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THE DYNAMICS OF SELF-EMPLOYMENT IN EAST GERMANY - AN EMPIRICAL ANALYSIS USING PANEL DATA AND ALLOWING FOR STATE DEPENDENCE AND ENDOGENOUS ATTRITION

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Abstract

The focus of the paper is on the analysis of the individual determinants of self-employment in East Germany after unification, with special respect to the dynamic issues which may arise. The data set used is the *Arbeitsmarkt-Monitor für die neuen Bundesländer*, which is a panel data set consisting of four waves covering the period from November 1990 to November 1991. The attrition rate in this data set is high.

The data set and the economic questions of interest give raise to methodological issues concerning estimation techniques for limited dependent variable models on panel data. Smooth Simulated Maximum Likelihood methods are proposed to allow for state dependence as well as endogenous attrition in the estimation. The results indicate the importance of the dynamics which drive the emergence of the small business sector in East Germany. Other important factors appear to be human capital aspects, institutional restrictions, expectations about the future of the local economy, the profession in 1989 and martial status. The simulations performed confirm the importance of the dynamics and suggest that self-employment in East Germany might reach the level of self-employment in West Germany as soon as 1995.

1 Introduction

After the introduction of the West German economic system in July 1990, the East German economy experienced serious problems. The generally large-scale plants which used out-dated equipment quickly become uncompetitive and either had to close down or reduce employment and output dramatically, or they absorbed large sums of subsidies, or both. Furthermore the increase in wages was much larger than the increase in productivity. All these and other problems led to high unemployment which continues to persist until today. One hope was and still is that an emerging vital small business sector would be able to make up for some of the production and job losses which occurred in the industrial sector. From this perspective it seems to be important to understand the reasons behind the individual decisions to become self-employed and to start a business. Ideally, this would allow us to predict the future development and impact of that sector and perhaps even to influence its future size by certain policy-changes.

In general it is expected that the decision to be self-employed is determined by personal and social characteristics, such as risk-aversion, independence of economic actions, family-tradition, sex, education, general outlook on life, habits and habit formation, ect., and economic characteristics such as potential income gains, availability of the necessary initial capital and/or access to capital markets, adjustment costs and institutional constraints such as the imposition of entrance regulations by the unification treaty, which requires some formal qualifications (which could have been obtained in the GDR) to be allowed to start a business (e.g. "Handwerksordnung"). For an extensive analyses of most of these factors in a microeconometric framework for West Germany see for example Börsch-Supan and Pfeiffer (1992), Hübler (1991), and Pfeiffer and Pohlmeier (1992). In East Germany there is at least one important difference which makes at least a modification of the analysis employed in these papers necessary. East Germans had up to July 1990 no personal experience with the functioning of a market economy. Even those people who were already self-employed in the GDR (only 2%), are not used to rapidly changing consumer tastes, international price competition and so on. Given that, it could appear as a very rational behaviour first to understand a market-economy and then to be able to make a decision to become self-employed, so that we would expect that such a behaviour could be reasonably approximated by some dynamic process which had its starting point in 1990.

Since there are still a lot of uncertainties about the 'nature' of this process, I refrain from using a tightly specified model, but employ a more empirically orientated reduced form approach. This is done by assuming a linear relationship between some underlying latent variable which is explained by observed and unobserved factors determining the 'propensity for self-employment' in a particular period. When the latent variable crosses a first threshold, an intention to become self-employed is observed, when it crosses the second threshold actual self-employment is observed. Since it is a priori not clear whether the intention to be become self-employed and actual self-employment are governed by the same process, a second model ignoring this distinction between the two groups of non-selfemployed is also considered.

The starting point of the process has been recently examined by Lechner and Pfeiffer (1993a) and Hübler (1992) using the first wave of the *Socio-economic Panel* (SOEP-East). Lechner and Pfeiffer (1993b) analyse the 'new' self-employed in 1991 using the second wave of the SOEP-East, but all the studies ignore the dynamics involved.

The emphasis in this work is on the understanding of more of the dynamic phenomena behind the observed behaviour. This is fostered by the availability of the first four waves of the panel data set *Arbeitsmarktmonitor für die neuen Bundesländer* covering the period from November 1990 to November 1991. Although this dataset is not as rich in terms of socio-economic variables as the SOEP-East, it contains a basic set of them. The panelsurvey is repeated every four months, which is important to trace the dynamics of the process. Although it is essential to have a reasonable number of time periods, this brings, besides the complications already inherent in dynamic binary or ordered choice models, the problem of possibly endogenous panel attrition, which may lead to biases for the coefficient estimates. The problem is tackled by estimating the coefficients of the process governing self-employment jointly with the attrition process and allowing for a correlation between the processes. Since the expressions for the exact likelihood are too complicated to be exactly computed, 'Simulated Maximum Likelihood (SML)' methods are used. The estimated dynamic model is used to simulate self-employment ratios, which are free of attrition bias and allow to get some insights in the implied future development of self-employment.

The paper is organised as follows: The next section gives some stylized facts about the labour market and in particular about the development of self-employment in East Germany. Section three describes the dataset and the variables used in the estimation. In the following section the modelling of attrition and nonresponse in dynamic limited dependent variables is discussed and a simulated maximum likelihood estimator is proposed. The results of the estimations are presented in section five and some dynamic simulations are given in section six. In section seven conclusions are drawn. Most of the descriptive analysis of the East German labour market and the sample used in the estimation is relegated to Appendix A. The derivation of the likelihood function used in the joint estimation of the coefficients of the attrition and the self-employment equations, a comparison between exact and simulated maximum likelihood and the implementation of the simulated maximum likelihood method is discussed in Appendix B. Appendix C contains additional estimation results under the assumption of ignorable attrition and in Appendix D additional results of the simulations are presented.

2 Some stylized facts

The situation in the last decade of the GDR has been dominated by the typical features of a centrally planed economy. After several waves of expropriations the private sector was very small, highly regulated and taxed, and restricted to a few sorts of trades and services. Furthermore, it was certainly not helpful to work in the private sector, if a descent position in the "official" society was a personal goal. One of the results of these circumstances was a self-employment rate of about 2% (see Table 1). A feature of the public sector was an extensive bias (compared to West Germany for example) towards large scale plants, a lack of differentiated products, services, market prices for inputs/outputs and so on.[1] Another difference compared to a western economy was the near absence of the risk of unemployment (unemployment rates were below 1%).

Table 1: Some features of the labour market in East Germany

	1980+	1989+	11/90	3/91	7/91	11/91	10/92
Total employment/1000	8225	8547	8037*	7732*	7459*	7271*	(6600)
Unemployment[a]	-	-	6.1*x	9.1*x	12.2*x	12.0*x	13.9*
Involuntary short time work[b]	-	-	17.9*	22.4*x	18.3*x	12.8*x	3.0x
Self-employment [c]	2.2[d]	2.2[d]	2.2*x	2.7*x	3.2*x	3.7*x	-

\+ Statistisches Jahrbuch der DDR, 1990.
* Arbeitsmarktmonitor, estimate of population totals using the sampling-weights.
x Amtliche Nachrichten der Bundesanstalt für Arbeit.
a ratio of the unemployed to those potentially employed in %.
b ratio of those working involuntary short time to those potentially employed in %.
c ratio of those being self-employed to those potentially employed in %.
d includes unpaid family workers.

After unification in July, 1, 1990 the West German political and economic system has been introduced in East Germany as a shock. The aim was to let living standards converge quickly towards western levels, so incomes increased rapidly. Actually this process started several months before unification and income levels are supposed to reach western levels not later than 1994 (see Geib et al., 1992). Although there have been huge subsidies flowing from West to East Germany the burden of the out-dated equipment and infrastructure of the (partly already privatised) industry was too heavy to increase productivity as fast as incomes. As a result the individual risk of unemployment increased dramatically. The combined number of those being unemployed and those being subject to involuntary short time work (that implied zero working hours in many cases)

1 More details can be found for example in Lechner and Pfeiffer (1993a).

peaked above 30% in the middle of 1991. However, this risk isn't evenly distributed among different sexes and professional groups. Females have been more subject to unemployment than males. Considering the groups of males only, those working in agriculture faced the largest risk, and those having technical occupations faced the lowest risks (for details see tables A2 and A3 in Appendix A1).

Starting with about 2% in early 1990, the self-employment rate increased to close to 4 % in November 1991 (latest figure available, rate for West Germany about 9%). The figures for registrations and cancellations of businesses in 1992 suggest that this rate is still increasing although at a lower speed (details in Table A4 in Appendix A). Comparing those figures for East Germany to comparable numbers for Northrhine-Westfalia (NRW), which is of similar population size, for 1991 the East German numbers are 2.5 times as high as in NRW for registrations and 8 times as high as in NRW for net registration (registrations minus cancellations). For the first three quarters of 1992 the respective numbers are 1.5 and 3. Due to a lack of reliable statistics for East Germany the distributions of the self-employed over different sectors of the economy could only be analysed for November 1990. In an east-west comparison (details in Table A5 in Appendix A) the agricultural sector in the east "suffers" from extreme under-self-employment,[2] whereas for the banking and insurance sector there is a higher self-employment rate than in West Germany. The latter is very probably much more attributable to insurance than to banking.

Data provided from a survey conducted by the "Deutsche Ausgleichsbank" (1992), a public bank sponsoring among other things the set-up of new businesses in East Germany, suggests that there is no reduction in the numbers of businesses which have been founded in 1992, compared to 1991, that more than one million people will work in that sector by the end of 1992, and that the bankruptcy rate is fairly close to zero.

Although this seems to suggest an extremely healthy, large and ever increasing small business sector, other numbers (for example by the 'Verein für Creditreform') imply a much higher failure rate. Nevertheless the emergence of an important small business sector is undisputable.

Part of this development may be due to the substantial amount of public aid available for the set-up of new businesses. Aid comes from all levels of government (EC, federal government, governments of the federal states). The information is contained in sometimes not too easy to understand booklets compiled by the federal and state governments. However due to the lack of (measurable) individual variations the effects due to availability of state aid cannot be modelled in the following empirical analysis and will be absorbed in the time effects.

2 For an intensive analysis of this phanomena, see Peter and Weikard (1993).

3 Data

The dataset used in the estimations is the *Arbeitsmarkt-Monitor für die neuen Bundesländer* (AMM). This is a panel dataset which started in November 1990 and is repeated every four months. Up to now there are four waves available. The observations of the first wave have been obtained by drawing 15000 individuals from the registrar of the GDR at random, subject to the restriction that they were born between 1926 and 1974. The survey is based on individuals and not on households. The information is obtained by sending out questionnaires by mail (more details can be found in Appendix A.2.). Comparing the AMM with a more popular dataset for East Germany, the *Socio-economic Panel-East* (SOEP), the AMM has the advantage that (i) it is based on more observations, (ii) it is a truly random sample, and that (iii) it is possible to trace short-run dynamics more easily since it is repeated every four months instead of every year. However, there are also drawbacks: (i) the first wave is five months after unification; (ii) panel mortality is rather high, and (iii) there is not so much information in the survey. This last point is more important and has two aspects. Firstly, not every question is contained in every wave, which is a particular problem if working and family conditions change. Secondly, information concerning the household, such as family composition, household income and assets is rather sparse.

The estimation is based on an unbalanced sample of men between 25 and 60 (in 1990), who were working in 1989. The last restriction has been imposed in order to be able to use all the information on former job characteristics. This reduced the sample size only marginally because unemployment and nonparticipation was nearly absent for these men. Females have been excluded since (i) all empirical results suggest that self-employment is most important for men, and (ii) women may well have a completely different decision model, where the choice between participation and nonparticipation can no longer be ignored. The age restriction has been chosen to avoid most of the influence of education and retirement decisions. The resulting sample contains 3309 observations in the first wave, 2600 in the second wave, 2206 in the third and 1889 in the fourth wave.

The following groups of variables have been constructed. Two measures of self-employment are used. Besides actual self-employment (self-reported, excluding unpaid family workers) individuals can indicate whether they intend to become self-employed in the future. Table A10 in appendix A3 contains a descriptive analysis of the pattern of the status self-employment and non-self-employment, which shows among other things that of those individuals who change their employment status 87% change from non-self-employment to self-employed and 18% from self-employment to non-self-employment. Table A11 gives a similar analysis for expected self-employment and subsequent realisations. This shows that about 20% of those who plan to become self-employed are subsequently observed as self-employed, about 40% change their mind, and about 40% are still planning self-employment in the last period observed. Furthermore about 40% of those observed self-employed have not planed that at least four months in advance.

Individual and family characteristics include age, martial status, number of children below and above six years living in the household, schooling and the highest professional degree obtained before unification. Regional information is available on the federal states and the size of the community in which the household lives. Information on job characteristics in 1989 include sectoral affiliation, professional group, firm size, the position in the firm, and self-employment.

Before the discussion of variables related to expected income and expected risk of unemployment, it should be noted that the estimation method which will be introduced in the next section requires that these features are exogenous, resulting in an indirect measurement in some cases. Income expectations are measured as part of the expected situation of the economy in the region in one year and by the predicted difference of ln(income) as a self-employed worker compared to being an employee. An indication whether other individuals with income live in the household can be seen as a very rough measure for additional resources available. The risk of potential unemployment if the individual would work as an employee has been proxied as follows: from the AMM the professional group (1989) is known, so that the potential labour force in any (of 34) professional groups can be predicted using the sampling weights. Furthermore, for 1991 the labour office publishes the total number of unemployed in each professional group on a monthly bases,[3] so that unemployment rates (which vary over time) can be constructed for each professional group. These rates are supposed to measure that risk. Ideally, one should also include at least part of the involuntary short time work, but these numbers are only available on a sectoral bases, so that there is no way of combining these numbers.

Self-employment may be attractive in sectors where the distortions of wages and productivity is high, so that larger firms with employees are not competitive compared to a self-employed who can 'pay' himself less than the contractual payments which have been determined by a central bargaining process. To compature these effects a variable has been constructed which contains the wage sectoral differential in East and West Germany.

A full description of the variables and descriptive statistics are contained in Appendix A3.

3 Disaggregated according to sex. For the first wave (11/90) those numbers have also been predicted from the AMM.

4 Econometrics

4.1 Introduction

Whereas the estimation of dynamic LDV models has attracted some attention in the literature after the publication of Heckman's (1981a,b,c) seminal papers[4], this is not the case for the problem of endogenous attrition and LDV models. However, this is not true for the estimation of linear models with endogenous selectivity. One of the first papers considering that problem was Hausman and Wise (1979) in their analysis of the results of the Gary income experiment. They estimated an income equation jointly by maximum likelihood with an attrition equation to get rid of attrition bias. However, this was feasible because they reduced the problem to two time dimensions. Recently a series of papers by Arellano et al. (1992), Nijman and Verbeek (1992), Ridder (1990), Verbeek (1990), and Verbeek and Nijman (1992 a,b) discussed that issue under various assumptions. With the exception of the first paper, they all focussed on the linear regression model. With the exception of Verbeek (1990), all the papers employ the control functions approach, e.g. the focus is on the distributions conditional on non-attrition, and predict the 'adjustment factors' by probits from the attrition equation. Random effect error structures are imposed to simplify these expressions considerably.

The paper by Arellano et al. (1992) considers dynamic LDV models with selectivity. A basic condition for the application of their method is that at least a continuous part of the latent variable can be observed. Conditional on selection they are able to identify and estimate a general class of latent variable autoregressive models. For the estimation they specify a reduced form of the model and use a minimum distance procedure in a second step to recover the structural parameters. Having obtained consistent and asymptotic normal estimates in the first step, no other essential problems arise in the second step.

A common feature of all these models is that by construction of the data (e.g. aggregation of monthly data to the level of yearly data) the explanatory variables of the attrition equation are observable, even for the periods where attrition /nonresponse occurred. Unfortunately such an assumption is not tenable with the dataset used in this paper.

4 See also Hsiao (1986), chapter 7.

4.2 The model

The approach to the estimation of the dynamic process of interest adopted in this paper is to model it jointly with the attrition process. In this section I will give an outline and a discussion of the model under consideration. The derivation of the objective function used to obtain the estimates is given in Appendix B.1. It is based on the assumption that each individual i is the result of an independent draw in the population. The following model is considered:

$$
\begin{aligned}
r_{ti} &= I[G_{t-1i}\gamma + \tilde{g}(y_{t-1i})\tilde{\alpha} + \epsilon_{ti} > 0] \quad, & t = 1,\ldots,T, && (1)\\
y^{*}_{0i} &= X_{0i}\beta_0 + u_{0i} \quad, & && (2a)\\
y^{*}_{ti} &= g(y_{t-1i})\alpha + X_{ti}\beta + u_{ti} \quad, & t = 1,\ldots,T, && (2b)\\
y_{ti} &= \bar{g}(y^{*}_{ti},\bar{\theta}) \quad, & t = 0,\ldots,T, \quad i = 1,\ldots,N, &&
\end{aligned}
$$

$$
\tilde{r}_{ti} = \prod_{\tau=0}^{t} r_{ti} \quad, \quad \tilde{r}_i = (\tilde{r}_{1i},\ldots,\tilde{r}_{Ti}), \quad G_i = (G_{0i},G_{1i},\ldots,G_{T-1i}),
$$

$$
y_i = (y_{0i},y_{1i},\ldots,y_{Ti}), \quad X_i = (X_{0i},X_{1i},\ldots,X_{Ti}),
$$

$$
\epsilon_i = (\epsilon_{1i},\ldots,\epsilon_{Ti}), \quad u_i = (u_{0i},\ldots,u_{Ti}), \quad v_i = (\epsilon_i,u_i).
$$

Equation (1) describes the attrition process. The indicator r_{ti} equals one if the observation is observed in period t. Furthermore, once attrition occurred it is assumed that the individual does not answer in any future interviews. A violation of this restrictive assumption of attrition being an absorbing state leads to an efficiency loss but not to inconsistent estimation. A way to think about attrition is the occurrence of some event between the last realised interview and the first non-realised one, so that it remains unobserved. Furthermore, there may be other factors which lead to higher attrition probabilities for particular groups of individuals. Due to the impossibility of observing any information between interviews or for observations with $\tilde{r}_{ti} = 0$, the deterministic part covering the observed heterogeneity has to be dated back by one period. The alternative to try to identify all model coefficients from the conditional distribution of $\tilde{r}_{ti} = 1$ alone, is not at all promising in empirical applications (see Maddala, 1983). The introduction of time specific constant terms, capturing all sorts of pure time effects, together with the modelling of attrition being an absorbing state, leads to an identification problem in a state dependence model. Since all of the individuals observed at a particular point in time have exactly the same histories, the time specific constant terms and the coefficient on the lagged endogenous variable could not be identified separately. No attrition equation has been specified for the initial period. The reason is that there is no information on individuals who did not reply in that period (November 1990). Therefore, all distributional assumptions which are subsequently made, are for distributions conditional on $r_{0i} = 1$.

The dynamic process whose parameters are of primary interest consists of a latent linear model which accounts for state dependence and observed and unobserved heterogeneity.[5] The latent variable y^*_{ti} is not fully observed and is mapped by a monotonous function $\bar{g}$ which may depend on some parameter vector $\bar{\theta}$, into an observed variable y_{ti}. An explicit initial condition is specified to approximate the pre-sample history of the process and no restrictions on the coefficients of the initial conditions and the remaining parameters are imposed. Note that in this context this initial condition has a different interpretation than for example in Heckman (1981a), where it is considered to approximate a dynamic process which has been running for a long time. In the context considered in this paper the Economic, Monetary and Social Union in July 1990 provided a natural endpoint for the dynamic processes which were running previously (this view could be contested by people claiming that this part of Germany is still run by the same people who ran it before July 1990; but still the structural break is significant). Hence, specifying an initial condition should be a much better approximation of 'reality' than in the contexts where these type of models have been applied to western data sources.

In the AMM there is not only information about self-employment but also about the intentions to become self-employed, so that it is possible to order these alternatives and estimate an ordered probit-type model with the propensity of self-employment as endogenous variable. In this model the functions $g(\cdot)$ and $\tilde{g}(\cdot)$ map the lagged endogenous variable in a vector with dummy variables for the category self-employed and expected to become self-employed, where α and $\tilde{\alpha}$ are the respective coefficient vectors. If the proposed latent linear model is a correct representation of this 'propensity', then the binary and the ordered models are both consistent, if the coefficient of the lagged expected self-employment is zero, but the ordered one is always more efficient.

The most important assumptions will be that the individuals are independently drawn, that the regressors (G_i, X_i) are independent of the error term ν_i, that the elements of ν_i are jointly normally distributed with mean zero, and that all coefficients (γ, $\tilde{\alpha}$, β_0, α, β, $\bar{\theta}$, $\tilde{\delta}$, $\tilde{a}$, δ_t, a, ρ, and σ, are nonstochastic constants. The last six of them are explained in the next paragraph.

5 In the estimations fixed time effects are also included to allow for a changing macroeconomic and social environment. Here they are suppressed for notational convenience.

In order to reduce the coefficients of the covariance matrix to keep the estimation tractable, the following flexible covariance structure of the one-factor autocorrelation type is imposed on the error terms, which are collected in ν_i.

$$\epsilon_{ti} = \tilde{\delta}_t \tilde{c}_i + \tilde{\nu}_{ti} \quad , \quad \tilde{\nu}_{1i} = \tilde{e}_{1i} \quad , \qquad t \geq 1,$$

$$\tilde{\nu}_{ti} = \tilde{\alpha} \tilde{\nu}_{t-1i} + \tilde{e}_{ti} \quad , \qquad t \geq 2,$$

$$u_{ti} = \delta_t c_i + \bar{\nu}_{ti} \quad , \quad \bar{\nu}_{0i} = e_{0i} \quad , \qquad t \geq 0,$$

$$\bar{\nu}_{ti} = \alpha \bar{\nu}_{t-1i} + e_{ti} \quad , \qquad t \geq 1.$$

The following restrictions hold:

$$E\tilde{c}_i \tilde{e}_{ti} = 0 \quad , \quad E c_i e_{ti} = 0 \quad , \quad E\tilde{c}_i e_{ti} = 0 \quad , \quad E c_i \tilde{e}_{ti} = 0 \quad ,$$

$$E\tilde{e}_{ti}^2 = \sigma_{\tilde{e}_t}^2 \quad , \quad E e_{ti}^2 = \sigma_{e_t}^2 \quad , \quad E\tilde{c}_i^2 = \sigma_{\tilde{c}}^2 \quad , \quad E c_i^2 = \sigma_c^2 \quad ,$$

$$E e_{ti} e_{si} = 0 \quad , \quad E\tilde{e}_{ti} \tilde{e}_{si} = 0 \quad , \qquad \forall t \neq s \quad ,$$

$$E c_i \tilde{c}_i = \rho^c \sigma_c \sigma_{\tilde{c}} \quad , \quad E e_{ti} \tilde{e}_{ti} = \rho^e \sigma_e \sigma_{\tilde{e}} \quad .$$

The error components $(c_i, \tilde{c}_i, e_i, \tilde{e}_i)$ are assumed to be jointly normally and independently of the regressors distributed with mean zero. The initial condition is taken literally in the sense that the dynamic evolutions of the error terms have an explicit starting point in the initial period for the self-employment equation and in the first period for the attrition equation. An alternative assumption frequently used in the literature is to assume that the process is in a stationary equilibrium. However, given that the initial condition here does not approximate an already on-going dynamic process, but instead describes the starting point of such a process, the stationarity assumption, although it simplifies the expression for the covariance matrix, is not adequate in this context. Collecting assumptions the following joint covariance matrix of ν_i is obtained:

$$E\epsilon_{ti}\epsilon_{si} = \tilde{\delta}_t\tilde{\delta}_s\sigma_c^2 + \sum_{\tau=1}^{s}\tilde{a}^{t-\tau}\tilde{a}^{s-\tau}\sigma_{\tilde{e}_\tau}^2 \quad , \qquad \forall \quad 1 \le s \le t \quad ,$$

$$Eu_{ti}u_{si} = \delta_t\delta_s\sigma_c^2 + \sum_{\tau=0}^{s}a^{t-\tau}a^{s-\tau}\sigma_{e_\tau}^2 \quad , \qquad \forall \quad 0 \le s \le t \quad ,$$

$$E\epsilon_{ti}u_{si} = \tilde{\delta}_t\delta_s\rho^e\sigma_c\sigma_{\tilde{c}} + \sum_{\tau=1}^{s}\tilde{a}^{t-\tau}a^{s-\tau}\rho^e\sigma_{\tilde{e}_\tau}\sigma_{e_\tau} \quad , \qquad \forall \quad 1 \le s \le t \quad ,$$

$$E\epsilon_{ti}u_{0i} = \tilde{\delta}_t\delta_0\rho^c\sigma_c\sigma_{\tilde{c}} \quad , \qquad \forall \quad 1 \le t \quad .$$

Due to the ordinal structure of the data, not all parameters of the covariance matrix are identified, even for large T. Firstly, note that exactly the same covariance matrix is obtained, if all $\tilde{\delta}_t$, δ_t change their sign simultaneously. The same is true for every single $\tilde{\delta}_t$, δ_t and ρ^e. So the following normalisation is chosen: The variance of the individual effects is restricted to unity and one of the factors in both equations is restricted to be positive.

Since identification of the coefficients in ordinal models is only up to scale the following variances are normalized, such that $\sigma_{\tilde{e}_1}^2 = 1$, $\sigma_{e_0}^2 = 1$, $\sigma_{e_1}^2 = 1$. The last normalisation is necessary, because there are no restrictions between the coefficients of the mean function of the initial period and the following periods.

In the estimation the case of homoscedasticity $\left(\sigma_{e_t}^2 = \sigma_e^2, \forall t\right)$ will be considered, because otherwise the estimations does not converge properly. For the attrition equation it turned that the one-factor coefficients are insignificant and also that homoscedasticity cannot be rejected. Since in particular the one-factor specification leads to a huge efficiency loss in the estimation, the $\tilde{\delta}_t = 0, \forall t$, and $\sigma_{\tilde{e}_t}^2 = \sigma_{\tilde{e}}^2, \forall t$, are imposed.

Besides the ability to provide a flexible approximation of the 7 x 7 dimensional covariance matrix, the chosen error structure has an additional interpretation in terms of unobservables. The one-factor part takes account of time varying influences of unobserved individual specific effects which are constant over time. The autoregressive part allows for example the persistence of the effects of shocks over time.

5 Estimation results

The simulated maximum likelihood estimations have been implemented as described in Appendix B1. Since computation is very time consuming,[6] the number of regressors (and covariance parameters) has to be limited. In a primary specification search for the self-employment equation which involved the first wave only, completely insignificant regressors have been deleted. These are age, number of children in different age groups, federal states other than Berlin (East), dummies for different sizes of the community, sectoral income in West Germany, in East Germany and the relative contractual sectoral income differential between East and West Germany, an indicator whether there are other members of the household who have an income, and other professional degrees than 'Master'. The same has been done for the attrition model by estimating a bivariate probit for the first attrition equation jointly with the self-employment equation of the initial period. It turned out that various income measures, regional indicators (dummies for community size and states) and indicators for the composition of the family do not play any role at all.

Table 2 presents the results of the attrition equation when estimated jointly the with self-employment equation for various specifications of the covariance matrix. In the first bloc of the table it is indicated whether the estimates have been obtained jointly with a binary or an ordered model for the self-employment equation, whether a correlation between the error terms of both equations has been allowed, which covariance restrictions have been chosen in both equations and which estimation method has been used. The middle part of the table contains the estimated coefficients which are significant at the 5% level. In the bottom of that table the estimate for the autocorellation parameter of the error term in the attrition equation and the correlation coefficient between the error terms of both equations are given.

Besides significant time effects the estimations indicate that the (conditional) probabilities to leave the panel increases significantly with self-employment, and with age for those older than about 46 years. The effect of potential unemployment leans in the same direction, but is only weakly determined. It decreases with the level of education and professional qualification and with age for those younger than 46. Furthermore, those who are married and either divorced or separated leave the panel with higher probability, especially when compared to singles.

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6 The estimation took about three weeks for one specification. A way to reduce computation time is to employ the 'weighted exogenous sampling (WESML)' approach of Manski and Lerman (1977) as has been done by Börsch-Supan and Pfeiffer (1992) and Mühleisen (1993), but the efficiency loss even for moderate sample size reductions (50%) appeared to be significant, resulting in very unstable estimates. Therefore, this approach has not been used.

Table 2: Estimation results for the attrition equation

model	-	binary	binary	binary	binary	ordered	ordered	ordered
simultaneous	no	yes	yes	yes	yes	yes	yes	yes
covariance:								
self-employ.	-	0	OF	OF	OF, AR	0	OF	OF, AR
attrition	0	0	0	AR	AR	0	AR	AR
estimation	ML	SML	SML	SML	SML	SML	SML	SML
Variable	coef.	coef.	coef.	coef.	coef.	coef.	coef.	coef.
time effects								
$t = 1$	-1.38	-1.42	-1.41	-1.64	-1.62	-1.29	-1.32	-1.11
$t = 2$	-1.12	-1.16	-1.16	-1.47	-1.46	-1.04	-1.04	-0.86
$t = 3$	-1.10	-1.13	-1.13	-1.46	-1.49	-1.01	-1.02	-0.83
self-empl.	-0.30	-0.30	-0.30	-0.37	-0.35	-0.31	-0.26	-0.24
exp. self-em.	-	-	-	-	-	*	*	*
econ. exp. +	*	*	*	*	*	*	*	*
econ. exp. -	*	*	*	*	*	*	*	*
school (8 y.)	*	*	*	*	*	*	*	*
school (12 y.)	*	*	*	*	*	*	*	*
university	0.35	0.34	0.34	0.40	0.39	0.35	0.34	0.34
eng./tech.	0.29	0.28	0.28	0.36	0.36	0.28	0.28	0.27
skilled w.	0.22	0.22	0.22	0.26	0.23	0.22	0.22	0.20
master	0.26	0.25	0.24	0.29	0.32	0.25	0.25	0.25
unemploym.	*	*	*	*	-1.70	*	*	-1.04
age	0.90	0.92	0.91	1.01	1.00	0.86	0.88	0.79
age ^{2}	-0.095	-0.097	-0.097	-0.11	-0.11	-0.091	-0.093	-0.085
single	0.12	0.11	0.12	*	0.14	*	0.11	*
separated	-0.27	-0.26	-0.27	-0.29	-0.30	-0.26	-0.27	-0.28
variance comp.								
$\tilde{\alpha}$	0	0	0	0.40*	0.61	0	-0.09*	-0.04*
correlation	0	0.16*	0.11*	0.11*	0.10*	-0.12*	-0.004*	-0.56$^+$

* not significant at 5% level; OF one factor error process; AR AR(1) error process; OF, AR one factor error process combined with AR(1) error process; ML maximum likelihood; SML simulated ML;
\+ t-val.: -8.4.

Finally all coefficients of the covariance matrix are insignificant. The one exception is the autocorrelation coefficient in the most general binary model and the correlation coefficient of the error terms of both equations for the most general ordered model. In that model the significantly negative correlation coefficient implies that additionally to lagged self-employment there are unobserved factors which lead to self-employment and attrition.

In the initial condition I include all variables which are also included in the dynamic process plus an indicator for being self-employed in 1989. It should be recalled that there have been such tremendous changes during 1990 that the assumption that this variable is not correlated with the error term does not appear to be implausible. In the dynamic equation this variable is dropped, since the lagged endogenous variable captures the dynamic effects, and including both types of variables is not feasible with the sample used.

Table 3 contains the estimation results for the most restricted and the most general versions of the binary and ordered model. Comparing the estimates under different covariance restrictions, it is found that they are very similar. This is not surprising, because the parameters of the initial condition can be consistently estimated by a binary probit. The joint estimation with the other periods and the attrition equation increases the efficiency of the estimates by taking into account the correlations of the error terms. A comparison of the results of the ordered and the binary models reveals that there are essentially no conflicting results, but that the ordered model is more efficient so that the influence of more factors can be determined.

Table 3: Estimation results for the coefficients of the initial period of the self-employment equation

model	binary		binary		ordered		ordered	
covariance:								
self-employ.	uncorrelated		one factor, AR(1)		uncorrelated		one factor, AR(1)	
attrition	uncorrelated		AR(1)		uncorrelated		AR(1)	
variable	coef.	t-value	coef.	t-value	coef.	t-value	coef.	t-value
self-empl.(89)	3.88	11.4	4.01	9.9	3.94	10.5	3.69	10.5
constant	-2.20	-10.4	-2.22	-9.4	-1.73	-12.2	-1.66	-11.3
econ. exp. +	0.15	1.0	0.15	1.1	0.14	1.3	0.20	2.0
econ. exp. -	-0.08	-0.5	-0.12	-0.8	0.03	0.2	0.05	0.5
school (8 y.)	-0.52	-3.1	-0.49	-2.9	-0.30	-2.8	-0.31	-3.0
school (12 y.)	0.27	1.9	0.30	2.0	0.24	2.2	0.27	2.5
master	0.22	1.3	0.17	1.1	0.28	2.4	0.31	2.5
income diff.	-0.23	-1.0	-0.18	-0.8	-0.43	-2.6	-0.53	-3.0
unemploym.	1.67	0.5	1.62	0.5	-0.64	-0.3	-1.65	-0.8
public sect. (89)	-0.49	-2.5	-0.55	-2.8	-0.30	-2.6	-0.36	-3.1
small firm (89)	0.22	1.2	0.15	0.8	0.28	2.1	0.26	2.0
top manag. (89)	0.32	1.5	0.33	1.6	0.19	1.2	0.27	1.7
middle man. (89)	0.35	2.0	0.35	2.0	0.44	3.4	0.46	3.7
craft (89)	0.01	0.0	-0.01	-0.0	0.43	2.3	0.47	2.6
p.services (89)	0.10	0.5	0.02	0.1	0.54	4.2	0.52	4.3
s.oth.serv. (89)	0.22	1.2	0.28	1.5	0.09	0.7	0.11	0.9
single	-0.38	-1.7	-0.43	-1.8	-0.14	-1.0	-0.13	-0.9
separated	0.41	1.8	0.40	1.7	0.59	3.7	0.58	3.8
Berlin (E)	-0.46	-1.2	-0.53	-1.5	-0.22	-0.9	-0.17	-0.7

In both models the most important factor is self-employment in 1989. Furthermore, having a higher schooling degree and having worked in the middle management increases the probability to be self-employed, whereas having worked in the public sector decreases it. In the ordered specification there are the additional positive effects of having a profession (1989) in crafts or services. These effects are expected from a priori considerations, but a significant negative effect of the potential income gains of self-employment and a positive effect of being married but living separated from the partner, is counterintuitive. The first of these two effects could be attributed to a imprecise measurement, since the differential is computed as a difference of predicted incomes estimated from selectivity corrected random effects human capital equations for the self-employed and employees. These may be a reasonable measure for current income gains, but not for the more important income gains in the future. In the most general model it appears that expecting a positve development of the regional economy is also a significant factor for being self-employed in November 1990.

Tables 4 and 5 contain the results of the self-employment equation for the periods following the initial one for various covariance specifications. For the computational most burdensome ordered model one intermediate specification has been omitted. The upper part of the tables contain the coefficients and the t-values (based on 'robust' estimates of the covariance matrix) of the explanatory variables. All specifications include time specific constant terms to account for changes for example in the macroeconomic environment which have the same impact on the behaviour of all individuals. The next part contains the estimated or restricted coefficients of the covariance structure of this equation.[7] The one factor specifications are tested against (i) a pure random effects structure and (ii) their complete absence by appropriate Wald tests which have an asymptotic χ^2 distribution with three and four degrees of freedom respectively. Following this the implied covariance matrix of the error term of the self-employment equation is given. Finally the values for $(b^y)^2$, the relative efficiency (see appendix B) and the value of the simulated log likelihood function are at the bottom of these tables. It should be noted that for a finite number of simulations the value of the log likelihood function depends on the relative magnitude of the error variance which is retained in the second error term $\omega^{(2)}$. The higher this value the larger is the value of the log likelihood function. However, the more general the specification of the covariance matrix the lower will this variance be. From this considerations it this clear that a large number of draws will be necessary for the likelihood ratio test to attain its asymptotic χ^2 distribution. 30 draws are clearly not enough.

The results of the binary model which are given in table 4 indicate a very large and highly significant value of the lagged status variable.[8] Other results, which are robust across specifications, are the negative impacts on the probability to be self-employed of the expectation that the situation of the regional economy gets worse. This indicates that people avoid the riskiness of self-employment when they have negative expectations about the overall economic performance in the region. Other negative factors are a lower level of schooling (only weakly determined), and those who have never been married. Whereas the first factor has a clear interpretation in terms of human capital, the latter may be an age effect or

7 δ_3 is restricted to be non-negative.

8 Note that from the value of this coefficient nothing could be inferred about 'stationarity', since the lagged variable is a dummy and the latent variable is continuous. In order to check 'stationarity', simulations should be performed. However, 'stationarity' is not important from an statistical point of view since all asymptotic arguments used are based on T fixed and N increasing.

indicating the non-availability of additional human and financial resources. Having a master degree and having already worked in a profession in the services in 1989 has a significant positive impact. Besides human capital considerations the influence of the masters degree can also be attributed to the already mentioned institutional restrictions. In some of the restricted versions the influence of having already worked in the middle management is also significant. Comparing these results with those of the initial condition, the following changes can be observed: The influence of having worked in the public sector has vanished, whereas the impact of economic expectations and professional experience in the services sector appeared. The influence of positions in the management and of schooling are close to being significant, so that the change is difficult to interpret.

Concerning the error structure it appears that the one factor structure is sufficient and AR(1) unnecessary. The pure random effects structure is rejected for two of the three specifications. The estimated covariance matrix reveals why all specifications lead to similar results, since the correlations are very small.

The results for the ordered model confirm the large and significant influence of both lagged states. All other explanatory variables which are significant in the binary model are also significant in the ordered model. Additionaly there is the schooling variable which is better determined and for the most general model the fact of living in Berlin (East), which is the largest city in East Germany and now part of a common federal state with the western part of Berlin.

Concerning the error structure the tests show that the AR(1) specification is sufficient and the one factor structure is not necessary. The estimated covariance matrix reveals that the AR(1) specification leads to different results compared to the other specifications, but still the correlations are not large.

Table 4: Results for the dynamic self-employment equation of the binary model

covariance: self-employ. attrition	uncorrelated uncorrelated		one factor uncorrelated		one factor AR(1)		one factor, AR(1) AR(1)	
variable	coef.	t-value	coef.	t-value	coef.	t-value	coef.	t-value
α	3.50	22.7	3.86	12.5	3.67	18.6	3.78	10.1
time effects								
$t = 1$	-2.46	-17.5	-2.55	-15.0	-2.55	-6.8	-2.51	-16.9
$t = 2$	-2.53	-17.8	-2.64	-17.2	-2.55	-9.3	-2.57	-18.5
$t = 3$	-2.31	-16.6	-2.64	-11.8	-2.54	-7.9	-2.54	-12.4
econ. exp. +	0.07	0.7	0.06	0.6	0.09	0.8	0.07	0.6
econ. exp. -	-0.31	-3.0	-0.32	-2.9	-0.29	-2.6	-0.34	-3.0
school (8 y.)	-0.21	-1.9	-0.22	-1.8	-0.21	-1.8	-0.21	-1.7
school (12 y.)	0.02	0.2	0.02	0.2	0.04	0.3	0.02	0.1
master	0.24	2.0	0.28	2.1	0.16	1.0	0.31	2.4
income diff.	-0.07	-0.6	-0.02	-0.2	0.00	0.0	0.00	0.0
unemploym.	0.30	0.3	0.62	0.5	0.89	0.7	0.94	0.8
public sect. (89)	0.01	0.1	-0.02	-0.2	-0.03	-0.3	0.01	0.1
small firm (89)	0.19	1.5	0.17	1.2	0.18	1.2	0.15	1.1
top manag. (89)	0.29	1.9	0.31	1.8	0.28	1.6	0.30	1.7
middle man. (89)	0.20	1.5	0.23	1.6	0.31	2.2	0.20	1.4
craft (89)	0.33	1.7	0.35	1.6	0.38	1.7	0.34	1.6
p.services (89)	0.54	3.7	0.58	3.7	0.53	3.6	0.57	3.7
s.oth.serv. (89)	0.13	1.1	0.19	1.4	0.20	1.7	0.20	1.5
single	-0.41	-2.5	-0.44	-2.4	-0.39	-2.3	-0.40	-2.3
separated	-0.06	-0.3	-0.12	-0.5	-0.10	-0.4	-0.17	-0.7
Berlin (E)	0.04	0.2	0.02	0.1	0.05	0.3	0.02	0.1
variance comp.								
δ_0	0		-0.31	-2.1	-0.13	-0.9	-0.30	-1.7
δ_1	0		0.20	0.6	-0.20	-0.5	0.14	0.6
δ_2	0		-0.19	-1.3	-0.10	-0.3	-0.14	-1.3
δ_3	0		0.65	3.5	0.55	2.8	0.61	3.3
α	0		0		0		-0.09	-0.3
Wald test			χ^2(df)	p-value	χ^2(df)	p-value	χ^2(df)	p-value
$\delta_t = \delta_s, \forall t, s$	-		18.0(3)	0.0	6.6(3)	8.6	13.8(3)	0.3
$\delta_t = 0, \forall t$	-		18.0(4)	0.1	8.4(4)	7.8	14.5(4)	0.6
covariance	1		1.1		1.0		1.0	
	0 1		-0.6 1.0		0.0 1.0		-0.1 1.0	
	0 0	1	0.6 -0.0	1.0	0.0 0.0	1.0	0.1 -0.1	1.0
	0 0	0 1	-0.2 0.1	-0.1 1.4	-0.1 -0.1	-0.1 1.3	-0.2 0.1	-0.2 1.4
σ_y^2 (rel. eff.)	0.67	(0.89)	0.67	(0.87)	0.50	(0.93)	0.42	(0.96)
value obj. fct.	-4357.9		-4353.3		-4384.4		-4394.1	

Table 5: Results for the dynamic self-employment equation of the ordered model

covariance:						
self-empl.	uncorrelated		one factor		one factor, AR(1)	
attrition	uncorrelated		AR(1)		AR(1)	
variable	coef.	t-value	coef.	t-value	coef.	t-value
α_1	2.04	20.2	2.21	7.6	2.20	7.3
α_2	3.77	22.9	4.15	7.2	3.84	8.9
$t=1$	-1.88	-12.3	-2.07	-6.4	-1.68	-11.2
$t=2$	-2.04	-15.7	-2.18	-8.4	-1.90	-9.6
$t=3$	-1.93	-12.7	-2.24	-3.5	-1.93	-5.4
econ. exp. +	0.10	1.3	0.10	1.0	0.08	1.0
econ. exp. -	-0.26	-3.3	-0.31	-2.7	-0.29	-3.7
school (8 y.)	-0.25	-3.1	-0.25	-2.7	-0.19	-2.5
school (12 y.)	-0.09	-1.0	-0.07	-0.8	-0.12	-1.4
master	0.21	2.3	0.23	2.2	0.17	2.0
income diff.	-0.08	-0.9	-0.05	-0.3	-0.06	-0.6
unemploym.	-0.96	-1.1	-0.72	-0.7	-0.25	-0.3
public sect. (89)	-0.09	-1.1	-0.09	-0.9	-0.04	-0.6
small firm (89)	0.15	1.6	0.14	1.3	0.15	1.7
top manag. (89)	0.18	1.4	0.15	1.1	0.05	0.4
middle man. (89)	0.18	1.9	0.19	1.7	0.12	1.3
craft (89)	0.17	1.3	0.06	0.2	0.10	0.9
p.services (89)	0.39	3.5	0.44	2.3	0.35	3.3
s.oth.serv. (89)	0.09	1.0	0.14	0.8	0.08	0.9
single	-0.31	-2.9	-0.31	-2.7	-0.43	-3.4
separated	0.09	0.7	0.05	0.3	0.13	1.0
Berlin (E)	0.18	1.5	0.18	1.5	0.26	2.3
2nd bound**	0.59	0.04*	0.63	0.06*	0.54	0.04 *
δ_0	0		-0.06	-0.1	-0.12	-0.9
δ_1	0		0.35	0.8	-0.10	-0.5
δ_2	0		-0.25	-0.6	-0.03	-0.2
δ_3	0		0.60	0.8	0.40	0.9
a	0		0		-0.24	-2.0
Wald test			χ^2(df)	p-value	χ^2(df)	p-value
$\delta_t = \delta_s, \forall t, s$	-		2.4(3)	49.1	3.2(3)	35.9
$\delta_t = 0, \forall t$	-		2.4(4)	65.7	3.5(4)	48.2
covariance	1		1.0		1.0	
	0 1		-0.0 1.1		-0.2 1.1	
	0 0	1	0.0 -0.1	1.1	0.1 -0.3	1.1
	0 0	0 1	-0.0 0.2	-0.1 1.4	-0.1 0.0	-0.3 1.2
σ_v^2 (rel. eff.)	0.62	(0.84)	0.70	(0.89)	0.35	(0.99)
value obj. fct.	-5327.4		-5298.2		-5389.9	

* standard error; ** first bound set to zero;
α_1 planned self-employment; α_2 observed self-employment.

A static model has also been estimated using the sequential method suggested by Chamberlain (1984). However the specification tests conducted as proposed by Lechner (1992) and the results of minimum distance estimations clearly reject the static specification.[9]

6 Dynamic simulations

Predictions from the above estimated models could be made for various purposes, such as to judge the ability of the model to explain the data, to predict the behaviour of individuals with well-defined characteristics, to get estimates of population totals free of attrition bias, to get insights into the dynamic implications of the estimates, to look at the short run and long run effects of changes of some of the exogenous variables, or to predict the future development of self-employment. The last four points are sketched in the following analysis.

For the case considered in this paper, which is based on repeated and independent observations in the cross-section dimension only, the out-of-sample-prediction in the time dimension is problematic, because, strictly speaking, nothing can be inferred from the probability laws which have been estimated for the sample period about future realisations. Assumptions have to be made about those which combine knowledge from the estimation with scenarios about the future.

The optimal prediction of moments of the endogenous variable for out-of-sample periods would be based on conditioning on the realisations of the sample, e.g. the observed endogenous and exogenous variables. However, the computations of these kinds of conditional moments in the non-linear dynamic model with endogenous attrition considered here are very complicated and will be substituted by simulations.

The descriptive statistics and the estimation results for the attrition equation show that there is the possibility of underestimating the self-employment ratios in the population when simulations are based on the sample of individuals which are observed in the last sample period. This is true even if selectivity corrected estimates are used. This stems from two sources: Unobserved factors and the lagged endogenous variable, and the distribution of the time varying explanatory variables. Since no time varying exogenous variable is significant in both the attrition and the self-employment equation, it is conjectured that the first source is the most important one. Therefore, the simulations are based on all individuals which are part of the sample in the initial period. For the ordered model, of which the binary model is a special case, the suggested simulation procedure can be described by the following equation, which is based on a partitioning of the vector

9 Results for a similar sample of a *habit persistence* specification ignoring attrition is contained in Lechner (1993).

of exogenous variables in two parts. The first part contains those which are constant over time and can be observed for all individual. The second part contains only those variable which vary over and are only observed if there is a valid observation for that particular wave, e.g. $\tilde{r}_{ti} = 1$. The coefficient vector β is partioned accordingly.

$$y^h_{0i} = \bar{g}[X_{0i}\hat{\beta}_0 + u^{*h}_{0i}, \hat{\theta}] \quad ,$$

$$y^h_{ti} = \bar{g}\left[g(y^h_{t-1i})\hat{\alpha} + X^{(1)}_i\hat{\beta}^{(1)} + (X^{(2)}_{ti}\hat{\beta}^{(2)})^{r_{ti}} + (X^{(2),h}_{ti\cdot}\hat{\beta}^{(2)})^{(1-r_{ti})} + u^{*h}_{ti}, \hat{\theta}\right] \quad ,$$

$$i = 1,\dots,3309, \quad t = 1,\dots,17, \quad h = 1,\dots,100.$$

u^h_{ti} denotes the h th realisation of the t th element of u^h_i. The H draws are independent for each draw and each individual and are based on the estimated or assumed parameters[10] of the marginal (with respect to r_i) distribution of u_i. $X^{(2)h}_{ti}$ denotes the h th draw of the t th component in the distribution of $X^{(2)} \mid X^{(1)} = X^{(1)}_i$. The use of realisations from draws in the distribution of $X^{(2)} \mid X^{(1)} = X^{(1)}_i$ instead of its expectation is necessary, because the purpose of the simulations is to compute moments of y, which is related to X and u by the nonlinear transformations $\bar{g}(\cdot)$ and $g(\cdot)$. Given the simulated values y^h_i the moments of interest can be estimated by their respective sample analogs. The availability of H estimates of these moments allows further judgement about the variability of those.

However the suggested way of simulation is not feasible because the distribution of the explanatory variables is unknown. But for the variables which are constant over time N, and for variables which vary over time N_t independent realisations from the distribution of X, are observed, where N_t $(t \leq T)$ denotes the number of observations which are valid in period t. The following procedure is suggested to allow the approximation of attrition free moments: For those individuals which are valid in a specific period the actually observed (realised) explanatory variables are used. In case they are not observed only the time constant part is used and the time variable part is simulated by H independent draws in the distribution of the explanatory variables which vary over time, given the realisations of the time constant variables. Using the realisations of observed variables has the advantage of reducing the variability of the simulations, but leads to a correlation of y^h_i and $y^{h'}_i$. Drawing in the distribution of the time varying variables given

10 All estimated coefficients are treated as fixed.

the time constant variables is difficult because of the large amount of possible cells and problematic if the realisations per cell are too small. However it is not necessary to draw the variables, but it is sufficient to draw the linear index of time varying variables given the linear index of the time constant variables. Fortunately the latter is heavily clustered so that nine homogeneous cells with about an equal number of observations can be formed and used for the conditional drawing. If the distribution of X is at least approximately independent of the attrition process, then for large N and large H this procedure should be a reasonable approximation. If there are large dependencies, although the simultaneity caused by endogenous attrition has been accounted for by the simulations, there remains a bias caused by drawing in the distribution of the time varying variables given non-attrition, whereas the drawing should have happened in the unobserved distribution of these variables given attrition. The fact that no time varying variables are significant in both equations indicates that this may not be a problem.

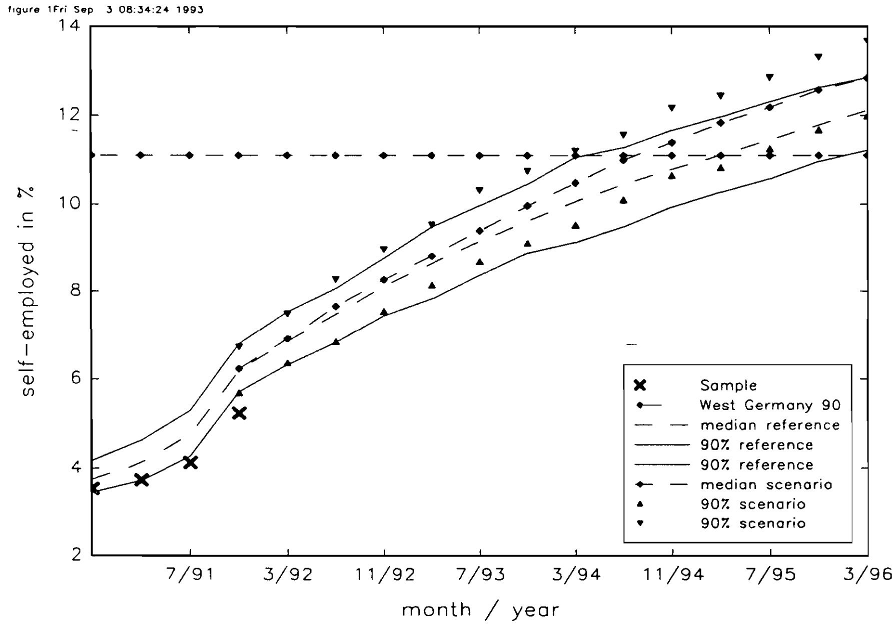
The ratio of self-employed men aged 25-60 compared to all men in this age group who worked in 1989 for particular points in time is the object of the following simulations. These ratios are estimated H times by the arithmetic mean of y_i^h. H has been set 100, and the following figures display the median and the upper and lower percentile of the distribution of the simulations. They give attrition corrected estimates for the sample period and predictions until March 1996. All plots contain also the self-employment rate for West Germany, which is fully compatible to the definition used for the sample, e.g. it is based on the potential male labour force obeying the age restriction and excluding unpaid family members (computed from: Statistisches Jahrbuch der Bundesrepublik Deutschland, 1992).

The simulations are based on the binary model with the one factor AR(1) error structure. However as figure D4 in appendix D shows there is virtually no difference between the binary and the ordered model with respect to the simulations. In the *reference* scenario the values of the time effects and the values for the explanatory variables are taken from the last observed period. The same is valid for all other coefficients, except the δ - terms in the covariance matrix. This has been fixed at 0.3, since a value of about 0.6 would have the implication of using much higher correlations outside the sample period than have been estimated inside the sample period. The high sensitivity of the results with respect to this assumption is shown in figure D3 in appendix D. It should be noted that the following simulations have much more a illustrative purpose to show the behaviour of the model, rather than really predicting self-employment until 1996. The observed sample period seems to be too short to postulate that the behavioural model will be stable over more than four years.

The reference scenario in figure 1 shows the large amount of positive dynamics in the development of future self-employment. The estimates imply an 'overtaking' compared to West Germany in 1995. The other scenario consists of allowing every four months that additionally 2% of skilled workers obtain a master degree. For comparison, the actual number of 'new' masters in West Germany is about 0.3% of the labour force per year (1990). The simulations show that the impact of such a costly measure would be very small.

The simulations show that 'realistic' changes in exogenous variables have no major impact on the development of self-employment in East Germany. This is especially true when compared to the intrinsic dynamics and to a variation of more or less arbitrary stochastic assumptions about the future parameters of the covariance matrix.

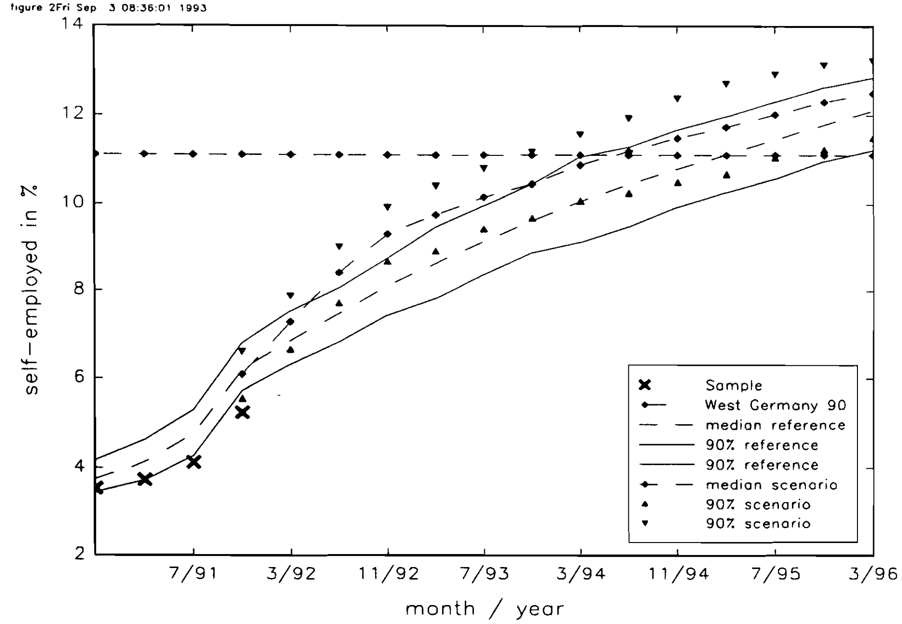
Figure 1: 'Conversion' of skilled workers to masters



Rate of skilled workers obtaining a master's degree: 3/92: 2%, 7/92: 2%, 11/92: 2%, 3/93: 2%, 7/93: 2%, 11/93: 2%, 3/94: 2%, 7/94: 2%, 11/94: 2%, 3/95: 2%, after 3/95: 0%. In 3/95 20% of the skilled workers or about 10% of the labour force as defined by the sample selection rule have obtained a masters degree.

Figure 2 shows how temporary changes of exogenous variables influence the shape of the time path of the self-employment ratio. It can be seen that after the shock the system comes close to its original time path.

Figure 2: Temporary change in exogenous variable



In 3/92, 7/92 and 11/92 only all skilled workers are treated as having obtained a masters degree

7 Conclusions

The focus of the paper is on the analysis of the individual determinants of self-employment in East Germany after unification, with special respect to the dynamic issues which may arise. The data set used is the *Arbeitsmarkt-Monitor für die neuen Bundesländer*, which is a panel data set consisting of four waves covering the period from November 1990 to November 1991. The attrition rate in this data set is high.

The data set and the economic questions of interest give raise to methodological issues concerning estimation techniques for limited dependent variable models on panel data. Smooth simulated maximum likelihood methods are proposed to allow for state dependence as well as endogenous attrition. Although computation time is high, the simultaneous estimation of a state dependence and attrition equations is feasible. The results indicate the importance of the dynamics which drive the emergence of the small business sector in East Germany. Other important factors appear to be human capital aspects, institutional restrictions, expectations about the future of the local economy, the profession in 1989 and the martial status. The influence of income differentials, unemployment risk, former state employee, federal state and age appeared to be among other factors not to be significant. The simulations performed confirm the significant dynamics and suggest that self-employment in East Germany might reach the levels of self-employment in West Germany as soon as 1995.

Concerning the questions which type of measures could be used for an additional boost of self-employment in East Germany the study points to at least a temporary suspension of the respective parts of the crafts regulation act ('Handwerks-ordnung'), which limit the set-up of now businesses to masters, investments in human capital and to a need to improve the predictions of the macro and regional economic development made by the individuals.

Besides the obvious extensions to use more waves as soon as they become available, the analysis could be fruitfully extended in several ways. The most immediate extension from an econometric point of view is to allow more flexible correlation patterns between the error terms of the self-employment and the attrition equation, and a different process for the planning and the realisation decision. Furthermore a structural model incorporating explicit utility maximisation and expectation formation should be developed and confronted with the data. As soon as more data becomes available the sectoral decomposition of self-employment can be analysed and the dynamics can be modified appropriately.

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Appendix A: Data

A.1 More details on the stylized facts

Table A1: Development of relative average incomes in selected sectors and sectoral self-employment rates (average income in East Germany divided by average income in West-Germany in %)

	Relative income					
Sector	1/90	7/90	10/90	4/91	7/91	10/91
mining	30,7	34,3	38,6	46,3	47,4	47,9
construction	33,9	44,2	49,9	60,4	61,4	65,4
metal industry	30,5	34,2	36,8	44,4	43,3	43,7
other industry	31,3	32,7	39,0	43,8	44,9	47,0
trade	29,7	31,3	42,5	46,6	46,9	51,7
banking	27,3	38,6	42,1	45,8	48,6	48,3

Exchange rate used for 1/90: 1:1; Statistisches Bundesamt, Fachserie 16, Reihe 2, Heft 2.2.

Table A2: Unemployment rates according to professional groups and sex in East Germany

professional group	unemployment rate+							
	11/90		3/91		7/91		11/91	
men / women	M	F	M	F	M	F	M	F
agriculture	6.6	9.8	13.3	16.5	12.8	17.9	13.2	21.4
mining	3.9*	0.0*	10.5*	5.8*	10.5*	13.0*	10.8*	20.0*
manufacturing	3.7	9.6	7.5	17.4	7.5	19.6	8.3	26.3
technical	4.0	3.8	3.3	7.1	3.1	7.1	4.1	9.6
services	5.4	4.1	7.8	8.2	7.8	8.7	8.8	11.5
others	4.4*	7.1*	24.9*	11.2*	25.9*	10.9*	26.9*	11.7*

+ Ratio of those unemployed relative to total population in occupational group in % ; * large error of prediction possible; Amtliche Nachrichten der Bundesanstalt für Arbeit und Arbeitsmarkt-Monitor (using sampling weights).

Table A3: Involuntary short-time work according to sector affiliation

Sector	11/90	3/91	7/91	11/91	11/92	1/93
agriculture	36.2	37.3	27.3	18.8	2.8	2.4
mining, energy	16.0	19.6	19.4	13.1	3.2	2.0
construction	12.1	15.5	11.7	6.6	1.2	2.6
metal, electric ind.	40.1	43.3	34.6	24.2	7.0	6.3
other manufacturing	44.4	44.6	34.9	23.3	5.1	4.3
banking, insurance	6.7	7.8	7.3	5.1	0.6	0.5

Ratio of unv. short-time work relative to total population in occupational group in %; The values for 11/92 and 1/93 relate to the population in 11/91; Amtliche Nachrichten der Bundesanstalt für Arbeit and Arbeitsmarkt-Monitor (using sampling weights).

Table A4: Registration and cancellation of businesses in East Germany (numbers are quarterly and devided by 100)

	1990				1991				1992		
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd
registration											
total	169	843	947	852	810	810	691	602	606	555	483
craft			114	85	76	70	66	58	63	61	47
trade*			514	390	376	410	319	268	282	260	227
registration minus cancellation											
total	156	822	858	708	608	587	420	309	293	250	207
craft			89	59	45	44	36	25	31	35	24
trade*			474	318	280	300	188	127	120	103	84

* Includes restaurants; Statistisches Jahrbuch, Bundesrepublik Deutschland, 1992.

Table A5: A comparison of sectoral self-employment ratios in East and West Germany in November 1990

	ratio of self-employment *		change of absolute numbers compared to Nov'90	
Sector	West Germany	East Germany	4/91+	1/92+
Agriculture, forestry, fishing	75.7	1.3		
Energy, water, mining	0.2	0.0		
manufacturing	4.0	2.5		
construction	10.0	6.0		
trade	16.8	8.3	+82	+106
transport, communication	5.2	3.4	+40	+34
banking, insurance	6.9	7.2	+81	+227
services	13.7	12.0	+102	+124

* Ratio of self-employment to total employment in sector in % (including unpaid family members); Statistisches Jahrbuch der Bundesrepublik Deutschland, 1992; + DIW-Wochenbericht 13/93 (based on *Mikrozensus* 1991, 1992), own computations; in %.

A.2 General features of the dataset

The population from which the *Arbeitsmarkt-Monitor für die neuen Bundesländer* (AMM) sample is drawn are all citizens of the former GDR which were born between 1926 and 1974. In each wave there is the additional restriction that individuals are still living (Wohnsitz) in the former GDR, e.g. the migrants and those who move without leaving their new address are dropped from the sample (0/1: 194; 1/2 wave: 70; 2/3 wave: 85; 3/4: 314).

15000 observation fulfilling the age restrictions are randomly drawn from the registrar (*Zentrales Melderegister der DDR*), and subsequently (November 1990) obtain a questionnaire by mail. 10751 (71.6%) return a usable questionnaire and these individuals are reinterviewed in the three following waves. In the forth wave 300 people born in 1975 (only 169, 56%, returned usable questionnaires) are drawn from the registrar to include another age cohort relevant for the labour market and to stabilise the cross-sectional number of individuals in the following waves.

Pensioners who indicate in the first wave that they are not looking for a job (843 in the second wave; 843 + 132 in the third wave) are not reinterviewed in the second and third wave, but in the fourth wave (79% response rate).

When analysing the nonresponse pattern, it is found (see Infratest, 1991) that the proportion of nonresponse (taken account of the changes in the panel design) decreases over time. This feature is very common to many panel studies and implies that in the beginning those individuals with a very low propensity for response are lost and that in the long run some lower 'equilibrium level of attrition' is reached.

Table A6 contains the numbers of responses in each wave. The *reduced* sample neglects those responses occurring after a previous non-response. The need for this sample is basically motivated by the need for identification and specification of the dynamic model, which requires the observation of current *and* lagged explanatory variables in each period. Only 30% of those who did not answer in wave 2 answer in wave 3, but 86% of those who answer in wave 1 and 2 answer in wave 3 as well. 89% of whose who answer in the first three wave also answer in wave 4, but only 36% of those answer in no more than one wave in wave 2 and 3, answer in wave 4 as well. In the fourth wave an additional sample of 300 people who were born in 1975 is drawn. The response rate is 56%. This selection is strictly dependent on age and hence ignorable.

Table A6: Sample sizes of raw data

Waves	individuals	1st wave	2nd wave	3nd wave	4th wave
1 - 4	5985	5985	5985	5985	5985
1, 2, 3	749	749	749	749	-
1, 2, 4	569	569	569	-	569
1, 2	626	626	626	-	-
1, 3, 4	358	358	-	358	358
1, 3	208	208	-	208	-
1, 4	875	875	-	-	875
1	1381	1381	-	-	-
4	169	-	-	-	169
full sample	10920	10751	7929	7300	7985
reduced sample	10920	10751	7929	6734	5985

In a recent paper Verbeek and Nijman (1992a) (VN) provided a useful classification of attrition and nonresponse which will be repeated below and related to the data of the AMM.

1. Initial nonresponse: Individual refuses to take part in the survey, or is not available. AMM: no information available.

2. Unit nonresponse: Initial nonresponse resulting in missing data for all variables; note that this is different from 1, only if the individual is interviewed at a later stage of the survey which is not the case with the AMM.

Given the panel design, it is not possible to distinguish type 1 and type 2 nonresponse. Although the amount of nonresponse seems to be substantial (28.4%), but since nothing about the initial population is observed, it is assumed that type one and type two nonresponses are purely random or strictly exogenous, e.g. in the notion of VN the selection is assumed to be ignorable.

3. Item nonresponse: Information on a particular variable is missing for some people. The relevance of this should be assessed on a variable by variable base.

4. Wave nonresponse: No information on a particular wave, but information on former and/or latter waves are available. There are 2010 individuals who do not answer either in wave two and / or wave three but answer in wave three and / or four.

5. Attrition: Individuals have participated for at least one wave and leave the panel without returning. There are 1381 individuals who leave the panel after the first wave, 626 after the second and 957 after the third wave. If those who realised an interview in a subsequent wave are included, the numbers are higher (2822 / 1195 / 749, see Table A6).

Table A7: Number of observations discarded in first wave because of:

Inconsistent number of persons in household	193
inconsistent number of adults in household	402
no information on:	
current employment or nonemployment status	12
selfemployment	185
educational degree - job	336
educational degree - schooling	434
future economic situation in the region	221
martial status	24
sector of employment in 1989 for participants	447
firm size in 1989 for participants	449
job position in firm in 1989 for participants	208
necessary job qualifications in 1989 for participants	142
working in the state sector in 1989 for participants	572
part-time/full-time work in 1989 for participants	143
total	2469

Note: The numbers don't add to the total because of overlaps.

In order to confront a relatively simple model of attrition with the data I have to make some a priori decisions which type of nonresponse is considered as ignorable. The most important assumption is that initial nonresponse, unit nonresponse, item nonresponse (for important variables) and wave non-response in the first wave are ignorable. Table A7 displays the variables on which the selection out of the sample in the first wave is made. This assumption has to be made simply because there is no data available to estimate a model of attrition in these cases. Since the goal is to identify a dynamic model of self-employment, wave non-response and attrition in wave 2, 3 and 4 are treated alike and as potentially non-ignorable. The assumption that *they never came back* is made for convenience and does not harm the consistency properties of the suggested estimator. There are three distinct ways to treat item-nonresponse. First, it can be assumed to be completely ignorable. Given that the analysis of the attrition process in other panel studies shows that people who do not respond to important items have a much higher propensity to leave the panel, this is not an attractive choice. A second, intermediate possibility is to assume that item nonresponse (for important variables) is ignorable, if it happens only once. If it happens for the second time, it will be assumed that it is part of the attrition process. The third possible assumption is non-ignorability. This is most convenient since there are no problems about how to treat unobserved explanatory variables. This assumption will be persued here. In the final sample used for estimation, only about 3% of the observations will be classified as non-ignorable here and would be classified as ignorable under the second assumption.

A.3 Description of the sample used in the estimation

Table A8: Definition of variables

Symbol	description
Self-employment (unpaid family workers are excluded)	
self-empl.	self-employed (TV)
exp. self-em.	self-employment planned (ZV)
self-em. (89)	self-employed in 1989 (TC)
Expected economic situation in the region in one year (reference category: no change)	
econ. exp.+	better than today (ZV)
econ. exp.-	worse than today (ZV)
Highest degree: schooling (reference category: 10 years of schooling)	
school (8 y.)	grade 8 (8 years of schooling, TC)
school (12 y.)	university entrance qualification (12 years of schooling, TC)
Highest degree: professional (reference category: unskilled or semi-skilled, "*Teilfacharbeiter*")	
university	university degree (TC)
eng./tech.	engineering or technical college education ("*Fachschulausbildung*" TC)
skilled w.	skilled worker ("*Facharbeiter*", TC)
master	master or technical degree ("*Meister, Techniker*", TC)
Income diff.	predicted ln(income) as self-employed net of predicted ln(income) as employee
Unemploym.	unemployment rate with respect to 34 professional groups in 1989 (TV)
Job situation in 1989	
public sect. (89)	employee in public sector (TC)
small firm (89)	between 0 and 20 employees in the firm (TC)
top manag. (89)	top management (TC)
mid. man. (89)	middle management(TC)
craft (89)	profession: crafts (ZK)
p.services (89)	profession: medical care and other services (TC)
s.oth.serv. (89)	sector of employment: other services
Age	age / 10 (TC)
age ^{2}	age squared / 100 (TC)
Marital status (reference category: widowed, married)	
single	single and previously not married (TC)
separated	divorced / separated (TC)
Berlin (E)	East Berlin (TC)
Note:	'TV' means that variable varies over time; 'TC' means that variable is constant over time.

Table A9: Descriptive statistics according to wave of exit from panel

Leaving sample after	1st wave		2nd wave		3rd wave		no exit	
Variable	mean	std.dev.	mean	std.dev.	mean	std.dev.	mean	std.dev.
self-empl. 1	0.052		0.046		0.032		0.028	
self-empl. 2	-		0.048		0.035		0.036	
self-empl. 3	-		-		0.054		0.039	
self-empl. 4	-		-		-		0.052	
exp. self-em. 1	0.030		0.025		0.016		0.036	
exp. self-em. 2	-		0.030		0.022		0.033	
exp. self-em. 3	-		-		0.022		0.028	
exp. self-em. 4	-		-		-		0.023	
self-em. (89)	0.034		0.020		0.019		0.015	
econ. exp.+ 1	0.36		0.42		0.32		0.36	
econ. exp.+ 2	-		0.21		0.17		0.20	
econ. exp.+ 3	-		-		0.29		0.31	
econ. exp.+ 4	-		-		-		0.32	
econ. exp.- 1	0.35		0.35		0.38		0.40	
econ. exp.- 2	-		0.47		0.52		0.51	
econ. exp.- 3	-		-		0.28		0.28	
econ. exp.- 4	-		-		-		0.28	
school (8 y.)	0.39		0.36		0.33		0.33	
school (12 y.)	0.14		0.13		0.15		0.20	
university	0.11		0.10		0.12		0.17	
eng./tech.	0.11		0.13		0.13		0.15	
master	0.09		0.13		0.13		0.12	
skilled w.	0.58		0.57		0.52		0.50	
s. skilled w.	0.048		0.038		0.041		0.023	
income diff. 1	0.23	0.35	0.26	0.36	0.24	0.35	0.22	0.34
income diff. 2	-		-0.24	0.37	-0.25	0.38	-0.31	0.37
income diff. 3	-		-		-0.27	0.48	-0.30	0.45
income diff. 4	-		-		-		-0.77	0.34
unemploym. 1	0.046	0.02	0.046	0.02	0.044	0.02	0.044	0.02
unemploym. 2	-		0.077	0.04	0.071	0.04	0.068	0.04
unemploym. 3	-		-		0.071	0.04	0.067	0.04
unemploym. 4	-		-		-		0.077	0.04
public sect. (89)	0.31		0.27		0.28		0.27	
small firm (89)	0.08		0.10		0.07		0.09	
top manag. (89)	0.07		0.06		0.05		0.06	
mid. man.(89)	0.08		0.10		0.11		0.10	
craft (89)	0.05		0.03		0.01		0.03	
p.services (89)	0.05		0.07		0.07		0.06	
s.oth.serv. (89)	0.16		0.14		0.17		0.19	
age	4.01	1.04	4.01	1.06	4.03	1.03	4.21	0.97
age ^{2}	17.18	8.69	17.17	9.0	17.29	8.61	18.70	8.23
single	0.13		0.12		0.13		0.11	
separated	0.10		0.12		0.08		0.06	
Berlin (E)	0.07		0.08		0.09		0.08	
observations	709		394		317		1889	
share of all observations	21%		12%		10%		57%	
share of valid observations	21%		15%		14%		-	

Table A10: Pattern of states (S: self-employed, N: not self-employed) according to wave of exit from sample

Exit from sample after		self-employed in 1989	not self-employed in 1989
1st wave		24	685
	S	23	14
	N	1	671
2nd wave		8	386
	SS	8	10
	NS	0	1
	NN	0	375
3rd wave		6	311
	SSS	5	4
	SNS	0	1
	NSS	0	2
	NNS	0	5
	NNN	1	299
No exit		28	1861
	SSSS	26	13
	SSSN	1	6
	SSNN	0	1
	NSSS	0	18
	NSSN	0	1
	SNNN	1	4
	NSNN	0	1
	NNSS	0	8
	NNSN	0	1
	NNNS	0	34
	NNNN	0	1774
status change after 1st wave: total		2	83
- out of self-employment		2	15
- into self-employment		-	72
self-employed in 1989 and not self-employed in at least one wave		4	-
self-employed in at least one wave		64	124

Table A11: Pattern of states (S: self-employed, E: expected self-employment, M: not self-employed and not E, X: S or E or M) according to wave of exit from sample

States of observations leaving the sample after		States of observations without exit	
1st wave	709	no exit	1889
E	21	ESXX	14
2nd wave	394	EMXX	24
ES	1	EEXX	30
EM	3	EESS	2
EE	6	EEES	6
XE	12	EEEE	14
3rd wave	317	XESX	5
ESX	1	XEMX	23
EMX	3	XEEX	35
EEX	1	XEES	13
EES	1	XEEM	7
XES	3	XEEE	15
XEM	3	XXES	18
XEE	1	XXEM	15
XXE	7	XXEE	19
MSX	1	XXXE	44
XMS	3	MSXX	6
		XMSX	4
		XXMS	16

self-employment planned in at least one wave	192
S planned, realisation observed	42
S planned, plan changed	86
S planned, and not yet realised	84
S realised, prev. not planned (after 1st wave)	30

Appendix B: Econometrics

B.1 The derivation of the objective function for the simultaneous model of state dependence and attrition

In the sample realisations from N independent draws in the distribution of the random variables $(\tilde{r}, \tilde{y}, \tilde{X}, \tilde{G})$ which are denoted by $(\tilde{r}_i, \tilde{y}_i, \tilde{X}_i, \tilde{G}_i)$ are observed. The relation between these observed variables and those used in section 4 is such that $\tilde{y}_{ti} = y_{ti}\tilde{r}_{ti}$, $\tilde{X}_{ti} = X_{ti}\tilde{r}_{ti}$, and $\tilde{G}_{ti} = G_{ti}\tilde{r}_{ti}$. Given the assumptions of section 4 (and the usual regularity conditions) a particular way to derive a tractable likelihood function based on the distribution of $\tilde{r}$, $\tilde{y}$, given $\tilde{X}$, $\tilde{G}$, will be discussed in this appendix. The derivation is based on three tools: Firstly, the normal error terms are partitioned in two parts, such that the first part contains all correlations and the second one is white noise. Secondly, the joint probabilities will be written as a product of appropriate conditioned univariate probabilities. Thirdly, it will be shown that these probabilities have a simple form, when they are computed conditional on the first part of the partitioned error term.

Suppose that ν is jointly normally distributed as: $\nu \sim N(0,\Sigma)$. Now consider the following decomposition of ν:

$$\nu = A\omega^{(1)} + B\omega^{(2)} ,$$

$$\omega^{(1)} \sim N(0, I_{2T+1}) , \quad \omega^{(2)} \sim N(0, I_{2T+1}) , \quad E\omega^{(1)}\omega^{(2)\prime} = 0 ,$$

$$B = \begin{pmatrix} b_1^r & 0 & \cdot & \cdot & \cdot & \cdot & \cdot & 0 \\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & b_T^r & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & b_0^y & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & b_1^y & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & 0 \\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot & 0 & b_T^y \end{pmatrix} .$$

AA' is positive semi-definite and fulfils the following constraints:

$$AA' = \Sigma - BB' .$$

Let a^r, b^r and a^y, b^y the rows of A and B which relate to ϵ and u respectively. In order to simplify notation, let $\theta = (\alpha', \tilde{\alpha}', \beta_0', \beta', \gamma', \tilde{\theta}, \mathrm{vec}(\Sigma)')'$. Furthermore $\int_{\omega^{(1)}} \cdot \; d\omega^{(1)}$ denotes the (multidimensional) integral over the support of $\omega^{(1)}$.

The likelihood of the sample conditional on the exogenous variables can be written as follows ($f(\cdot)$ being a probability conditional on $\tilde{X}, \tilde{G}$, and evaluated at the unknown parameter vector θ):

$$f(\tilde{r}_1, \ldots, \tilde{r}_N, \tilde{y}_1, \ldots, \tilde{y}_N) = \prod_{i=1}^{N} f(\tilde{r}_i, \tilde{y}_i) \quad ,$$

$$\begin{aligned} f(\tilde{r}_i, \tilde{y}_i) &= \int_{\omega^{(1)}} f(\tilde{r}_i, \tilde{y}_i, \omega^{(1)}) d\omega^{(1)} \\ &= \int_{\omega^{(1)}} f(\tilde{r}_i, \tilde{y}_i \mid \omega^{(1)}) f(\omega^{(1)}) d\omega^{(1)} \\ &= \mathop{\mathrm{E}}_{\omega^{(1)}} f(\tilde{r}_i, \tilde{y}_i \mid \omega^{(1)}) \quad . \end{aligned}$$

Note that no simplification has been achieved so far, since the evaluation of the expectation necessitates a multidimensional numerical evaluation of the integral over the multivariate normal distribution, which is not feasible for more than four dimensions. However the method of "Simulated Maximum Likelihood" (SML) can be used and $f(\cdot)$ is estimated by an unbiased estimator $\tilde{f}^H(\cdot)$, which is obtained by taking the average of $f^h(\cdot)$ for H independent draws of $\omega^{(1)}$, which are different for each individual. Given that the usual regularity conditions hold, Gouriéroux and Monfort (1991) show that the resulting estimator is consistent if H and N tend to infinity. It is asymptotically normal and efficient when $\frac{\sqrt{N}}{H}$ tends to zero. In that case the asymptotic covariance matrix can be estimated as usual by the sample analogs of the outer product of the gradient matrix (OPG) or the expected Hessian, or by a combination of both. For N increasing and H fixed the SML-method leads to biased estimates. However, Gouriéroux and Monfort (1991) show that this bias is of order H^{-1} and can be evaluated for H large. The bias increases c.p. the smaller the true probabilities, and the larger the variance of the simulated probabilities are.

In the following the joint probabilities are computed as a product of conditional probabilities which have conditional on $\omega^{(1)}$ a simpler form. Let $\tilde{y}^L_{ti} = \tilde{y}_{0i}, \ldots, \tilde{y}_{t-1i})'$ and $\tilde{r}^L_{ti} = \tilde{r}_{0i}, \ldots, \tilde{r}_{t-1i})'$, By successive backward conditioning the following expressions are obtained:

$$f(\tilde{r}_i, \tilde{y}_i \mid \cdot) \quad = \quad f(\tilde{y}_{Ti} \mid \tilde{r}_{Ti}, \tilde{r}^L_{Ti}, \tilde{y}^L_{Ti}, \cdot) \quad f(\tilde{r}_{Ti}, \tilde{r}^L_{Ti}, \tilde{y}^L_{Ti} \mid \cdot) \quad ,$$

$$f(\tilde{r}_{Ti}, \tilde{r}^L_{Ti}, \tilde{y}^L_{Ti} \mid \cdot) \quad = \quad \prod_{t=1}^{T-1} f(\tilde{r}_{t+1i}, \tilde{y}_{ti} \mid \tilde{r}^L_{t+1i}, \tilde{y}^L_{ti}, \cdot) \quad f(\tilde{r}_{1i} \mid \tilde{y}_{0i}, \cdot) \quad f(\tilde{y}_{0i} \mid \cdot) \quad ,$$

$$f(\tilde{r}_{t+1i}, \tilde{y}_{ti} \mid \tilde{r}^L_{t+1i}, \tilde{y}^L_{ti}, \cdot) \quad = \quad f(\tilde{r}_{t+1i} \mid \tilde{r}^L_{t+1i}, \tilde{y}^L_{t+1}, \cdot) \quad f(\tilde{y}_{ti} \mid \tilde{r}^L_{t+1i}, \tilde{y}^L_{ti}, \cdot) \quad .$$

Furthermore, from the construction of variables it follows that:

$$f(\tilde{r}_{ti} = 0 \mid \tilde{r}_{\tau i} = 0) \quad = \quad 1 \quad , \qquad \forall \tau \leq t \quad ,$$

$$f(\tilde{y}_{ti} = 0 \mid \tilde{r}_{\tau i} = 0) \quad = \quad 1 \quad , \qquad \forall \tau \leq t \quad .$$

As an example the likelihood function for the binary probit model is given. The generalisation to the ordered probit model is exactly is for the usual cross section analysis (see Maddala, 1983). Let J_i be the last wave before an individual which has so far been continuously observed in the panel, leaves the panel. Its contribution to the likelihood-function is:

$$\underset{\omega^{(1)}}{E}\ \Phi\left(\frac{X_{0i}\beta_0 + a^y_0\omega^{(1)}}{b^y_0}\right)^{y_{0i}} \left[1 - \Phi\left(\frac{X_{0i}\beta_0 + a^y_0\omega^{(1)}}{b^y_0}\right)\right]^{1-y_{0i}}$$

$$\prod_{t=1, J_i>1}^{J_i} \left\{\Phi\left(\frac{G_{t-1i}\gamma + y_{t-1i}\tilde{\alpha} + a^r_t\omega^{(1)}}{b^r_t}\right)\Phi\left(\frac{X_t\beta + y_{t-1i}\alpha + a^y_t\omega^{(1)}}{b^y_t}\right)^{y_{ti}} [1 - \Phi(\cdot)]^{1-y_{ti}}\right\}$$

$$\left[1 - \Phi\left(\frac{G_{J_i i}\gamma + y_{J_i i}\tilde{\alpha} + a^r_{J_i+1}\omega^{(1)}}{b^r_{J_i+1}}\right)\right]^{I(J_i<T)} \quad .$$

$\Phi(x)$ denotes the cumulative distribution function of the univariate standard normal distribution evaluated at point x, a^y_t the $(t+1)^{th}$ row of a^y, and a^r_t denotes the t^{th} row of a^r respectively.

When the error terms of the attrition and the self-employment equation are independent, implying appropriate zero off-diagonal blocs in the matrix A, the self-employment and the attrition part of the likelihood function factor out, and consistent and efficient estimates are obtained by maximising both parts separately. When $\tilde{\alpha} = 0$ the coefficients of the attrition equation can be consistently estimated by maximising the respective part of the likelihood function alone. However, when the error terms of the two equations are correlated, these estimates are not efficient.

It is relevant for the finite drawing behaviour of the SML-method to reduce the variability which is caused by drawing $\omega^{(1)}$, so that the variance of $\omega^{(1)}$ should be as small as possible and the variance of $\omega^{(2)}$ as large as possible (see Börsch-Supan and Hajivassiliou, 1993, and Stern, 1992). The approach persued here is closely related to Stern (1992). Let η be a scalar and $AA' = \Sigma - \eta I$. η will be chosen a little bit smaller than the smallest eigenvalue of Σ. A is computed by a Choleski-decomposition of $(\Sigma - \eta I)$. This implies:

$$b_j = \sqrt{\eta} \quad , \quad \forall j \ .$$

B.2 Comparison of exact and simulated maximum likelihood estimates

Table B1 gives a comparison of maximum likelihood estimates (MLE) and simulated maximum likelihood estimates (SMLE) for an estimation of the self-employment equation only. These results are not interesting in themselves, but serve only the purpose of comparing the performance of MLE and SMLE. The MLE has been obtained by using the gaussian quadrature as implemented in GAUSS 3.01 to integrate out the one-dimensional error in this one factor only specification. The SMLE has been computed for 8, 15 and 30 individual specific draws in the distribution of $\omega^{(1)}$.

The procedure for the determination of η is as follows: During the iteration η is fixed. Before the first iteration η is chosen to be much smaller than the smallest eigenvalue to allow for an estimate of Σ which may be very different than the starting values. After convergence, η is increased (if possible) and the iteration starts again. This process is stopped, if (after convergence) η is larger than 80% of the smallest eigenvalue of the estimated covariance matrix Σ. The ratio of maximal η to the value actual used is called relative efficiency in table B1 and all other tables. The number of replications for the simulations is restricted to 30, as a compromise between sufficient accuracy of the estimation and excessive computation time.[11] This procedure has also been used for the SMLE's presented in all other parts of this paper.

Comparing the coefficient estimates, for most of the significant estimates it is found that the 'bias' (compared to the MLE) is small even for 8 draws. Increasing the number of draws results in a better accuracy of the estimates. The same is more or less true of the estimates of the standard-errors, which are based on so-called 'robust' estimates combining the inverse of the hessian with the matrix of the outer product of the gradient (OPG). It seems that a higher number of draws is particularly important to get good estimates of the covariance parameters and hence also for the state dependence parameters, whereas it does not matter for the other variables.

Appendix C: Additional estimation results

If ϵ and u are uncorrelated, separate estimation of the attrition equation will give consistent estimates for $\tilde{\alpha}$ and γ (up to scale) and the respective parameters of Σ (see Appendix B.1). Table C1 contains the estimation results for various specifications of the covariance matrix and a comparisons of maximum likelihood (ML) and simulated maximum likelihood for the autoregressive error specification (SML). Since there are only three time periods ML estimation is still feasible involving a three dimensional integration of the normal probability density function, which has to be done numerically.[12] Additionally models combining the autoregressive and the one factor specification and allowing for heteroscedasticity over time have been estimated. Since the coefficients of the covariance components are not significant, it is not surprising that the results of the various specifications differ not very much, besides a significant efficiency loss in the one factor model. The results are very similar to those presented in the main part of the paper.

11 Appendix B.2 contains a comparison of exact and simulated maximum likelihood estimation for various choices of H for the state dependence model. All SML computations have been done on a PC 486/25 with GAUSS 3.0 using analytical gradients.

12 According to the GAUSS-handbook, the approximation error of the integral is about +/- 2.5×10^{-14}.

Table B1: Comparison of exact and simulated Maximum Likelihood estimates of the self-employment equation for different numbers of draws of $\omega^{(1)}$ for the binary model

estimation	ML		SML (H = 30)		SML (H = 15)		SML (H = 8)	
variable	coef.	t-value	coef.	t-value	coef.	t-value	coef.	t-value
α^B	4.24	10.5	3.90	17.2	3.82	20.2	3.68	20.3
time effects								
t = 1	-2.55	-12.2	-2.51	-15.8	-2.48	-16.6	-2.44	-16.9
t = 2	-2.66	-13.1	-2.61	-17.5	-2.60	-16.7	-2.60	-15.8
t = 3	-2.68	-8.0	-2.60	-10.9	-2.68	-11.4	-2.49	-11.7
econ. exp. +	0.07	0.6	0.09	0.8	0.09	0.8	0.09	0.8
econ. exp. -	-0.33	-2.8	-0.36	-3.2	-0.33	-2.9	-0.34	-3.1
school (8 y.)	-0.26	-2.0	-0.23	-1.9	-0.25	-2.1	-0.22	-1.9
school (12 y.)	0.02	0.2	0.04	0.4	0.02	0.2	0.04	0.3
master	0.28	2.1	0.30	2.3	0.25	2.0	0.27	2.2
income diff.	-0.01	-0.1	-0.04	-0.3	-0.04	-0.3	-0.05	-0.4
unemploym.	0.58	0.5	0.72	0.6	0.74	0.6	0.44	0.4
public sect. (89)	-0.03	-0.2	-0.02	-0.2	-0.00	-0.0	-0.01	-0.1
small firm (89)	0.17	1.1	0.19	1.4	0.21	1.4	0.23	1.7
top manag. (89)	0.24	1.3	0.27	1.7	0.31	1.8	0.28	1.7
middle man. (89)	0.25	1.7	0.24	1.7	0.27	2.0	0.25	1.9
craft (89)	0.34	1.5	0.31	1.5	0.32	1.6	0.31	1.5
p.services (89)	0.59	3.6	0.58	3.8	0.57	3.7	0.57	3.8
s.oth.serv. (89)	0.24	1.7	0.18	1.4	0.18	1.3	0.13	1.1
single	-0.44	-2.2	-0.42	-2.3	-0.41	-2.2	-0.35	-2.0
separated	-0.16	-0.6	-0.11	-0.5	-0.20	-0.8	-0.06	-0.2
Berlin (E)	0.02	0.1	0.04	0.2	0.05	0.3	0.01	0.1
variance comp.								
δ_0	-1.64	-0.6	-0.60	-3.6	-0.21	-2.5	-0.16	-1.8
δ_1	0.30	1.4+	0.24	1.6	0.01	-0.3	-0.05	-0.6
δ_2	-0.23	-0.9	-0.14	-0.9	-0.09	-1.0	-0.22	-1.9
δ_3	0.72	2.7	0.62	2.8	0.68	3.4	0.49	2.6
Wald test	χ^2(df)	p-value	χ^2(df)	p-value	χ^2(df)	p-value	χ^2(df)	p-value
$\delta_t = \delta_{t'}, \forall t,t'$	28.2(3)	0.0	15.4(3)	0.1	18.4(3)	0.0	7.7(3)	5.1
$\delta_t = 0, \forall t$	32.1(4)	0.0	15.6(4)	0.4	18.4(4)	0.1	7.8(4)	10.1
covariance	3.7		1.4		1.0		1.0	
	-0.5 1.1		-0.1 1.1		-0.0 1.0		0.0 1.0	
	0.4 -0.1	1.1	0.1 -0.0	1.0	0.0 -0.0	1.0	0.0 0.0	1.1
	-1.2 0.2	-0.2 1.5	-0.4 0.1	-0.1 1.4	-0.1 0.0	-0.1 1.5	-0.1 -0.0	-0.1 1.2
b^2_y (rel. eff.)			0.80	(0.89)	0.90	(0.95)	0.85	(0.92)
value obj. fct.	-656.6		-671.5		-668.7		-675.9	

* standard error.

Tables C2 and C3 contain the estimation results of the binary and ordered models under the assumption that the error terms of the self-employment and the attrition equation are uncorrelated. The coefficients of the initial period are omitted, because they are very similar to those presented in table 2.

Table C1: Separate estimation of the attrition equation by ML and SML ($H = 30$) with different specifications of the covariance structure

estimation	ML		ML		ML		SML	
variable	coef.	t-value	coef.	t-value$^+$	coef.	t-value$^+$	coef.	t-value
time effects								
$t = 1$	-1.38	-4.0	-1.80	-1.8	-1.51	-3.8	-1.47	-4.1
$t = 2$	-1.12	-3.2	-1.07	-1.7	-1.32	-3.1	-1.27	-3.4
$t = 3$	-1.10	-3.1	-0.91	-1.2	-1.29	-3.0	-1.24	-3.3
self-empl.	-0.30	-3.6	-0.41	-1.7	-0.33	-3.6	-0.32	-3.5
exp. self-em.	0.01	0.1	0.01	0.1	-0.01	-0.1	-0.01	-0.1
econ. exp. +	0.03	0.8	0.04	0.6	0.04	0.8	0.04	0.9
econ. exp. -	0.06	1.5	0.09	1.2	0.06	1.5	0.06	1.5
school (8 y.)	-0.07	-1.5	-0.10	-1.2	-0.08	-1.6	-0.07	-1.4
school (12 y.)	0.05	0.7	0.08	0.8	0.06	0.8	0.06	0.8
university	0.35	3.4	0.41	1.6	0.37	3.4	0.34	3.2
eng./tech.	0.29	3.6	0.35	1.6	0.32	3.4	0.31	3.5
skilled w.	0.22	3.4	0.25	1.6	0.24	3.2	0.22	3.2
master	0.26	3.1	0.31	1.6	0.28	3.1	0.27	3.1
unemploym.	-0.97	-1.8	-1.80	-1.2	-1.18	-2.0	-1.19	-2.1
age	0.90	5.4	1.18	1.8	0.95	5.1	0.94	5.5
age ^{2}	-0.095	-4.9	-0.13	-1.8	-0.10	-4.6	-0.10	-4.9
single	0.12	2.0	0.16	1.4	0.13	2.0	0.13	2.1
separated	-0.27	-4.3	-0.35	-1.8	-0.29	-4.1	-0.28	-4.3
variance comp.								
δ_1	0		-0.74	-0.6	0		0	
δ_2	0		1.07	0.6	0		0	
δ_3	0		1.62	1.0	0		0	
$\tilde{a}$	0		0		0.26	1.1	0.18	1.4
Likelihood ratio	χ^2(df)	p-value	χ^2(df)$^+$	p-value$^+$	χ^2(df)$^+$	p-value$^+$	χ^2(df)	p-value
heteroscedast.	2.8*(2)	24.7	x		2.6(2)	27.3	-	
One factor	5.2(3)	15.8	-		4.6(3)	20.4	-	
AR(1)	1.4(1)	23.7	0.8(1)	37.1	-		-	
One fac/AR(1)	6.0(4)	19.9	-		-		-	
covariance	1		1.6		1.0		1.0	
	0 1		-0.8 2.1		0.3 1.1		0.2 1.0	
	0 0 1		-1.2 1.7 3.6		0.1 0.3 1.1		0.0 0.2 1.0	
σ_y^2 (rel. eff.)	-		-		-		0.56	(0.84)
value obj.fct.	-3660.1		-3657.5		3659.4		3667.3	

* difference of two *minimum distance* estimates; + based on OPG-matrix, because of inaccurate numerical approximation of hessian; x no proper convergence obtained.

Table C2: Estimation results of the dynamic self-employment equation for the binary model with ignorable attrition with ML and SML ($H = 30$)

estimation	ML		ML		SML	
variable	coef.	t-value	coef.	t-value	coef.	t-value[x]
α	3.55	22.6	4.24	10.5	3.98	15.6
time effects						
$t = 1$	-2.42	-16.7	-2.55	-12.2	-2.54	-11.5
$t = 2$	-2.52	-17.4	-2.66	-13.1	-2.60	-12.5
$t = 3$	-2.29	-13.8	-2.68	-8.0	-2.70	9.0
econ. exp. +	0.07	0.7	0.07	0.6	0.05	0.4
econ. exp. -	-0.33	-2.9	-0.33	-2.8	-0.33	-2.1
school (8 y.)	-0.23	-2.1	-0.26	-2.0	-0.24	-1.5
school (12 y.)	0.02	0.2	0.02	0.2	0.05	0.3
master	0.24	1.9	0.28	2.1	0.28	1.8
income diff.	-0.07	-0.7	-0.01	-0.1	0.02	0.1
unemploym.	0.43	0.4	0.58	0.5	0.93	0.6
public sect. (89)	-0.01	-0.0	-0.03	-0.2	-0.02	-0.2
small firm (89)	0.21	1.7	0.17	1.1	0.21	1.2
top manag. (89)	0.28	1.8	0.24	1.3	0.26	1.2
middle man. (89)	0.22	1.5	0.25	1.7	0.25	1.6
craft (89)	0.32	1.7	0.34	1.5	0.36	1.2
p.services (89)	0.53	3.3	0.59	3.6	0.57	3.8
s.oth.serv. (89)	0.14	1.1	0.24	1.7	0.23	1.3
single	-0.39	-1.9	-0.44	-2.2	-0.43	-1.6
separated	-0.04	-0.2	-0.16	-0.6	-0.15	-0.6
Berlin (E)	0.02	0.1	0.02	0.1	0.03	0.2
variance comp.						
δ_0	0		-1.64	-0.6	-0.48	-1.8
δ_1	0		0.30	1.4	0.28	1.4
δ_2	0		-0.23	-0.9	-0.03	-0.1
δ_3	0		0.72	2.7	0.73	3.7
a	0		0		0.02	0.2
Wald test			χ^2(df)	p-value	χ^2(df)[x]	p-value[x]
$\delta_t = \delta_{t'}, \forall t, t'$	-		28.2(3)	0.0	23.3(3)	0.0
$\delta_t = 0, \forall t$	-		32.1(4)	0.0	28.4(4)	0.0
covariance	1		3.7		1.2	
	0 1		-0.5 1.1		-0.1 1.1	
	0 0 1		0.4 -0.1 1.1		0.0 0.0 1.0	
	0 0 0 1		-1.2 0.2 -0.2 1.5		-0.4 0.2 0.0 1.5	
σ^2_y (rel. eff.)					0.79	(0.89)
value obj. fct.	-668.5		-656.6		-667.1	

x based on OPG-matrix, because of inaccurate numerical hessian.

Table C3: Estimation results of the dynamic self-employment equation for the ordered model with ignorable attrition with ML and SML ($H = 30$)

method	ML		SML		SML	
variable	coef.	t-value	coef.	t-value	coef.	t-value[x]
α_1	2.10	22.7	2.25	9.3	2.33	23.3
α_2	3.90	22.0	4.10	11.2	4.19	30.1
time effects						
$t = 1$	-1.94	-17.6	-2.00	-11.3	-2.02	-16.8
$t = 2$	-2.10	-20.7	-2.21	-12.0	-2.17	-17.1
$t = 3$	-1.96	-14.9	-2.10	-6.3	-2.27	-15.9
econ. exp. +	0.10	1.2	0.11	1.4	0.09	1.0
econ. exp. -	-0.29	-3.5	-0.30	-3.6	-0.28	-2.7
school (8 y.)	-0.26	-3.2	-0.26	-3.1	-0.25	-2.4
school (12 y.)	-0.06	-0.7	-0.07	-0.8	-0.08	-0.7
master	0.23	2.3	0.23	2.5	0.22	2.2
income diff.	-0.05	-0.5	-0.02	-0.5	-0.01	-0.1
unemploym.	-0.89	-1.0	-0.79	-0.9	-0.97	-0.9
public sect. (89)	-0.09	-1.0	-0.08	-0.9	-0.12	-1.1
small firm (89)	0.16	1.6	0.14	1.4	0.17	1.2
top manag. (89)	0.20	1.6	0.18	1.3	0.14	0.9
middle man. (89)	0.18	1.7	0.19	2.0	0.20	1.9
craft (89)	0.16	0.9	0.14	1.0	0.11	0.4
p.services (89)	0.38	3.0	0.41	3.4	0.39	3.6
s.oth.serv. (89)	0.11	1.0	0.14	1.9	0.18	1.4
single	-0.33	-2.6	-0.31	-2.7	-0.36	-1.7
separated	0.06	0.4	0.05	0.3	0.03	0.2
Berlin (E)	0.18	1.5	0.18	1.5	0.19	1.3
2nd bound**	0.71	0.06*	0.64	0.06*	0.65	0.03*
variance comp.						
δ_0	0		-0.34	-0.9	0.23	2.9
δ_1	0		0.21	1.2	0.22	2.4
δ_2	0		-0.28	-1.8	0.10	0.9
δ_3	0		0.45	1.6+	0.64	9.2+
α	0		0		-0.18	-5.8
Wald test			χ^2(df)	p-value	χ^2(df)	p-value[x]
$\delta_t = \delta_{t'}, \forall t, t'$	-		4.2(3)	24.2	25.7(3)	0.0
$\delta_t = 0, \forall t$	-		4.5(4)	34.8	109.5(4)	0.0
covariance	1		1.1		1.1	
	0 1		-0.1 1		-0.1 1.1	
	0 0 1		0.1 -0.1 1.1		0.1 -0.2 1.0	
	0 0 0 1		-0.2 0.1 -0.1 1.2		0.1 0.2 -0.1 1.4	
σ_y^2 (rel. eff.)			0.80	(0.89)	0.79	(0.97)
value obj.fct.	-1613.1		-1624.0		-1619.1	

* standard error; ** first bound set to zero; α_1 planned self-employment; α_2 realised self-employment; x based on OPG-matrix, because of inaccurate numerical hessian.

Appendix D: Additional simulations

This appendix contains results of additional simulations based on the model described in section six.

Figure D1: From 3/84 on all skilled workers having a craft profession (84) in 1989 are treated like masters

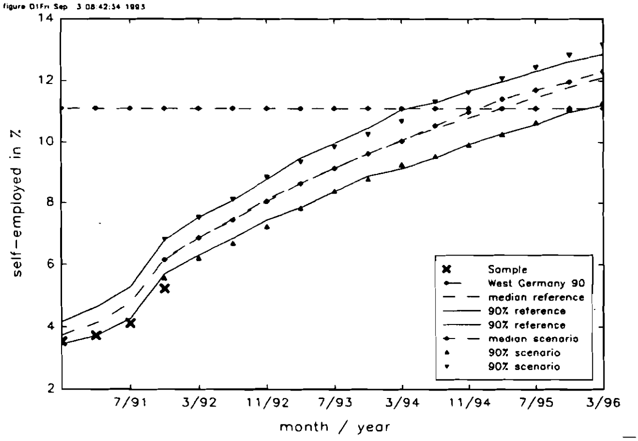
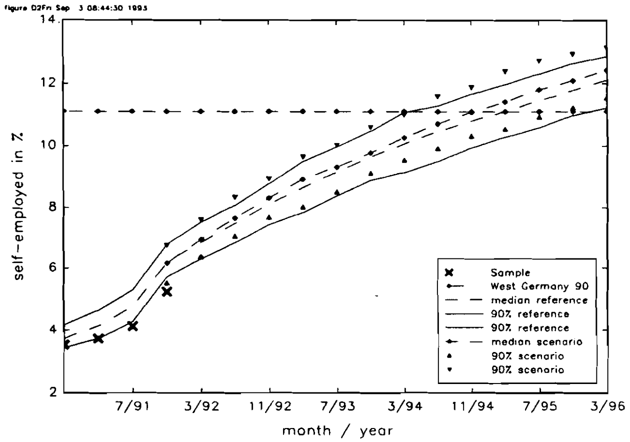


Figure D2: A more realistic time path of the 'bad expectation for regional economy' variable is assumed: 3/92: 14%, 7/92: 14%, 11/92: 20%, 3/93: 28%, 7/93: 28%, 11/93: 28%, 3/94: 20%, 7/94: 14%, 11/94: 14%, 3/95: 14% ....



It is known that the number of bad expectations in the AMM (males) drops from about 28% in 11/92 to 14% in 5/93. The time path however assumes that due to the recession the expectations get worse again, and afterwards improve towards their lowest level. The effects of these changes are minor.

Figure D3: Comparison of two extreme assumptions about the covariance structure: $\delta_s = 0.6, \quad \delta_s = 0, \quad s > T$.

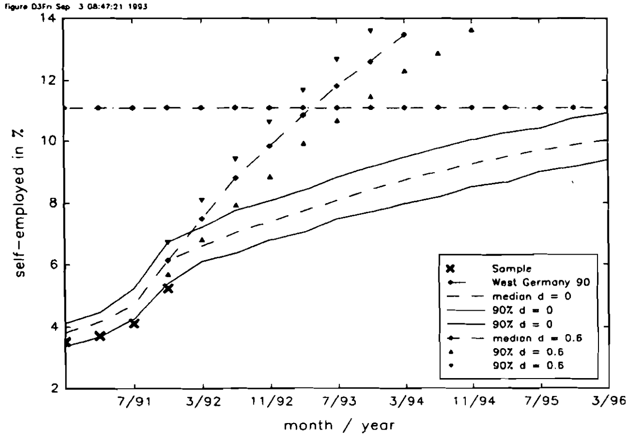


Figure D4: Comparison of binary and ordered model: errors uncorrelated over time