power of shareholders with stock market drift**

a high interest rate which induces high credit supply in the following period. Then, leverage will increase and output will grow along with net value. Nevertheless, due to high interest rates, there is low profitability and capital increase depends more and more on credit than on retained profits. Firm equity remains at a low level. At some point leverage is too high to sustain the high interest payments and there is a deep slump in output because firms go bankrupt.

Over time the total output does not grow and only exhibits cycles. If firms pay high interest rates there is no profit that can be retained and add to the net worth. Capital may increase due to increasing credit supply but the collateral basis does not improve over time on a wider scale. Growth would be credit driven. This is the classical story of Minsky (1970) where leverage builds up over time and interest payments are financed to an increasing extent by new credit rather than profits. Eventually, firms will go bankrupt which constitutes repeated cycles in economic activity and output. In such a scenario it would be good to implement a policy that limits the influence of shareholders in bankruptcy procedures. This, however, is subject to the absence of injecting further equity by the shareholders.

5 Stock-related Remuneration

In this section we base the managements' payoff on the stock price at the end of a period. Two questions will be addressed: if some share of the management compensation consists of granted shares, how does this affect total output and the average interest rate? And what impact do volatility cycles have in this context? In major corporations the overall payment of managers consists of a package that includes fixed salaries and a performance-based payout. This performance-based payout is linked to the stock price by granting some shares or issuing stock options. This means that the higher the stock price, given a prior benchmark, the higher the managers' salary.[4] We consider a management that is concerned about the likely stock price at the end of a period only. They do not consider any further price increases or decreases since we assume that they could sell the stock immediately.[5] The stock price at the particular point in time is then uncertain also due to the volatility that reigns in the stock market. It is a well established fact of financial markets that volatility is persistent (Bollerslev and Jubinsky, 1999; Lux and Kaizoji, 2007) and that it is also positively correlated with trading volume (Karpoff, 1987; Brock and Lebaron, 1996). The connection between stock market volatility and business cycles is discussed by Fornari and Mele (2010). They find that aggregate stock market volatility explains up to 55% of real growth. Theoretical models of this connection differ in the timing of the correlation. There are models that explain countercyclical influences (Campbell and Cochrane, 1999) while others explain procyclical connections (Bernanke et al., 1999). The countercyclical models assume no feedback from the

[4] There are different sorts of stock-related compensations which have a contrary effect on risk taking. See Bryan, Hwang, and Lilien (2000) for more details. As for bank managers, this type of compensation has been discussed as contribution to the financial crisis due to subprime lending as banks could benefit from their earnings but their losses were borne by taxpayers through bailouts. The managers had each incentive to take large risks in exchange for the chance of large earnings. See Admati & Hellwig (2013), pp. 122,123 for some more detailed discussion. Since a payment in common stocks is possibly one of the easiest way to look at, this is chosen for this approach.

[5] Usually, there are some minimum holding times before managers can sell the stock granted.

real economy to asset prices while the financial accelerator approach of Bernanke et al. does (See Fornari and Mele, 2010).

We stick to the latter concept and build in exogenous levels of stock market volatility on top of the real economy feedback. Furthermore, we stay as close as possible to the prior approach and model volatility as sensitivity to profit, that is the level of profit extrapolation.

The Greenwald and Stiglitz (1990) approach acknowledges that the leverage a (non-financial) firm manager is willing to take in order to finance production is bound by the conditional probability of bankruptcy. The reason is that those managers do bear the downside risk by loss in reputation ("being a bad manager") and loss in salary due to unemployment if the firm goes bankrupt. If the firm is a corporation (i.e. a publicly listed company) the management remuneration is likely to depend also on the stock performance. In that case a manager would take the expected stock price into account for his or her capital demand decision. In the underlying model the stock price affects the manager's decision of how much leverage to accept.

In this context there needs to be some deviation from the former approach. Since there is no labour market in the model, there are also no wages for the management or workers. If the remuneration is tackled as channel of influence, there needs to be a distinction between the acting managers and the owners of the firm. The managers' decision problem under investigation is not to maximize mere expected profit for the firm but to maximize their own expected payoff.

The remuneration package of the management is assumed to consist of the number of company shares φ_{it} granted as incentive and a fixed salary c_{it}^M which also depends on the firm size in the form $c_{it}^M = \phi K_{it} c^m$ where $c^m > 0$ is a constant. The value of the compensation π_{it}^M depends on the stock price that is realized *at the end* of the period and the share of salary that is paid in granted shares $\beta \in [0,1]$: $\pi_{it}^M = \beta \varphi_{it} P_{it} + (1-\beta) c_{it}^M$. Note that the stock price itself depends positively on profit. Assuming the costs of bankruptcy borne by the management include losses from future salary and reputation, this is captured by c_{it}^f. The management can only reap the benefits from granted stocks if the firm is not bankrupt. If the firm goes bankrupt, they suffer the costs c_{it}^f. Denote the probability of bankruptcy as $\text{Prob}(BR_{it}) = \mathbb{P}_{it}$. The expected payoff for the management is

$$\mathbb{E}[\pi_{it}^M] = (1-\mathbb{P}_{it})\beta \varphi_{it} \mathbb{E}[P_{it}] + (1-\beta) c_{it}^M + \mathbb{P}_{it} c_{it}^f \tag{19}$$

where $c_{it}^f < 0$. Stocks are assumed to be traded at the end of each period when investors know whether a firm will continue existing and under which conditions. Therefore, the stock price at period t is not known when the investment decision of the management is due. It is assumed that the number of granted shares is smaller for *single* managers if the share price is high so that the individual performance based remuneration on average does not grow just because the firm is large. On firm level we assume a relation $\varphi_{it} \equiv \frac{E_{it}}{A_{it}} \phi K_{it}$. Furthermore, we again assume that $E_{it} = E = 1$ for all i,t. The managers' expected payoff is in detail

$$\mathbb{E}[\pi_{it}^M] = (1-\mathbb{P}_{it})\beta \frac{1}{A_{it}} \phi K_{it} \mathbb{E}[P_{it}] + (1-\beta)\phi K_{it} c^m + \mathbb{P}_{it} c \phi^2 K_{it}^2.$$

Remember that $\mathbb{P}_{it} = \frac{\overline{u}_{it}}{2}$. Managers are assumed to have some knowledge about the composition of the stock price and they try to maximize their payoff by influencing the stock price. The management knows the prior period deviation of the stock price from the fair value of the company.

They also can figure out how much the market over- or undervalued the profit. Therefore, they have some expectation about the deviation. Assume that ε_{it} still is the market deviation from the value of profit. But assume now that the management does see it as *sensitivity* to profit. Then, ε_{it} also determines an amplification of negative profits. We specify

$$P_{it} = A_{it} + \pi_{it}\varepsilon_{it} \tag{20}$$

The term ε_{it} can now be understood as markup on the multiplier of profit if we assume that the stock price is supposed to be a multiple of profit or dividend. This refers to the concept that share prices should reflect the present value of the expected stream of dividends.
The managers' payoff depends on the expected valuation of net worth and on the probability that the firm is not bankrupt at the end of the period. The stock price is positive only if the firm is not bankrupt. The expected stock price is

$$\mathbb{E}\left[P_{it}\right] = \left(\frac{A_{it-1}}{E} + (\phi - gr_{it})K_{it} + (\phi - gr_{it})K_{it}\frac{\mathbb{E}[\varepsilon_{it}]}{E}\right)$$

The managers optimize their expected payoff from Equation (20) by choosing the amount of capital to employ for production:

$$K_{it}^{d} = \frac{\frac{A_{it-1}}{2}\left[(E + \varepsilon_{it-1} + 1)\,\beta(gr_{it} - \phi) - \beta\phi - E\right] + (\beta - 1)E\phi c^{b}}{\beta\,(E + \varepsilon_{it-1})\left(g^2 r_{it}^2 - 3gr_{it}\phi + 2\phi^2\right) - Egr_{it}\phi}$$

Then, the equilibrium interest rate becomes:

$$r_{it} = \frac{1}{-4\beta\phi^2\,(E_{it} + \varepsilon)} \cdot \left(\Lambda_1 - \sqrt{(\Lambda_1)^2 + \Lambda_2}\right) \tag{12c}$$

with

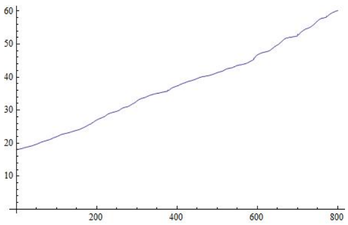
$$\Lambda_1 = g\phi\left(2c^b E_{it} + 6\beta E_{it} + 6\beta\varepsilon_{it}\right)\frac{A_{it-1}g\beta\,(1 + E_{it} + \varepsilon_{it})}{L_{it}^{s} + A_{it-1}}$$

$$\Lambda_2 = 8g^2\beta\,(E_{it} + \varepsilon) - 4g^2\beta\,(E_{it} + \varepsilon)\,\frac{1}{L_{it}^{s} + A_{it-1}}\left(A_{it-1}\beta\phi\,(2 + E_{it} + \varepsilon_{it}) + c\phi E_{it}\,(-2\beta + 2 + A_{it-1})\right)$$

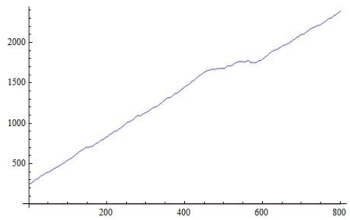
Details about the computation are provided in Appendix B.

Since this setting deviates slightly from the baseline case we start with examining the case where the management is paid only a fixed salary. Compared to the baseline case of the prior two settings here the interest rate is slightly higher on average as is total output. Figure 8 shows the over time dynamics of a typical baseline scenario. There are business cycle patterns (Figure 8a) and the number of firms active is increasing (Figure 8b). The interest rate is fluctuating a lot (Figure 8c). Due to the increasing number of firms the market power is low but occasionally there is a high market power (Figure 8d). The bad debt shows that there are frequent bankruptcies but those are usually small firms (Figure 8e).

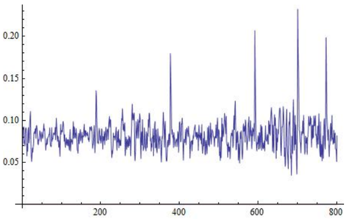
The dynamics resemble the baseline scenario of the underlying model except that the interest rate varies more. The reason is that due to the fixed payoff component the payoff is less sensitive to the interest rate. Therefore, for given credit supply the equilibrium interest rate varies more.



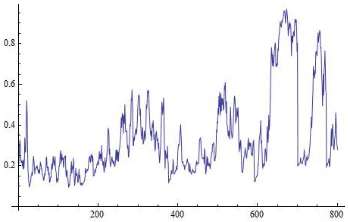
(a) GDP Scen. (3)



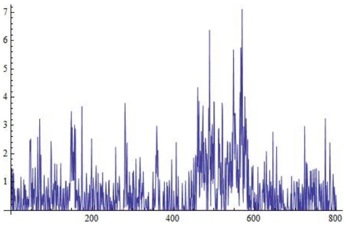
(b) Firm number with Scen. (3)



(c) Average interest rate, Scen. (3)

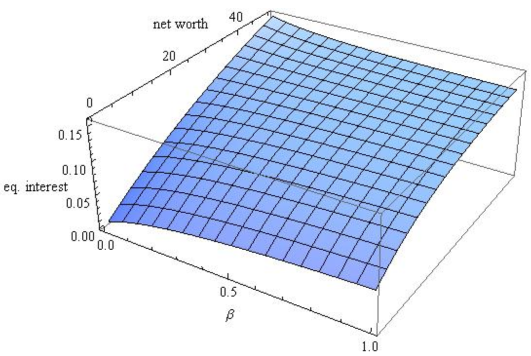


(d) Market Power Scen. (3) (β low)

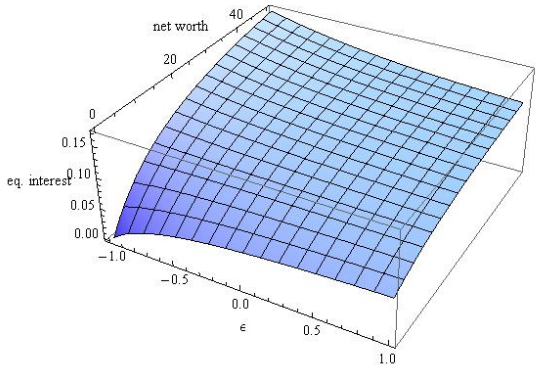


(e) Bad Debt Scen. (3)

Figure 8: **Uncorrelated stock prices (β low)**



(a) sensitivity to performance-based share



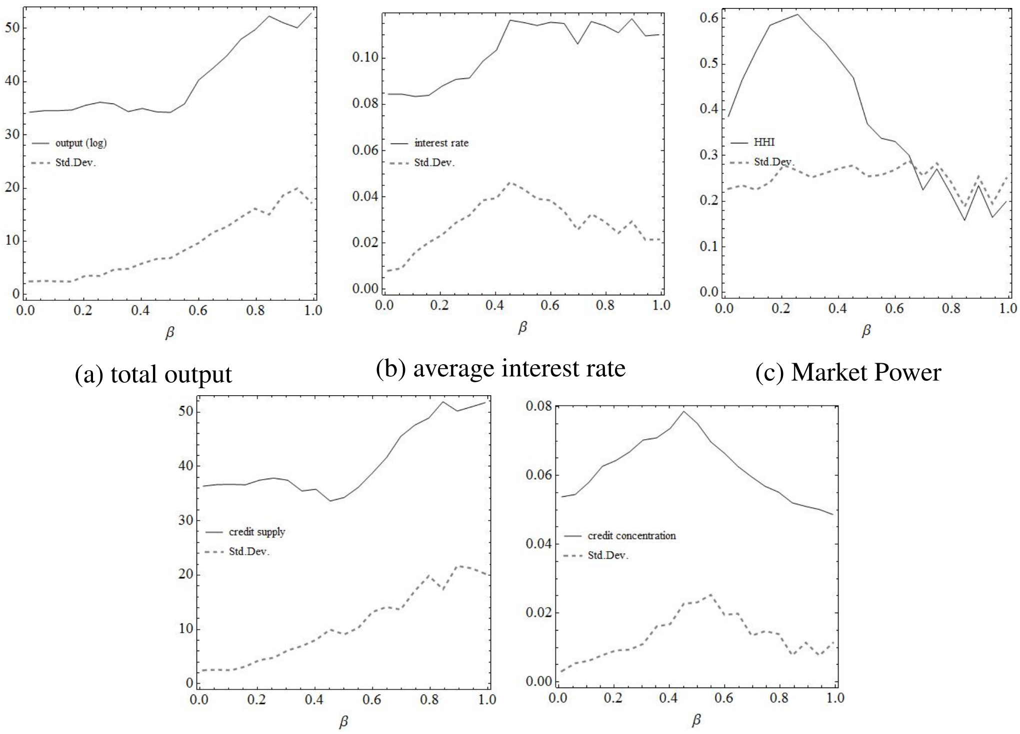
(b) sensitivity to stock price extrapolation

Figure 9: **Interest sensitivity**

Figure 9a shows the equilibrium interest rate depending on net worth and the share of stock based compensation. The amount of credit supply is fixed so that the net worth indicates the leverage of a firm. If the leverage is high, that is, the net worth is low, then an increasing share of stock based compensation leads to a higher equilibrium interest rate. If the leverage is low, then an increasing share of stock based remuneration leads to a *decreasing* equilibrium interest rate (Figure 9a). This picture also shows that for any distribution of leverage, a higher share of stock price based compensation will result in a narrower distribution of equilibrium interest rates. The interest sensitivity to the amplification of profit shows a similar pattern (Figure 9b).

This indicates that managers demand higher capital if their payoff relies on a good performance of the firm but once the firm is financially sound, a higher β causes a more prudent behaviour.

5.1 No Cycles at the Stock Market



(a) total output (b) average interest rate (c) Market Power

(d) Credit Supply (e) Credit Concentration

Figure 10: **Impact of β**

Comparing the long-term impact of various shares of compensation based on stock prices β, for low values of β an increase in performance based compensation does result in a higher interest rate (Figure 10b) and higher market power (Figure 10c). Output and credit supply are unaffected (Figures 10a and 10d). For values of β above some threshold (about β=0.5) output and credit supply are higher (Figures 10a and 10d), but here the interest rate is unaffected (Figure 10b). Market power decreases for higher levels of β (Figure 10c). Credit is supplied to only a few firms for a medium value of β. For low β, that supply concentration increases but after the peak decreases again as β approaches one (Figure 10e). Representative runs show (Figures 11) there is a highly cyclical dynamic effect so that the reliability of those results has to be handled with care. The sensitivity of the interest rate to the performance-based remuneration share (Figure 9) indicates that for large β, the interest rates across firms will be less dispersed. Therefore, growth differences among firms will be less dispersed, too. At the same time, if the firm is financially sound the expected performance based payoff is relatively high through the low bankruptcy probability. Any changes in the payoff weights have a rather large effect through the performance based part because now it may change faster than the fixed payoff. As a result, the optimal capital is lower for stable firms if more weight is put on the performance based part because the possible stock price is then less influenced by capital. Additionally, the probability of yielding that price is relatively sensitive.

A lower level of capital might then induce a comparatively higher probability and only a slightly lower possible price whereas the net gain is positive in this case.

The marginal changes in the probability of bankruptcy and the stock price differ in β which accounts for its effect on the long run dynamics. For firms any additional unit of capital contributes to the growth perspective and to the probability of bankruptcy at the same time. If a firm is highly leveraged its probability of bankruptcy is high, too. An additional unit of capital however, will increase the profit perspective as the expected stock price increases. This is based on the high probability of bankruptcy that increases less than the stock price perspective increases. Remember that also the expected costs of bankruptcy depending on the job loss increase slowly for highly leveraged firms.

Managers of financially sound firms who rely mostly on performance based compensation will not risk the survival prospects and thus most of their payoff for only small increases in the anticipated amount of payoff. Therefore, as this part of their salary becomes more important, it is optimal for them to reduce capital and therefore the possible stock price by a little if at the same time the survival probability increases significantly. Managers of leveraged firms can afford using more capital because the decrease in survival probability is meager but the potential gain is huge. As performance based compensation becomes more important, the gains by the anticipated price become more important and together with the only slight trade off in the survival probability, it pays off to increase capital. In the long run leveraged firms grow comparatively less because of higher interest rates. Colloquially expressed, leverage is more costly for $\beta = 1$ and financial soundness is rewarded more for high levels of performance based remuneration compared to a regime of fixed compensation.

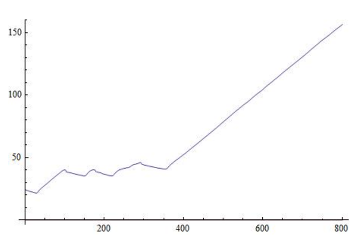
If managers are affected more by the well being of the firm they act more prudently if they also bear the downside risk. This induces less cyclical output dynamics except when there are phases when their degree of participation changes due to stock market fads. The mood at the stock market determines to what extent the managers' downside risk is outweighed by gains through profit. Also the design of the remuneration package determines to what extent their salary is depending on the stock price. This design determines how much market moods affect the bearing of risk.

The single run of high β reveals that the extreme case leads to unreasonable dynamics since there are no business cycles visible (Figure 11a). The number of firms is more or less stable (Figure 11b) and the interest rate fluctuates in a tight corridor but at a relatively high level (Figure 11c). Also the market power remains relatively stable at a low level (Figure 11d).

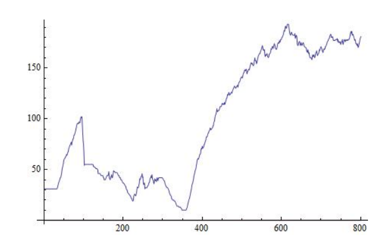
5.2 Volatility Cycles

In this sub-section we will examine the effects of volatility cycles of the stock prices on the dynamics in a strictly performance based remuneration situation. The volatility cycles are supposed to reflect phases of wide-spread sensitivity of stock investors to news or data. They are included by adding a cyclical drift to the random component of *all* stock prices.

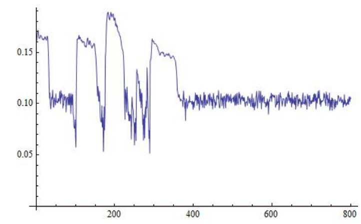
In Figure 12 it is visible that the stock investors' mood has a significant impact on the dynamics. Overall output shows about the same dynamics as with non-correlated stock prices (Figure 12a). The number of firms increases since there are almost no firms leaving (Figures 12b and 12e). Both, the interest rate (Figure 12c) and market power (Figure 12d) show rich dynamics but there are no



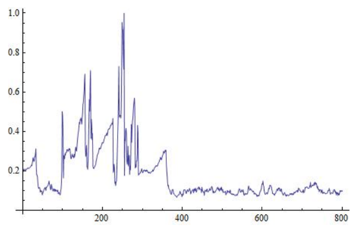
(a) GDP Scen. (3)



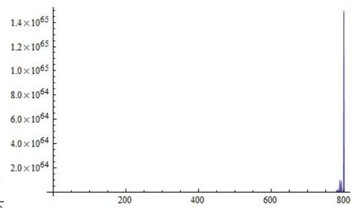
(b) Firm number with Scen. (3)



(c) Average interest rate, Scen. (3)

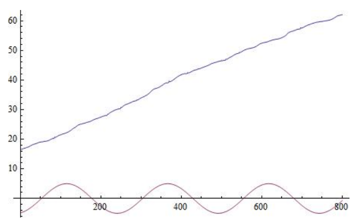


(d) Market Power Scen. (3)

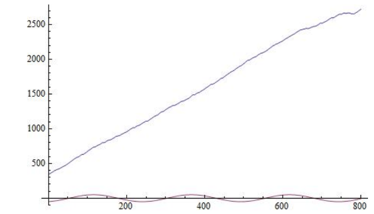


(e) Bad Debt Scen. (3)

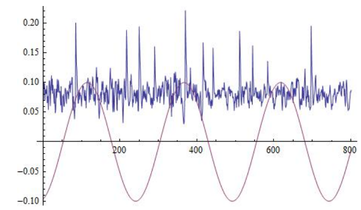
Figure 11: **Uncorrelated stock prices (β high)**



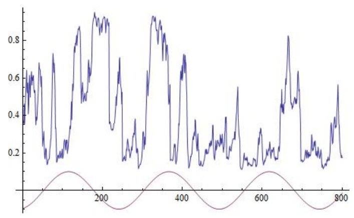
(a) GDP Scen. (3)



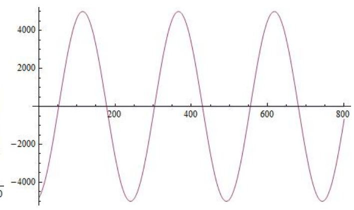
(b) Firm number with Scen. (3)



(c) Average interest rate, Scen. (3)



(d) Market Power Scen. (3)



(e) Bad Debt Scen. (3)

Figure 12: **Stock prices with persistent volatility**

clear patterns identifiable that would emerge due to the drift in stock prices. Figure 13 shows the credit demand conditional on the interest rate and its sensitivity to the stock price extrapolation ε. The demand curve rotates in ε rather then being shifted. For $\varepsilon > 0$ it becomes flatter, for $\varepsilon < 0$ it is steeper. This explains why there are more fluctuations in the equilibrium interest rate but no clear responses to the cyclical volatility.

Credit demand is not higher or lower for all levels of interest as it would be with a shift of the credit demand curve. The rotation results in more extreme interest rates.

For $\varepsilon > 0$ firms with tight constraints pay less credit but those who have plenty of credit supplied pay comparatively more. For $\varepsilon < 0$ this impact is reversed because the credit demand curve is steeper. Under supplied firms pay comparatively high interest rates and well supplied firms pay comparatively less.

Thus, there are no phases where *all* firms pay relatively more or relatively less interest.

Economically, for extrapolations $\varepsilon > 0$ credit demand is less sensitive, for $\varepsilon < 0$ it is more sensitive. This is because the expected payoff changes due to two things, the probability of bankruptcy and the profit that is expected. For any ε the probability of bankruptcy changes the same in the interest rate as does the profit that is expected. The stock price that is expected however, changes less if $\varepsilon < 0$. This is a situation where the probability of bankruptcy increases faster in capital than the possible payoff. Therefore, in times of low volatility the capital demand is more sensitive.

This section shows that managers adjust their behaviour to the stock market situation if their payoff depends on it. If they face an asymmetric payoff pattern and bear the downside risk of bankruptcy they have an incentive not to take too much risk. If they can benefit over proportionally from firm profits due to an extrapolation of profit at the stock market they act more accurate in a sense. This accuracy reveals their willingness to pay interest for a given level of credit. In times of volatile stock markets their willingness to pay interest is much less elastic. Therefore, firms evolve more similarly but they pay high interest rates. This hinders capital accumulation and growth. In times of changing volatility the fluctuations lead to a more cyclical output pattern but in times where there are no changing volatility the firms on average pay a high interest. These high average interest rates are beneficial for the development of the economy since the bank makes higher profits and through the monetary multiplier supplies much more credit to the firms. Hence the economy grows fast. Moreover, in this setting it does not show any unusual behaviour over time, neither with stock market volatility cycles nor without it. Therefore, governmental regulation would not need to aim at restricting the share of payoff that depends on the performance. It is to say that this may only hold in a world where the management actually bears some downside risk as well.

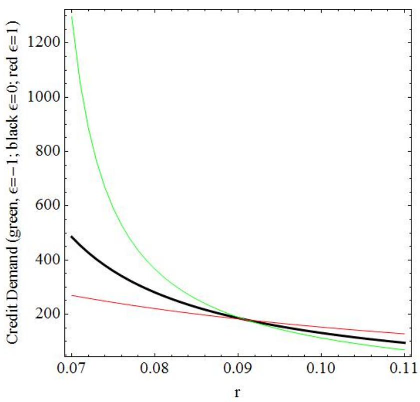


Figure 13: **Credit demand for different ε**

(black$\rightarrow \varepsilon = 0$, red$\rightarrow \varepsilon > 0$, green$\rightarrow \varepsilon < 0$)

6 Concluding Remarks

The central point of this paper is to assess the impact of three known transmission channels of stock prices to the real economy. One matter of interest is the influence of cyclical stock price patterns in such transmissions. We discuss boom-bust cycles and phases of persistent volatility using a particular transmission example.

This paper abstracts from the typical theory of stock price influences on the real side of the economy. Usually, the focus lies on the demand side: increased output follows increased stock prices because consumers possess a higher wealth and thus consume more. In this paper, the supply side is explored looking at three channels that are known to link stock prices to the real economy. All three channels deal with the influence that stock prices have on credit that firms rely on in order to finance their production: banks use the stock price as proxy for firms' prospects when evaluating creditworthiness, firms in financial distress might continue to exist if the market assessment is good, and last, top managers of listed companies are paid by a remuneration package that relies on stocks. Relying on an agent-based model that employs credit and financial fragility as driver of output and firms' growth dynamics the impact of the stock market is visible in all three channels.

A central point of the examination is the mutual influence, therefore a computer simulation is used. The basis is an existing model by Delli Gatti et al. (2005) that is able to reproduce business cycles and further stylized facts of firm sizes etc. Since individual access to credit is key in this model, it provides a sound basis for introducing the intended links to stock prices and for carrying out a comparative analysis.

The simulation for all three channels shows that all of them have a non-negligible impact: first, the effect of banks' rating policy where it takes stock prices into account is non beneficial as it reduces output and increases concentration. The reason is that the selection is even more concentrated as the firms size matters less than equity which cancels out the advantage of leverage. Leverage has an economy-wide advantage although a larger number of individual firms go bankrupt along the way. There are fewer possibilities for firms to grow by applying leverage. The importance of credit diminishes to the extent with which the bank takes the stock price into account. As financial health exerts more impact in this case, some firms have more persistent advantages and market dominance emerges earlier and is also more persistent. This result relies, however, on the assumption that the stock price reflects to some extent the firm's equity. Secondly, in cases of financial distress the stock market can determine whether the firm can sustain or whether it will face legally declared bankruptcy. The amount of bargaining power does not have a significant impact on the long run development of the economy if firms face idiosyncratic impacts that cancel out on average. If the stock prices are correlated the behaviour of firms becomes correlated, too. Then it matters if the shareholders have a high bargaining power. The cyclical stock prices result in pronounced business cycles but without long term growth. Firms' managers are willing to pay high interest rates in boom times which lowers profits. Because there are almost no profits to be retained in those phases there is no long-term growth. Therefore, if there are boom bust periods on the stock market, it makes sense to consider relying less on shareholders' opinion in bankruptcy rulings.

Thirdly, if managers are paid also in stocks, they are more prudent if stock prices are volatile because they are assumed to be risk averse. Their behaviour impacts the economy in a more complicated way. The impact that an increase in the performance based share has depends on the level of that share. Overall, the economy benefits from the managers having stakes in the company because they act in a more sensitive manner. Even when there are periods of changing volatility at the stock market and their compensation consist only of granted stock they do not take excessive risk. Therefore, it is not necessary to limit the share of compensation based on performance. This holds true in this model because the managers bear a significant downside risk.

All three channels have a significant impact on the dynamics of the economy. It matters not only to what extent the stock price enters the decisions in the real economy but also to what scope those decisions correlate. If there are phases of optimism or pessimism on the stock market there is also correlation in real economy dynamics.

Acknowledgements This work was carried out within International Research Training Group EBIM (Economic Behavior and Interaction Models) financed by the DFG under contract GRK 1134/2. Further financial support by the Franco-German University (DFH/UFA) is gratefully aknowledged. I would like to thank Antoine Mandel, Herbert Dawid and the participants of the 8^{th} EBIM Doctoral Workshop 2013 in Bielefeld for very useful comments and remarks.

References

[1] Admati, Anat and Martin Hellwig (2013): “The Bankers’ New Clothes”, Princeton University Press, Princeton (NJ).

[2] Allen, Franklin and Anthony M Santomero (2001): “What Do Financial Intermediaries Do?”, *Journal of Banking and Finance*, Vol. 25, pp. 271-294.

[3] Altissimo, Filippo, Evaggelia Georgiou, Teresa Sastre, Maria Teresa Valderrama, Gabriel Sterne, Marc Stocker, Mark Weth, Karl Whelan and Alpo Willman (2005): “Wealth and Asset Price Effects on Economic Activity”, *European Central Bank Occassional Paper Series*, No. 29.

[4] Altman, Edward I. (1968): “Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy”, *The Journal of Finance*, Vol. 23, No. 4, pp. 589-609.

[5] Altman, Edward I and Anthony Saunders (1998): “Credit risk measurement: Developments over the last 20 years”, *Journal of Banking & Finance*, Vol. 21, pp. 1721-1742.

[6] Aoki, Masanao and Hiroshi Yoshikawa (2007): *Reconstucting Macroeconomics*, Cambrigde University Press, Cambridge.

[7] Atiya, Amir (2001): “Bankruptcy Prediction for Credit Risk Using Neural Networks: A Survey and New Results”, *IEEE TRansactions on Neural Networks*, Vol. 12, pp. 929-935.

[8] Bank of England (2014): *Senior Management Arrangements, Systems and Controls (Remuneration Code-Clawback) Instrument 2014*.

[9] Barro, Robert J (1990): “The Stock Market and Investment”, *The Review of Financial Studies*,Vol. 3 (1), pp. 115-131.

[10] Battiston, Stefano, Domenico Delli Gatti, Mauro Gallegati, Bruce Greenwald, and Joseph E Stiglitz (2007): “Credit chains and bankruptcy propagation in production networks”. *Journal of Economic Dynamics and Control*, Vol. 31 (6), pp. 2061-2084.

[11] Bernanke, Ben, M Gertler and S Gilchrist (1999): “The Financial Accelerator in a Quantitative Business Cycle Framework”, in. M Woodford and JB Taylor (eds.), *Handbook of Macroeconomics*, pp. 1341-1393.

[12] Bongini, Paola, Luc Laeven, and Giovanni Majnoni (2002): “How Good is the Market Assessing Bank Fragility? A Horse Race Between Different Indicators”, *Journal of Banking and Finance*, Vol. 26, pp. 1011-1028.

[13] Bollerslev, Tim and Dan Jubinski (1999): "Equity trading volume and volatility: Latent information arrivals and common long-run dependencies", *Journal of Business & Economic Statistics*, Vol. 17, No. 1, pp. 9-21.

[14] Bordo, Michael D and John Landon-Lane (2013): *Does Expansionary monetary Policy Cause Asset Price Booms; Somne Historical and Empirical Evidence*, NBER Working Paper, No. 19585.

[15] Brock, William A and Blake D LeBaron (1996): "A dynamic structurral model for stock return volatility and trading volume", *Review of Economics and Statistics*, Vol. 78, pp. 94-110.

[16] Bryan, Stephen, LeeSeok Hwang, and Steven Lilien (2000): “CEO Stock-Based compensation: An Empirical Analysis of Incentive-Intensity, Relative Mix, and Economic Determinants”, *Journal of Business*, Vol. 73, No. 4, pp. 661-693.

[17] Campbell, John Y and John H Cochrane (1999): "By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior", *Journal of Political Economy*, Vol. 107, pp. 205-251.

[18] Crouhy, Michel, Dan Galai, and Robert Mark (2000): “A comparative analysis of current credit risk models”, *Journal of Banking and Finance*, Vol. 24, pp. 59-117.

[19] DeBondt, Werner FM and Richard Thaler (1985): “Does the Stock Market Overreact?”, *The Journal of Finance*, Vol. 40, (3), pp. 793-805.

[20] DeBondt, Werner FM and Richard Thaler (1987): “Further Evidence On Investor Overreaction and Stock Market Seasonality”, *The Journal of Finance*, Vol. 42, (3), pp. 557-581.

[21] Delli Gatti, Domenico, Corrado Di Guilmi, Edoardo Gaffeo, Gianfranco Giulioni, Mauro Gallegatti, and Antonio Palestrini (2005): “A new approach to business fluctuations: heterogeneous interacting agents, scaling laws and financial fragility”, *Journal of Economic Behavior & Organization*, Vol. 56, pp. 489-512.

[22] Delli Gatti, Domenico, Edoardo Gaffeo, Gianfranco Giulioni, Mauro Gallegatti, Alan Kirman, Antonio Palestrini, and Alberto Russo (2007): “Complex dynamics and empirical evidence”, *Information Sciences*, Vol. 177, No. 5, pp. 1204-1221.

[23] Dubey, Pradeep, John Geneakoplos and Martin Shubik (1989): “Default and Efficiency in A General Equilibrium Model with Incomplete Markets”, *Cowles Foundation Discussion Paper*, No. 879R.

[24] European Central Bank (2012): “Money and Credit Growth after Economic and Financial Crises - A Historical Global Perspective”, *ECB Monthly Bulletin*, February 2012.

[25] Fornari, Fabio and Antonio Mele (2010): "Financial volatility and economic activity", *Journal of Financial Management Markets and Institutions*, Vol. 1, No. 2, pp. 155-196.

[26] Frankfurter Allgemeine Zeitung [FAZ] (2014): *Bitte nur noch profitable Unternehmen an der Börse*, (Please do only let profitable firms go public), published Oct. 14, 2014, available at http://www.faz.net/aktuell/finanzen/internet-boersengaenge/boersenneulinge-bitte-nur-noch-profitable-unternehmen-an-der-boerse-13206402.html, accessed October 14, 2014.

[27] Gabaix,Xavier (2011): “The Granular Origins of Aggregate Fluctuations” , *Econometrica*, Vol. 79, No. 3, pp. 733-772.

[28] Graham, John R and Mark T Leary (2011): "A review of empirical capital structure research and directions for the future." Annual Review of Financial Economics, Vol. 3.1, pp. 309-345.

[29] Greenwald, Bruce and Joseph Stiglitz (1990): “Macroeconomic Models with Equity and Credit Rationing”, in *Asymmetric Information, Corporate Finance, and Investment*, edited by R. Glenn Hubbard, University of Chicago Press.

[30] Karpoff, Jonathan M (1987): "The relation between price changes and trading volume: A survey", *Journal of Financial and Quantitative Analysis*, Vol. 22, No. 1, pp. 109-126.

[31] Keynes, John M (1921): *A Treatise on Probability*, McMillan, London.

[32] Keynes, John M (1936): *The General Theory of Employment, Interest and Money*, Harcourt, Brace and World, New York.

[33] Kindleberger, Charles P and Robert Z Aliber(2005): *Manias, panics and crashes*, 5^{th} ed., Palgrave Macmillan, Beasingstoke.

[34] Knight, Frank (1921): *Risk, Uncertainty and Profit*, Houghton Mifflin, Boston (MA).

[35] Lee, Seung-Hyun, Mike W Peng and Jay B Barney (2007): “Bankruptcy Law and Entrepreneurship Development: A Real Options Perspective”, *The Academy of Management Review*, Vol. 32, No. 1, pp. 257-272.

[36] Lux, Thomas and Kaizoji Taisei (2007): "Forecasting volatility and volume in the Tokyo stock market: Long memory, fractality and regime switching", *Journal of Economic Dynamics and Control*, Vol. 31, pp. 1808-1843.

[37] Minsky, Hyman P (1970): “Financial Instability Revisited: The Economics of Disaster”, in Hyman P Minsky, *Can 'It' Happen Again? Essays on Instability and Finance*, Armonk (1982).

[38] Morck, Randall, Andrei Shleifer, Robert W Vishny, Matthew Shapiro and James M Poterba (1990): “The Stock Market and Investment: Is the Market a Sideshow?”, *Brookings Papers on Economic Activity*, Vol. 1990, No. 2, pp. 157-215.

[39] Ormerod, Paul (2009): *Coping with the Complexity of Economics*, Springer, Milan.

[40] Pesaran, M Hashem and Martin Weale (2006) "Survey expectations", *Handbook of economic forecasting*, No. 1, pp. 715-776.

[41] Reichling, Peter, Daniela Biethe and Antje Henne (2007): *Praxishandbuch Risikomanagement und Rating*, 2^{nd} ed., Gabler, Munich.

[42] Sabry, Faten and William P. Hrycay (2014): *An Economist’s View of Market Evidence in Valuation and Bankruptcy Litigation*, NERA Consulting, available under http://www.nera.com/67_8561.htm, accessed June 6, 2014.

[43] Semmler, Willi (2011): *Asset Prices, Booms and Recessions, financial Economics from a Dynamic Perspective*, Springer, Berlin.

[44] Sheskin, David J (2011): *Handbook of parametric and nonparametric statistical procedures*, 5th edition, CRC Press, Boca Raton.

[45] Shiller, Robert J (1981): “Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends?”, *The American Economic Review*, pp. 421-436.

[46] Standard and Poor’s (2011): “Principles Of Credit Ratings”, *Global Credit Portal*, published February 16, 2011, available at http://www.standardandpoors.com/spf/upload/Ratings_EMEA/PrinciplesOfCreditRatings.pdf, accessed December 4, 2014.

[47] Suarez, Javier and Oren Sussman (2007): “Financial distress, bankruptcy law and the business cycle”, *Annals of Finance*, No. 3, pp. 3-35.

Appendix

A Capital Demand for Stock Related Remuneration

$$
\begin{aligned}
\Gamma_{it} &= -0.5cK_{it}^2\phi^2\left(\frac{gr_{it}}{\phi}-\frac{A_{it-1}}{K_{it}\phi}\right)\\
&+\beta K_{it}\phi\left(1-0.5\left(\frac{gr_{it}}{\phi}-\frac{A_{it-1}}{K_{it}\phi}\right)\right)\left(\frac{A_{it-1}}{E_{it}}+K_{it}\left(\frac{\varepsilon_{it-1}}{E_{it}}+1\right)(\phi-gr_{it})\right)+(1-\beta)c^bK_{it}\phi
\end{aligned}
$$

Then, the derivative becomes

$$
\begin{aligned}
\frac{\partial\Gamma_{it}}{\partial K_{it}} &= -cK_{it}\phi^2\left(\frac{gr_{it}}{\phi}-\frac{A_{it-1}}{K_{it}\phi}\right)-0.5A_{it-1}c\phi\\
&+\beta K_{it}\phi\left(\frac{\varepsilon_{it-1}}{E_{it}}+1\right)(\phi-gr_{it})\left(1-0.5\left(\frac{gr_{it}}{\phi}-\frac{A_{it-1}}{K_{it}\phi}\right)\right)\\
&+\beta\phi\left(1-0.5\left(\frac{gr_{it}}{\phi}-\frac{A_{it-1}}{K_{it}\phi}\right)\right)\left(\frac{A_{it-1}}{E_{it}}+K_{it}\left(\frac{\varepsilon_{it-1}}{E_{it}}+1\right)(\phi-gr_{it})\right)\\
&-\frac{0.5A_{it-1}\beta\left(\frac{A_{it-1}}{E_{it}}+K_{it}\left(\frac{\varepsilon_{it-1}}{E_{it}}+1\right)(\phi-gr_{it})\right)}{K_{it}}+(1-\beta)c^b\phi
\end{aligned}
$$

This yields from the first order condition

$$
\begin{aligned}
K_{it}^d &= \\
&\frac{1}{-4\beta\varepsilon_{it-1}\phi^2+2cE_{it}gr_{it}\phi-4\beta E_{it}\phi^2-2\beta E_{it}g^2r_{it}^2+6\beta E_{it}gr_{it}\phi-2\beta g^2r_{it}^2\varepsilon_{it-1}+6\beta gr_{it}\varepsilon_{it-1}\phi}\\
&\cdot(A_{it-1}\beta\varepsilon_{it-1}\phi+2.A_{it-1}\beta\phi+A_{it-1}cE_{it}\phi+A_{it-1}\beta E_{it}\phi-A_{it-1}\beta E_{it}gr_{it}\\
&-A_{it-1}\beta gr_{it}\varepsilon_{it-1}-A_{it-1}\beta gr_{it}-2\beta c^bE_{it}\phi+2c^bE_{it}\phi
\end{aligned}
$$

Define for the numerator:

$$
\begin{aligned}
-A_{it-1}gr_{it}\beta\left(1+E_{it}+\varepsilon_{it}\right) &=: \Psi_1\\
A_{it-1}\beta\phi\left(2+E_{it}+\varepsilon_{it}\right) &=: \Psi_2\\
c\phi E_{it}\left(-2\beta+2+A_{it-1}\right) &=: \Psi_3
\end{aligned}
$$

And for the denomiator:

$$
\begin{aligned}
gr_{it}\phi\left(2c^bE_{it}+6\beta E_{it}+6\beta\varepsilon_{it}\right) &=: \varphi_A\\
-4\beta\phi^2\left(E_{it}+\varepsilon\right) &=: \varphi_B\\
-2g^2r_{it}^2\beta\left(E_{it}+\varepsilon\right) &=: \varphi_C
\end{aligned}
$$

Such that

$$
K_{it}^d = \frac{\Psi_1+\Psi_2+\Psi_3}{\varphi_A+\varphi_B+\varphi_C}.
$$

Using $K_{it} = L_{it} + A_{it-1} \Leftrightarrow L_{it} = K_{it} - A_{it-1}$ and with the equilibrium condition and capital demand

$$
L_{it}^s = \frac{\Psi_1+\Psi_2+\Psi_3}{\varphi_A+\varphi_B+\varphi_C} - A_{it-1}
$$

this can be rearranged to

$$\varphi_A + \varphi_B + \varphi_C = \frac{1}{L^s_{it} + A_{it-1}} \left(\Psi_1 + \Psi_2 + \Psi_3\right)$$

leading to

$$\underbrace{\varphi_C}_{r^2_{it}a} + \underbrace{\varphi_A - \frac{\Psi_1}{L^s_{it} + A_{it-1}}}_{r_{it}b} + \underbrace{\varphi_B - \frac{\Psi_2 + \Psi_3}{L^s_{it} + A_{it-1}}}_{c} = 0.$$

For this expression is of the form $ar^2_{it} + br_{it} + c = 0$ for

$$a = -2g^2\beta\left(E_{it} + \varepsilon\right)$$
$$b = g\phi\left(2c^b E_{it} + 6\beta E_{it} + 6\beta\varepsilon_{it}\right)\frac{-A_{it-1}g\beta\left(1 + E_{it} + \varepsilon_{it}\right)}{L^s_{it} + A_{it-1}}$$
$$c = \frac{1}{L^s_{it} + A_{it-1}}\left(A_{it-1}\beta\phi\left(2 + E_{it} + \varepsilon_{it}\right) + c\phi E_{it}\left(-2\beta + 2 + A_{it-1}\right)\right) - 4\beta\phi^2\left(E_{it} + \varepsilon\right)$$

this can be solved, e.g. by using the p-q-form such that the known solution is

$$r_{1/2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

yielding

$$r_{1/2} = \frac{g\phi\left(2c^b E_{it} + 6\beta E_{it} + 6\beta\varepsilon_{it}\right)\frac{A_{it-1}g\beta(1+E_{it}+\varepsilon_{it})}{L^S_{it}+A_{it-1}}}{-4\beta\phi^2\left(E_{it}+\varepsilon\right)}$$
$$\pm\frac{\sqrt{\left(g\phi\left(2c^b E_{it} + 6\beta E_{it} + 6\beta\varepsilon_{it}\right)\frac{A_{it-1}g\beta(1+E_{it}+\varepsilon_{it})}{L^S_{it}+A_{it-1}}\right)^2 + 8g^2\beta\left(E_{it}+\varepsilon\right) - 4g^2\beta\left(E_{it}+\varepsilon\right)\frac{1}{L^S_{it}+A_{it-1}}\left(A_{it-1}\beta\phi\left(2+E_{it}+\varepsilon_{it}\right) + c\phi E_{it}\left(-2\beta+2+A_{it-1}\right)\right)}}{-4\beta\phi^2\left(E_{it}+\varepsilon\right)}.$$

Note that $b = \Lambda_1$ and $-4ac = \Lambda_2$. Since $r_1 > r_2$, r_2 is the interest rate that will emerge in equilibrium because firms yield the global maximum profit with it.

B Parameters and Variables

Control Parameters		
stock price weight in credit supply	μ	[0,1]
influence of shareholders	n^s	[0,1]
share of performance based remuneration	β	[0,1]

Parameters		
productivity	ϕ	0.1
retooling costs	g	1.1
bankruptcy costs component	c (c^b)	1
weighing parameter for credit supply	λ	0.3
interest spread coefficient	ω	0.002
risk coefficient banking sector	ν	0.08
entry parameter	N	5
entry parameter	d	100
entry parameter	f	0.1
initial number of firms		100

Parameter Ranges for Robustness Check		
productivity	ϕ	$[0.05, 0.15]$
bankruptcy costs component	c	$[0.5, 1.5]$
interest spread coefficient	ω	$[0, 0.004]$
risk coefficient banking sector	ν	$[0.05, 0.1]$

C Wilcoxon Signed Rank Test

In order to check whether the results are robust, a `Wilcoxon Signed Rank` test is conducted. The Wilcoxon Signed Rank test is performed because it allows for testing samples where a normal distribution cannot be assumed and where the variance is unknown. It is a non parametric test. The following procedure is as described by Sheskin (2011). Basically, the test is whether the medians of two sample populations (data sets) are likely to be the same at a certain level of significance. If so, the two sample populations can be assumed to be drawn from the same distribution. Some assumptions are essential for the test:

1. The observed data either constitute a random sample of N independent pairs of items.
2. The observed data are measured at a higher level than the ordinal scale.
3. The distribution of the population of difference scores between repeated measurements of between matched items of individuals is approximately symmetric.

The Null-hypothesis is that the two populations which the results stem from do not differ in their median ν: $H_0 : \nu_1 = \nu_2$ while the alternative is for a two tailed test $H_{alt} : \nu_1 \neq \nu_2$. that is, the median of population 2 is either below or above the median of population 1. The results are checked for a significance level of 95%, that is $\alpha = 0.05$. Each pair of data is compared and the difference taken $W_i = x_{1i} - x_{2i}$ for all $i = 1, ..., N$. Zero differences $W_i = 0$ are discarded and the sample size left is n. Since a two tailed test is conducted, the test statistics is the minimum of the sums of negative and positive differences in the pairs of the samples,

$$W := Min[|W_-|, W_+].$$

μ			$\bar{r}_{it}$	$Herfindahl$	$Output$
$\mu = 0$	vs.	$\mu = 0.5$	$>$	$<$	$>$
$\mu = 0.5$	vs.	$\mu = 1$	x	$<$	x
$\mu = 0$	vs.	$\mu = 1$	$>$	$<$	$>$

Table 1: **Impact of μ**

If the *sample size* is sufficiently large, W can be assumed to be normally distributed. Then, a z-value can be computed using the number of nonzero differences n. This can also be done for the continuation of data in order to better compare the continuous normal distribution with discrete data in the form

$$z = \frac{\left|W - \frac{n(n+1)}{4}\right| - 0.5}{\sqrt{\frac{n(n+1)(2n+1)}{24}}}.$$

In this test, the H_0 hypothesis can be rejected if $|z| \geq z^{crit}$ where z^{crit} is the critical value at a significance level chosen according to a table. For a significance level $\alpha = 0.05$ the critical value is $z^{crit} = 1.645$.

D Robustness Check

The robustness check is aimed to see whether the results do hold qualitatively for a wider range of parameters. Therefore,

1. intervals for parameter values are determined,
2. a number of random profiles is generated within the parameter ranges,
3. simulations are run for each setting of the control parameter under investigation for all of the random profiles.
4. Then, the generated results for each different control parameter setup are compared using a Wilcoxon-Signed Rank test. This test reveals whether the output for the random profiles is significantly different under a different control parameter value. If so, the test provides also which output distribution has the higher median and thus provides information for the impact of the relevant parameter.

In particular, the control parameters are μ, n^s, and β. Since n^s has no impact, only robustness of μ will be tested. Three levels of *mu* and β will be compared. The qualitative difference will then be indicated with ">" if the mode is larger for the first distribution and with "<" vice versa. If there is no significant difference, this will be indicated by "x".

β			$\bar{r}_{it}$	$Herfindahl$	$Output$
$\beta = 0$	vs.	$\beta = 0.5$	$<$	$<$	$<$
$\beta = 0.5$	vs.	$\beta = 1$	$<$	$<$	$<$
$\beta = 0$	vs.	$\beta = 1$	$<$	$<$	$<$

Table 2: **Impact of β**