

# Sensitivity analysis

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A systematic sensitivity analysis was run. Table 1 shows the values that were run for each parameter while all the other parameters remained at baseline values; each parameter combination was run 100 times. Here, only the surprising or otherwise interesting results are presented in detail; all remaining results are discussed briefly and are available in detail from the author.

The outcome variables that were taken into consideration and compared were: Average duration of an investment, proportion of profit that entrepreneurs pay as interest to investors, absolute interest that entrepreneurs pay out to investors, overall level of trust, proportion of entrepreneurs that exit the market voluntarily, proportion of links cut by entrepreneurs, age of entrepreneurs when exiting the market. Those variables provide a decent overview of what is happening in the market.

## 1 Size of the market

When analyzing the effect of market size on the outcome variables it is particularly interesting to look at relative numbers of entrepreneurs and investors.

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**Table 1** – Parameter values run during sensitivity analysis; the other parameters are set to their baseline values.

Measure	Values run
Number of entrepreneurs	100, 160, 200
Number of investors	100, 210, 300
Time constraint investors	5, 10, 15
Time constraint entrepreneurs	5, 10, 15
Productivity	1.0, 1.6, 2.0
Variance of random term	.2, .8, 1.6
Investment	10, 70, 150
Disappointment threshold	.2, .6, 1.0
Trust cutoff	0, .2, .6
Trust decrease	.1, 1.7, 3.0
Trust increase	.1, .5, 1.0
Adaptation speed	1, 5, 10, 50, 100
Saving target	100, 600, 1000
$p3$ (minimum amount used for consumption)	0, 6, 15

### 1.1 Number of entrepreneurs

The number of entrepreneurs was set to 100, 160 and 200 while keeping the number of investors fixed at 210. Hence, the relation of entrepreneurs to investors was set to 0.476, 0.762 and 0.952. The proportion of profit that entrepreneurs pay to investors on average is the larger, the fewer entrepreneurs there are.

The mechanism behind this is as follows: If the number of entrepreneurs per investor is small, every unit paid to the investors has a larger impact on next period's investment with this entrepreneur in absolute terms. In their first year, entrepreneurs split the profit that remains after subtracting  $p3$  in equal parts and return exactly half. In the following period, if their profit is higher than the previous period's, they increase the proportion of profit returned to the investors. If not, they decrease it. From then on, entrepreneurs increase the proportion of profit given to the investors if an increase in  $p1$  has led to an increase in profit. Some of the entrepreneurs will be lucky in their second period of existence and their profit will increase because of a favorable influence of the random component of the production function. Hence they will increase  $p1$ . This initial increase in return for the investor will cause him to invest more with this particular entrepreneur in

the future. The smaller the number of entrepreneurs, the larger this effect will be. If the stochastic component of the production function is larger than 0 the following period, the entrepreneur will return even more afterwards. This increase in interest payment for the investor is the larger, the larger the increase in investment with this entrepreneur was, which depends on the number of entrepreneurs.

The number of entrepreneurs had no impact on the duration of an average investment. Trust per entrepreneur and absolute return received from an entrepreneur decreased with the number of entrepreneurs, which was to be expected as time constraint and investment were fixed.

## 1.2 Number of investors

The more investors there are, the longer the average duration of investment and the *lower* the proportion of voluntary exits.

If there are many investors, entrepreneurs remain connected to some of them and continue to receive funds, even if other investors were disappointed and cut their links with them. Therefore, entrepreneurs that are victims of several negative productivity shocks in a row stay in the market instead of going bankrupt, as they would have, had they not received investments from so many sources.

However, if entrepreneurs receive investment, they have to return it. They can only decide what they do with the remaining profit. Those entrepreneurs that have negative profits therefore do not have the ability to accumulate capital of their own and reach their saving target. They stay in the market longer. However, their buffer is low, so when they are hit by another negative productivity shock, they eventually go bankrupt.

Therefore, the fewer investors, the more dynamic the market - the shorter the average duration of investment, and the higher the proportion of entrepreneurs that leave voluntarily. In this way, a low number of investors helps to separate the productive from the unproductive entrepreneurs.

## 2 Spatial dimension

The spatial dimension of the model is held fixed. Entrepreneurs and investors are spread out on a grid of  $30 \times 30$  patches of a size of 30 pixels. The distribution on the grid is completely random. A large part of the variation when parameter values are held fixed springs from random variations in the setup.

## 2.1 Time constraint - Investors

The time constraint that determines the number of links investors are able to maintain to other investors - the higher the value of the parameter, the more links can be maintained - has almost no effect on any of the observed variables.

## 2.2 Time constraint - Entrepreneurs

The time constraint that determines the number of links investors are able to maintain to entrepreneurs has almost no effect on any of the observed variables, either. Obviously, the time constraint parameter increases total trust, but this effect is entirely due to the higher number of links. Trust per link does not depend on the time constraint.

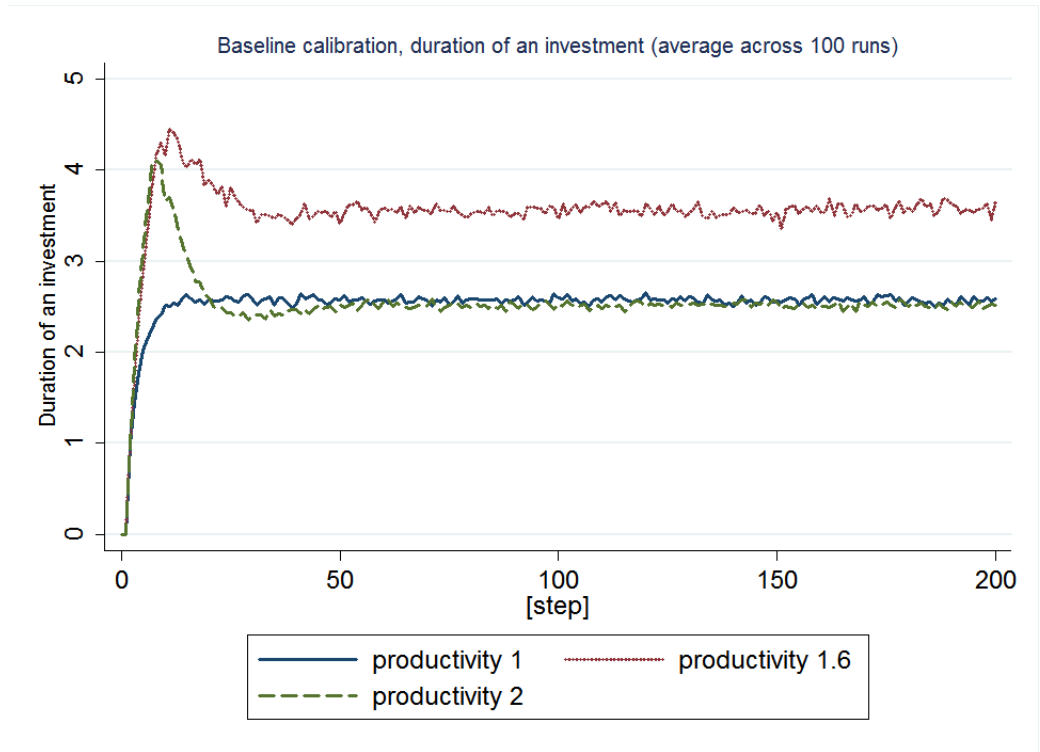
# 3 Production function

In the baseline version of the model, the production function is the same for all of the entrepreneurs and there is a productivity shock  $\epsilon_{i,t}$  that is idiosyncratic. In a variant of the model this assumption will be altered and the productivity differences between entrepreneurs will become permanent (see section NOCH EINFUEGEN). Here, however, all that is analysed is a different level of productivity, common to all entrepreneurs, and the impact of the variance of the random productivity shock.

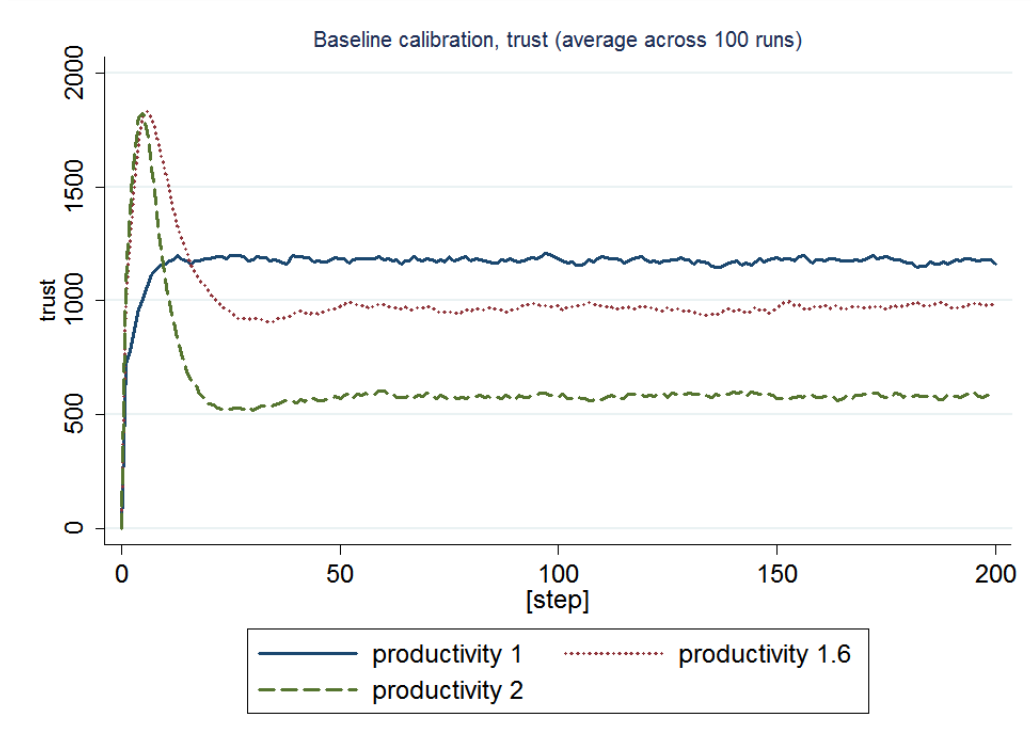
## 3.1 Productivity

Interestingly, the average duration of an investment is longest at a medium level of productivity (fig. 1). This is because at low levels of productivity, a lot of entrepreneurs go bankrupt fairly soon and the investment ends. At high levels, entrepreneurs reach the saving target quickly and exit the market. This is also reflected very clearly in the relationship between productivity and proportion of voluntary exits: At a productivity level of 2.0, about 80% of exits are voluntary, at the baseline level of 1.6 about 40% are, and at a level of 1.0, almost none are. The proportion of profit that is paid to the investors is highest when productivity is at 2.0. Whether it is 1 or 1.6 does not make a difference.

At first sight one might think this is because the entrepreneurs learn that it is worthwhile to return more to the investors because additional investment with them yields larger increases in profits. However,  $p_1$  is not larger



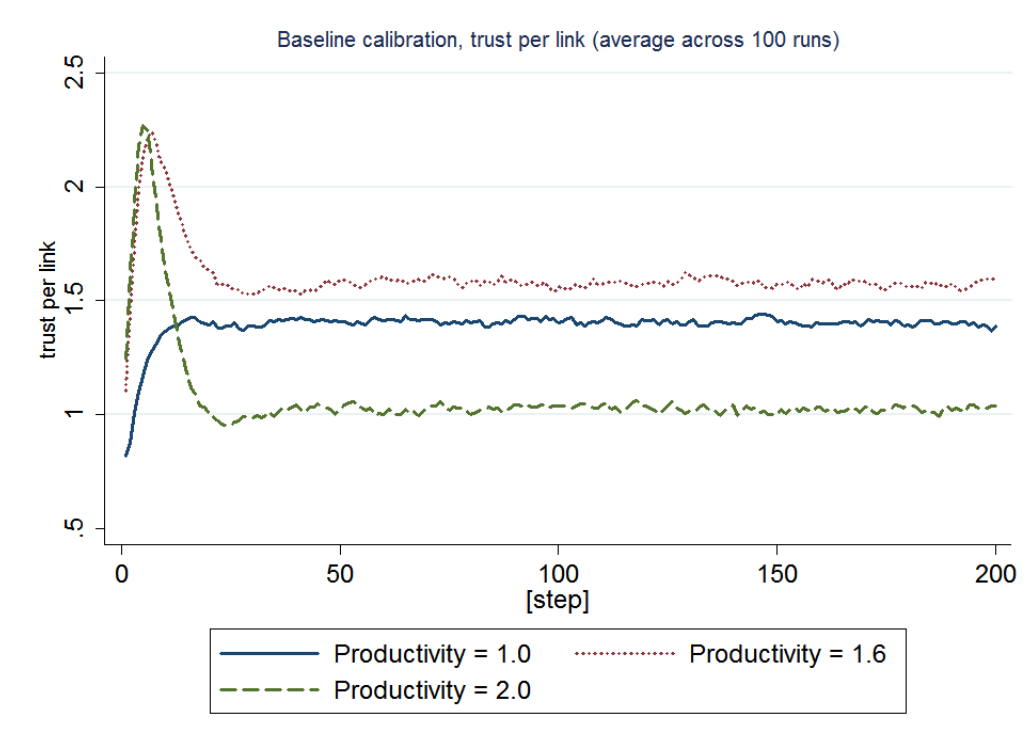
**Figure 1** – Effect of productivity level on average duration of investment



**Figure 2** – Effect of productivity level on total trust in the market

than  $p_2$  when productivity is high; it is rather the case that profits exceed the minimum consumption  $p_3$  more often and therefore the proportion of total profits that is allotted to  $p_1 + p_2$  is higher.

At first sight, it seems like trust decreases with productivity (see fig. 2), which is true for trust added up across links. The number of links per investor however, is higher when productivity is low. At low levels of productivity, many entrepreneurs go bankrupt and are replaced by random new entrepreneurs. Investors who are disappointed, cut a link and look for a new entrepreneur to connect to in the following period do not have to look very far for a new entrepreneur because there are likely to be fresh entrepreneurs that they have not previously been connected to in their proximity. This contrasts with a situation in a less dynamic setting when entrepreneurs stay in the market for longer. In this case, there tend to be several entrepreneurs close to the investor that the investor has previously been connected to, but who disappointed him. Thus, an investor has to connect to entrepreneurs that are farther away. This means that he cannot afford to have as many

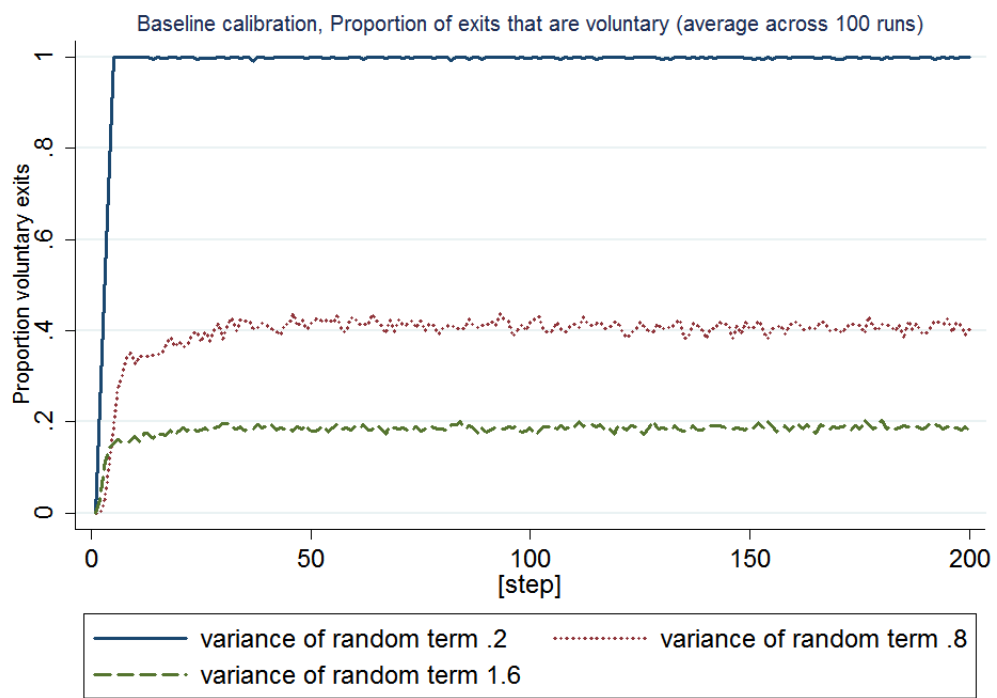


**Figure 3** – Effect of productivity level on trust per link

links, because he has to use a larger proportion of his fixed time budget for the connection. Accordingly, when the fluctuation is higher, suitable entrepreneurs tend to be closer to investors so that they do not have to spend as much on them and can afford a higher number of links. Thus, trust *per link* is highest at a medium level of productivity (see fig. 3) because (i) the number of links is lower and (ii) the longer duration of investments at medium levels of productivity allows trust to build up over time.

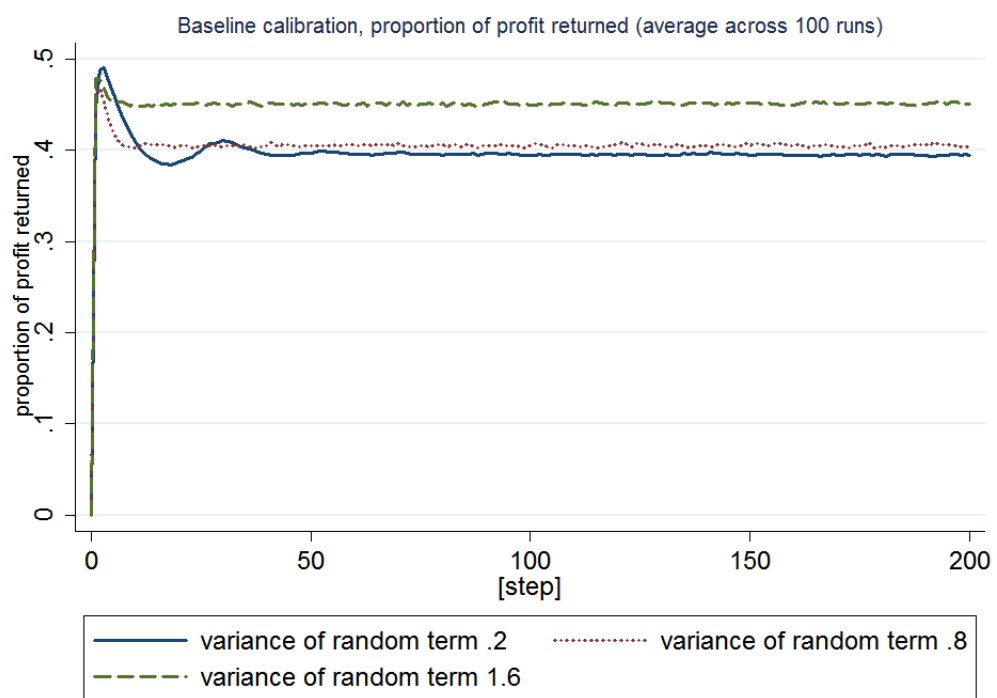
### 3.2 Variance of random term

The lower the variance of the random term of the production function, the more beneficial for entrepreneurs. The lower the variance, the higher the proportion of links that are cut by entrepreneurs; in fact, at a variance level of .2 almost all entrepreneurs exit the angel segment voluntarily (see fig. 4). The average duration of investment is longer although entrepreneurs actually pay a lower proportion of their returns as interest (see fig. 5).

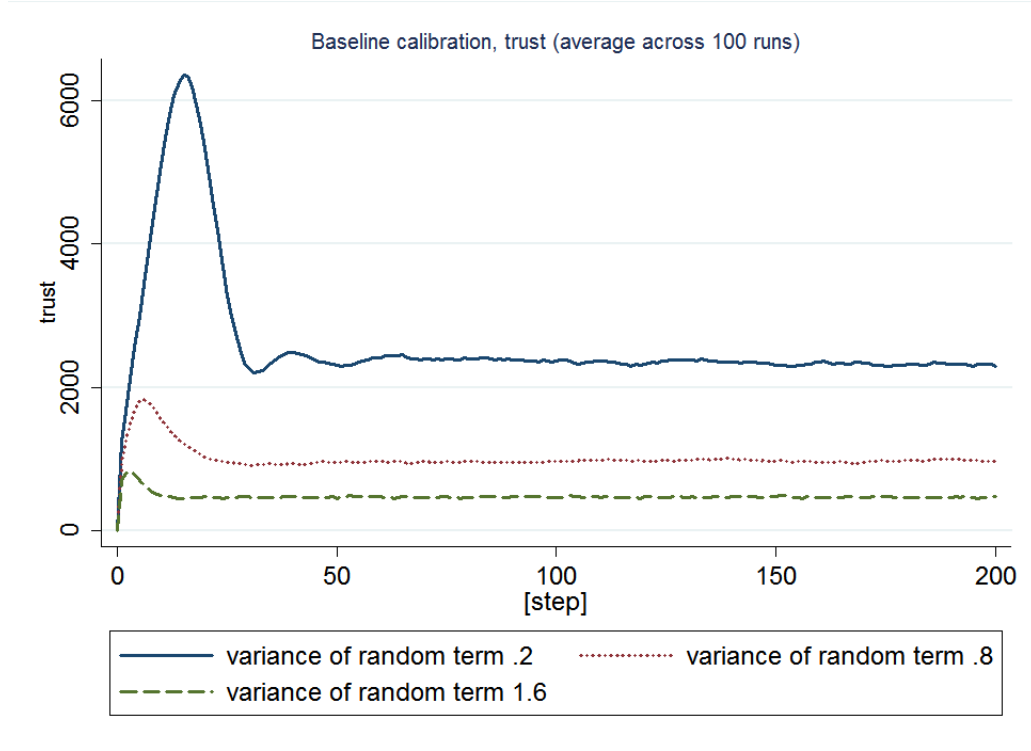


**Figure 4** – Effect of the variance of the random term on proportion of entrepreneurs who leave the angel segment voluntarily





**Figure 5** – Effect of the variance of the random term on proportion of proportion of profit that entrepreneurs pay as interest to the investors

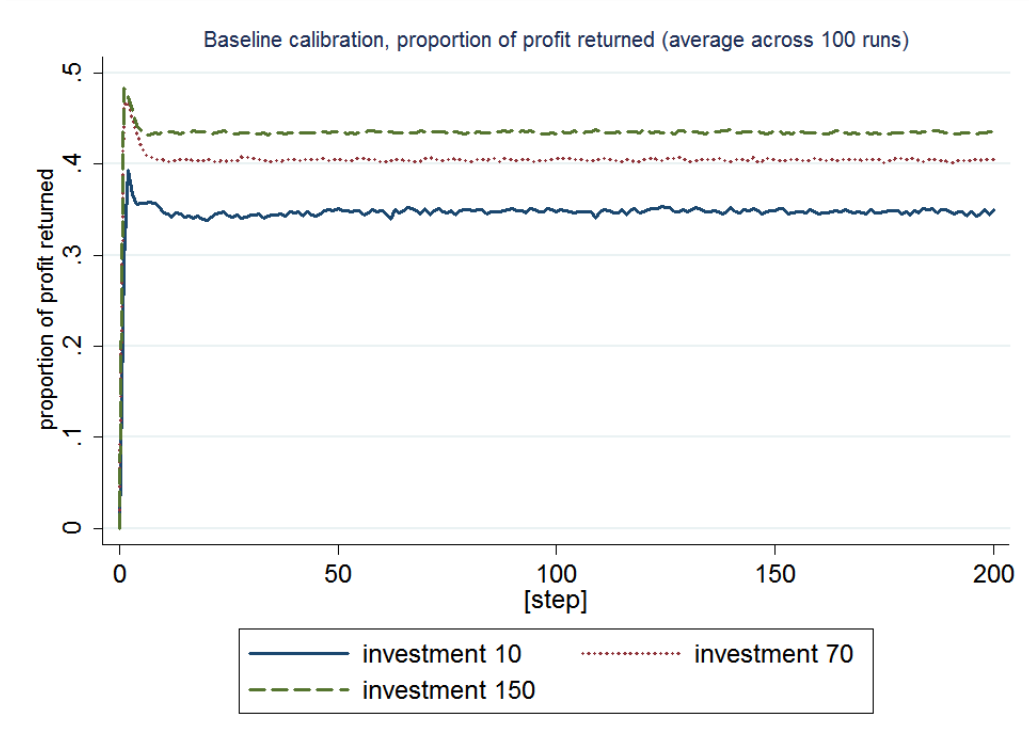


**Figure 6** – Effect of the variance of the random term on total trust

This apparent paradox occurs because when the variance of returns is low, interest payments from entrepreneurs are more uniform, so investors do not get disappointed easily (see fig. 6).

## 4 Behavior of investors

The effects of the behavior of the investors will be studied extensively in sections EINFUEGEN and EINFUEGEN. Therefore, its treatment here will be rather brief and it will only cover the effect on those variables that are not considered in sections EINFUEGEN and EINFUEGEN. In contrast to section EINFUEGEN, here only one parameter is altered at a time and all investors are assumed to behave in the same way; the latter assumption will be released in section EINFUEGEN.

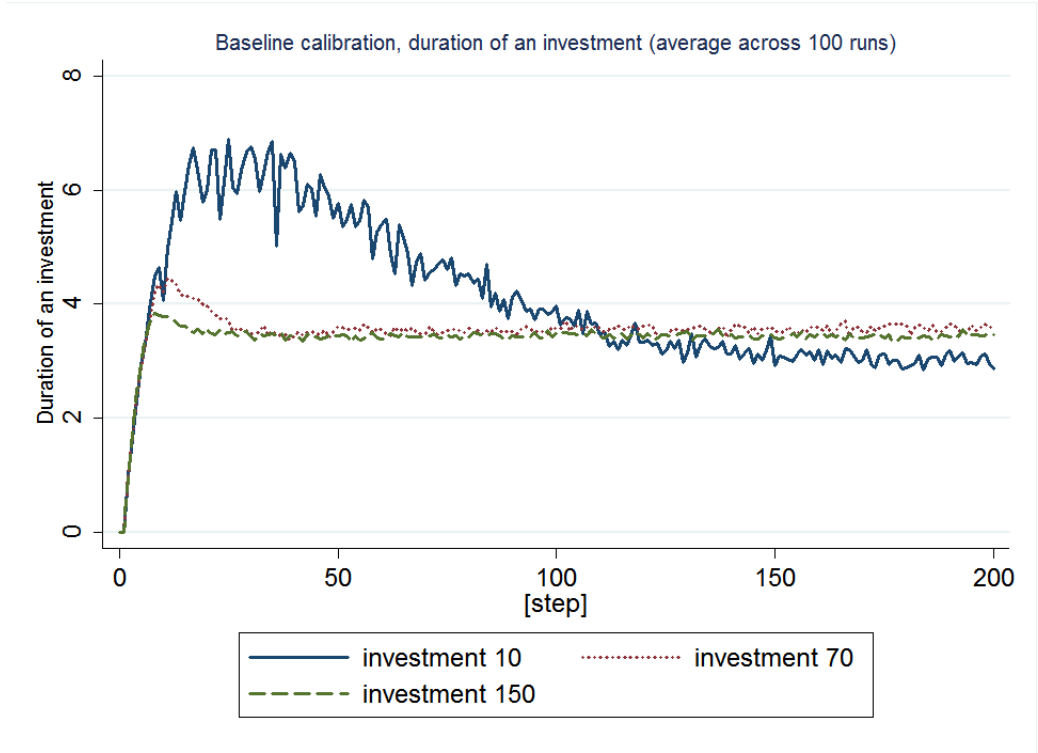


**Figure 7** – Effect of amount invested by investors on proportion of profit that entrepreneurs pay as interest to investors.

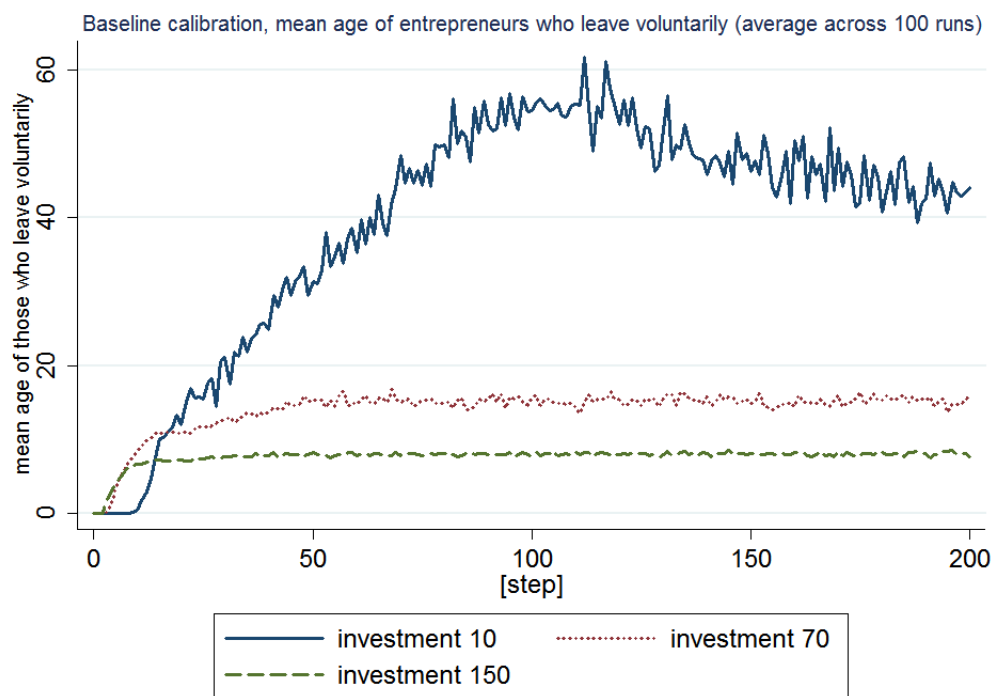
#### 4.1 Investment

All investors invest the same amount every period, the amount *investment*, and split it up among entrepreneurs. For the parameter *investment* there is a large nonlinearity in reactions of market outcomes to parameter changes. There is no large difference between values of 70 and 150, but outcomes for investment level 10 are very different. It seems to be the case that for very low levels of investment, entrepreneurs learn over time that it is not worthwhile to return anything to the investors. The proportion of profit paid as interest to the investors is lowest for the lowest level of investment (see fig. 7). The duration of investment decreases until approximately step 100; mean age of entrepreneurs when exiting the market voluntarily increases synchronously (see figures 8 and 9).

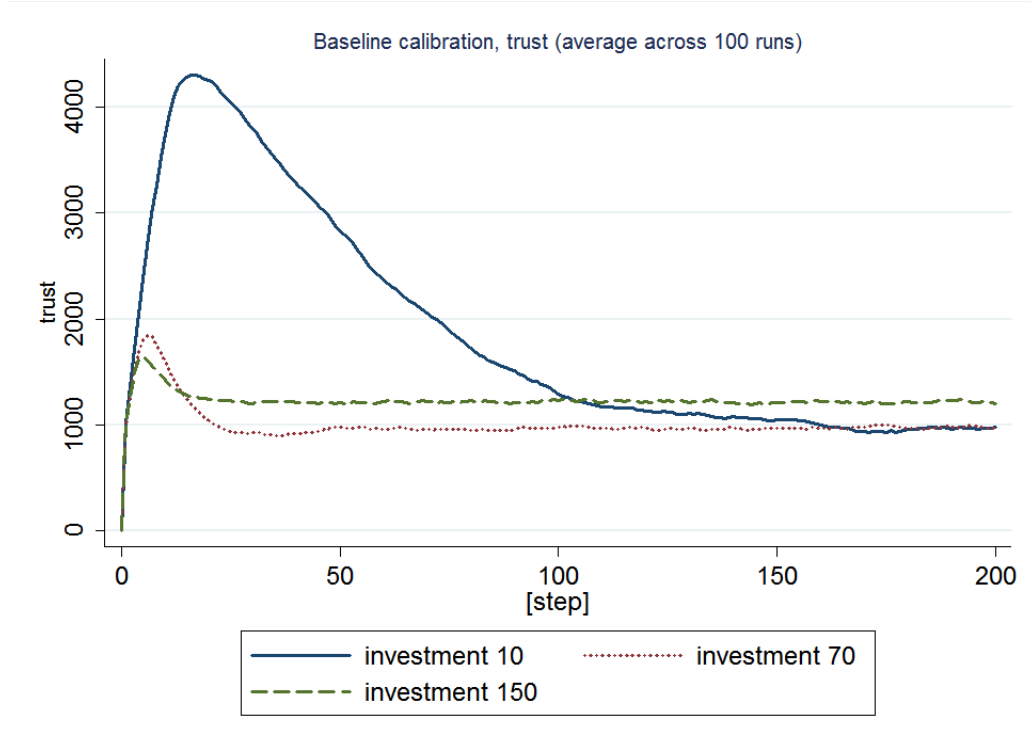
This confirms the hypothesis that entrepreneurs become independent from investors: they remain in the market until they have accumulated



**Figure 8** – Effect of amount invested by investors on average duration of investment



**Figure 9** – Effect of amount invested by investors on mean age of entrepreneurs when exiting the angel segment voluntarily



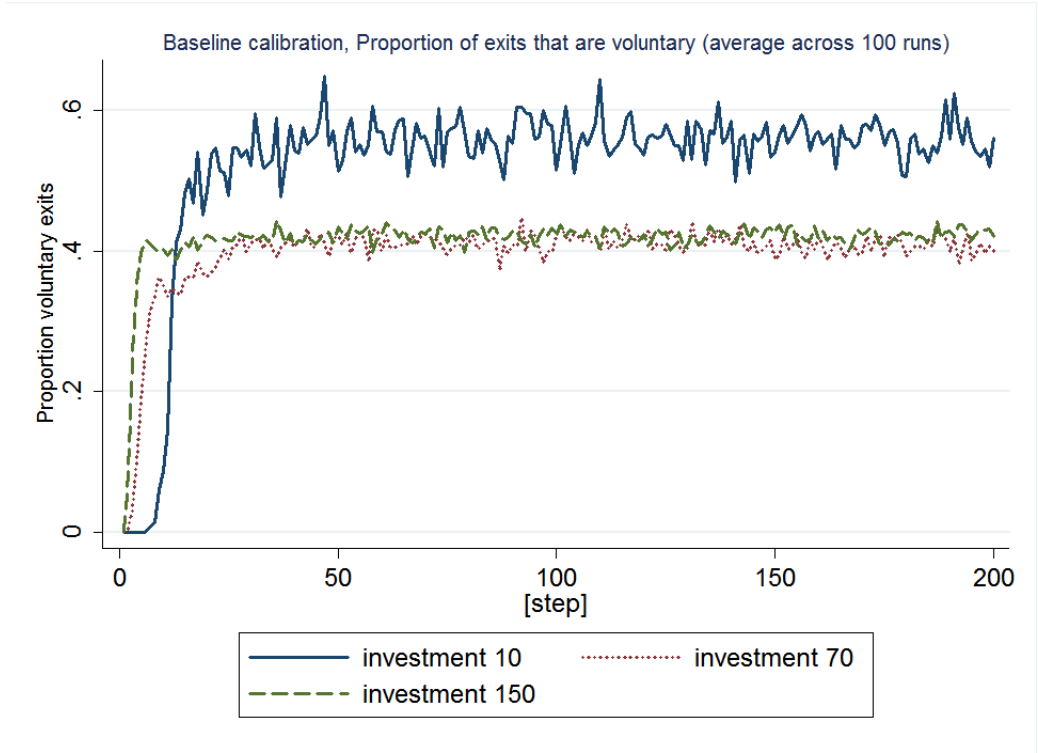
**Figure 10** – Effect of amount invested by investors on total trust

enough savings of their own, which takes about 50 years. Investors successively cut all their links, which is accompanied by a huge loss in trust over time (see fig. 10).

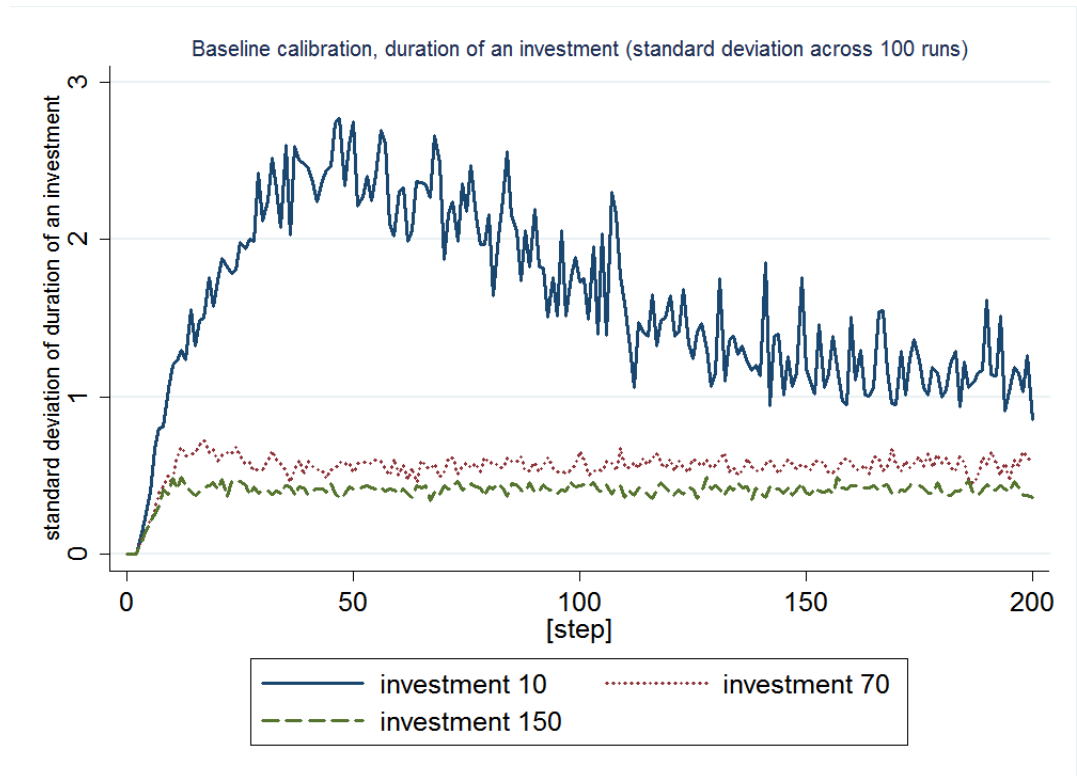
It looks like entrepreneurs as a collective would actually prefer a lower level of investment, since the proportion of voluntary exits is highest at the lowest level of investment (see fig.11). However, it takes unrealistically long until entrepreneurs' firms reach a decent size - about 50 years - and the variances of market outcomes at the low level of investment are extremely high (see fig. 12).

## 4.2 Disappointment threshold

The meaning of the disappointment threshold  $d$  is the following: An investor is disappointed by an entrepreneur if the return he receives from him is lower than  $d$  times the average return that the other investors who are his network neighbors received from their entrepreneurs. Therefore, the lower  $d$ ,

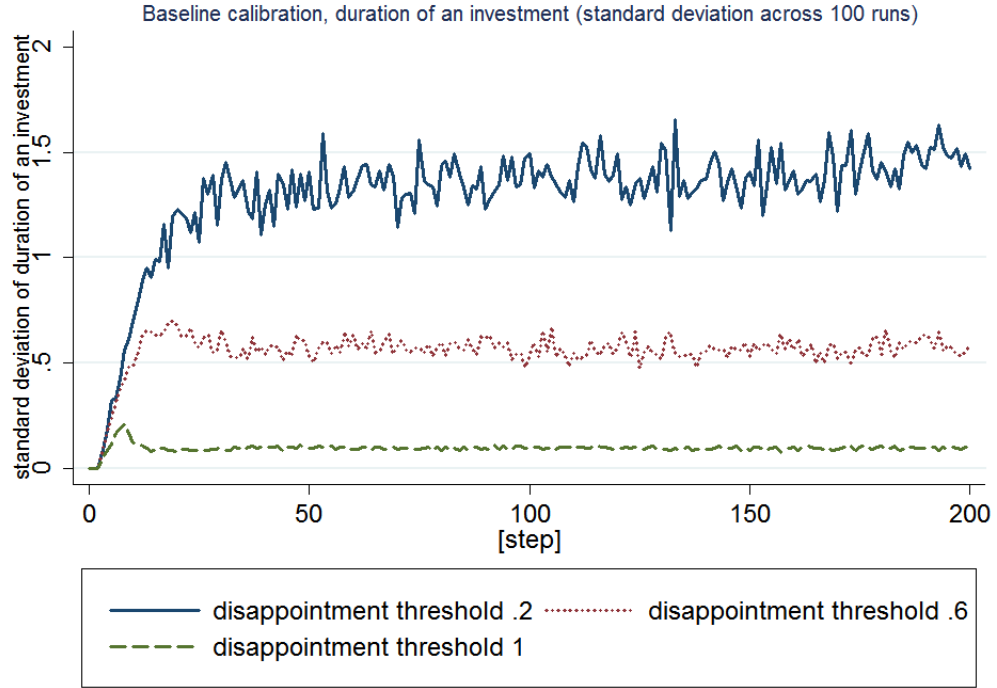


**Figure 11** – Effect of amount invested by investors on proportion of entrepreneurs who exit the angel market segment voluntarily



**Figure 12** – Effect of amount invested by investors on standard deviation of duration of investment





**Figure 13** – Standard deviation of duration of an investment at different levels of the disappointment threshold

the more lenient the investor in the sense that he will only be disappointed if the interest payment from an entrepreneur is *much* lower than what the other investors received.

The effect of altering the disappointment threshold on the duration of investment is straightforward: the more easily investors are disappointed, the shorter the average duration of investment. Interestingly, the more lenient investors are, the larger the variance of duration of an investment (see fig. 13).

### 4.3 Trust cutoff

The trust cutoff  $c$  is the level of trust at which investors cut a link to an entrepreneur because they have been disappointed too often. There is almost no effect of this parameter on the observed measures. The reason why  $c$  has so little effect on market outcomes is that with an average initial trust of 3.8

and a trust decrease level of 1.7 in the baseline scenario there are not many cases in which it will matter whether the cutoff level is 0, .2 or .6 (the values that were checked). There would be a stronger effect for larger variations in  $c$ . However, *trust decrease* and  $c$  are directly related:

$$c = \bar{t} - td \cdot \bar{nd} \quad (1)$$

where  $c$  is the level at which trust is cut,  $\bar{t}$  is the average level of trust between an investor and an entrepreneur,  $td$  is the parameter level of *trust decrease*, and  $\bar{nd}$  is the average number of disappointments tolerated. It is decided to only study the impact of trust decrease further (see section EINFUEGEN).

#### 4.4 Trust decrease

The effect of the size of each decrease in trust each time an investor is disappointed –  $tr2$  – will be analyzed and interpreted in detail in section EINFUEGEN. In particular, its effect on investors' return and entrepreneurs' chance of voluntary exit will be studied.

The effect of  $tr2$  on the average duration of an investment is nonlinear: For low levels, the duration of investment is much longer than for intermediate or high levels (see fig. 14). The effect on total trust is also nonlinear. The *larger* decreases in trust, the larger the proportion of entrepreneurs who exit the angel market segment voluntarily (see fig. 15). This somewhat counterintuitive result will be analyzed in section EINFUEGEN.

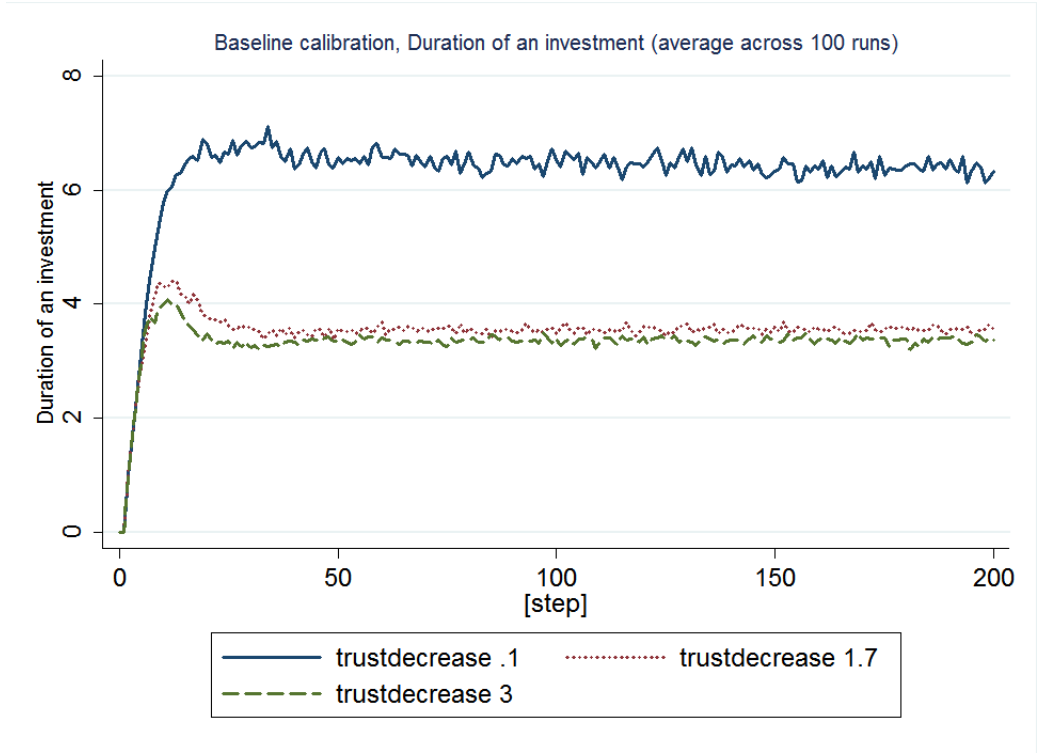
#### 4.5 Trust increase

The effect of the size of increases in trust when an investor is satisfied  $tr1$  is essentially the same in size as the one for  $tr2$ , but in the opposite direction. Even the nonlinearities remain. The only difference is that there does not seem to be an effect of  $tr1$  on the proportion of entrepreneurs who leave the market voluntarily.

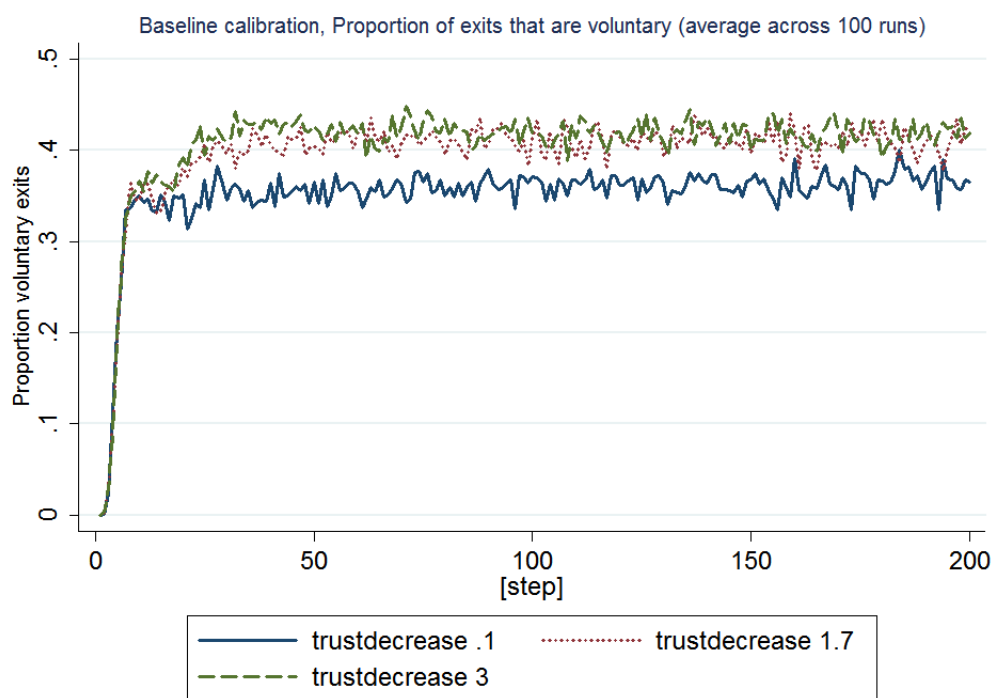
### 5 Behavior of entrepreneurs

#### 5.1 Adaptation speed

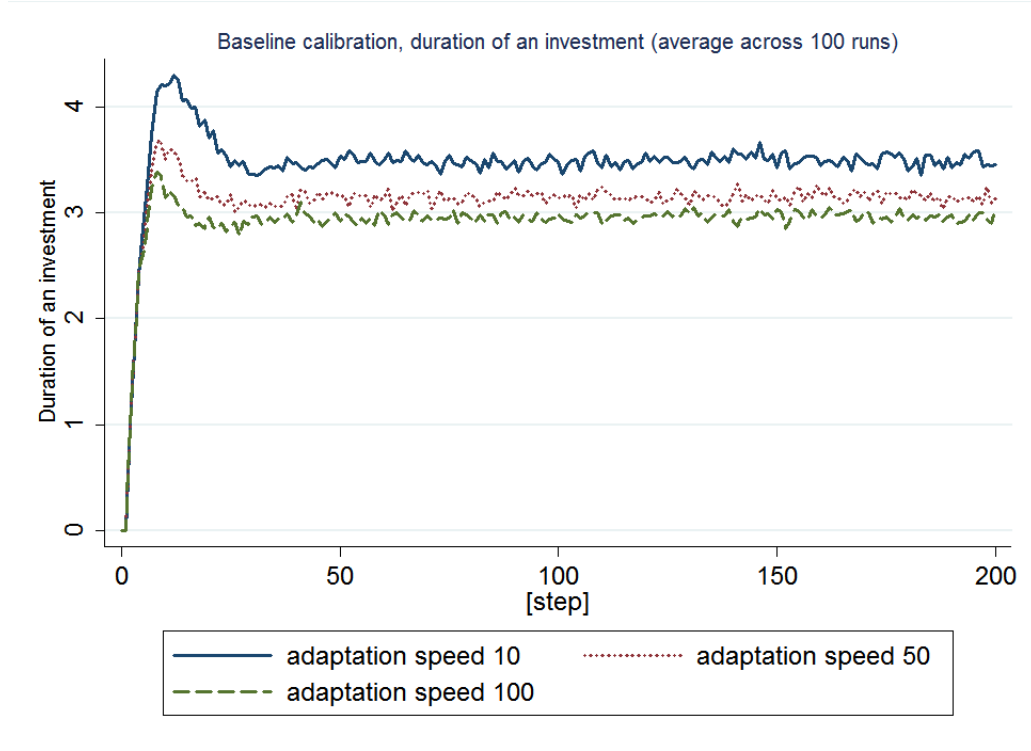
The level of adaptation speed only has an impact on market outcomes when very large values that are far away from the baseline value of 5 are compared, and even then its effect is rather small compared to that of the other parameters.



**Figure 14** – Effect of size of decreases in trust on average duration of investment



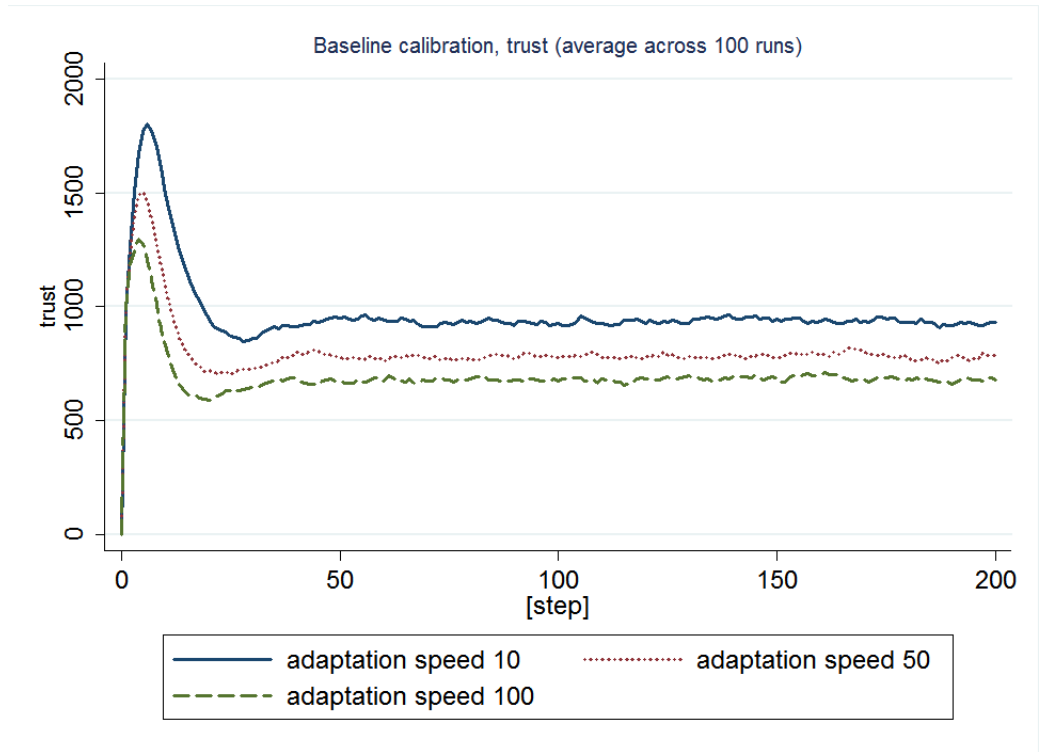
**Figure 15** – Effect of size of decreases in trust on proportion of entrepreneurs who exit the angel segment voluntarily



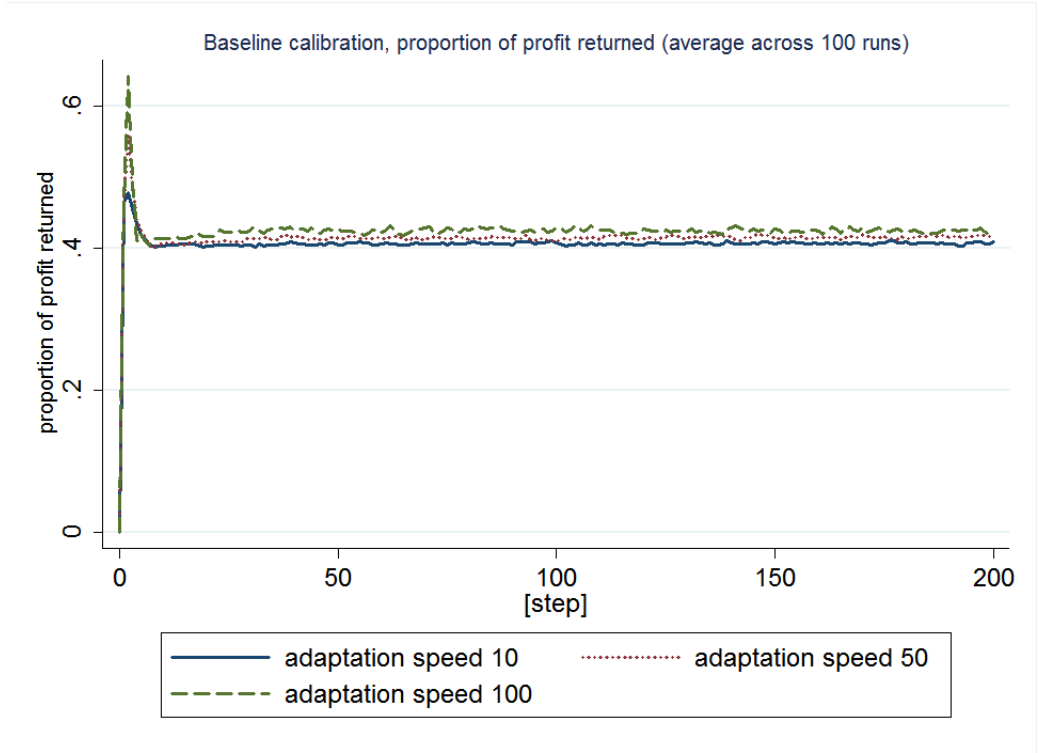
**Figure 16** – Effect of adaptation speed on average duration of investment

When entrepreneurs adapt their decision rules in large steps, duration of investment is somewhat shorter (see fig. 16). This is probably because a larger specialization occurs in, on the one hand, entrepreneurs who pay a lot of interest and receive funding mostly from investors, and, on the other hand, entrepreneurs who do not pay interest, do not receive funding and finance themselves. Investors get disappointed by those who suddenly pay a lot less interest compared to those who suddenly pay much more and cut links to them. This mechanism is also reflected in total trust in the market (see fig. 17). It is not even offset by the fact that on average, entrepreneurs pay out a *larger* proportion of their profit as interest to investors when the adaptation speed is high (see fig.18).

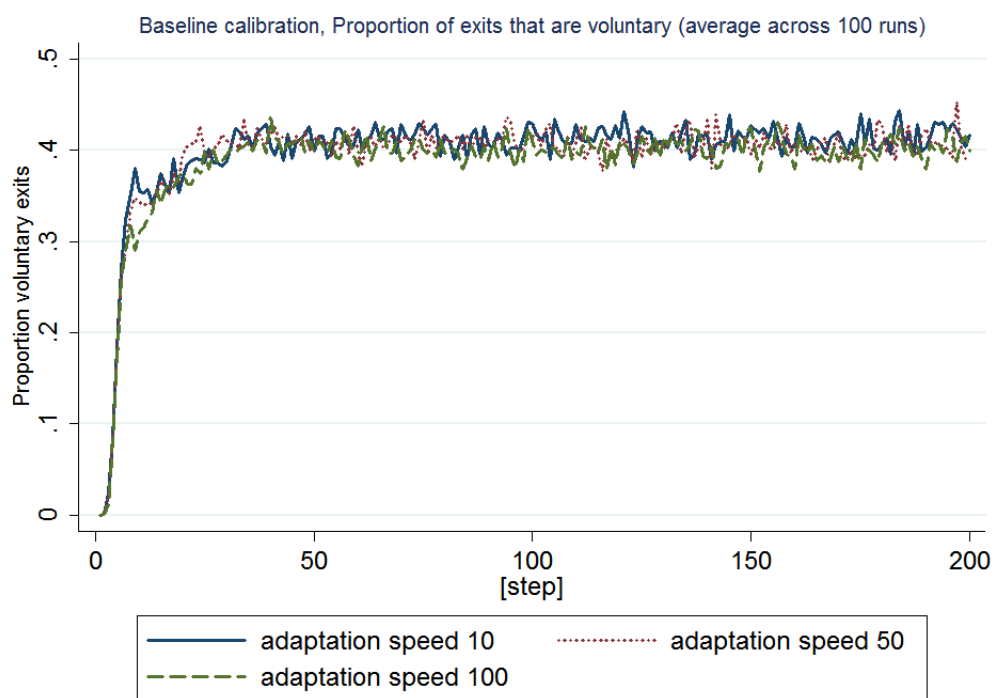
For the entrepreneurs' own wellbeing, measured in terms of proportion of links cut by entrepreneurs and proportion of voluntary exits (see fig.19), it does not seem to matter whether the entrepreneurs adapt quickly or not.



**Figure 17** – Effect of adaptation speed on total trust

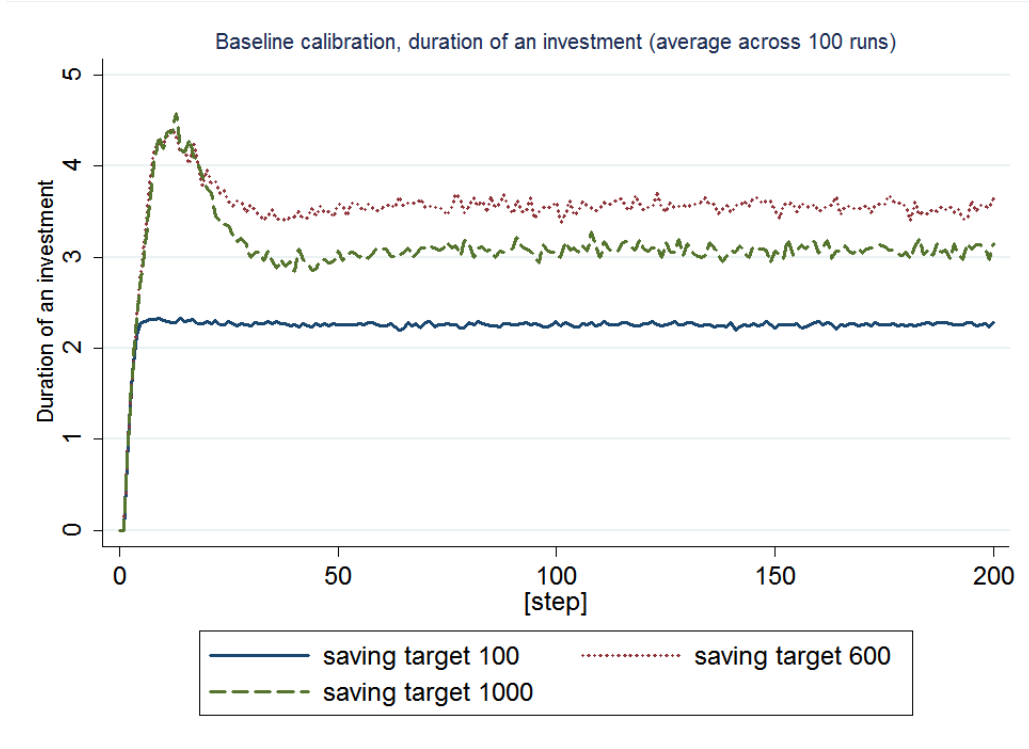


**Figure 18** – Effect of adaptation speed on proportion of entrepreneurs’ profit paid as interest to the investors



**Figure 19** – Effect of adaptation speed on proportion of entrepreneurs that leave the angel segment voluntarily.

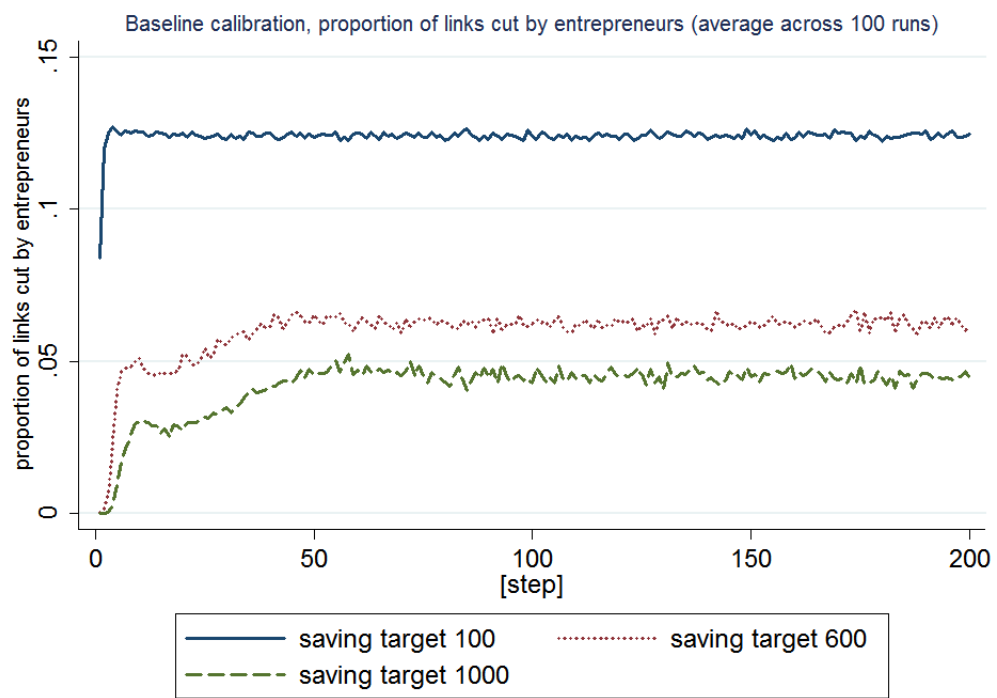




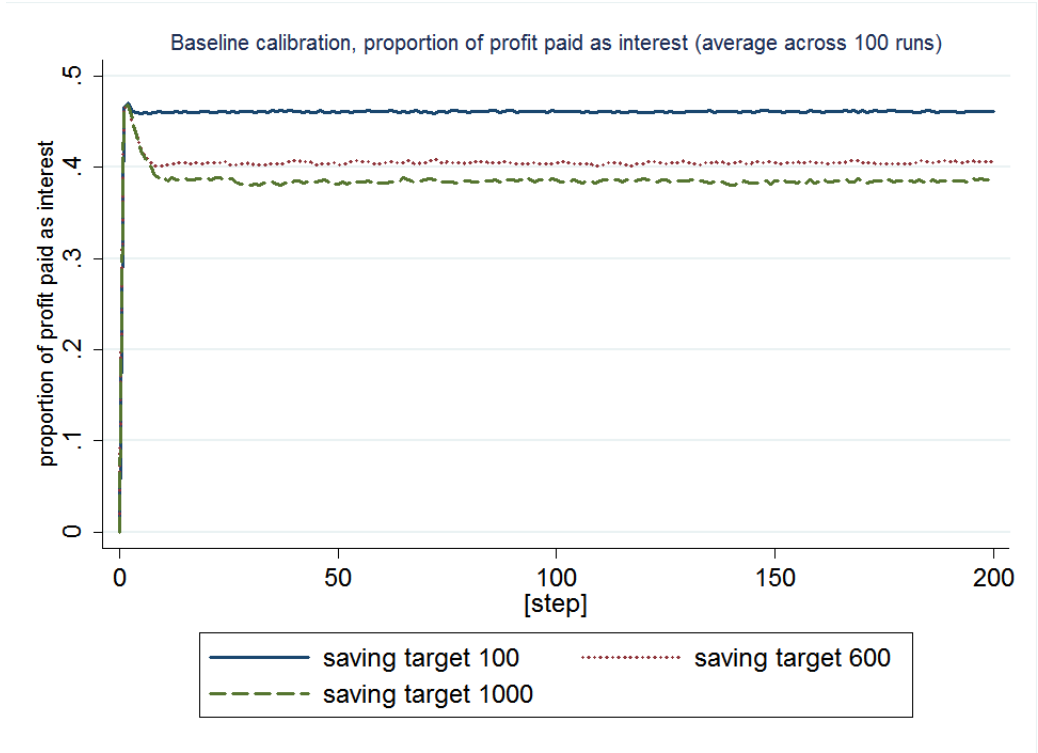
**Figure 20** – Effect of saving target on average duration of investment

## 5.2 Saving target

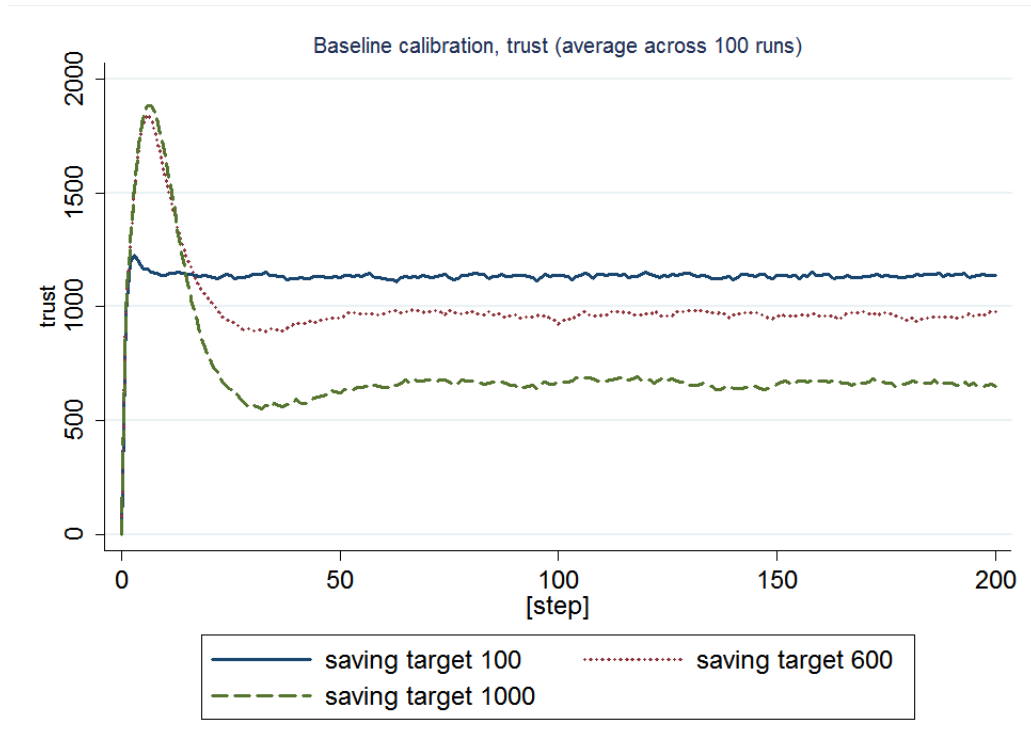
The saving target is the amount of capital that entrepreneurs have to accumulate before they are able to leave the angel segment of the market and can e.g. access the venture capital segment. The average duration of investment is longest for a medium level of the saving target (see fig. 20). For the low level, entrepreneurs reach the saving target quickly and end the relationship. For a high level of the saving target, the relationship is terminated more often by the investor (see fig.21). This is because the proportion of profit paid as interest to the investors declines with the saving target (see fig.22): Over time, entrepreneurs pay less, receive less from the investors as a consequence, and finance production more and more out of their own capital. Investors become disappointed with the “older” entrepreneurs because they pay less interest than the younger ones, trust declines (see fig.23), and so the links to older entrepreneurs are cut, which causes an overall average shorter duration of investment. As was to be expected, the proportion of ex-



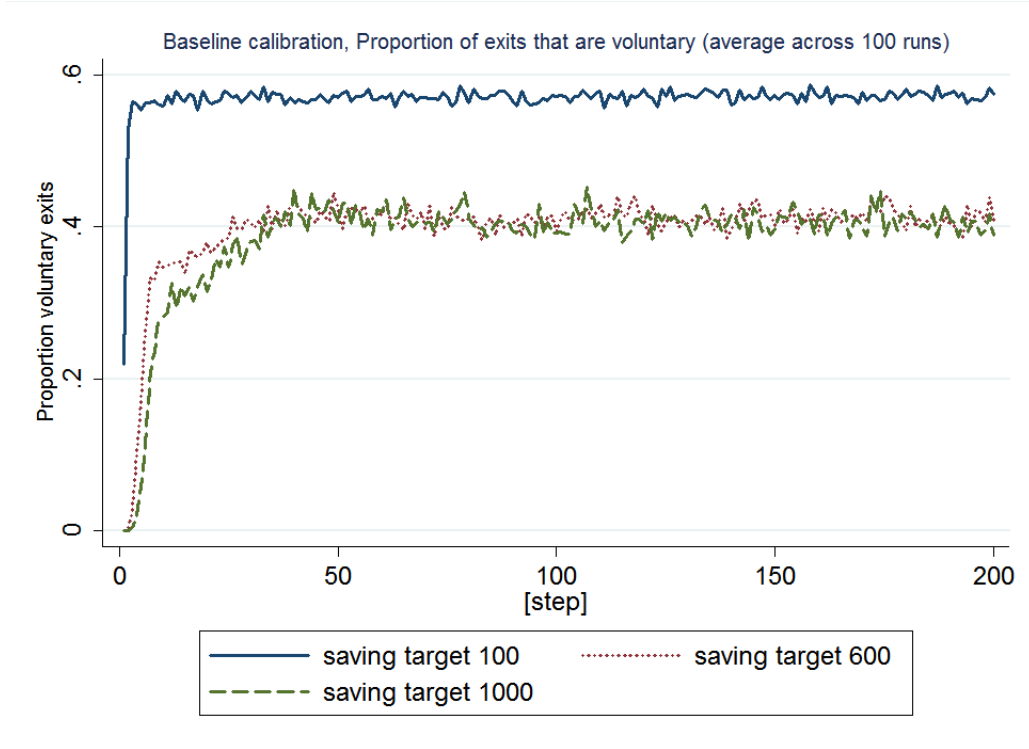
**Figure 21** – Effect of saving target on proportion of links cut by the entrepreneur



**Figure 22** – Effect of saving target on proportion of entrepreneurs’ profit that is paid to the investors



**Figure 23** – Effect of saving target on overall trust

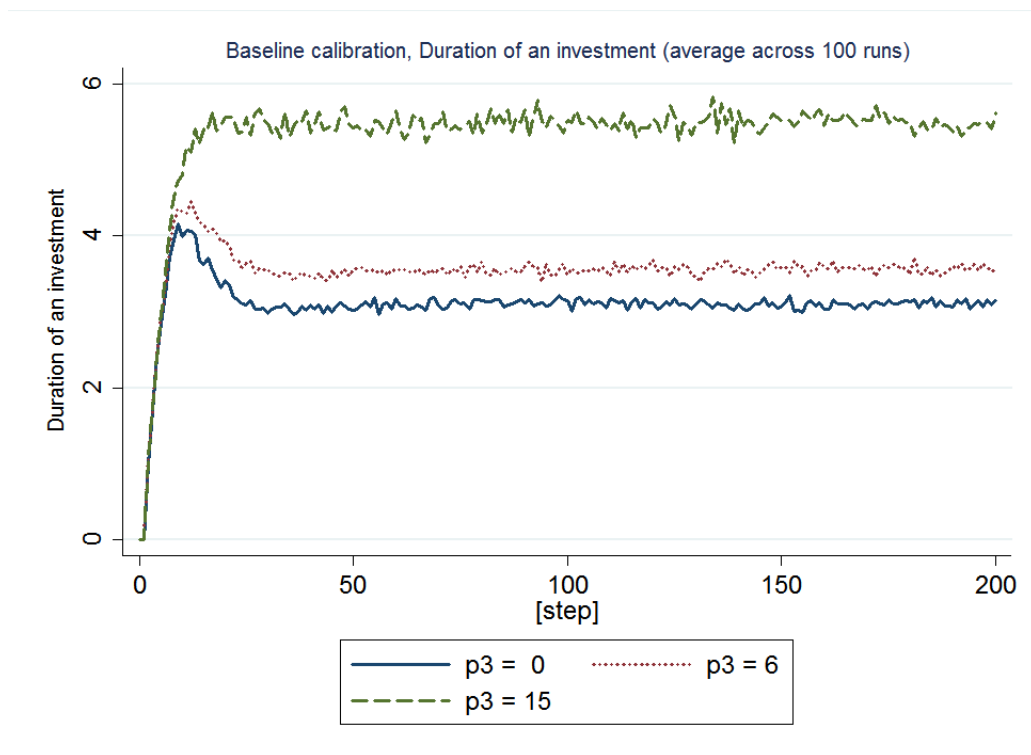


**Figure 24** – Effect of saving target on proportion of voluntary exits

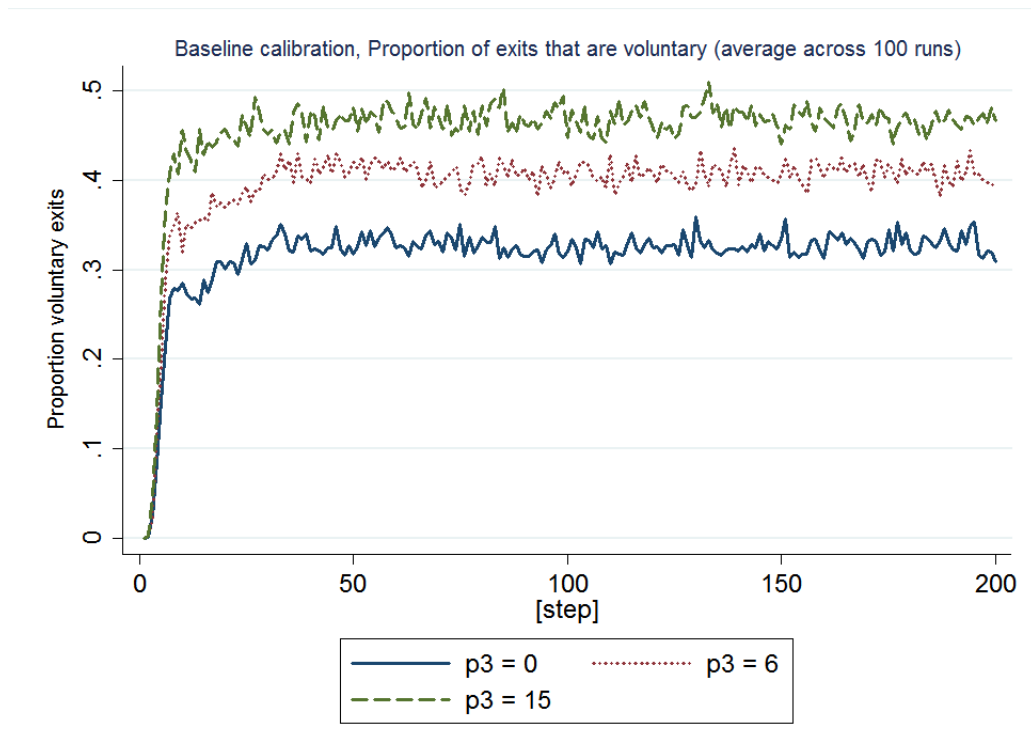
its by entrepreneurs that are voluntary and do not constitute a bankruptcy declines with the saving target. The effect is highly nonlinear (see fig. 24).

### 5.3 $p_3$

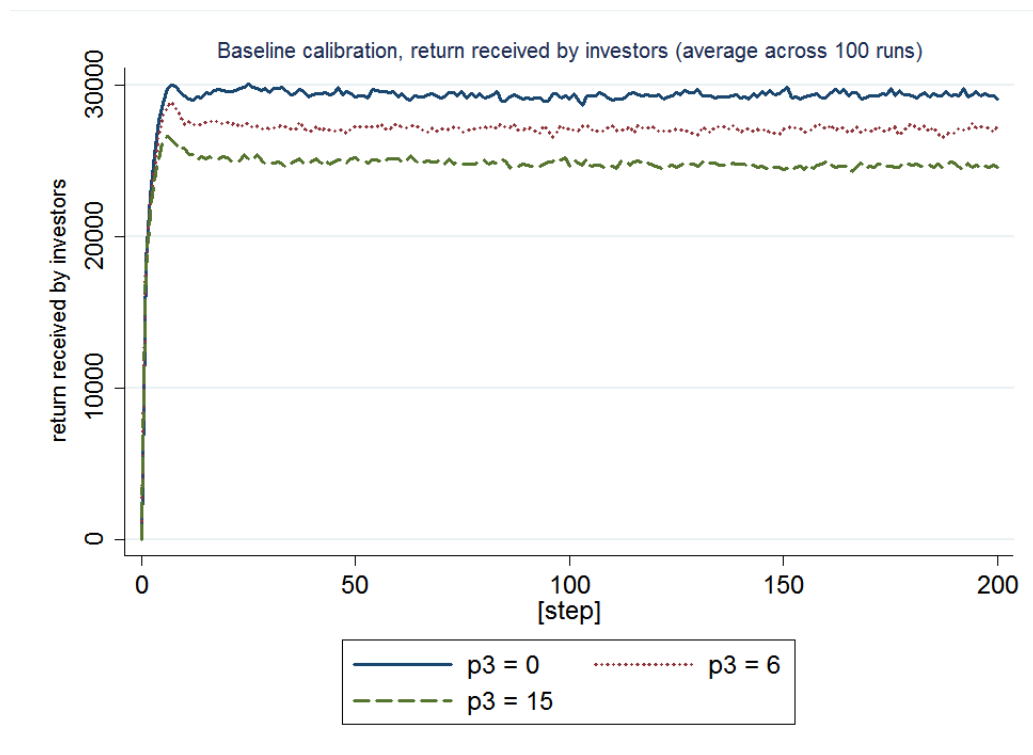
The minimum consumption  $p_3$  serves as a safety buffer to entrepreneurs:  $p_3$  is retained and added to private wealth while only the remainder of profit is split up between interest payment to the investors and their own investment into the business next period. The larger the safety buffer, the less likely it is for entrepreneurs to go bankrupt in any given period. Duration of investment is longer (see fig. 25) and the proportion of voluntary exits is higher (see fig. 26). Although investors receive less absolute interest payment (see fig. 27), their trust is higher when  $p_3$  is high because all entrepreneurs survive longer and so trust can accumulate (see fig. 28).



**Figure 25** – Effect of  $p3$  on average duration of investment

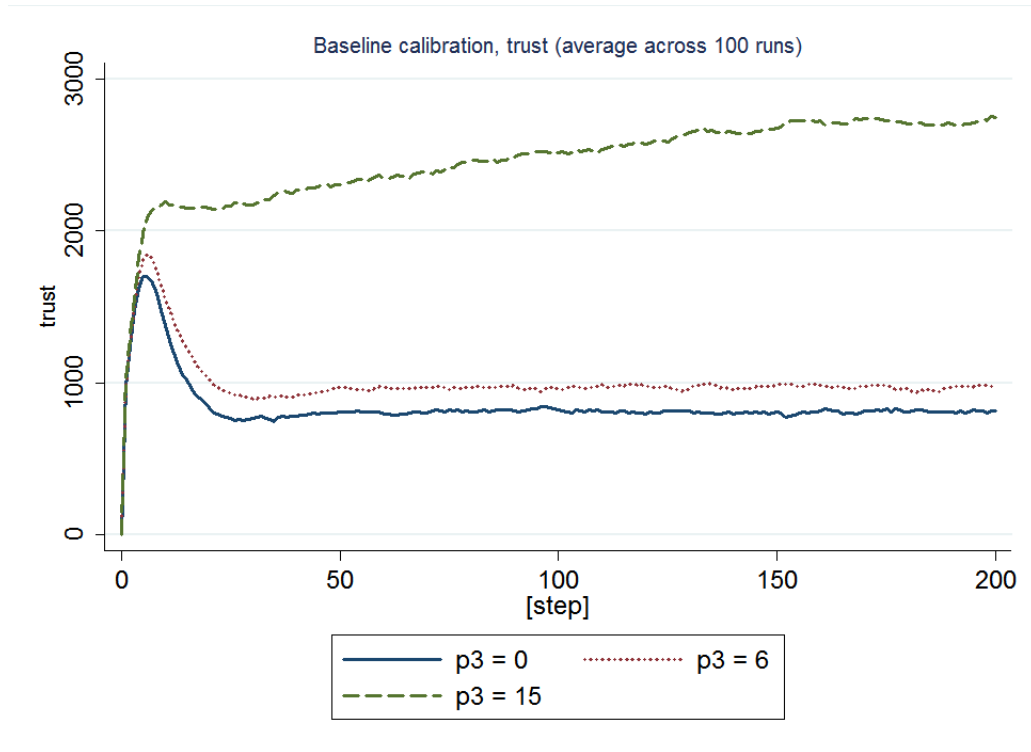


**Figure 26** – Effect of  $p3$  on proportion of entrepreneurs who leave the market voluntarily



**Figure 27** – Effect of  $p3$  on absolute return of investors





**Figure 28** – Effect of  $p3$  on total trust

## References