Investment Reluctance: Irreversibility or Imperfect Capital Markets?

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Abstract

Low investment rates are a puzzling phenomenon particularly in transition economies with an urgent need for modernization. Literature on the subject offers two explanations for this fact: first, limited availability of financial funds due to imperfect capital markets and second, the interaction of irreversibility, uncertainty and flexibility – known as real options' effects – may result in investment reluctance. We suggest a generalized model that combines imperfect capital markets and real options' effects. The econometric implementation has the structure of a generalized Tobit model. Applying this model to German farm-level panel data it is demonstrated that ignoring real options' effects may lead to erroneous conclusions in the context of empirical investment equations.

Keywords: irreversibility, uncertainty, q model, capital market imperfections

JEL classification: D81, D92, O12

1. Introduction

Investments have an impact on the profitability and the competitiveness of farms. This is particularly the case for transition economies where an urgent need for modernization and rationalization exists. However, observed investment rates are frequently lower than expected, resulting in a lagged catching up of productivity and a slow structural change. This paper aims to investigate the determinants of such reluctant investment behaviour.

Against this background numerous studies have already tried to identify factors that hinder the investment activity of farms. Several authors point out the important role of finance in the realization of investments (e.g., Benjamin and Phimister, 2002 or Barry *et al.*, 2000). While neoclassical theory asserts that investment decisions are independent of financial decisions under perfect capital market conditions, this is not true for the more realistic case of imperfect capital markets. Imperfect capital markets are characterized by informational asymmetries and agency problems between lenders and borrowers. These problems may lead to credit rationing which means that farms have no or only limited access to debt (Stiglitz and Weiss, 1981). Moreover, due to transaction costs a gap appears between the costs of internal and external financing. This leads to a pecking order or hierarchy of finance (Bond and Meghir, 1994, Barry *et al.*, 2000). As a result, the timing and the size of investments will depend on the availability of (cheap) internal funds. This is in particular the case in transition economies where underdeveloped institutions and weak macroeconomic conditions deter investments (Cungu *et al.*, 2008) and lead to constrained capital access (e.g., Rizov, 2004). Empirical evidence for the existence of credit rationing and a pecking order of finance is provided by Foltz (2004), Petrick (2004) and Latruffe (2005).

An alternative explanation of investment reluctance and low investment rates is offered by the real options approach (Dixit and Pindyck, 1994). Real options theory asserts that an investor can increase profits by deferring an investment instead of realizing it immediately if costs for the adjustment of the capital stock are at least partially irreversible, and future investment returns are uncertain. This means, in the case of irreversible decisions, waiting has a value in an uncertain world, since new information about the expected investment cash flow may become available. Carrying out the investment reduces the investor's flexibility. This loss of flexibility must be covered by the expected investment cash flow in addition to the investment outlay. Thus the joint occurrence of irreversibility, uncertainty and the opportunity to wait cause a kind of inertia, i.e., there is a large range of marginal returns on investment in which inaction appears to be optimal. Chang and Stefanou (1988) or Oude Lansink and Stefanou (1997) provide empirical evidence for this based on the dynamic dual approach and Gardebroek and Oude Lansink (2004) by means of a Euler equation (primal) approach. Real options models usually assume that a riskless hedging portfolio can be set up and thus optimal investment decisions are not affected by the individual risk propensity of decision makers. This assumption is questionable and therefore some authors attempt to incorporate risk aversion into dynamic investment models (e.g., Sckokai and Moro, 2005, Coyle, 2005 or Serra *et al.*, 2009).

Certainly both explanation concepts for investment reluctance – capital market imperfections and options effects – are not mutually exclusive. Rather, it is likely that they coexist in reality as the aforementioned preconditions which make these concepts meaningful, i.e., information asymmetry, irreversibility, and uncertainty are widespread. However, it is interesting to note that the relevant strands of literature, namely neo-institutional finance and the real options theory, have developed independently. Except for a few theoretical contributions (e.g., Caggese, 2007) these strands have not interacted until now (Lensink *et al.*, 2001). On the one hand, empirical investments models based on neo-institutional finance do not consider options effects and the value of waiting. On the other hand, real options models assume generally perfect capital markets. The linkage of these strands of literature is the contribution of our paper.

The major aim of this study is to disentangle the impact of imperfect capital markets on investment behaviour from investment reluctance due to irreversibility and uncertainty. Why is it important to consider both effects simultaneously when analyzing investment behaviour empirically? From a theoretical viewpoint, disregarding either capital market imperfections or irreversibility and uncertainty may result in a misspecification of empirical investment models and hence in biased estimates for the included explanatory variables. Separating the two effects is not only an academic exercise, but it is also important from a policy perspective. Capital market imperfections lead to an inefficient factor allocation (e.g. underinvestment) and should be addressed by appropriate measures. Depending on the particular context, such measures may comprise the development of reliable rating systems, the establishment of a legal framework for banking regulation and competition or the provision of investment aid. By contrast, option related investment reluctance does not call for policy intervention at all as it is the outcome of optimal dynamic decision making under uncertainty.

For the purpose of estimating the joint impact of capital market imperfections and irreversibility on investments we proceed as follows. Our starting point is a standard dynamic stochastic q model (Abel and Eberly, 1994).[1] By modifying the adjustment cost function of this model we are able to account for additional costs depending on the financial structure of the farm. These costs reflect capital market imperfections. Based on this extended q model we derive estimable investment equations. The econometric model has the structure of a generalized Tobit model. As we aim to reveal the effect of a model misspecification, a simpler benchmark model is also introduced. The benchmark model assumes smooth adjustments of the capital stock over time. It consists of a linear investment equation which is augmented by the cash flow as an additional determinant. The cash flow represents internal financial ability and aims to account for costly or limited access to capital. This model type, that ignores irreversibility and sunk costs, is frequently used in assessing the impact of financial constraints on investment behaviour (Bond and Van Reenen, 2007). Both models are then applied to German farm-level panel data. The rationale behind using this data is that German reunification constitutes a natural experiment that allows investment behaviour to be compared between established market economies (West Germany) and transition economies (East Germany). Though no formal restrictions were in place that might have affected the capital movement to East Germany we argue that the extent of capital market imperfections differs between both parts of Germany. Due to economic reasons, particularly information asymmetry in conjunction with missing collateral, we conjecture that financing frictions are more pronounced in East Germany than in West Germany.

2. A q Model for Irreversible Investments in Imperfect Capital Markets

We refer to the dynamic and stochastic investment model suggested by Abel and Eberly (1994). The model considers production and (dis)investment decisions for a representative firm i which maximizes its present value of net income depending on the capital stock K_t and the stochastic revenues X_t at time t. The value function V for this problem is defined as

$$V(K_0, X_0) = \max_{\{I\}} E_0 \sum_{t=0}^{\infty} \psi^t \cdot [\pi(X_t, K_t) - C(I_t, K_t, CF_t)] \tag{1}$$

where $\pi(X_t, K_t)$ denotes profits and $C(I_t, K_t, CF_t)$ refers to costs attached to adjusting the capital stock. The latter are a function of (dis)investments I_t, the beginning of period capital stock K_t and the cash flow defined as $CF_t = \pi(X_t, K_t) + \delta \cdot K_t$. δ denotes the depreciation rate which is assumed to be constant over time. At this point the profit function π is left unspecified to keep the model as general as possible. K_0 and X_0

[1] The relation between stochastic q models and real options models is explained in Abel *et al*. (1996).

represent the respective initial values, $\{I\}$ indicates the sequence of investments over time and ψ is the firm's individual discount factor, where $0 < \psi \leq 1$. ψ can be interpreted as a risk adjusted discount factor and thus no explicit assumptions on the risk attitude of the agents is necessary. Finally, we assume that farmers' investment decisions can be separated from household decisions.

The transition equations for the capital stock and the stochastic revenues over time are given by

$$\Delta K = -\delta \cdot K_t + I_t \text{ and} \tag{2}$$

$$\Delta X = \mu_X(X,t) \cdot \Delta t + \sigma_X(X,t) \cdot \Delta z\,, \tag{3}$$

where $\Delta z = \varepsilon \cdot \sqrt{\Delta t}$ and $\varepsilon \sim N(0,1)$. $\mu_X(X,t)$ denotes the instantaneous expected change of the revenues, $\sigma_X(X,t)$ the standard deviation, and Δz is the Wiener increment capturing productivity shocks.

Incorporation of costly reversibility and capital market imperfections can be achieved by an appropriate specification of the adjustment cost function. Our idea is to augment the well known adjustment cost function of Abel and Eberly (1994) by an additional parameter accounting for imperfect capital markets. The main advantage of this ad hoc procedure is that the dimensions of the model are not increased.[2] The augmented adjustment cost function is defined by

[2] Alternatively, one could introduce further restrictions, e.g., a borrowing constraint as for instance shown by Rizov (2004) or Bond and Meghir (1994). This procedure allows modelling the impact of the debt-capital ratio on investments (e.g. Vercammen, 2007), however, it comes at the cost of a higher model dimension.

$$C(I_t, K_t, CF_t) = \begin{cases} a + a^{+} \cdot K_t + b^{+} \cdot I_t + g^{+} \cdot \left(\frac{I_t}{K_t} \right)^2 \cdot K_t + d^{+} \cdot \frac{I_t}{K_t \cdot CF_t} & \text{if} \quad I_t > 0 \\ 0 & \text{if} \quad I_t = 0 \\ a + a^{-} \cdot K_t + b^{-} \cdot I_t + g^{-} \cdot \left(\frac{I_t}{K_t} \right)^2 \cdot K_t & \text{if} \quad I_t < 0. \end{cases} \tag{4}$$

where a represents the 'true' fixed costs, e.g., set up costs. The second term, $a^{+/-} \cdot K_t$, represents fixed costs proportional to the capital stock but independent of investment activities accounting for size effects. When $a^{+/-} > 0$ and/or $a > 0$, fixed (sunk) costs are related to the investment decision. Costly reversibility is captured by the third term, $b^{+/-} \cdot I_t$, when the costs for investing, b^{+}, exceed the costs for selling capital b^{-}. The possible gap between the acquisition and resale price reflects capital specificity (Cooper and Haltiwanger, 2006). If reversibility is costly, it is essential that $b^{+} > b^{-} \geq 0$ and/or $g^{+}, g^{-} \geq 0$. This gap, together with the fixed costs, creates a range of inactivity along the optimal path of investment. The traditional internal adjustment costs are represented by the fourth term, $g^{+/-} \cdot \left(I_t / K_t \right)^2 \cdot K_t$, which are quadratic in investment and strictly convex as the traditional q theory proposes (Abel and Eberly, 2002).

By means of the last term, $d^{+} \cdot \left(I_t / \left(K_t \cdot CF_t \right) \right)$, additional transaction costs are incorporated which arise when capital markets are not perfectly competitive. This is a rather implicit way of modelling capital market imperfections and is based on the idea that acquisition costs of debt and equity capital differ under conditions of imperfect capital markets (cf. Barry *et al*., 2000). The acquisition of debt capital is more expensive compared to equity due to informational costs, signalling costs or risk premia. Hence the cost of capital depends on the financial structure of the farm. Farms with low internal financing resources need to acquire costly capital as equity capital does not suffice.[3] It is common to measure the internal financing capacity by a cash flow based indicator. Here we use the self-financing ratio of investments, i.e. CF_{it} / I_{it}. The higher this term, the less dependent is the firm on debt capital and hence it will incur lower costs under imperfect capital markets. Therefore the inverse expression, I_{it} / CF_{it}, enters the adjustment cost function. As we wish to estimate investment functions in relative terms we divide this expression by the amount of capital. Within the logic of this approach the investment sensitivity to this variable provides evidence of imperfect capital markets (Hubbard, 1998).[4]

Applying dynamic programming yields the Bellman equation for problem (1):

$$V(K_t, X_t) = \max_I \left\{ \pi(X_t, K_t) - C(I_t, K_t, CF_t) + \psi \cdot E_t \left[V\left(K_{t+1}, X_{t+1}\right) \right] \right\}. \tag{5}$$

The optimal path of investment solves the term $\max_I \left\{ -C(I_t, K_t, CF_t) + I_t \cdot q_t \right\}$, where q_t is the marginal valuation of a unit of installed capital q, i.e., $q \equiv V_K$. Thus an optimal investment obeys

$$\frac{I_t^+}{K_t} = -\frac{b^+}{2g^+} + \frac{1}{2g^+} \cdot q_t - \frac{d^+}{2g^+} \cdot \frac{1}{K_t \cdot CF_t}. \tag{6a}$$

Full cost recovery requires that $I_t^+ \cdot q_t > C(I_t^+, K_t, CF_t)$. This is fulfilled if q_t passes an upper threshold (q_t^+) given by

[3] A direct flow of equity capital from external investors into agricultural enterprises is more an exception than a rule, because farms are usually not traded on capital markets. As a consequence, farm financing is more or less restricted either to internal funds (self financing) or bank loans.

[4] It should be stressed that it is very difficult to trace an observed cash flow sensitivity of investment back to imperfect capital markets. Alternatively, the cash flow might merely reflect expected profits. Accordingly, Gilchrist and Himmelberg (1995) and Erickson and Whited (2000) argue that measurement problems associated with marginal q affect the estimated sensitivity of investment to the availability of internal funds. Gomes (2001) and Alti (2003) show that a positive cash flow-investment sensitivity may even occur without financial frictions.

$$q_t > q_t^+ = b^+ + 2 \cdot \sqrt{\frac{a \cdot g^+}{K_t} + a^+ \cdot g^+} + d^+ \cdot \frac{1}{K_t \cdot CF_t} . \tag{6b}$$

Similarly optimal disinvestment follows

$$\frac{I_t^-}{K_t} = -\frac{b^-}{2g^-} + \frac{1}{2g^-} \cdot q_t \tag{7a}$$

if q_t falls below a lower threshold q_t^- which is defined by

$$q_t < q_t^- = b^- - 2 \cdot \sqrt{\frac{a \cdot g^-}{K_t} + a^- \cdot g^-} . \tag{7b}$$

As long as $q_t^- \leq q_t \leq q_t^+$, neither investing nor disinvesting is optimal. This range of q_t is also known as the range of inaction. Note that under imperfect capital markets the financial status of the firm has an impact on the range of inaction represented by the last term in (6b). The larger (smaller) internally generated funds are, the smaller (larger) is the increase in the range of inaction. Thus, the suggested model comprises irreversible investments and impacts of imperfect capital markets on the optimal path of investment.

3. Econometric Model

3.1. Econometric Specification

In general, the shadow value of capital is not observable and in order to make the model (6a)-(7b) estimable we need a proxy for q. The literature offers several directions, for instance Gilchrist and Himmelberg (1995) and Benjamin and Phimister (2002) suggest a VAR (vector auto-regression) approach. However, it is not possible to combine the VAR model with the three-regime model suggested in this paper. Thus we refer to another approximation that basically resembles the VAR model, but is more tractable.

In the theoretical investment model presented above the shadow value of a unit of installed capital is defined as

$$q_t = \pi_K(X_t, K_t) - C_K(I_t, K_t, CF_t) + \psi \cdot E\left[q_{t+1}\right] \tag{8}$$

where π_K and C_K denote the respective derivatives of the profit and the adjustment cost function with respect to K. It should be noted that $\pi_K(X_t, K_t)$ depends on the stochastic revenues X_t. Referring to Ito's Lemma, the standard deviation of those, σ_X, appears in q.[5] Basically, q refers to the present discounted value of future marginal revenue products of capital. However, the revenue product and the underlying process are not observable and require an approximation. Referring to Nilsen *et al*. (2007) the shadow value of capital is approximated by a function of observable variables:

$$q_{it} = \beta' Z_{it} + \varepsilon_{it} \tag{9}$$

ε_{it} denotes an error term and is assumed to be normally independently distributed (*n.i.d.*) with zero mean and variance σ_ε^2. This term reflects idiosyncratic shocks and measurement errors. This rather basic error specification enables a straightforward estimation of the empirical model. Therefore, we replace q_{it} in the theoretical model (6a)-(7b) by its approximation given in (9).

β is a parameter vector to be estimated. Z_{it} consists of variables that proxy the information contained in the shadow value of capital and the underlying process of future marginal products of capital. The specification of the information set Z_{it} requires imposing further structure on the model. We do so by presuming that the production underlying the stochastic revenues is Cobb Douglas in capital and labour, where the latter can be adjusted without additional costs. Assuming further that the firm acts as a price taker, it follows that q is proportional to the profit-capital ratio and the revenue-capital

[5] Note that uncertainty, in general, will have multiple impacts on the investment decision, which are not fully captured by q. For example the risk exposure of the farm may affect its access to debt capital. Moreover, it is difficult to distinguish option-like effects of uncertainty from risk aversion in the framework of our model.

ratio. In line with Nilsen *et al*. (2007) it is further assumed that farms use an AR(2) process to forecast the revenue-capital ratio. Hence, present, once and twice-lagged values, as well as the respective quadratic terms of the profit-capital ratio or the revenue-capital ratio, are tested to belong to the information set Z_{it}. Moreover, as shown by equation (8), q_{it} depends on the stochastic revenues. Under the additional assumptions and choosing a particular form of the general Ito process in (3), for instance a Geometric Brownian Motion, it can be shown that q is proportional to the farms' individual standard deviation of relative revenue changes over time (years), $\sigma_{X,i}$ (Abel and Eberly, 1994). Accordingly, $\sigma_{X,i}$ appears additionally in Z_{it}.

Using this approximation we abstract from the fact that the partial derivative of the adjustment cost function with respect to the lagged capital stock is not zero in our model. We consider several variations with respect to the time lag, the quadratic term and the choice of profit-capital ratio or revenue-capital ratio to find as good as possible an approximation for the shadow value of capital. The approximations are ranked according to the Bayesian information criterion (BIC).

Furthermore, in the empirical equations we use the term CF_{it}/K_{it} even though the term $1/\left(K_{it} \cdot CF_{it}\right)$ would directly result from the theoretical model. However, the rationale for the use of the inverse of the self financing ratio is only meaningful for positive values of the cash flow. Unfortunately, our data sample includes farms showing negative values for the cash flow at some times. Since the function $1/CF_{it}$ is nonlinear with different slopes for positive and negative values of the cash flow, we use the cash flow-capital ratio in the empirical model specification.

The empirical investment equation is given by

$$\frac{I_{it}^{+}}{K_{it}} = c_0^{+} + \beta' Z_{it} + c_2^{+} \cdot \frac{CF_{it}}{K_{it}} + \varepsilon_{it} \qquad (10a)$$

if[6]

$$\gamma_0^+ + \gamma_1^+ \cdot \frac{1}{K_{it}} + \beta' Z_{it} + \gamma_2^+ \cdot \frac{CF_{it}}{K_{it}} + \varepsilon_{it} > 0 \tag{10b}$$

and disinvestment is described by

$$\frac{I_{it}^-}{K_{it}} = c_0^- + \beta' Z_{it} + \varepsilon_{it} \tag{11a}$$

if

$$\gamma_0^- + \gamma_1^- \cdot \frac{1}{K_{it}} + \beta' Z_{it} + \varepsilon_{it} < 0 . \tag{11b}$$

3.2. Estimation

The model (10a) to (11b) has the structure of a generalized two-sided Tobit model. The parameter estimates are obtained by using a two-stage method in the sense of Heckman (1979).

In the first stage, the triggers from equations (10b) and (11b) are estimated using a generalized ordered Probit model (Boes and Winkelmann, 2006). This model estimates the probabilities of being in the investment, disinvestment or inaction regime. The inverse capital stock, $1/K_{it}$, enters the model only through the selection equations (10b) and (11b) and thus provides an exclusion restriction to identify the model.[7] The log-likelihood function of the generalized ordered Probit model is:

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[6] In order to make the model estimable, the nonlinear parts of the thresholds q^+ and q^- are linearly approximated: $b^+ + 2 \cdot \sqrt{a \cdot g^+ / K_{it} + a^+ \cdot g^+} \cong \gamma_0^+ + \gamma_1^+ \cdot 1/K_{it}$ and $b^- - 2 \cdot \sqrt{a \cdot g^- / K_{it} + a^- \cdot g^-} \cong \gamma_0^- + \gamma_1^- \cdot 1/K_{it}$.

[7] We have checked the robustness of this specification by implementing several alternatives, for example by adding nonlinear terms of the inverse capital stock. Moreover, we use the European Size Unit (ESU) as an alternative exclusion restriction. It turns out that such modifications induce only small changes in the absolute value of the estimation results in the second stage.

$$\log L = \sum_{I_{it}^D=1} \log\left(1-\Phi\left(\frac{\gamma_0^+ + \gamma_1^+ \cdot (1/K_{it}) - \beta' Z_{it} + \gamma_2^+ \cdot CF_{it}/K_{it}}{\sigma_\varepsilon}\right)\right) + \sum_{I_{it}^D=-1} \log\Phi\left(\frac{\gamma_0^- + \gamma_1^- \cdot (1/K_{it}) - \beta' Z_{it}}{\sigma_\varepsilon}\right) + \sum_{I_{it}^D=0} \log\left(\Phi\left(\frac{\gamma_0^+ + \gamma_1^+ \cdot (1/K_{it}) - \beta' Z_{it} + \gamma_2^+ \cdot CF_{it}/K_{it}}{\sigma_\varepsilon}\right) - \Phi\left(\frac{\gamma_0^- + \gamma_1^- \cdot (1/K_{it}) - \beta' Z_{it}}{\sigma_\varepsilon}\right)\right) \tag{12}$$

where $\Phi(\cdot)$ denotes the standard normal cumulative distribution function. I_{it}^D indicates whether a firm invests ($I_{it}^D = 1$), disinvests ($I_{it}^D = -1$) or is inactive ($I_{it}^D = 0$). The parameters can only be identified up to a scale parameter and are normalized by σ_ε; this is hereafter denoted by ~. The results from the first stage are used to obtain an estimate for q, $\hat{q}_{it} = \tilde{\beta}' Z_{it}$.

In the second stage, the investment and disinvestment rates (10a) and (11a) are estimated using only the respective observations. When only the positive and negative investment observations are used then it is necessary to account for the decision rule itself given by (10b) and (11b). This is achieved by using the inverse Mill's ratios, λ_{it}^+ and λ_{it}^-, defined as the expected value of ε_{it} conditional on being in the (dis)investment regime. The Mill's ratios are used to correct the estimates of q. This ensures consistent parameter estimates in the second stage regression. The respective equations for the second stage are:

$$\frac{I_{it}^+}{K_{it}} = c_0^+ + c_1^+ \cdot \left(\tilde{\beta}' Z_{it} + \hat{\lambda}_{it}^+\right) + c_2^+ \cdot \frac{CF_{it}}{K_{it}} + u_{it}^+ \tag{13a}$$

$$\frac{I_{it}^-}{K_{it}} = c_0^- + c_1^- \cdot \left(\tilde{\beta}' Z_{it} - \hat{\lambda}_{it}^-\right) + u_{it}^- \tag{13b}$$

where u_{it}^{+} and u_{it}^{-} are zero mean error terms with the variances $\sigma_{u^{+}}^{2}$ and $\sigma_{u^{-}}^{2}$. The parameters are defined as $c_0^{+} = -b^{+}/2g^{+}$, $c_0^{-} = -b^{-}/2g^{-}$, $c_1^{+} = 1/2g^{+}$, $c_1^{-} = 1/2g^{-}$, $c_2^{+} = -d^{+}/2g^{+}$ ((6a) and (7a)).

It is assumed that all the variables from the generalized ordered Probit model are uncorrelated with the errors ε_{it} which allow consistent parameter estimates to be obtained. Further, all explanatory variables in the second stage regressions are assumed to be uncorrelated with u_{it}^{+} and u_{it}^{-}. As in those regressions only one single generated regressor appeared in each equation, consistent estimates are still given, and the asymptotic t-statistics can be used for inference (Pagan, 1984). In addition, we use robust standard errors obtained by using a robust estimator of the variance-covariance matrix initially developed by White (1982).

3.3. The Benchmark Model

We postulate that sunk costs and the irreversibility of investments have an impact on the estimation of capital market imperfections. In order to demonstrate the effects of ignoring uncertainty and irreversibility when explaining investment behaviour under imperfect capital market conditions, we additionally specify a simpler linear model. This model serves as a benchmark for the more general model developed in the previous section. The benchmark model refers to a reduced-form investment equation that is augmented by a cash flow variable. This type of model is often used to find empirical evidence of imperfect capital markets (cf. Bond and Van Reenen, 2007):

$$\left(\frac{I_{it}}{K_{it}}\right)^{b} = \alpha_0 + \alpha_1 \cdot \left(\tilde{\beta}' Z_{it}^{*}\right) + \alpha_2 \cdot \frac{CF_{it}}{K_{it}} + u_{it} \qquad (14)$$

where the superscript *b* denotes 'benchmark'. The disturbance term, u_{it}, is assumed to be identically independently distributed (*i.i.d*) with zero mean, and the variance σ_u^2. Z_{it}^* refers to the information set for q without $\sigma_{X,i}$.

We find the following advantages of the generalized Tobit model: First, though still being an approximation, the estimated q accounts additionally for uncertain revenues by including $\sigma_{X,i}$ in Z_{it}. This is not the case in the benchmark model (Z_{it}^*). Second, the general model accounts for the decision rules (10b) and (11b) empirically represented by the selectivity regressors, whereas the benchmark model violates the presence of irreversibility because the respective estimate $\left(\tilde{\beta}' Z_{it}^*\right)$ is not corrected by the inverse Mill's ratios. Implicitly, for the benchmark model it is assumed that firms invest as soon as the shadow value of capital exceeds the purchase price of capital, and the firms sell capital if the shadow value of capital is less than the sales price. Both features reduce the informational content of the approximation of q in the benchmark model. This is comparable to a general omitted variable problem. However, it is not straightforward to develop a priori hypotheses on how the results of the Tobit model should differ from the linear benchmark model. The specific differences depend on the data, in particular on the proxy variables used for q and the respective estimates from the first stage. We expect that the differences are driven by less content in the approximation of q (the uncertainty and the Mill's ratios) and this might be compensated by the parameter estimates.

Huettel *et al*. (2008) carry out estimations with both model types using Monte Carlo simulations. They find evidence of *seemingly imperfect* capital markets in the presence of an inaction regime induced by irreversibility. In this case the significant cash flow parameter accounts for the range of inaction and the presence of this regime is interpreted as capital market frictions. As mentioned above, in empirical applications the cash flow variable might also account for measurement errors in the approximation of q. However, as both models face the same problems in measuring q, we are confident that the effect of ignoring irreversibility is not distorted by this measurement problem.

Figure 1 illustrates the different model types by means of simulated data. In figure 1a data are simulated, referring to a stochastic representation of (6a). If the data exhibited such a simple structure, the benchmark model (14) would be appropriate. The data in figure 1b are simulated using a stochastic representation of (6a) – (7b). Figure 1b depicts the complexity of the relationship between investments, q, and the cash flow in the presence of capital market frictions and irreversibility. In this case the generalized Tobit model ((10a)-(11b)) is the appropriate empirical model. For clarification purposes, we further apply the Cox-Pesaran test for non-nested models (Pesaran, 1974). This test procedure allows both competing model specifications to be ranked and the idea behind this is to define a comprehensive model of which both models, the benchmark model and the second stage Tobit model, are special cases.

Insert figure 1 here

4. Application: Investment Behaviour in Germany

4.1. Background Information and Data

Like most other small and medium size enterprises, farms in Germany have limited direct access to capital markets. The major sources of investment financing are self financing and debt capital (Odening, 2003). The latter is particularly important in the case of expanding farms. The largest part of agricultural investment is financed by bank loans (76 %). Credit substitutes such as leasing, for example, are not yet widespread in agricultural financing. With respect to the bank loans, cooperative banks lend the largest share of agricultural loans at about 47 %, and private credit banks and local savings banks lend a share of 12 % and 33 %, respectively. Such loans are mainly long term loans with fixed interest rates. Additionally, programs offered by the Landwirtschaftliche

Rentenbank, which is a public law institution with the aim of supporting the agricultural sector, are available. These credits are designed for farms and characterized by more favourable conditions compared to banks. However, access to debt capital differs between West and East Germany. These differences, which were most pronounced immediately after German reunification in 1990, are vanishing over time but still exist.

In the East German transition period, starting in 1989, macroeconomic stability was established rather quickly compared to other Central and Eastern European countries. Monetary union and the Act on opening balances in German Marks (D-Marktbilanzgesetz) in 1990 aligned the legal foundations for capital market operations in East and West Germany. This rapidly established steadiness was a precondition for the development of financial markets and a banking system. Actually most of the major West German banks expanded into East Germany.

Despite these developments, financial problems hindered the development of competitive farms in East Germany at the beginning of the nineties (Rothe and Lissitsa, 2005). Former co-operatives, state-owned farms and newly established farms had an enormous capital demand for replacement and expansion investments. However, banks were reluctant to issue loans for the following reasons. First of all, the restructured or newly established farms had no history in the sense of documented economic performance under market conditions. Assessment of credit worthiness, however, is usually based on past financial records. A second problem concerned a lack of collateral. Farms in East Germany showed a low equity share. This difference in financial leverage can be traced back to the unequal share of leased land. While family farms in West Germany own about 50 % of the land they cultivate, farms in East Germany typically operate on leased land (with a share of 90 %). The problem of a lack of collateral was aggravated by the legal status chosen by the former state cooperatives and state-owned farms. The dominant legal forms adopted by the successors of the former socialistic farms were co-operatives, stock companies and corporations, which are all characterized by limited liability. In addition, property rights with respect to the farms' assets were unclear for a rather long period of time. Finally, access to debt capital was frequently hindered by the existence of old loans stemming from the former East German period. Though there was a partial debt relief, considerable debt remained without corresponding assets of comparable value. In addition, in the western part of Germany mainly family farms exist (90 % of the used agricultural area in 2005) and they have traditionally had a close relationship with the local banks. Benjamin and Phimister (2002) argue that such a close relation might reduce information costs.

There are also differences in the supply side of loans. For example, the density of branches of private banks, cooperative banks, and savings banks was (and still is) lower in East than in West Germany. The volume of agricultural credits per used agricultural area (UAA) shows the same differences. In West Germany 2,564 Euros per hectare were paid out in 2005, whereas in East Germany 365 Euros (Deutsche Bundesbank, 2006) were paid out. In addition, the Landwirtschaftliche Rentenbank reports significantly fewer interest reduced loans (in absolute and relative terms) issued to farmers in the new federal states.

In view of the aforementioned peculiarities affecting East German farms, it is conjectured that moral hazard and adverse selection problems in the lender-borrower relationship are more pronounced in those farms compared to the case of West German farms. These problems are accompanied by a higher default risk and/or higher transaction costs for potential lenders which, in turn, may lead to higher costs when borrowing or in the case of credit rationing (Barry *et al.*, 2000). Thus, it can be hypothesized that the degree of capital market imperfections is different in both parts of Germany. Hence, German reunification may be regarded as a natural experiment with respect to the impact of capital market imperfections on investment behaviour in agriculture.

This relationship will be examined empirically by applying the models presented in the previous sections to farm-level panel data from the national German farm accountancy data network (FADN) covering the years from 1996 to 2007. Unfortunately, this sample does not allow analysis of the first years of economic transition in East Germany (1991 – 1995). The FADN is based on the annual balance sheet data from representative farms in Germany and must conform to consistent accounting procedures stipulated by the European Commission (EU Commission, 1990). Generally, on average 8 % of farms in the German FADN (hereafter referred to as BMELV Testbetriebsnetz) are exchanged every year and replaced by new farms.

Prior to the estimation we exclude farms which are specialized in horticulture, orchards, fishery and forestry. Only those farms are considered which appeared for at least seven consecutive years in the sample. Observations that are below the 1 % percentile and above the 99 % percentile of the disinvestment and investment rates as a whole, as well as of the revenues-capital ratio, are considered as outliers and removed from the sample. These rules are common in investment literature (Benjamin and Phimister, 2002). The final data set is unbalanced and contains 7,142 farms in the Western federal states and 1,463 farms in the Eastern federal states with nine years of duration on average. The basic features of the variables used and further financial characteristics are presented in table 1, using the common summary statistics for East and West German farms.

Insert table 1 here

The capital stock includes permanent crops, machinery, buildings, livestock and immaterial capital. On average, East German farms feature a higher capital stock than farms in West Germany, whereas the share of equity is lower for East German farms (83 % versus 58 %). This is followed by a higher debt-cash flow ratio. Farms in the eastern part need 3.9 years in the mean to compound their debt whereas in the western part on average 1.4 years are required. The mean revenues-capital ratio X_{it} / K_{it} of East German farms is higher than that of West German farms. The measure of uncertainty $\sigma_{X,i}$ (i.e. the standard deviation of relative revenue changes) differs only slightly between the regions. The mean cash flow-capital ratio is slightly higher in East Germany than in West Germany. The average of the disinvestment and investment rates together is positive. The (positive) average investment rates also reveal slight differences between the regions: 13.7 % in East Germany and 9.7 % in West Germany. However, the investment rates are rather constant over time at the aggregate level. The share of observations of farms belonging to the inaction regime (I_{it}/K_{it} below/above +/- 2 %) is 22 % in East Germany and 50 % in West Germany. The share of observations with investments in East Germany is 75 % and in the Western federal states 45 %. Unfortunately, the data set does not allow us to account for further differences as for instance in soil quality and weather conditions.

4.2. Estimation Results

The data set that was used is unbalanced. The panel mortality in the FADN is exogenous, and thus we cannot account for a sample selection bias. Several specifications of the information set Z_{it} have been examined.[8] The Bayesian information criterion supports the following one which is used for subsequent calculations:

$$Z_{it} = \left[\left(X_{it-1}/K_{it-1} \right), \left(X_{it-2}/K_{it-2} \right), \left(X_{it-1}/K_{it-1} \right)^2, \sigma_{X,i} \right].$$

The Breusch-Pagan test rejects the null of homogeneity at any usual significance level and discloses the presence of an unobserved heterogeneity effect for the first and second stage models. In the first stage we apply a random effects generalized ordered probit estimator to account for these effects. We thereby have to presume that the effects are uncorrelated with the explanatory variables and are normally distributed. This allows us to use the method of maximum likelihood for panel data. Further, for convergence reasons it is necessary to scale the inverse capital stock for the first stage estimation

[8] All estimation results were obtained using STATA 10.

procedure. The inverse of the capital stock shows very small values compared to the range of the other explanatory variables. This causes convergence problems in the maximization routine of the likelihood function and leads to rather wide confidence intervals. By means of a log transformation this problem is solved. In the second stage regressions, the Hausman test reveals that the unobserved effects are correlated with the explanatory variables. A classical 'fixed effects estimation' is applied. Using the difference from means transformation of the data, the farm individual heterogeneity effects are eliminated and the Least Squares Estimator for panel data can be applied. In addition, we consider in all estimation steps a farm type dummy, DT_{it} [9], a size dummy DS_{it} [10] and a time dummy.

We start with a discussion of the results of the first stage Probit model (12) and then turn to the results of the second stage (dis)investment equations (13a) and (13b), both separated according to East and West Germany. Finally, the results of the second stage regressions are compared with the outcome of the benchmark model (14).

Table 2 depicts the results of the generalized ordered Probit model for West and East Germany.

Insert table 2 here

The pseudo R-squared of McFadden shows a rather satisfactory fit for both models, 0.309 for West Germany and 0.286 for East Germany. The estimated means of the shadow value

[9] Dummy variables for cash-crop farms, pig and poultry farms, specialized grazing livestock farms, permanent-crop farms and mixed farms are defined referring to standard gross margins.

[10] Referring to standard classification criteria (Eurostat), the size dummies were defined according to the following size classes for West Germany: 8-16 European Size Units (ESU), 16-50 ESU, 50-100 ESU and >100 ESU. With respect to East Germany, the dummies refer to the following classes: 8-16 ESU, 16-50 ESU, 50-100 ESU, 100-250 ESU and >250 ESU.

of capital, $\hat{q}_{it}$, are 0.436 and 0.390 for East and West Germany, respectively. A significant positive relation for q and the revenues-capital ratio for both regions is confirmed. The second order lag is rejected for both regions and thus the assumption that farms use an AR(2) process to forecast their revenues. The estimate for the quadratic term of the revenues-capital ratio is negative; however, the overall relation of the revenues to the approximation of q remains positive. The impact of uncertainty, $\sigma_{X,i}$, is significant in both regions, and the estimates do not differ much in size. The results indicate a positive relation of the volatility of revenues and the value of q_{it}; thus an increase in volatility increases the probability of investments. This result is consistent with the theoretical model suggested by Abel and Eberly (1994), but contradicts the empirical findings of Pietola and Myers (2000) or Hinrichs *et al*. (2008).

The results provide evidence of a significant range of inaction ((6b) and (7b)) induced by irreversible investment costs. For *West Germany* the estimated mean of the investment trigger is 0.691 and -1.842 for the disinvestment trigger. The Wald test rejects the null of equal parameter estimates. The respective estimates of the threshold equations for West Germany (including only significant variables) can be written as:[11]

$$\hat{q}_{it} > \hat{q}_{it}^{W+} = -2.067 - 0.207 \cdot \log\left(1/K_{it}\right) - 0.853 \cdot CF_{it}/K_{it} \tag{15a}$$

$$\hat{q}_{it} < \hat{q}_{it}^{W-} = 0.980 - 0.064 \cdot \log\left(1/K_{it}\right). \tag{15b}$$

The results show that farms' individual thresholds might be negative, i.e., even a negative capital productivity is tolerated without inducing a disinvestment. This finding is in line with the real options approach. The significant cash flow parameter in the investment trigger equation discloses the presence of transaction costs due to imperfect capital markets for West Germany also. The significance of the inverse capital stock together with the constant terms indicate the presence of fixed adjustment costs. The linear approximation of the trigger equations does not allow the structural parameters of the adjustment cost function representing the fixed costs, i.e., *a* and $a^{+/-}$, to be fully recovered.

The investment trigger and disinvestment trigger for *East Germany* are on average -0.751 and -2.691, respectively. The Wald test rejects the equality of the parameter estimates. The equations for East Germany are:

$$\hat{q}_{it} > \hat{q}_{it}^{E+} = 2.125 + 0.190 \cdot \log\left(1/K_{it}\right) - 1.429 \cdot CF_{it}/K_{it} \tag{16a}$$

$$\hat{q}_{it} < \hat{q}_{it}^{E-} = 0.031 - 0.194 \cdot \log\left(1/K_{it}\right). \tag{16b}$$

The estimated cash flow coefficient indicates the presence of transaction costs for East German farms that might be due to imperfect capital market structures. These are significantly higher than for West German farms. A one-tailed score test confirms this difference between East and West German farms at any usual significance level. Moreover, the marginal effects with respect to the probability of investing is less pronounced for farms in the Western federal states (0.319) than for farms in the Eastern federal states (0.391). This result demonstrates that the acquisition of capital in East Germany is more difficult and provides further evidence of the sizeable differences between the transition region (East Germany) and an established economy (West Germany). The results further confirm the different extent of the range of inaction already provided by the initial distribution of the data over the three regimes. On average the inaction regime in West Germany is wider than in East Germany. This implies that the ‘natural’ investment reluctance in West Germany is more pronounced compared to East Germany. This reflects the fact that during economic transition stagnation is not sufficient and farm investments were required to meet Western production standards, in

[11] The impact of the inverse capital stock on the trigger equations can be derived by a multiplication with the mean capital stock.

particular in animal production. The significant estimate for the capital stock and the constant term also indicate the presence of fixed adjustments costs as in West Germany.

A comparison between East and West Germany is challenging because differences might simply be caused by differences in the explanatory variables. Therefore, we decompose the difference in the prediction of the investment probability for East (0.732) and West Germany (0.437) following Even and MacPherson (1990).[12] It turns out that only 54 % of the differences in the investment probability are related to differences in the explanatory variables. The rest (46 %) can be attributed to divergent estimated coefficients in both regions. This share is even more important when decomposing the mean investment trigger: 94 % of the differences are due to different parameter estimates.

Table 3 presents the results of the second stage regressions, (13a) and (13b), which estimate the (dis)investment rates conditional on the decision to invest or disinvest, as well as the results of the benchmark model (14). In addition, the recovered structural parameters of the adjustment cost function are provided.

Insert table 3 here

The results of both investment equations show a positive and significant relation of $\hat{q}_{it}$ to the investment rate. The significance of the intercept in East Germany shows the relevance of the linear term of the adjustment cost function, i.e. the capital costs, for the investment rate. For West Germany, this term is rejected. The signs and absolute values of the respective recovered adjustment cost parameters that are related to investments are consistent with the theoretical model. The results provide further evidence of the

[12] We thank an anonymous referee for suggesting this decomposition.

sensitivity of investments and the cash flow in both regions.[13] The sensitivity to the cash flow is higher for East Germany, which supports our initial hypothesis that capital market imperfections are more pronounced in a transition economy. However, the differences are less pronounced compared to the first stage results. A decomposition reveals that the difference between East and West Germany in the mean investment rate is mainly driven by differences in the explanatory variables (92 %) whereas differences in the parameter estimates contribute only 8 %.

The results of the disinvestment rate are not satisfactory in either region. One reason might be the overall high heterogeneity in combination with the low number of observations, in particular in East Germany. As already indicated by the estimated parameters, the signs of the structural parameters related to disinvestments are not in line with the theoretical expectations and rather unsatisfactory.

Column 3 and 6 present the results of the benchmark model for West and East Germany, respectively. Recall that the benchmark model does not account for the uncertainty in farm revenues. Moreover, the approximation for q is not corrected by the inverse Mill's ratios. This implies that the inaction regime and thus the respective decision rules induced by irreversibility are not taken into consideration. Against this background it is surprising that the fit of the general model, as indicated by the R-squared is not higher compared to the simpler benchmark model. However, the results of the Cox-Pesaran test for non-nested models (Pesaran, 1974) for West Germany reject the benchmark model in favour of the second stage Tobit regression at any usual significance level. Unfortunately, the test results are not unique for East Germany.

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[13] At first glance the positive relation between investment cash flow seems to contradict the theoretical model. However, recall that the theoretical model refers to the inverse cash flow, while the cash flow enters the empirical model directly. Thus, an increasing cash flow would induce increasing investment rates despite the negative sign.

The parameter estimates for the cash flow have the same sign in both models, but the size differs significantly. An intuitive explanation is that due to the enhancement of q this variable can explain more of the variation of investments in the Tobit model. In turn, the explanatory power of the cash flow variable is reduced in comparison with the benchmark model. Furthermore, it can be expected that the constant in the Tobit model is lower than in the benchmark model, since truncation implies that q should exceed a threshold before a positive investment is triggered. Again, this conjecture is confirmed by the results.

Interestingly, for East Germany the constant term is rejected in the benchmark model. This term reflects adjustment cost parameters related to the acquisition costs of capital. The findings of the benchmark model would indicate that only internal adjustment costs are present and acquisition costs that occur are related to imperfect capital markets. Thus, the classical convex adjustment costs model would be confirmed and it would be concluded that there are severe problems due to imperfect capital markets in East Germany.

In view of the approximation of q and the simplified treatment of uncertainty effects one may question if the observed difference between the estimates of the Tobit model and the benchmark model can in fact be traced back to option-like effects. In order to further validate our results we have tested the estimation procedure with simulated data. Additional estimations based on artificial data generated by our theoretical model show that the difference between the second stage Tobit and the benchmark estimates increases with increasing volatility of the revenues.[14] Thus, the misinterpretation of the impact of

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[14] For the simulations we refer to the definition of q provided by Abel and Eberly (1994). We run 1000 random simulations and estimate both models each run. It turns out that under conditions of perfect capital markets the cash flow variable in the benchmark model is significant if irreversibility determines the optimal path of investments. This result holds for 62 % of the simulations. Further simulations with an increase in the volatility of the revenues under perfect capital market conditions (but with irreversibility) results in increasing and significant estimates of the cash flow parameter in the benchmark model, even though the parameter has been set to zero in the simulations.

imperfect capital markets in the benchmark model becomes more severe with higher volatility of the revenues because the proxy for q becomes weaker in the benchmark model compared to the Tobit model. This finding confirms our empirical results and is in line with Erickson and Whited (2000).

5. Conclusions

The objective of this study was to analyze the joint effect of imperfect capital markets, irreversibility and uncertainty on the investment behaviour of farms. Imperfect capital markets caused by agency problems induce additional transaction costs to acquire finance or even a limited access to capital. However, we argue that the impacts of agency problems and informational asymmetries in the capital market are not solely responsible for low investment rates. Costly reversibility and uncertain future expectations lead to reluctance and a range of inactivity along the optimal path of investment even under perfect capital markets. In order to account for this, a stochastic and dynamic investment model was enhanced. This model explicitly considered the consequences of capital market imperfections inducing the dependence on finance and coexistent irreversibility as well as uncertain future revenues. This was achieved by an augmented adjustment cost function within the frame of a stochastic q model, as the presence of irreversibility did not make it possible to use strictly convex adjustment costs as traditional q theory proposes. The application of this model to German farm-level panel data confirms that capital market frictions, costly reversibility and uncertainty coexist. The findings support the hypothesis that farms in East Germany face significantly higher transaction costs expressed in terms of a greater cash flow sensitivity. Contrasting these findings with results from a simpler linear model, which solely accounts for capital market imperfections, affirms that disregarding irreversibility reduces the informative power of such models and gives way to a misinterpretation of financial variables such as the cash flow. It has been shown that this potential increases if the degree of irreversibility becomes large.

Nonetheless, the empirical specification of the generalized Tobit model has potential for improvement. An important issue is the approximation of q, which plays a crucial role in the theoretical investment model. This approximation could be further improved by considering market values of farms' assets to come closer to the shadow value of capital. However, these are unfortunately hardly available. We conjecture that the differences between the Tobit model and the linear investment model become more visible if the approximation of q can be further improved. Moreover, the incorporation of the error term into the Tobit model is rather basic. Future extensions should consider more complex error term structures such as multivariate distributed disturbances for the thresholds and the particular (dis)investment rate.

Beyond the methodological issue of this paper, our findings have practical implications. Our results indicate that both capital market frictions and irreversibility determine farm investment behaviour. However, simplified models, which do not allow for a joint consideration of both issues, may find an exaggerated impact of capital market frictions or even seemingly imperfect capital markets. An immediate consequence is that comparisons between countries with different banking systems in the spirit of Benjamin and Phimister (2002) may be biased if capital market imperfections are measured incorrectly. This, in turn, may lead to wrong conclusions about the relative performance and the superiority of agricultural credit markets. Second, and perhaps even more important, is the fact that capital market imperfections are frequently used as an argument by politicians for justifying measures like investment aid, state bail-outs, tax privileges and other kinds of subsidies. It has been emphasized in the literature that such measures, which can be summarized as soft budget constraints, are often ineffective (Kornai *et al*., 2003; Zinych *et al*., 2007). If an empirical analysis reveals that farmers' reluctance to invest simply reflects dynamically optimal behaviour then there is little justification for policy intervention. Insofar, a correct measurement of capital market imperfections may help to avoid an inappropriate use of soft budget constraints. An evaluation of alternative instruments aimed at reducing or compensating for capital market frictions is beyond the scope of this paper. However, the estimation approach presented here offers a framework for such an analysis.

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Table 1. Summary Statistics of the Main Explanatory Variables

	West Germany				*East Germany*			
Variable	minimum	maximum	mean	standard deviation	minimum	maximum	mean	standard deviation
K_{it}	1.234	9 260	898	719	13.522	25 200	1 760	2 630
$(I/K)_{it}$	-0.117	0.878	0.043	0.090	-0.117	0.876	0.102	0.126
$(X/K)_{it-1}$	0.024	2.479	0.296	0.351	0.024	2.474	0.495	0.327
σ_i	0.133	3.462	0.445	0.236	0.044	3.221	0.487	0.264
$(CF/K)_{it}$	-4.487	3.411	0.107	0.135	-1.764	2.661	0.188	0.161
$(Equity/K)_{it}$	0.001	1.000	0.832	0.192	0.000	1.000	0.580	0.250
[1)] $(Debt/CF)_{it}$	-31 875	5 225	1.364	196	-2 928	7 488	3.994	92
No. of observations		*69 942*				*13 913*		

1) Only investing farms.

Note: The database is the BMELV Testbetriebsnetz, 1996-2007. Capital stock is in thousand Euros.

Table 2. Results of the First Stage Generalized Ordered Probit Model

	West Germany		*East Germany*	
Proxy variables for q				
$(X/K)_{it-1}$	1.569 (0.085)***		1.009 (0.201)***	
$(X/K)_{it-2}$	-0.009 (0.042)		0.063 (0.124)	
$(X/K)_{it-1}^{2}$	-0.620 (0.037)***		-0.437 (0.093)***	
σ_i	0.135 (0.029)***		0.128 (0.065)**	
Mean of q	0.390		0.436	
Standard deviation	0.237		0.156	
Variables of the investment and disinvestment thresholds q^+ and q^-				
	q^+	q^-	q^+	q^-
$(CF/K)_{it}$	-0.853 (0.020)***	--	-1.429 (0.067)***	--
$\log(1/K_{it})$	-0.207 (0.015)***	-0.064 (0.036)***	0.190 (0.029)***	-0.194 (0.042)***
Constant	-2.067 (0.210)***	0.980 (0.253)***	2.125 (0.485)***	0.031 (0.707)
Mean of $q^{+/-}$	0.691	-1.842	-0.751	-2.691
Standard deviation	0.248	0.054	0.255	0.226
Log Likelihood	*-39 582*		*-6 234*	
Pseudo R^2	*0.309*		*0.286*	

Note: Standard errors in brackets. Single (*), double (**) and triple (***) asterisks denote significant at 10%, 5% and 1%, respectively.

Table 3. Results of the Second Stage Investment and Disinvestment Equations and the Benchmark Investment Equations

	West Germany			East Germany		
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	$(I_{it}/K_{it-1})^{+}$	$(I_{it}/K_{it-1})^{-}$	$(I_{it}/K_{it-1})^{b+}$	$(I_{it}/K_{it-1})^{+}$	$(I_{it}/K_{it-1})^{-}$	$(I_{it}/K_{it-1})^{b+}$
	second stage tobit		*benchmark*	*second stage tobit*		*benchmark*
$(q_{it} + \lambda^{+})$	0.068 (0.006)***	-0.008 (0.003)**	--	0.179 (0.027)***	-0.002 (0.004)	--
q_{it}	--	--	0.093 (0.012)***	--	--	0.431 (0.043)***
$(CF/K)_{it}$	0.113 (0.024)***	--	0.181 (0.021)***	0.123 (0.057)**	--	0.288 (0.041)***
Constant	-0.021 (0.015)	-0.067 (0.009)***	0.042 (0.015)***	-0.253 (0.060)***	-0.062 (0.015)***	-0.020 (0.025)
Structural parameters						
$b^{+/-}$	0.309 (0.235)	-8.375 (2.460)***		1.413 (0.152)***	-31.745 (61.701)	
$g^{+/-}$	7.353 (0.704)***	-62.500 (19.331)***		2.793 (0.434)***	-250.000 (529.319)	
d^{+}	1.662 (0.472)***	--		0.687 (0.403)**	--	
"R^2"	0.15	0.01	0.15	0.06	0.05	0.09
Observations	22 966	2 692	22 966	7 404	339	7 404

Note: Standard errors in brackets. Single (*), double (**) and triple (***) asterisks denote significant at 10%, 5% and 1%, respectively.

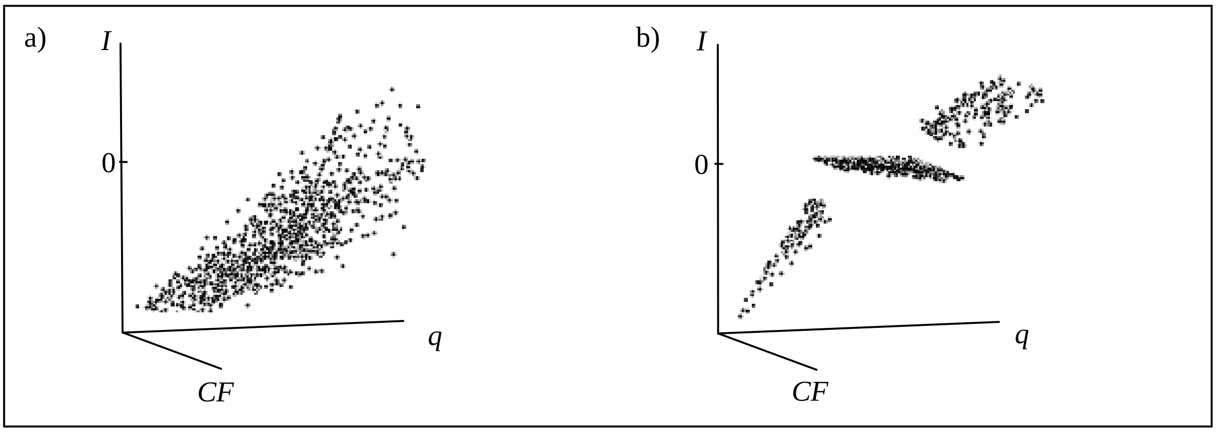

Figure 1: The Relationship of Investments, q and the Cash Flow.