Team Size and Effort in Start-Up-Teams – Another Consequence of Free-Riding and Peer Pressure in Partnerships*

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Abstract

Start-Up-Teams are almost always small and very often consist of no more than three members. Why is this? We argue that founders choose the size of their start-up-team in order to economize on the effort costs of teams. We develop a model to analyse the relationship between effort and team size. Free-riding and peer pressure, both have an effect on the effort level, however in different directions and their magnitude depends on the size of the team. The theoretical implications of our model are twofold. First, given the particular business situation of a start up we expect an optimal team size with regard to effort and second, this optimal team size should usually be small in numbers. We test these implications based on a large data set on start-ups in the Cologne area. All implications are borne out in the data. Individual effort of the founders varies significantly with team size and we clearly identify a maximum which is on average given with three team members.

Keywords: Team Size, Peer Pressure, Free riding, Start-up Teams

JEL Classification: M5, M13, M21

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Introduction

Economic theory tells us, on the one hand, that a person who partly owns a firm chooses the efficient effort level to maximise the value of his or her firm. According to Jensen and Meckling (1976) efficiency is achieved, if ownership and residual rights belong to the same person. Since in a partnership the partner is a residual claimant and decision maker, efficiency should be reached and no agency problems like moral hazard should be found. On the other hand, partnerships like any other team may be faced with free-riding problems since partnerships use profit sharing plans to avoid shirking, but each partner only receives 1/N of the benefit created by their additional efforts (Demski, 1972). So the individual partner has an incentive to work less than the efficient level.[1] However, Kandel and Lazear (1992) argue that free-riding may be successfully counterbalanced by peer pressure, i.e. an action taken by one of the partners that raises the cost of a reduction in individual effort to the other partners. So far there is no answer as to which of the two effects dominates. We argue, that for the joint effect of free-riding and peer pressure the number of partners is an important issue, because not only the free rider effect depends on *N* but also the peer pressure effect. While the effort level decreases in N due to the free-rider effect, it increases in N due to the peer pressure effect (given a few well specifiable circumstances). Analyzing the typical situation in start-ups we argue, that effort should be concave in N with a maximum at a relatively small team size.

Although there is quite an extensive literature on peer pressure and free-riding in partnerships or[2] on start-up teams, the joint effect of free-riding and peer pressure depending on partnership size has never been analysed – despite some rather obvious facts that should raise these questions. There are typical patterns in size of ownership teams, e.g. medical practices are usually small whereas consulting firms are very often large.[3] In contrast, if we do not look at established companies but at newly founded firms, the teams are usually very small, independent of the industry sector. This should be particularly surprising since over and over again empirical analyses have shown that financial as well as working hour constraints are two of the major problem of start-ups. Both problems could easily be solved, with an increase in the number of partners. However, what we observe are small start-up teams, even in cases where those problems are severe. A first empirical result pointing at the problems of teams

1 Adams (2003) shows, that the existence of the free-riding effect is crucially dependent on the assumption on the production function. In particular, if worker effort levels are complementary, effort levels can increase with the number of partners. His empirical results suggest that the incentives increase with firm size, at least for small firms.

2 Many papers are based on the results of Kandel and Lazear 1992, e.g. Barua, Lee and Whinston 1995, Barron und Paulson Gjerde 1997, De Aghion 1999, Austen-Smith 2002.

that might rise with size is found in the empirical study of Brüderl, Preisendörfer and Ziegler (1996: 188f.), although not much attention is given to the result. They find that the proportion of start-up firms with strong interpersonal conflicts rises in *N* and they argue that it is due to personal conflicts about working hours. Cooper, Gascon and Javier (1995) find, that despite some very obvious advantages of team start-ups their survival is not higher then that of single person foundations. Personal conflicts again are assumed to be the reason.[4]

However, these personal conflicts do not suffice to explain the huge differences between the number of partners in start-up firms and established partnerships. We assume that unlike established partnerships, founder teams are characterized by a particular communication structure between the team members and by a close and steady personal interaction. Founders in the service sector typically work in one or a few offices side by side; in manufacturing they may start in a garage, a big hall or small lab. Due to this spatial closeness and the requirement to continually take fast and often fundamental decisions, they constantly interact (informal, formal or random) and stay in close personal contact. We build on this special feature of start-up teams and analyse its impact on peer pressure and the joint effect of peer pressure and free-riding depending on the size of start-up teams. Thus, it is argued that the strength of peer pressure depends on the "monitoring technology" used in teams. Unlike many established partnership, start-ups are characterized by close personal and frequent interactions which in turn lead to a strong peer pressure effect that heavily increases with the first additional partners added, levelling off with every additional partner very soon.

Our aim is to analyze how peer pressure and free-riding influence the effort decisions in start-up teams, particularly with regard to the impact of team size on effort. Kandel and Lazear (1992) argue that free-riding may be counterbalanced by peer pressure. In their paper the level of peer pressure is exogenous and not dependent on *N*. In contrast, we argue in our paper that peer pressure depends on *N*. Therefore, effort depends on *N*, i.e. the individual effort of each member of the team is a function of *N*. To analyze the effect of free-riding as opposed to peer pressure, regard the simple case of a single person venture: neither a free-rider effect nor a peer pressure effect exists. If we look at a venture with two or more partners both effects exist and interact and result in an optimal effort for each partner. Absent specific assumptions taking into account the typical situation in start-ups it is not obvious whether peer pressure dominates free-riding or vice versa. Thus, we introduce several start-up-assumptions and

[3] An explanation of why partnerships are dominant in service industries but not in manufacturing is given by Levin and Tadelis 2004.

thereby model the two diverging effects of team size on the effort of partners in start-up teams.

Furthermore, there is little empirical research on effort in start up teams and the effect of peer pressure and free-riding on effort in start-ups has never been studied. Our study analyses the combined effects for the first time. Our empirical work is based on 790 start ups in and around Cologne. We use several econometric models to analyse the relationship between effort and team size. As a dependent variable we use the actual weekly working hours a founder works in his or her start-up. The major explanatory variable in our model is a start-up's team size, which was operationalised by the number of partners who founded the new venture. Our results show a significant concave relationship between team size and individual effort, i.e. effort *increases* with the number of founders up to a particular team size but then *decreases* with additional founders. A maximum level of effort is observed with approximately three individuals founding a new business.

The rest of the paper proceeds as follows. Section 2 presents a theoretical analysis of the relationship between free-riding and peer pressure. In Section 3 we introduce our dataset and present econometric evidence on the relationship between team size and individual effort. In Section 4 we summarize our results.

1. Theoretical Analysis of Team Incentives

The problem of free-riding in team production when team members agree to share the output has frequently been analysed theoretically (Alchian and Demsetz, 1972; Holmström 1982), and empirically (e.g. Bailey, 1970 and Newhouse, 1973). However, most of the research concentrates on the effect of different compensation schemes.[5] Frequently, team production and especially free-riding are analysed in a standard principal agent world. In contrast, Kandel and Lazear (1992) analyse team work in partnerships, i.e. in a group of profit sharing owners. In a partnership every member makes his or her contribution to the team output and possibly monitors the other team members and earns $1/N$ of the team output.[6] In their seminal paper Kandel and Lazear model the interaction of free-riding and peer pressure effecting

4 See also Birley and Stockley (2000) or Lechner and Gemünden (2002).

5 McAfee and McMillan, 1991; and for a short survey on the team production literature see Prendergast, 1999: 39-44; or Kräkel, 1999: 39ff and 213ff.

6 Compare Steiner (2000) for a comprehensive analysis of partnerships.

partnerships and conclude that peer pressure can counterbalance the effect of free-riding. Our analysis is based on the Kandel and Lazear model and specifies their mutual monitoring by introducing a particular monitoring technology.

2.1 A Simple Model of Team Incentives

Consider a start-up company with N homogenous partners i *(i=1, ..., N),* , who share their team output by profit sharing $1/N$.[7] Each partner chooses an effort level e_i with $C(e_i)$ as cost function, such that $\frac{\partial C(\cdot)}{\partial e_i} > 0, \frac{\partial^2 C(\cdot)}{\partial^2 e_i} > 0.$ Individual effort is not observable. Team output is a function of each worker's individual effort, given by $f(e)$. To provide a reason for partnerships, we assume that $f(e)$ is not separable in e_i. We specify the production function as follows,

$$f(e) = f\left(\sum_{i=1}^{N} e_i\right)$$

so that team size can vary without a change in production technology. The partial derivative on i's effort is positive and there are diminishing returns in i's effort, $\frac{\partial f(\mathrm{e})}{\partial e_i} > 0$, $\frac{\partial^2 f(\mathrm{e})}{\partial^2 e_i} < 0, \forall i.$

Thus, each partner receives $f\left(\sum_{i=1}^{N} e_i\right)/N$.[8] Further, we assume that effort levels are not complementary (the output of total effort is no more than the sum of outputs of individual efforts). If this was not assumed, effort levels could increase with the number of partners despite the existence of free-riding as is shown by Adams (2002). Thus, we isolate free-riding and peer pressure.

Each partner wants to maximize his utility, that means his share of the output minus his costs of effort

$$u_i^{FR}(e_i) = \frac{f\left(\sum_{i=1}^{N} e_i\right)}{N} - C(e_i) \to \max_{e_i}!$$

with first-order condition for partner i

$$\frac{\partial u_i^{FR}(e_i)}{\partial e_i} = \frac{1}{N}\frac{\partial f(\cdot)}{\partial e_i} - C'(e_i) = 0\,.$$

7 The model follows Kandel and Lazear (1992).

8 Profit sharing is typical for partnerships, compare e.g. Farrell and Scotchmer (1988) or Steiner (2002)

e_i^{FR} solves this condition. Since the cost function is convex, e_i^{FR} is lower than the efficient level. The efficient solution requires that the total surplus is maximized, so that the first order condition would be $\frac{\partial f(\cdot)}{\partial e_i} - C'(e_i) = 0$. Consequently, the effort level falls short the efficient level as a result of profit sharing and this reaction increases with *N* (proposition 1) as is shown for example by Barua, Lee and Whinston (1995:500).

Proposition 1 $e_i^* > e_i^{FR}$. *The free-riding effect increases with team size N.*[9]

In a start up company each partner knows this free-rider problem. So everybody knows, that everybody works less than the efficient level, i.e. less than in a company owned by a single partner. Hence, each partner wants the other partners to choose a higher than their individually optimal "free-rider" effort level. However, if efforts are non observable and a non-separable production function is assumed, monetary incentives introduced by an alternative compensation scheme (other than even profit sharing) cannot be used to solve the problem (see Kandel and Lazear, 1992:804). Thus, peer pressure seems to be a good alternative as is argued by Kandel and Lazear.[10]

2.2 Peer Pressure

Kandel and Lazear (1992) theoretically analyse peer pressure in partnerships. They list two conditions for peer pressure being effective as a motivational device (p. 805f): First, the effort choice of team member i affects the utility of the other team members. So the rest of the team has an incentive to exert pressure on *i*. Given profit sharing, this condition is fulfilled. Second, each team member has the ability to affect the choices of *i*.

Following Kandel and Lazear, peer pressure counteracts to free-riding in the following way. Peer pressure is a function of the own effort choice e_i and of an established group norm of

9 This proposition is yet proved, see for example Barua, Lee and Whinston (1995:500).

10 Contract theory tells us, that peer pressure can only exists, if the actions of the group members are observable within the team, but not verifiable. That means, that the effort levels can not be proved by a court and therefore an incentive contract can not be based on this effort levels.

effort $\bar{e}$: $P_i(e_i, \bar{e})$. The peer pressure, that i feels, decreases in his effort, $\frac{\partial P_i(\cdot)}{\partial e_i} < 0$, but with a diminishing effect, $\frac{\partial^2 P_i(\cdot)}{\partial^2 e_i} > 0$. Now, the maximization problem of team member i is[11]

$$u_i^{PP}(e_i) = \frac{f(\cdot)}{N} - C(e_i) - P_i(e_i, \bar{e}) \to \max_{e_i}!$$

with first order condition

$$\frac{\partial u_i^{PP}(e_i)}{\partial e_i} = \frac{1}{N}\frac{\partial f(\cdot)}{\partial e_i} - \frac{\partial C(e_i)}{\partial e_i} - \frac{\partial P_i(e_i, \bar{e})}{\partial e_i} = 0. \tag{1}$$

The level of effort e^{PP} that solves this first order condition exceeds the level of effort in the case without peer pressure. Peer pressure acts like an additional cost of effort, which can be manipulated by an individual i's own effort choice. The more i works, the less peer pressure he feels.

Proposition 2 *In comparison to a situation with free-riding only, the effort level chosen under free-riding and peer pressure is higher,* $e^{PP} > e^{FR}$.

With peer pressure the effort level is higher than in the case without. A proof of this proposition can be found in Kandel and Lazear (1992:805). So, peer pressure acts as a counterbalance to free-riding.

It is well known that the team size drives the free-rider effect. However, what drives peer pressure is not obvious. We argue in the next section, that the peer pressure effect is driven by the monitoring technology used in a team and show that mutual monitoring in small ownership teams heavily depends on N.

2.3 Mutual Monitoring

In addition to the effort choice, now each team member can monitor other team members by an action a_i. These monitoring actions have no direct effect on output (neither positive nor negative). However, these actions require additional attention and concentration. Thus there is

11 Sociologists call this kind of peer pressure guilt, because there is no external pressure, i.e. a team member feels guilty although no one observes his effort choice. For more details see Kandel and Lazear (1992: 806-809).

a cost to taking action a_i. So we redefine the cost function as $C(e_i, a_i)$, with $\frac{\partial C(\cdot)}{\partial a_i} > 0$ and $\frac{\partial^2 C(\cdot)}{\partial^2 a_i} > 0$.

In start-up companies these monitoring actions are typically a result of personal interactions between the partners. Team members usually work close to each other, e.g. in rooms located next to each other or just in the garage of one of the partners or in a start-up center or else. Frequent meetings are typical for start-ups, not only due to the spatial closeness, but also due to a constant need of decision taking and coordination due to an often highly volatile environment. Accordingly, the founders have many possibilities to monitor each other along the way because of these intensive interactions and the extensive informal exchange of information. So peer pressure in this special set up results from the probability of being discovered by a peer while working lazy and withholding effort. Our interpretation of the nature of peer pressure is backed up by experimental evidence of Sausgruber (2003) and Falk and Ichino (2003). Sausgruber finds that team members contribute more to their team's project when they observe each others' performance and discriminates team spirit induced by mutual peer pressure as a cause for this result. Falk and Ichino obtain clean evidence on the way peer pressure works in a field experiment. In one treatment the test person works in front of others, so any person can observe any time what other team members are doing. For this treatment – as opposed to a treatment where there is no personal interaction - they find strong evidence on peer pressure having a positive effect on effort. However, in their paper they do not present a formal model as to how peer pressure is generating this effect. We want to close this gap and show how a mutual monitoring technology that generates peer pressure can be modeled.

We assume that the peer pressure a partner i feels increases if another partner j raises his monitoring action a_j but at a decreasing rate. That means if there is already a large amount of information about i's work available, adding more information has only a small influence on the peer pressure he already feels. In line with this argument we adjust the peer pressure function, $P_i(e_i, \bar{e}, a_{-i})$ with $\frac{\partial P_i(\cdot)}{\partial a_j} > 0$, $\frac{\partial^2 P_i(\cdot)}{\partial^2 a_j} < 0$ and $\frac{\partial^2 P_i(\cdot)}{\partial a_j \partial e_i} < 0$. So, the incentive not to shirk is higher, the higher are the monitoring actions. That is reasonable because the probability for being discovered is higher if the monitoring actions rises. As a consequence the incentive to reduce peer pressure by showing higher effort increases. The maximization problem is then

$$u_i^{MM}(a_i,e_i)=\frac{f(\cdot)}{N}-C(e_i,a_i)-P_i(e_i,\bar{e},a_{-i})\rightarrow \max_{e_i,a_i}!$$

Peer pressure explicitly depends on the other's monitoring actions and represents the disutility that *i* feels. In order for the monitoring action to have an impact on the effort decision, we assume, that the monitoring actions are chosen first and that the effort decisions are made after. To solve this sequential structure, we work backward.

Stage 2: choice of e_i

$$\frac{\partial u_i^{MM}(\cdot)}{\partial e_i}=\frac{1}{N}\frac{\partial f(\cdot)}{\partial e_i}-\frac{\partial C(\cdot)}{\partial e_i}-\frac{\partial P(\cdot)}{\partial e_i}=0 \tag{2}$$

Stage 1: choice of a_i

$$\frac{\partial u_i^{MM}(\cdot)}{\partial a_i}=\frac{1}{N}\sum_{j,j\neq i}\left(\frac{\partial f(\cdot)}{\partial e_j}\frac{\partial e_j}{\partial a_i}\right)-\frac{\partial C(\cdot)}{\partial a_i}=0 \tag{3a}$$

Condition (3a) determines the choice of the monitoring action. The reaction of the other partners *j* to the chosen monitoring level a_i in regard to their effort choices e_j is included. Each partner knows how the other team members respond. In this framework many equilibriums may exists. We just analyse the symmetric equilibrium.

Lemma 1 A symmetric equilibrium with $e_1 = e_2 = ... = e_n$ und $a_1 = a_2 = ... = a_n$ exists.

If such a symmetric equilibrium exists, then $e_i = e_j$ is the best answer to $(e_1 = e_2 = ... = e_j)$ and analog $a_i = a_j$ is the best answer to $(a_1 = a_2 = ... = a_j)$. Given the effort and monitoring choices of the other partners (e_{-i} und a_{-i}) group member *i* maximizes his utility.

Stage 2 The first order condition (equation (2)) does not change. Every partner has the same cost function and the same peer pressure function, and therefore they all choose the same effort level e_i^{M*}.

Stage 1 The first order condition changes to

$$\frac{\partial u_i^{MM}(\cdot)}{\partial a_i} = \frac{1}{N}\left[\frac{\partial f(\cdot)}{\partial e_1^{M*}}\frac{\partial e_1^{M*}}{\partial a_i} + \frac{\partial f(\cdot)}{\partial e_2^{M*}}\frac{\partial e_2^{M*}}{\partial a_i} + \ldots + \frac{\partial f(\cdot)}{\partial e_{N-1}^{M*}}\frac{\partial e_{N-1}^{M*}}{\partial a_i}\right] - \frac{\partial C(\cdot)}{\partial a_i}$$

$$= \frac{N-1}{N}\frac{\partial f(\cdot)}{\partial e_j^{M*}}\frac{\partial e_j^{M*}}{\partial a_i} - \frac{\partial C(\cdot)}{\partial a_i} = 0 \tag{3b}$$

From (3b) it follows that an equilibrium exists, in which all members choose the same monitoring action a_i^{M*}. Referring to the special situation in a start-up team this means for example that all partners participate in the same meeting or work in the same room. Thus, partner *i* solves the following problem[12]

$$u_i^{M*} = \frac{f(\cdot)}{N} - C(e_i, a_i) - P(e_i, (N-1)a_j) \rightarrow \max_{e_i, a_i}!$$

By using the implicit function theorem we can figure out, how team member *j* reacts by his effort choice e_j to the monitoring action of member *i*, a_i, in the equilibrium. Therefore, we differentiate condition (2) to a_i, because the problem is symmetric over all partners.

$$\frac{\partial e_i}{\partial a_i} = -\frac{-\frac{\partial^2 P_i(\cdot)}{\partial e_i \partial a_i}}{\frac{1}{N}\frac{\partial^2 f(\cdot)}{\partial^2 e_i} - \frac{\partial^2 C(\cdot)}{\partial^2 e_i} - \frac{\partial^2 P(\cdot)}{\partial^2 e_i}} > 0 \tag{4}$$

The numerator is positive and the denominator is negative, so that equation (4) is positive. As a result, additional monitoring increases the level of effort (as in Kandel and Lazear 1992: 812).

2.4 Team Size and Mutual Monitoring

Following Kandel and Lazear (1992) we have shown that in our model too, peer pressure has a positive effect on the choice of effort. The question, whether there is a systematic interaction between team size and the level of monitoring is still open. We argue, that the number of team members (monitors) seems to be crucial. If more partners control the others, the probability of being discovered while shirking rises. If more partners participate in a meeting, the probability of being discovered increases because each partner is monitored by more partners and the monitoring costs are still the same for each partner, because they all sit in the same meeting or same office floor. However, we assume that the marginal effect of team size

[12] If $N \rightarrow \infty$, (3b) nearly equals $\frac{\partial f(e)}{\partial e_j}\frac{\partial e_j}{\partial a_i} - \frac{\partial C(\cdot)}{\partial a_i}$, because the cost function is independent of *N*.

decreases with the number of partners, because the additional information that may be revealed by adding an additional partner (monitor) can be assumed to be limited. This translates into our model as follows:[13]

Proposition 3 *Mutual monitoring increases in the number of partners,* $\frac{da_i}{dN} > 0$.

$$(5)$$

To derive this result, we assume that the peer effect is decreasing, $\frac{\partial^2 e_j}{\partial^2 a_i} \leq 0$. That means, that the monitoring action has a positive but decreasing effect on effort.

Proof : *A detailed derivation can be found in the appendix.*

Thus, the monitoring action a_i rises with the number of founders N.[14] This result is driven by the assumption, that the cost function does not depend on the team size. Consequently, the monitoring costs of each partner do not rise with the team size. This is plausible because the individual monitoring costs, e.g. for the participation in a meeting, are independent of the team size.[15]

2.5 Interaction of free-riding and peer pressure in start-up teams

At the beginning we considered the free-rider effect separately. The well-known effect of free-riding is that the effort level reduces. This reduction increases with the number of partners. On the other hand, we analysed the impact of peer pressure separately. Peer pressure counteracts to free-riding because the effort level rises due to peer pressure. We modelled a mutual monitoring to create peer pressure in a group of founders. Given the monitoring technology that we assumed, the monitoring action, i.e. the probability of being detected, rises with the number of the team members.

Lemma 2 The effort level depends on two counteracting effects whereas both effects intensify in *N*.

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[13] Also Kandel and Lazear (1992) discuss the effect of group size on mutual monitoring (p. 812f.) They argue, that the effect of the monitoring action on the effort choice is close to zero if $N \to \infty$. In contrast to them, we analyse the situation in start-up companies, which are founded by a small number of partners.

[14] It follows that given our mutual monitoring model the so called second order public good problem, as discussed in Steiner (200: 155-160) does not arise.

[15] Bowles, Carpenter and Gintis (2001) show in an experimental study that monitoring actions do not decrease in larger teams.

To figure out, how the effort level depends on *N*, we differentiate with regard to *N*.[16]

$$\frac{de_i}{dN} \gtrless 0$$

(6)

From this we cannot derive a unanimous prediction. Both, the free-riding effect and the peer pressure effect increase in the number of partners, but so far we cannot predict which effect dominates for which team size. To achieve a result about the relationship between effort and team size, we differentiate a second time.[17]

$$\frac{d^2 e_i}{d^2 N} < 0$$

(7)

This second order condition proves the following proposition.

Proposition 4 *The effort function is concave in N. Assuming an interior solution, there exists a maximum.*

Consequently, if an extremum depending on *N* exists, it is a maximum effort level.

This result allows the following interpretation of the relation between free-riding and peer pressure. Since, the function is concave, we have high monitoring returns in really small teams (e.g. if the team size rises from 2 partners to 3). The peer pressure effect dominates free-riding up to the maximum. After this critical team size the relation is vice versa, so the effort level diminishes because of the dominating free-rider effect.

Thus we can derive the following hypothesis for our empirical analysis. The effort level increases in team size, levels off, and then decreases with growing team size. There is an optimal team size *N** for which individual effort of every single team founder is highest.

16 A detailed derivation can be found in the appendix.

17 Again, a detailed derivation can be found in the appendix.

2. Data, Measurement Issues and Methodology

To test the implications the implications of our model on peer pressure in start-up-teams, we use a dataset of start-ups in the cologne area. The data set was collected in 1999 in a project on entrepreneurship in the Cologne area. They cover a representative sample of start-ups from 1992 to 1998.[18] Around two thirds of the start-ups are from the service industry; about a quarter is in retailing, and 13 percent is in manufacturing. Average turnover in the first year amounts to 728,000 Euros. The founders were predominantly male (79 percent) and on average 36 years old. Almost 35 percent of the start-ups were team start-ups. For each start-up, we have a 6-page questionnaire with a broad spectrum of questions on the founder and his or her personal background, the economic background of the start-up, it's financial situation, and it's production technology. Thus, we have a broad set of variables that can be used to test our hypotheses, including the size of the start-up's team and the weekly working hours each founder spends on the start-up (for more details on the Cologne Founder Study, see Backes-Gellner, Demirer, and Moog, 2000).

If our model is correct in explaining the effects of the monitoring technology in start-ups on peer pressure and it's joint effect with freeriding on effort in start-up teams, we should observe the following empirical pattern in our data:

Effort at first *increases* with the number of founders up to a certain maximum and then *decreases again* with the number of founders in a start-up-team (the peer pressure effect dominates the free rider effect in small start-up-teams and the free rider effect dominates the peer pressure effect in large start-up-teams).

Dependent and independent Variables

As a dependent variable we use the actual weekly working hours a team founder works in his or her start up. Thus we assume that hours worked is one of the crucial aspects of effort for the success of start-up teams.[19] Since our dependent variable "weekly hours worked in the start-up" is a metric variable, we use OLS-regression.
As our major explanatory variable we use the number of partners in the start-up-team.

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[18] The data were collected with financial support of the German National Science Foundation (DFG) under project number STE 628/5-1, the German Founder Bank (Deutsche Ausgleichsbank, DtA) and the Cologne Savings Bank. We thank Petra Moog and Güldem Demirer for introducing us into their dataset.

[19] We assume that start-ups's team menbers are on equal footing concerning financial issues (Mellewigt/Witt, 2002). And we assume that they are more or less equally efficient and productive given a certain amount of time they spend on the company, which is reasonable to assume because otherwise they would not have matched as a team on a profit-sharing basis.

Table 1 shows descriptive results on start-up's partnership size and the weekly working hours

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>table 1 around here

The average size of the start-up teams in our sample is 1,55 and average working hours are 51,1 hours per week. However, single person start-ups work less than average (49.2 hours) and if the number of partners in the start-up team increases to two, three or four team members working hours increase. But if start-up size increases to more than four team members, average working hours start to decrease. Thus, the descriptive results already indicate that effort at first *increases* in small ownership teams but then *decreases* again with the size of the start-up team.

However, this result may be the result of other intervening variables, such as the industry of the start-up or the age of the start-up, which we have to control for in the next step. According to standard entrepreneurship literature we use the industry (different underlying industry specific production functions), the economic background (year of founding, turnover, profits, take-over start-up) and demographic factors (age, sex) as major control variables (Barckham, 1990; Brüderl/Preisendörfer/Ziegler, 1996; Nerlinger, 1998; Hundley, 2000; Adams 2002) (cf. Table 2 for descriptive results).

>table 2 around here

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3. Empirical results

Table 3 displays the results of OLS-estimations using robust variance estimators with average weekly working hours as dependent variable.[20] In the first and second model we use a specification that includes team size variables only. We square the team variable in the second model to test for the non-linear impact of our explanatory variable. In the third and fourth

[20] Because of a wide spread of missing values in a number of variables the number of cases were substantially reduced in some of the regression models. To avoid distortions we use an embedded model with the same number of observations.

model we include a set of control variables to test the robustness of our estimations. In the fifth model we take out team-square again to test for the robustness of the non-linearity effect.

If we look at the results, we find that our hypothesis is born out in the data. Model one and model five which implicate a linear impact of team size on effort show no significant effects in the team size variable. Contrary, in model 2, 3 and 4 the positive coefficient of team size and the negative coefficient of team-size-square are highly significant, meaning that effort first *increases* with the number of founders up to a certain team size and then *decreases.* Furthermore, we find that the goodness of fit increases from model 1 to model 3 without having an effect on our explanatory variables. This indicates the high robustness of our estimations and the relevance of the non-linear, *concave* impact of team size on effort. Thus, we can conclude that the peer pressure effect dominates the free rider effect in small founder teams and the free rider effect dominates the peer pressure effect in larger founder teams.

To test whether our finding of a concave relationship between team size and effort is just predetermined by the specification of the regression function, we calculated an additional model which replaces "TEAM" and TEAMSQURE" with a set of team size dummies. These dummies are "TEAM_1", "TEAM_2", "TEAM_3", "TEAM_4" and "TEAM_5+" (Team size = 5 and more). The latter group ("TEAM_5+") is used as the reference group. Other than that, we include the same set of control variables as in Model IV and V. The results of this specification are given in Table 4.

>table 4 around here<

As can be seen, the *concave* relationship between team size and effort remains stable. The variables "TEAM_2" and "TEAM_3" are significant and the signs of the coefficients are positive. TEAM_1 and TEAM_4 are not significantly different from TEAM_5+. This means that teams with two or three founders exert more effort than teams with one or more than 4 founders. Thus, the finding that effort rises with team size to a maximum and then falls again holds.

After having shown that the impact of team size on effort is concave we further analyze that relationship and the optimal team size number. Figure 1 shows the partial effect of team size on effort in small ownership teams where all other independent variables take their average and the dummies are set to zero (parametric results).

>figure 1 around here

Up to a start-up team size of three founders effort is rising, indicating that the peer pressure effect dominates the free-rider effect. In teams larger than three the free rider effect dominates the peer pressure effect in turn. Thus, our estimations indicate that the optimal number of partners in a start-up team with regard to effort seems to be around three founders, which is consistent with the fact that most start-up teams are small and very rarely consist of more than four members.

4. Conclusion

As shown by Kandel and Lazear (1992) free-riding and peer pressure have a counterbalancing effect on the effort level in partnerships. However, the magnitude of both effects is unclear as well as the overall effect on individual effort. We assume that the magnitude of both effects depends on the size of the team and present a model to analyze the joint effect of freeriding and peer pressure in start-up teams. We show that given the particular mutual monitoring technology in start-up-teams there should be an optimal team size with regard to effort. Unlike many established partnerships, start-ups are characterized by close personal relationships and frequent interactions which in turn lead to a strong peer pressure effect that increases with the first additional partners added, but levelling off with every additional partner very soon. We test our model based on a large data set on start-up-teams in and around Cologne and find that individual effort of founders varies significantly with team size and that effort is concave in N. And we clearly identify a maximum effort which is on average given with three team members.

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Appendix

In a symmetric Nash equilibrium $e_i = e_j, \forall i, j$ and $a_i = a_j, \forall i, j$; further, the reaction functions for each partner are according to (2) and (3). We here refer them F_1 and F_2:

$$F_1 = \frac{1}{N}\frac{\partial f}{\partial e_i} - \frac{\partial C}{\partial e_i} - \frac{\partial P}{\partial e_i} = 0, \quad F_2 = \frac{N-1}{N}\frac{\partial f}{\partial e_j}\frac{\partial e_j}{\partial a_i} - \frac{\partial C}{\partial a_i} = 0$$

The total differentials are:

$$dF_1 = \alpha de_i + \beta da_i = \gamma dN, \quad dF_2 = \delta de_i + \varepsilon da_i = \eta dN$$

with

$$\alpha = \frac{1}{N}\frac{\partial^2 f}{\partial^2 e_i} - \frac{\partial^2 C}{\partial^2 e_i} - \frac{\partial^2 P}{\partial^2 e_i} < 0, \quad \beta = -\frac{\partial^2 P}{\partial e_i \partial a_i} > 0, \quad \gamma = \frac{1}{N^2}\frac{\partial f}{\partial e_i} > 0$$

and

$$\delta = 0, \quad \varepsilon = -\frac{\partial^2 C}{\partial^2 a_i} < 0, \quad \eta = \frac{1}{N^2}\frac{\partial f}{\partial e_j}\frac{\partial e_j}{\partial a_i} + \frac{N-1}{N}\frac{\partial f}{\partial e_j}\frac{\partial^2 e_j}{\partial a_i \partial N} < 0$$

$$|J| = \begin{vmatrix} \alpha & \beta \\ \delta & \varepsilon \end{vmatrix} = \alpha\varepsilon - \delta\beta > 0$$

a) Proof of proposition 3

$$|J_2| = \begin{vmatrix} \alpha & \gamma \\ \beta & \eta \end{vmatrix} = \alpha\eta - \beta\gamma > 0$$

$$\frac{da_i}{dN} = \frac{|J_2|}{|J|}\frac{\alpha\eta - \beta\gamma}{\alpha\varepsilon - \delta\beta} > 0$$

b) Proof of equation (6)

$$|J_1| = \begin{vmatrix} \gamma & \beta \\ \eta & \varepsilon \end{vmatrix} = \gamma\varepsilon - \eta\beta \gtrless 0$$

$$\frac{de_i}{dN} = \frac{|J_1|}{|J|} = \frac{\gamma\varepsilon - \eta\beta}{\alpha\varepsilon - \delta\beta} = \gtrless 0$$

c) Proof of equation (7)/proposition 4

We assume that the third-order partial derivatives equal zero.

$$\frac{d^2 e_i}{d^2 N} = -\frac{\frac{\partial^2 F_1}{\partial^2 e_i}\frac{\partial F_1}{\partial N}\frac{\partial F_1}{\partial N} - 2\frac{\partial^2 F_1}{\partial e_i \partial N}\frac{\partial F_1}{\partial e_i}\frac{\partial F_1}{\partial N} + \frac{\partial^2 F_1}{\partial^2 N}\frac{\partial F_1}{\partial e_i}\frac{\partial F_1}{\partial e_i}}{\frac{\partial F_1}{\partial N}\frac{\partial F_1}{\partial N}}$$

with

$$\frac{\partial F_1}{\partial e_i} = \alpha; \qquad \frac{\partial^2 F_1}{\partial^2 e_i} = 0$$

$$\frac{\partial F_1}{\partial N} = \beta; \qquad \frac{\partial^2 F_1}{\partial^2 N} = -\frac{1}{N^2}\frac{\partial^2 f}{\partial^2 e_i} \text{ and}$$

$$\frac{\partial^2 F_1}{\partial e \partial N} = \frac{2}{N^3}\frac{\partial f}{\partial e_i}.$$

Inserting the values and figuring out, leads to $\frac{d^2 e_i}{d^2 N} < 0$.

Table 1
Descriptive Statistics on Team size and Weekly Working Hours

start-up team size	N	Percent	weekly working hours of founders
1	513	65,4	49,2
2	166	21,1	54,7
3	69	8,8	54,9
4	26	3,3	56,5
5 and more	11	1,4	51,5
Mean: 1,55	Total: 790 founders	100	Mean: 51,1

Note: Data are from the Cologne Founder Study

Table 2
Definitions of Control Variables and Descriptive Statistics

	Scale	Definition of variables	Mean
SERVICES	Dummy	Industry: services	0.63
TRADE	Dummy	Industry: trade	0.24
MANUF	Dummy	Industry:Manufacturing (*reference*)	0.13
1992	Dummy	start-up founded: 1992	0.09
1993	Dummy	start-up founded: 1993	0.08
1994	Dummy	start-up founded: 1994	0.17
1995	Dummy	start-up founded: 1995	0.17
1996	Dummy	start-up founded: 1996	0.23
1997	Dummy	start-up founded: 1997	0.22
1998	Dummy	start-up founded: 1998 (*reference*)	0.04
TURNOVER	metric	Turnover	0.86
PROFITS	Dummy	Start-up profitable = 1	0.55
TAKEOVER	Dummy	Take-over start-up = 1	0.15
AGE	metric	Founders' age	35.9
SEX	Dummy	Male founder=1	0.84

Note: Data are from the Cologne Founder Study

Table 3
Robust Regression Results: Peer Pressure in Small Ownership Teams

Coeff. (t-value)	Model I	Model II		Model III		Model IV		Model V	
TEAM	0.78 (0.79)	10.26	(3,81)**	9.55	(3.59)**	8.32	(3.51)**	0.08	(0.08)
TEAMSQUARE		-1.85	(-3.82)**	-1.71	(-3.69)**	-1.61	(-3.50)**		
SERVICES[a]				-4.43	(-1.57)	-4.4	(-1.65)	-4.81	(-1.83)
TRADE[a]				0.04	(0.01)	0.42	(0.14)	0.36	(0.12)
1992[b]				12.51	(2.28)*	10.51	(1.99)*	9.56	(1.84)
1993[b]				11.70	(2.02)*	10.18	(1.80)	10.46	(1.88)
1994[b]				7.74	(1.46)	5.93	(1.15)	5.82	(1.15)
1995[b]				11.79	(2.21)*	10.39	(2.00)*	10.11	(1.97)*
1996[b]				7.53	(1.44)	5.56	(1.08)	5.22	(1.03)
1997[b]				4.21	(0.80)	2.97	(0.58)	2.39	(0.48)
TURNOVER				3.16	(0.81)	1.53	(0.44)	1.54	(0.43)
PROFITS				-1.07	(-0.55)	-1.14	(-0.60)	-1.12	(-0.59)
TAKEOVER				6.29	(2.37)*	5.66	(2.18)*	5.64	(2.19)*
AGE						3.71	(4.22)**	3.75	(4.25)**
AGESQUARE						-0.05	(-4.18)**	-0.05	(-4.20)**
SEX						7.65	(2.85)**	7.82	(2.87)**
CONST.	52.4 (26.69**)	43.8	(14.01)**	38.88	(6.06)**	-32.92	(1.88)	-25.96	(1.50)
N	449	449		449		449		449	
F	0.6	7.46*		3.35**		4.96**		4.46**	
R^2	0.00	0.02		0.076		0.137		0.123	

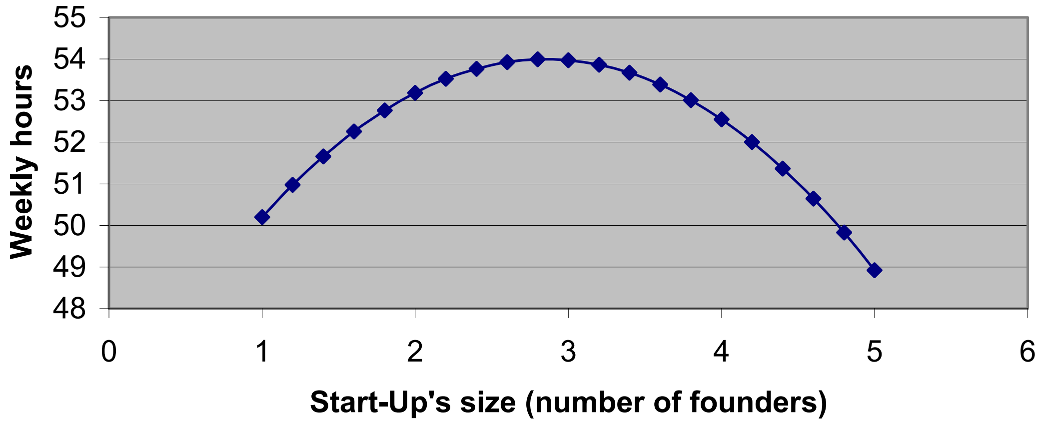
Dependent variable: weekly hours working in start-up
t-values in parentheses
** Significant on the 1 % level; * Significant on the 5 % level
[a] Reference: Manufacturing
[b] Reference 1998
Note: Data are from the Cologne Founder Study

Table 4
Robust Regression Results: Peer Pressure in Small Ownership Teams

Coeff. (t-value)	Model VI	
TEAM_1[a]	11.50	(1.83)
TEAM_2[a]	14.24	(2.22)*
TEAM_3[a]	16.21	(2.45)*
TEAM_4[a]	12.18	(1.58)
SERVICES[b]	-4.34	(-1.62)
TRADE[b]	0.63	(0.21)
1992[c]	11.04	(2.07)*
1993[c]	10,32	(1.83)
1994[c]	5.82	(1.13)
1995[c]	10.29	(1.98)*
1996[c]	5.54	(1.08)
1997[c]	2.78	(0.55)
TURNOVER	1.59	(0.44)
PROFITS	-1.05	(-0.55)
TAKEOVER	5.83	(2.21)*
AGE	3.70	(4.18)**
AGESQUARE	-0.05	(-4.14)**
SEX	7.67	(2.83)**
CONST.	-37.51	(-2.02)*
N	449	
F	4.15**	
R^2 (adj.)	0.135	

Dependent variable: weekly hours working in start-up
t-values in parentheses
*** Significant on the 1 % level; ** Significant on the 5 % level; * Significant on the 10 % level
[a] Reference: Team-Size_5+
[b] Reference: Manufacturing
[c] Reference: 1998
Note: Data are from the Cologne Founder Study

Figure 1:
Parametrical results: partial effect of team size on effort in small ownership teams



Quelle:

Note: Data are from the Cologne Founder Study