The Performance of German Firms in the Business-Related Service Sectors: a Dynamic Analysis

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Abstract

We analyze the performance of firms in the German business-related services sector. A quarterly business survey provides the panel data base of our study. Firm performance is measured by the survey respondents' ordinal indication of their changes in total sales. We use a first-order Markov chain and a multinomial logit specification to model the transition probabilitites. Three variants of the model are estimated: a linear index model with and without unobserved firm heterogeneity and a semiparametric model. Main results are that firm size has a positive effect on firm performance, that young firms outperform older competitors, that a bank-relationship with a single creditor has a stabilizing effect and that the degree of diversification has a negative impact on firm performance. The legal status appears to have no significant effect.

Keywords: Markov chain, service sector, business survey, firm performance, multinomial logit model, generalized additive model

JEL classification: L89, C23, C14

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Non-technical Summary

What determines the post-entry performance of firms? While numerous studies on the post-entry performance of firms from manufacturing industries have been undertaken, empirical evidence for the service sector is still scarce. This paper provides an empirical analysis of the determinants of firm growth for a large sample of German firms from the business-related services sector.

The data are taken from the Service Sector Business Survey, a quarterly business survey which is collected by the ZEW in collaboration with Germany's largest credit rating agency Creditreform. Roughly 1,100 firms are interviewed every three months since the second quarter of 1994.

Most of the information contained in the one-page questionnaire of the SSBS is ordinal. In particular, firms are asked to indicate on a three-point ordinal scale whether their total sales have increased, remained unchanged or decreased in the present quarter relative to the respective last quarter. The measure of firm performance used in this paper is the ordinal change in total sales firm report in the SSBS questionnaire. The econometric analysis hence concerns the discrete transitions from each the three different states (increased, unchanged or decreased sales changes) into another (or the same) state.

The specifications involve three different types of model: (1) a model where the determinants of the transitions between different states of firm performance are linearly related to the explanatory variables and where unobservable differences across firms are not allowed for, (2) an extension of the former model which allows for the presence of such unobserved firm heterogeneity and (3) a model where the effect of some of the explanatory variables may a priori take on any functional form. Test results suggest that the simplest model, model (1), gives a sufficiently accurate description of the data.

The main substantive results of this paper are the following: (1) firm size has a positive effect on firm performance in the business-related service sectors; (2) age has a weak negative impact; (3) a relationship with a single creditor has a stabilizing effect but credit relations with several banks allow firms with declining sales to improve their situation; (4) diversification has a negative effect on performance, while legal status has no significant impact.

1 Introduction

The success of the German economy in the seventies and eighties has often been traced back to three fundaments: monetary stability, social stability and industrial specialization in fields with high value added. Germany appears, however, to have had difficulties in adapting to the changes in the world economy which occurred in the nineties. According to Casper and Vitols (1997), the German economy currently suffers from three major weaknesses, namely a non-transparent tax system which imposes too high tax burdens, excessive labor costs, and an omnipresent bureaucracy. An indicator for the current weakness of the German economy is the all time high unemployment rate of 12.6% at the beginning of 1998 (11.6% seasonally adjusted). This spurned a lively debate on Germany's international competitiveness (*Standortdebatte*) with a corresponding host of theoretical and empirical studies.

However, mainly because of inappropriate data provision, this debate largely ignores the service sector and focuses on the declining manufacturing industries. In fact, not much is known about the German service sector, and especially about its particularly dynamic sub-sector of business-related services. While total employment declined by about 11% between 1982 and 1996 in West Germany, employment in the service sector increased by about 22%. In particular, business-related services, which account for a third of total employment in services, gained in overall economic importance with an employment growth rate of about 41% in the same period (Janz and Licht, 1999, part 2, ch. 2).

The end of the nineties has witnessed a surge of interest for the business-related service sector in Germany. Existing studies on firm *performance* are still mainly related to traditional sectors like manufacturing and trade only. Our aim in this paper hence is to analyze if the results found for those sectors are also valid for the business-related services sector.

We analyze a sample of 2520 firms (11455 firm-years) recorded by a quarterly business survey in the business–related service sector called the *Services Sector Business Survey* (SSBS). The SSBS is collected since the second quarter of 1994 by the Centre for European Economic Research (*Zentrum für Europäische Wirtschaftsforschung, ZEW*) and Germany's largest credit rating agency Creditreform. In order to enrich the data, we merge additional firm–level information to the SSBS from additional data sources provided to the ZEW by Creditreform.

Our measure of firm performance is an ordinal measure of the change in sales between subsequent quarters: the firms participating in the SSBS give their assessment of sales changes on a three point scale (increase, decrease, and no change in sales).

We use Markov-chain and multinomial logit models to study firm performance. We introduce unobservable firm heterogeneity into the multinomial logit model, and estimate the effect of firm size on firm performance non-parametrically. By expanding the multinomial logit model in these two respects, this paper contributes to the current revival of the multinomial logit approach in empirical industrial organization (Berry 1994, Breshnahan *et al.* 1996, Kaiser 2000).

Theoretical and empirical studies on industrial dynamics and market structure generally focus on three main topics: firm survival, firm growth, and the relationship between firm performance and firm characteristics, typically taken as static. Sutton (1997) provides an excellent survey of the first two topics. The last one is studied, i.a., by Ettlinger and Tufford (1996), who analyze the performance of manufacturing firms located in Ohio (United States) and by Majumdar (1997), who studies Indian firms. This paper is concerned with the last topic, and we extend the existing literature on firm performance by adopting a dynamic instead of a static approach.

Four main results emerge from this study: (i) firm size has a positive effect on firm performance in the business-related service sectors; (ii) age has a weak negative impact; (iii) a relationship with a single creditor has a stabilizing effect but credit relations with several banks allow firms with declining sales to improve their situation; (iv) diversification has a negative effect on performance and firms' legal status does not have a significant effect on firm performance.

These results are broadly supported by both the parametric and semiparametric model. We find, however, that the parameter vectors are more precisely measured by the semiparametric model than by the parametric model. However, the precision with which actual transitions are predicted improves if the parametric rather than the semiparametric estimates are used.

The paper is organized as follows: the existing theoretical concepts and empirical studies motivating our own empirical approach are discussed in Section 2; the econometric models used are described in Section 3; data and empirical findings are presented in Sections 4 and 5, respectively. Section 6 concludes.

2 Theoretical Concepts

Before actually presenting the various theoretical concepts which justify the specification of our empirical models described in Section 3 below, it is useful to clarify what is understood by "firm performance". Several definitions coexist in the literature. For example, while Ettlinger and Tufford (1996) define firm performance by sales, or by value added per employee, Majumdar (1997) measures it by productivity (defined as the ratio value added and output), and/or by profitability (realized profits over sales). An interesting and often applied measure of firm performance is Tobin's q, the ratio of the present value of flows of future income as reflected by the stock market valuation of the firm and the value of realized investments at replacement cost (see the survey by Blundell *et al.*, 1996). Some authors use the employment growth rate to measure firm performance (e.g., Harhoff *et al.*, 1998; Almus and Nerlinger, 1999).

All these measurements are subject to some sort of criticism. Concerning employment growth as performance measure, a firm whose production depends heavily on technology is likely to create fewer jobs than firms whose production heavily depends on labor input. Moreover, the *shareholder value* age has brought quite a number of such cases to a broad audience where even firms in a strong financial position have released workers in order to increase worth.

In this study we choose a definition in line with Ettlinger and Tufford (1996) as well as Majumdar (1997) and measure firm performance on the basis of sales. Yet, while the aforementioned authors consider actual sales, we use sales changes depicted on an ordinal scale here. In the SSBS, firms are asked to indicate whether their sales increased (hereafter denoted by "up"), decreased ("down") or remain unchanged ("unchanged") in the actual current quarter with respect to the previous quarter. A major advantage of this approach is that virtually all business surveys ask for sales changes on an ordinal scale so that the econometric methods suggested in this paper can be picked up by other researchers opening up the possibility to compare results across countries and sectors.[1]

The explanatory variables included in our estimations are based on five groups of theoretical concepts. The first two concepts concern firm size and firm age: economies of scale and learning-by-doing effects imply that firm size and age may be important determinants of firm performance. This intuition is concretized by an abundant literature in industrial economics concerning minimum optimal scale, learning-by-doing and organizational structure. Empirical results for the impact of age and size on firm performance often contradict one another depending on the data used and the estimation method applied (Sutton 1997).

With regard to firm age, it is well known that due to learning effects, old companies possess more experience in production than young companies. On the other hand, old firms are said to be less flexible in adapting to changes in market environments. Consequently, a theoretical prediction for the impact of age on firm performance is impossible *a priori*. By using two different definitions of performance — productivity and profitability — Majumdar (1997) finds for Indian cross sectional data that older firms are more productive but less profitable (in the sense given above) than young firms. Studies analyzing the relationship between firm characteristics and

[1] In a synoptic table, the Centre for International Research on Economic Tendency Surveys (CIRET 1998) lists 318 business surveys throughout 57 countries.

firm survival and growth also stimulated our work. Evans (1987a, b) and Dunne *et al.* (1988, 1989) find for US manufacturing firms that age has a positive effect on the survival probability and a negative effect on growth. By contrast, Das (1995) finds that age has a positive effect on firm growth in a study of the Indian computer industry.

Economic theory is also equivocal with regard to the effect of firm size on firm performance. Large enterprises may more easily reach their desired economies of scale or an advanced technological level than small and medium-sized enterprises (SMEs) and hence may even outperform them in terms of technology and competitiveness. The recent reorganization and concentration of European firms justify at least partially this assertion. For Germany, using a panel of more than 4,500 West German manufacturing firms, Wagner (1993) finds that firm size positively influences firm performance, which he measures by the exports/sales ratio.

SMEs have, however, a clear advantage over large enterprises in that they are more flexible, both in terms of geographical localization and their abilities to adapt to a changing economic environment. For instance, Fendel and Frenkel (1998), show that SMEs stabilize employment net of cyclical effects to a larger extent than large firms. Job turnover is larger, but net employment fluctuations are lower for SMEs than for large enterprises. Hence, SMEs are more flexible vis-a-vis the changes of their economic environment than the large firms. In this context, Majumdar (1997) finds for Indian firms that size has a negative impact on productivity and a positive effect on profitability.

The impact of size on firm growth is extensively studied in industrial economics. The 'law of proportional effect' established by Gibrat (1931), and roughly stating that a firm's growth rate is independent of its size, is at the origin of this abundant literature (see Sutton 1997 for a survey). Evans (1987a, b) and Dunne *et al.* (1988, 1989) notice that the survival probability of firms in US manufacturing increases with firm size while a firm's growth rate, conditional on its survival, decreases with size. Das (1995) finds similar results for Indian computer firms: size has a negative impact on growth. Just like the other studies, in an analysis for Germany, Wagner (1992) has to reject the validity of Gibrat's law.

A shortcoming of the empirical industrial organization literature on firm growth and performance is the lack of microeconomic foundations. An exception is Burdett and Coles (1997) who develop an original approach to model firm age, size and performance.[2] Firms and consumers interact strategically in an infinite horizon game. Each firm makes arbitration between the income obtained from sales at the highest possible price for a clientele which

[2]Other well-known exceptions are Ericson and Pakes (1995, 1998), and Jovanovic (1982). The former develop a model of learning and sketch how this model can be implemented empirically, at least in principle. The latter set up a model of creative destruction.

it already possesses on the market, and the income obtained from sales at a lower price, corresponding to a more numerous clientele. Potential entrants are supposed to consist of small and young firms, with size measured by the number of customers. Before entering a market, firms do not have customers. The consumers look for the lowest price, a costly search activity. The authors show that the equilibrium in this economy corresponds to a dispersion of prices, i.e., young (small) firms propose lower prices than the incumbent firms. The sales of young (small) firms consequently grow more rapidly than those of old firms. As firm size grows through time, their sales increase at a decreasing rate so that empirical evidence is needed in order to gain further insight into the growth and size relationship.

A third potentially important determinant of firms' post entry performance is legal status. According to Harhoff *et al.* (1998), the choice of legal status of a firm reflects its evaluation of risk. It determines the mode of financing (external financing by banking loans, internal financing by the titles of participation, etc.), the type of responsibility (full, limited or mixed) and the mode of transfer of property rights. German commercial law distinguishes two main legal forms: corporate firms and non-corporate firms. The owners (shareholders) of a corporate firm are liable up to the amount of their individual shares and are taxed at the level of the corporation, while the owners of a non-corporate firm are fully liable, with their entire personal assets, and are taxed proportionally to their shares. Each legal status implies different costs (transaction costs, opportunity costs, costs of capital raising and taxes), and the choice of legal status can be regarded as a cost minimization problem.

The share of limited liability companies (*Gesellschaft mit beschränkter Haftung, GmbH*) in the German economy has increased considerably in recent years. The percentage of *GmbHs* increased from 1.8% to 15% between 1970 and 1997. The share of *GmbHs* in total employment increased from 15% to 26% for the same period.[3] Why have limited liability firms gained so markedly in economic importance? Using a sample of more than 10,000 German firms of four sectors (manufacturing, construction, trade and services) observed between 1989 and 1994, Harhoff *et al.* (1998) show that firms with limited liability exhibit a higher growth rate, but also a larger insolvency rate, than firms with other legal forms.

The relationship with banks constitutes the fourth group of variables considered in our empirical investigation. The German banking system presents its own specificities: banks have a universal status and an almost unlimited competence (loans, investment banking, stock issuing, consultancy, mergers and acquisitions, takeover, etc.). Furthermore, Germany was up to now little exposed to the competition of foreign banks, speculative modes and international financial innovations. These universal banks are attentive to

[3]Source: Federal Statistical Office (Statistisches Bundesamt, 1998).

the needs of enterprises and engage in a durable relationship of confidence with them. While the large enterprises have access to direct financing (via the stock market), the German SMEs usually have a relationship with only one bank called house bank (*Hausbank*) which often directly influences a firms' management's decision (Edwards and Fischer, 1994).

A new economic and financial environment is developing in Europe due to the deregulation of the banking sector. The emergence of new sectors of activities, the entry of a growing number of foreign banks, and the introduction of new financial instruments, characterize the recent period. The status of *Hausbanks* seems to erode: firms consider more and more the possibility of a relationship with several banks. In order to optimally gain from bank financing and the related services, a firm must ex-ante determine the number of banks with which it wants to maintain a relationship. According to Harhoff and Körting (1998), this choice is based on the following three criteria: (C1) the cost of debt renegotiation in case of a default (bankruptcy, liquidation), (C2) the financial problems which a firm can face (insolvency, refusal of financing on behalf of the bank, delay of repayments, etc.), and (C3) the benefits and costs of information circulating between the firm and its banks. A relationship with a single bank allows the firm to reduce capital and renegotiation cost (C1), improves the access to new credits and sends a positive signal on its financial health to the market (C2). It also allows firms to receive management advice and strategic information (C3). However, an exclusive bank-firm relationship also entails some costs such as opportunity costs (the firm depends heavily on an individual bank and does not benefit from competition between banks), switching costs (the longer the relationship with a single bank is, the higher these costs are), and the costs related to non-diversification of risk (a relationship with several banks reduces the risk of delayed payments compared to a banking relationship with a single bank).

Harhoff and Körting (1998) apply a logit model to a sample of more than 1,500 German SMEs surveyed over the period 1992-1997 to study the determinants of the number of creditors. They find that there is an *ex-ante* positive effect of age and size on the number of creditors. They also show that innovative firms have more creditors than non-innovative firms. Finally, firms in a weak financial condition have more creditors than others. It should be noted that Harhoff and Körting (1998) study only the *ex-ante* relationship between firm characteristics and the number of its creditors while the three aforementioned criteria imply that the choice of the number of banks can have *ex-post* effects on performance. Petersen and Rajan (1994) study the relationship between the number of creditors and cost and credit availability (first two criteria) of US SMEs on the basis of data from 3400 firms collected between 1988 to 1989. They show that a relationship with several banks increases the cost of credit (measured by the interest rate of the most recent loan) and decreases the availability of credit (measured by the delay in the payment of the trade credit). According to Foglia *et al.* (1998), a relationship with several creditors is a typical Italian characteristic. By using a discriminant analysis on a sample of 3,300 Italian manufacturing enterprises observed over the period 1991-1995, they find that this type of relationship increases the fragility of firms since it increases their rate of insolvency.

Diversification is the last variable discussed in this section. According to the model of Jovanovic (1993), the motives for diversification are the following: (i) *increase in market power*: a firm with market power in two substitute product fields can obtain larger profits than two single product monopolies acting noncooperatively; (ii) *risk reduction*: diversification allows firms to decrease the risk of bankruptcy and liquidity constraints (just like a diversified financial portfolio); (iii) *increased access to financial resources*: diversified firms increase their financial capacity due to a greater influence on the financial market; (iv) *efficient use of production factors*: diversified firms gain from the complementarities between production factors. Diversification also allows to create general-purpose abilities of the labor force. Furthermore, diversified firms can gain from product complementarities (for example, in the electronic and computer sectors: complementarities between software packages); (v) *efficiency gains*: diversified firms can realize economies of scale. Yet, it is not the case that diversification only concerns large firms: according to Aw and Batra (1998), SMEs are also often diversified, especially in the form of entry to new markets and (vi) *advantages for managers*: diversification allows managers to gain prestige and gives them the opportunity to decrease the preciseness of financial information communicated to the shareholders.

Hughes and Oughton (1993) show within a game-theoretic framework that diversification increases profitability. Indeed, diversification implies that companies can meet competitors on several markets at the same time, which may have anticompetitive effects if the firms cooperate and maximize joint profits in some markets. Diversification still implies opportunity costs, costs corresponding to a suboptimal combination of various inputs in the process of production (non-fruitful activities take away resources from more fruitful activities), costs associated with information dispersion and costs related to the divergence between the objectives of the shareholders and the managers, or to the asymmetry of information between the managers of different subsidiaries. For a sample of more than 3,650 US firms recorded between 1986 and 1991, Berger and Ofek (1995) show that diversification involves an over-investment in various sectors and is at the origin of the decline of firm performance. At the same time, it reduces profitability and firm value. Lang and Stulz (1994) point out that diversification has had a negative effect on Tobin's q for US firms during the 80s and that the q of diversified firms is smaller than that of the non-diversified firms. As the diversifying firms in their sample already had poor performances before diversification, their study only suggests that diversification is not a way to boost the performance of ailing firms.

In the remainder of this paper, we empirically study the impact of size, age, legal status, banking relationships, and diversification on the performance of German firms from the business-related services sector.

3 Model

Markov chains are a powerful instrument to study dynamic economic phenomena. They allow to describe and to forecast individual behavior over time. Given that our measure of firm performance is ordinal and reflects transitions form the different states 'up', 'unchanged' and 'down', Markov chains suit our purpose. We assume that firms' performances follow a Markov chain of order 1. A Markov chain of a higher order does not seem advisable here because (i) it would considerably decrease the number of observations, and (ii) it does not correspond to the structure of our sample, in which changes from period to period rather than levels are observed. We propose a new application of the multinomial logit model to introduce explanatory variables to the specification of the transition probabilities. We shall estimate three versions of this model: the first one postulates that explanatory variables influence transition probabilities through a linear index; the second one introduces unobserved heterogeneity both between firms and between transitions; the third relaxes the linear index assumption and is semiparametric.

3.1 Parametric model without heterogeneity

The general model presented here is inspired by Gouriéroux (1989). Let S_{it} denote the variable indicating the state in which individual i is at time t ($S_{it} = j$ if the individual is in state j). The probability of transition of individual i from the state j at $t-1$ to the state j' at time t is given by[4]

$$P_{ijj'}(t) \equiv P(S_{it} = j' \mid S_{it-1} = j) = \frac{\exp(\mathbf{x}_{itj}\,\mathbf{b}_{jj'})}{\sum_{l=1}^{J} \exp(\mathbf{x}_{itj}\,\mathbf{b}_{jl})},$$

$i = 1, \ldots, N$, $t = 0, \ldots, T$ and $j, j' = 1, \ldots, J$.

We assume that the characteristics $\mathbf{x}_{itj}$ observed at time $t-1$ when firm i was in state j can influence the probability of transition to state j' in a way that depends both on j an j'. Imposing the identifying restriction $\mathbf{b}_{j1} = 0$,

[4]Bold characters represent vectors or matrices.

we obtain the following expression:

$$P_{ij1}(t) = \frac{1}{1+\sum_{l=2}^{J}\exp(x_{itj}b_{jl})}, \tag{1}$$

$$P_{ijj'}(t) = \frac{\exp(x_{itj}b_{jj'})}{1+\sum_{l=2}^{J}\exp(x_{itj}b_{jl})}, \tag{2}$$

where now $j = 1,\ldots,J$, $j' = 2,\ldots,J$. We thus specify a multinomial logit model for each row of the transition matrix (i.e. for each $j = 1,\ldots,J$). Let us define $n_{i,t-1,t}(jj') = 1$ if $S_{it-1} = j$ and $S_{it} = j'$, and 0 otherwise. Then the log-likelihood conditional on the state occupied at the initial date is

$$\ln L = \sum_{j=1}^{J}\sum_{j'=1}^{J}\ln L_{jj'}\text{ , with }\ln L_{jj'} = \sum_{i=1}^{N}\sum_{t=1}^{T} n_{i,t-1,t}(jj')\ln P_{ijj'}(t). \tag{3}$$

Since the quantity $\sum_{j'=1}^{J}\ln L_{jj'}$ only depends upon parameters $b_{jj'}$, $j' = 2,\ldots,J$, the maximum likelihood estimator, $\hat{b}_{ML}$, can be obtained by separate maximization of the quantities $\sum_{j'=1}^{J}\ln L_{jj'}$, $j = 1,\ldots,J$.

3.2 Parametric model with heterogeneity

In order to obtain a more robust specification, we now allow for the possibility of random effects, one for each firm and for each type of transition, while keeping the linear index assumption. The transition probability becomes:

$$P_{ijj'}(t) = \frac{\exp(x_{itj}b_{jj'} + \sigma_{jj'}u_{ijj'})}{\sum_{l=1}^{J}\exp(x_{itj}b_{jl} + \sigma_{jl}u_{ijl})},$$

where $i = 1,\ldots,N$, $t = 0,\ldots,T$ and $j,j' = 1,\ldots,J$. The terms $\sigma_{jj'}u_{ijj'}$ are assumed to be mutually independent and independent of x, with mean 0 and variance $\sigma^2_{jj'}$. The random variable $u_{ijj'}$ is assumed to be standard normal distributed. With the identifying restriction $b_{j1} = 0$, we obtain

$$P_{ij1}(t) = \frac{1}{1+\sum_{l=2}^{J}\exp(x_{itj}b_{jl} + \sigma_{jl}u_{ijl} - \sigma_{j1}u_{ij1})} \tag{4}$$

$$P_{ijj'}(t) = \frac{\exp(x_{itj}b_{jj'} + \sigma_{jj'}u_{ijj'} - \sigma_{j1}u_{ij1})}{1+\sum_{l=2}^{J}\exp(x_{itj}b_{jl} + \sigma_{jl}u_{ijl} - \sigma_{j1}u_{ij1})}. \tag{5}$$

The parameters $\sigma_{jj'}$ have to be estimated. Since the transition probabilities depend upon unobservable variables, it is necessary to integrate them out in order to compute the likelihood function for the observations, and thus obtain:

$$\hat{E}P_{ijj'}(t) = \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} P_{ijj'}(t)\varphi\left(u_{ij1}\right)\varphi\left(u_{ij2}\right)\varphi\left(u_{ij3}\right)\mathrm{d}u_{ij1}\mathrm{d}u_{ij2}\mathrm{d}u_{ij3}$$

where $\varphi(.)$ denotes the density of the standard normal distribution. It is possible to approximate $\hat{E}P_{ijj'}(t)$ by the following simulators:[5]

$$\hat{E}P_{ij1}(t) = \frac{1}{H}\sum_{h=1}^{H} \frac{1}{1+\sum\limits_{l=2}^{J}\exp(x_{itj}b_{jl}+\sigma_{jl}u_{ijl}^{h}-\sigma_{j1}u_{ij1}^{h})},$$

$$\hat{E}P_{ijj'}(t) = \frac{1}{H}\sum_{h=1}^{H} \frac{\exp(x_{itj}b_{jj'}+\sigma_{jj'}u_{ijj'}^{h}-\sigma_{j1}u_{ij1}^{h})}{1+\sum\limits_{l=2}^{J}\exp(x_{itj}b_{jl}+\sigma_{jl}u_{ijl}^{h}-\sigma_{j1}u_{ij1}^{h})}$$

where the u_{ijl}^{h} are independent draws from the standard normal distribution.

The ML estimator with firm heterogeneity is obtained in the same way as the estimator without firm heterogeneity but with $\ln L_{jj'} = \sum_{i=1}^{N}\sum_{t=1}^{T} n_{i,t-1,t}(jj')\ln\hat{E}P_{ijj'}(t)$, and again it can be obtained by separate maximization of the quantities $\sum_{j'=1}^{3}\ln L_{jj'}$, $j = 1,2,3$. A likelihood ratio test of the restricted model (without heterogeneity, i.e. with all $\sigma_{jj'}$ set to 0) against the unrestricted model is performed later on.

3.3 Semiparametric model

The models specified in the preceding subsections assume that the impact of the explanatory variables on the transition probabilities can be represented by a linear index. A more flexible and still tractable specification is the following

$$P_{ijj'}(t) = \frac{\exp\left[\eta_{jj'}\left(x_{itj}\right)\right]}{\sum\limits_{l=1}^{J}\exp\left[\eta_{jl}\left(x_{itj}\right)\right]},$$

where $\eta_{j'}\left(x_{itj}\right) \equiv z_{itj}b_{jj'} + \sum_{k=1}^{q} f_{jj'}^{k}\left(w_{itj}^{k}\right)$, $x_{itj} \equiv \left(z_{itj}, w_{itj}\right)$ and z_{itj} and w_{itj} being $1\times p$ and $1\times q$ vectors, respectively. $f_{jj'}^{k}(.)$ is an unknown function of exogenous variable w_{itj}^{k}.

Specifically, in the application we assume that the form of the impact of firm size on each transition probability is unknown. By contrast, most empirical studies assume that the impact of (log-) size on the dependent variable, e.g. the growth rate of the firm, is linear or quadratic, both of which can be accommodated by a linear index through consideration of both

[5] For a presentation of the method of simulated maximum likelihood followed here, see e.g. Stern (1997). We chose H equal to 20 during the simulation.

ln(size) and its square. In our results it will turn out that a LR test of the linear index specification against the semiparametric specification cannot reject the former.

It is also worth noting that even if w is restricted to be a single variable, we allow for a different function for each arrival state.

This specification belongs to the class of generalized additive models suggested by Hastie and Tibshirani (1987, 1990) and Abe (1999). We still need identifying restrictions and again set $b_{j1} = 0$ for all j and also $f_{j1}^{k}(.) = 0$ for all j and k, and obtain:

$$P_{ij1}(t) = \frac{1}{1 + \sum_{l=2}^{J} \exp\left[z_{itj} b_{jl} + \sum_{k=1}^{q} f_{jl}^{k}\left(w_{itj}^{k}\right)\right]}, \tag{6}$$

$$P_{ijj'}(t) = \frac{\exp\left[x_{itj} b_{jj'} + \sum_{k=1}^{q} f_{jj'}^{k}\left(w_{itj}^{k}\right)\right]}{1 + \sum_{l=2}^{J} \exp\left[z_{itj} b_{jl} + \sum_{k=1}^{q} f_{jl}^{k}\left(w_{itj}^{k}\right)\right]}. \tag{7}$$

with $E[f(.)] = 0$.

The functions $f(.)$ and the coefficients b can be estimated by the method proposed by Hastie and Tibshirani (1987, 1990) and Abe (1999) which allows non-parametric estimation of the functions $f(.)$ and which is presented in Appendix 2. Due to the fact that the functions $f_{jl}^{k}(.)$ all are univariate, the curse of dimensionality that plagues multivariate non-parametric estimation is avoided. Estimation can again be performed by separate maximization of each $\sum_{j'=1}^{3} \ln L_{jj'}$, $j = 1, 2, 3$.[6] To take into account unobserved heterogeneity is a priori unproblematic, but since we cannot reject the assumption of absence of heterogeneity for the linear index model, we did not pursue that extension here.

4 Data and Variables

We use two complementary data sources in our empirical investigation, the SSBS and a data set called MARKUS which was provided to the ZEW by Creditreform, Germany's largest credit rating agency. The SSBS is collected since the second quarter of 1994. Roughly 3,500 firms of ten business-related service sectors are sent a one-page questionnaire which consists of two parts. In the first part, which is used throughout this paper, firms answer questions on their changes in sales, profits, demand, and employment on a three-point ordinal scale. They are also asked to assess their expectations for

[6] The method turns out to be relatively fast computationally: on a Pentium II with 350Mhz, the estimation of the semiparametric model requires 30 minutes for each departure state. By comparison, the single index model without heterogeneity took 3 minutes to convergence.

the respective subsequent quarter. The second part of the SSBS is used to analyze issues of current economic interest and is not considered here. The SSBS is constructed as a panel and is thoroughly described in Kaiser *et al.* (2000).[7]

The second data source is the MARKUS data file. It is a CD-Rom which contains information on roughly 600,000 German firms and is quarterly updated. The SSBS sample was originally drawn from this data base so that firms contained in the SSBS can be matched to those contained in the MARKUS data. As is well known from US studies using the Small Business Data Base (Acs and Audretsch 1990, ch. 2.3) which is based on credit files provided by the largest US credit rating agency Dun and Bradstreet, credit rating agency data are often noisy and require special attention (also see Almus and Engel, 2000). The MARKUS data set contains information on legal status, the number of bank relations, the number of business fields a firm is active in, on the number of employees and on the firm's foundation date. After meticulous data cleaning, we are left with a panel of 11,455 observations (firm-years) covering 2,520 firms participating more or less regularly in the 20 waves under consideration. The number of observations markedly increased at the 13th wave: after the 12th wave, a sample enlargement took place. Table 1 presents the number of firms which participate 1, 2,..., or 20 times in this panel.[8]

Table 1

More than 68% of the SSBS-firms participated less than four times. This is, however, not very constraining since we use a Markov chain of order 1. The corresponding reduction in sample size is tolerable, as the number of observations effectively used in the estimations remains large (6,859 observations).

Let us brifly discuss the definitions of the variables used in the estimations:

• Performance. The (ordinal) change in sales is used as our measure of firm performance. It obviously does not, just like the other measures discussed in Section 2, capture all aspects performance but it is the best measure we have at hand. The variable S_{it} represents the state of firm i's performance at the date t. It takes on three possible values: '1' (sales at t remained unchanged compared to time $t-1$; this is our reference category), '2' (increased sales) and '3' (decreased sales). Consequently, we obtain 9 dummy variables $n_{\mathsf{i,t-1,t}}(jj')$, $j, j' = 1, 2, 3$ corresponding to the 9 possibilities of transition. The definition of states deserves some comments. One

[7] Anomynized public use files are available from the ZEW upon request. Write to konjunkturumfrage@zew.de.

[8] Survivor bias might of course be a problem here. However, since there are no official registers in Germany which record voluntary market exits, the refusal to participate in the survey cannot be distinguished from actual market exits.

problem is that the sales judgement depends on the own subjective valuation of the respondent in the firm. The answer "unchanged" can correspond in fact to a weak increase or a weak decrease (Ronning, 1984). Likewise, a strong increase (decrease) may not necessarily mean the same thing as a weak increase (decrease). Another problem is that the meaning of the answer "unchanged" for an evaluation of the firm's performance can depend on the level of the sales. None of these problems is taken into account by our model, and we do not see a possibility to cope with them given the data we have at hand. A final problem is the choice of sales as carrier variable: alternatives have been discussed in the introduction, but none of them dominates the others on all accounts.

• *Sector*. Our sample consists of 2,520 firms of ten business-related service sectors.[9] The dummy variables corresponding to these sectors are: ACCOUN (accounting), ADVERT (advertising), ARCHIT (architecture), CAR (vehicle renting), CONSUL (management consulting), MACHIN (machine renting), PLANNI (technical planning), SOFTWA (software), TRANSP (transport) and WASTE (waste disposal). Technical planning, which contains the largest number of observations, 17% of total observations, is the reference group. The sector of vehicle renting is the smallest, with only 5% of the observations.

• *Age*. Firm age is represented by three dummy variables, OLD (for OLD firm), YOUNG (young firm) and MIDDLE. Because some sectors are more recent than others, these variables are defined with regard to each sector and not with regard to some arbitrarily chosen age as in most studies.[10] By examining the distribution of the year of foundation by sector and by wave, we find that the values corresponding to the first quartile (25%) and to the third quartile (75%), which we expected to increase over time, are in fact almost constant across waves. Firms are labeled OLD if their age is in the first quartile, and YOUNG if they are in the third quartile. Table 2 describes how these variables are defined.[11] In countries where firm creation is subsidized, which is not the case for Germany, this definition of the YOUNG dummy would pick other effects than age.[12]

Table 2

[9] The firm distribution by sector is presented in Table A2 of Appendix 1.

[10] For example, Evans (1987a , b) regroups firms in five age groups: 0-6 , 7-20 , 21-45, 46-95 and 96 years and more. For the first group, firms are called young and age is treated as continuous variable (the age of a young firm is the difference between the current year and the foundation year). For the rest, firms are called old, and the age average of each group is used (because of the non availability of data for all firms).

[11] A graphical example of this definition is presented in Appendix 1 (Figure A1) for the sector machine renting.

[12] This was pointed out to us by Olivier Chanel.

• *Size.* Firm size is measured by the number of employees. In the estimations we use its natural logarithm (LSIZE). The smallest firm has one employee, the largest 21,546 employees. The average firm size is about 103 employees. SMEs constitute for a large majority in our sample: 2,356 firms (6,369 observations) have less than 250 employees, 2,442 firms have less than 500 employees. This points out the importance of SMEs in the business-related service sectors.

• *Legal status.* SINGPART and LIMSTOCK are two dummy variables indicating the legal status of a firm. German law basically allows for four types of establishments: (1) sole proprietorship which includes single individual enterprises (*Einzelperson*), liberal professions, business establishments (*Gewerbebetrieb*) and sole proprietorship (*Einzelfirma*); (2) associations without independent legal existence (partnership) including civil law associations (*BGB-Gesellschaft*), civil law associations (working party) (*BGB-Gesellschaft-Arbeitsgemeinschaft*), general commercial partnership (*O-HG*), and limited commercial partnership (KG); (3) firms in a corporate form are limited liability companies (*GmbH*) and stock listed companies (*AG*), and finally (4) firms in mixed form (limited commercial partnership formed with a limited liability company (*GmbH&Co.KG*).[13] As type (2) only represents 2.9% of the observations and is quite close to type (1), we aggregate type (1) and type (2) firms to our SINGPART group (32.4% of observations). Due to the fact that no firm of the last type (4) is present in our sample, we define LIMSTOCK as being the type (3). As in the data set used by Harhoff *et al.* (1998), the *GmbH* form dominates our sample: among 7,747 observations of type LIMSTOCK, 7,658 firms are *GmbH*s. Business-related services are thus in majority SMEs with limited liability.

• *Relationship with banks.* The dummy variable BANK represents banking relationships. It takes the value 1 if firm has only one creditor, and 0 if it has at least two. The maximum number of creditors of a firm in our sample is three, the minimum is one. The proportion of firms in relation with only one bank is 48% (5,479 observations), slightly higher than that of the sample used by Harhoff and Körting (1998). For comparison, the median numbers of creditors for our sample (Harhoff and Körting, 1998, report the same) and for the sample of Foglia *et al.* (1998) are 2 and 7, respectively: Italian firms are in relation with more creditors than German firms.

• *Diversification.* The dummy variable DIVERS indicates the number of business fields of a firm. It takes the value 1 if the firm is in two business fields and 0 otherwise. Only 961 firms are diversified (4382 in total or 38%).

• *Region.* EAST is a dummy variable which is coded 1 if a firm belongs to East Germany, 0 if it belongs to West Germany. There are 37% observations from East Germany in the sample.

[13] BGB : *Bürgerliches Gesetzbuch*; OHG : *Offene Handelsgesellschaft*; KG : *Kommanditgesellschaft*; GmbH : *Gesellschaft mit beschränkter Haftung*; AG : *Aktiengesellschaft.*

• *Time.* We include time dummies to capture business-cycle and seasonal effects. The dummy variables Y94 to Y99 correspond to observations recorded in the years 1994-1999. Y95 is the reference category. Seasonal fluctuations are taken into account by quarter dummy variables Q1 (first quarter)-Q4 (fourth quarter). The reference quarter is Q1.

A summary of the definitions of all the variables, as well as descriptive statistics, which are computed for the sample effectively used in estimations, are given in Appendix 1 (Tables A3 and A4). Table 3 gives the number of observations by transition and by variable.

Table 3

The last column of Table 3 presents the distribution of observations effectively used in the estimations. The sample effectively used contains 6,859 observations. This sample and the initial sample of 11,455 observations present almost the same characteristics. A majority of observations (about 58%) stays in the state of the previous quarter [columns $n(11)$, $n(22)$ and $n(33)$]. A quite large proportion of observations switches from 'down' to 'up' and 'unchanged'. There are 23.8% of the observations which arrive in the 'down' state, 33.6% arrive in the 'unchanged' state, and 42.5% arrive in the 'up' state.

Enterprises can modify their characteristics to adapt to the changes of their environment. However, we notice that few of these changes occur in our sample. The change of legal status (from SINGPART to LIMSTOCK) concerns only 415 observations (3.6%). 147 observations change their fields of main economic activity. Finally, 90 observations change their number of creditors. The econometric model presented in this paper allows a proper treatment of such time varying regressors, but as they are only of marginal importance, we shall not discuss them when interpreting the results.

5 Results

Our estimations for the determinants of firm performance include three different versions of the multinomial logit model for the probabilities of transition between states of firm performance: a linear index model without unobservable firm heterogeneity, a linear index model with unobservable firm heterogeneity, and a semiparametric model. Interestingly, and quite surprisingly, it turns out that the three models do not significantly differ: the maximized log-likelihood of the linear index model with heterogeneity is $\ln L^{\mathrm{H}} = \sum_{j=1}^{3}\sum_{j'=1}^{3} \ln L_{jj'} = -2590.54 - 2135.74 - 1493.49 = -6219.77$, while that of the linear index model without heterogeneity is $-2590.70 - 2138.33 - 1494.85 = -6223.88$. The overall LR test statistic thus is 8.22 which is way below the critical value at the 5% level, $\chi^2_{.95}(9)$

$= 16.9$. Looking at the three pairs of models corresponding to each departure state, the corresponding values are 0.32, 5.18, and 2.72, to compare with $\chi^2_{.95}(3) = 7.81$. Consequently, the model without heterogeneity is not rejected by our data, and that by a wide margin.

For the semiparametric model the maximized log-likelihood is $-2587.77-2130.69-1493.39 = -6211.85$. The LR test statistic for the test of the linear index model without heterogeneity against the semiparametric model (which nests it) is thus $2\,(6223.89 - 6211.85) = 24.08$.

The number of degrees of freedom (*df*) of this test is computed as the difference between the total effective number of parameters of the semiparametric model and the number of estimated parameters in the parametric model. For the semiparametric model, ther are two functions $f(.)$ to estimate for each departure state. According to Hastie and Tibshirani (1990, Appendix B), the equivalent number of parameters for each function can be approximated by $1.25tr(\mathsf{S}) - 0.5$ where $tr(\mathsf{S})$ is the trace of the smoothing matrix S corresponding to this function. More details can be found in Appendix 2 of this paper. As a result, *df* is $30-6 = 24$ (the equivalent number of parameter for the unchanged, up, and down departure state are 9.2, 12.4, and 8.4, respectively; and 6 is the number of slope coefficients for LSIZE in the linear index model). The computed value of the LR test statistic is smaller than $\chi^2_{.95}(24) = 36.42$. Hence, the linear index model is not rejected against the semiparametric model. The same conclusion holds if we look at each departure state separately.

5.1 Linear index model

Tables 4a and 4b present the estimation results of the linear index model without heterogeneity.[14] The estimated coefficients represent the marginal effects of the corresponding explanatory variables on the logarithm of the ratio of transition probabilities, i.e. $\ln[P_{ijj}(t)/P_{ij1}(t)]$ for $j' = 2,3$, and $j = 1,2,3$ (log-odds ratios). The marginal effect of a continuous exogenous variable, x^q_j, on the transition probability between the states j and j' is:

$$\delta_{jj'} \equiv \frac{\partial P_{jj'}}{\partial x^q_j} = P_{jj'}\left(b^q_{jj'} - \sum_{l=1}^{J} b^q_{jl} P_{jl}\right). \qquad (5)$$

The sign of the marginal effect depends on the expression in brackets: it can thus differ across observations, and differ from the sign of $b^q_{jj'}$. For an indicator variable, the difference in the probability of transition for the values 0 and 1 has to be computed, and again its sign may differ across

[14] STATA 6.0 was used to obtain all estimates in the paper. The asymptotic t-statistics reported are based on the robust estimate of the variance, computed as $J^{-1}IJ^{-1}$ on the basis of the empirical variance of the score, I, and the Hessian of the log-likelihood function, J.

observations. Therefore, in the sequel, all effects on transition probabilities will be expressed at sample means, and we will not systematically restate this.

The results displayed in Tables 4a and 4b can be interpreted as follows. The logarithm of firm size, LSIZE, has a significant effect on most of the log-odds ratios. We also estimated a model including the square of LSIZE, but a LR test yields a value of 2.81, much smaller than the critical value $\chi^2_{5\%}(6) = 12.6$. LSIZE has a significantly negative effect on $\ln(P_{13}/P_{11})$ and $\ln(P_{33}/P_{31})$, and a significantly positive effect on $\ln(P_{22}/P_{21})$. The effect on the other log-odds ratios is insignificant. One way to interpret this is to say that firm size has a positive impact on firm performance since state 3 ('down') is worse than state 1 ('unchanged'), and state 2 ('up') is better than state 1 ('unchanged'): the relative probability of arriving at a worse situation decreases with increasing firm size.

The marginal effect of LSIZE on transition probabilities appears, however, to be rather complex in view of the graphs displayed in Figure 1, which shows how the marginal effect of LSIZE varies with LSIZE when it is computed at sample means for the other involved variables.

Figure 1

Table 4a

Table 4b

The marginal effect on P_{33} stays at a more or less negative and constant level whatever the firm's size is, while the effect on P_{32} slightly increases with firm size. In general, we do find a size effect on performance in the business-related service sectors of Germany, but this effect is small: as Figure 1 shows, it is at most about 4% in absolute value at sample means. If sales growth is considered as a measure of firms' performance, we thus come to a conclusion which is in contradiction with Evans (1987a, b), Dunne *et al.* (1988, 1989), Das (1995), and Harhoff *et al.* (1998), who all find a negative impact of size on the growth rate of manufacturing firms.

Our estimation results also show that younger firms are more successful than older firms: the effect of YOUNG on P_{12} at sample means (0.09) is almost twice the effect of OLD (0.05). Older firms have a smaller chance to witness two successive sales increases (the effect of OLD on P_{22} is -0.09, and furthermore, young firms have better chances to arrive at an improved state (the marginal effect of YOUNG on P_{32} is 0.05). Hence, age has a negative impact on firm performance, albeit a small one — at least at mean sample. Our results are in this respect consistent with those of Majumdar (1997), Evans (1987a, b), Dunne *et al.* (1988, 1989) and Harhoff *et al.* (1998), and in contradiction with Das (1995).

Affiliation to East Germany has a negative effect on the probability of a transition to a better state: EAST has a significantly negative effect on $\ln(P_{12}/P_{11})$ and $\ln(P_{22}/P_{21})$ and a significantly positive effect on $\ln(P_{13}/P_{11})$. The corresponding effects on the transition probabilities at sample means are -0.06, -0.09, and 0.08.

The relationship with a single bank (reference group: relationship with several banks) has a stabilizing effect on firm performance since it has a negative impact on both $\ln(P_{32}/P_{31})$ and on $\ln(P_{23}/P_{21})$, i.e., if a firm has one creditor only, it has an improved probability to arrive in the 'unchanged' state. The effects on probabilities underline this assertion: BANK has a negative effect on P_{32} (-0.04) and on P_{23} (-0.02). If a firm departs from the decreased sales state, a relationship with a single bank reduces the possibility of arriving at a better state. Thus a relationship with several creditors allows firms which are in a bad situation to improve their performance. Our result is compatible with that of Harhoff and Körting (1998) for whom firms in weak financial conditions *ex-ante* have several creditors.

The only significant impact of diversification is related to $\ln(P_{13}/P_{11})$, which it raises by 3.8% (marginal effect on P_{13} 0.04) if the firm is active in at least two different activities (DIVERS = 1); thus we have a negative effect of diversification on performance.

Legal status appears to have no significant impact: advantages and drawbacks associated with the different legal forms thus seem to balance out each other.

We shall not discuss the sectorial and time indicators, since these were merely introduced as control variables, except to point out that the first quarter is obviously the most difficult for the firms in the business services sector.

A comparison between the frequencies of actual and predicted outcomes corresponding to the various transitions is given in Table 5. The marginal predictions of the destination states are fairly accurate, though somewhat optimistic: 2,331 observations (34.0%) are predicted to end up in the 'up' state, which is actually the case for 2,306 observations (33.6%) so that the predictions of our model are quite accurate indeed. A good fit of reality is also present for the 'down' state: 1,450 observations (21.1%) are predicted to end up in the 'down' state, while 1,635 observations (23.8%) are actually observed in this state. The predictions for the individual transitions are, however, not very accurate: for instance, there are 1,700 observations actually staying in the 'unchanged' state (a conditional frequency of 60%), whereas the prediction gives the much larger number of 2,220 observations (a conditional frequency of 98.8%).

Table 5

Multinomial logit models impose the assumption of "Independence of irrelevant alternatives" (IIA), according to which the ratio of the probabilities of any two transitions does not depend on the presence of other transition possibilities. We hence test for the validity of the IIA assumption along the lines of Hausman and McFadden (1984). For a multinomial logit model with J modalities with an associated estimated parameter vector $\hat{\boldsymbol{\theta}}_{\mathsf{J}}$ and a submodel with I modalities ($I < J$),[15] and an associated parameter vector $\hat{\boldsymbol{\theta}}_{\mathsf{I}}$, the Hausman test statistic

$$\xi^{\mathsf{H}} = \left(\hat{\boldsymbol{\theta}}_{\mathsf{I}} - \hat{\boldsymbol{\theta}}_{\mathsf{J}}\right)' \left[V\left(\hat{\boldsymbol{\theta}}_{\mathsf{I}}\right) - V\left(\hat{\boldsymbol{\theta}}_{\mathsf{J}}\right)\right]^{-} \left(\hat{\boldsymbol{\theta}}_{\mathsf{I}} - \hat{\boldsymbol{\theta}}_{\mathsf{J}}\right)$$

(where A^{-} denotes any generalized inverse of A) is asymptotically distributed as χ^2 with a number of degree of freedom equal to the rank of the matrix $V\left(\hat{\boldsymbol{\theta}}_{\mathsf{I}}\right) - V\left(\hat{\boldsymbol{\theta}}_{\mathsf{J}}\right)$. One computational difficulty is that the estimate of $V\left(\hat{\boldsymbol{\theta}}_{\mathsf{I}}\right) - V\left(\hat{\boldsymbol{\theta}}_{\mathsf{J}}\right)$ can turn out not to be a positive definite matrix. In this case, we can use a correction to obtain a positive value (the details are given in Appendix 3). For each separate estimation, $J = 3$, we compute two Hausman test statistics ξ^{H_1} and ξ^{H_2}, which both follow a $\chi^2(25)$ distribution, corresponding to the removal of state 2 (up) and that of state 3 (down), respectively. None of the Hausman tests performed with our data rejects the IIA hypothesis. The values of ξ^{H_1} and ξ^{H_2} are 0.654 and 1.012, respectively, for the transitions from state 1 to j, $j = 1, 2, 3$; they are 0.150 and 0.555 for the transitions from state 2; and they are 0.366 and 1.564 for the transitions from state 3. The corresponding critical value is $\chi^2_{5\%}(25) = 37.65$. Thus the multinomial logit specification of our model is not rejected by the data.

Lastly, the explanatory power of the model is quite low, with a McFadden R^2 of 0.05.

5.2 Semiparametric model

To estimate the functions $f_{\mathsf{j}'}$ (LSIZE), we use the kernel method with a normal kernel and fixed bandwidth.[16] The estimation results of the semiparametric model are presented in Tables 6a and 6b. The estimated functions $\hat{f}(.)$ are displayed in Figures 2 and 3.

All the significant parameters of interest in the parametric model remain significant with only slight differences in magnitude, and there are two more significant parameters in the semiparametric model.

Table 6a

Table 6b

Table 7 presents prediction results using the semiparametric model, which should be compared to the predictions reported in Table 5: the results are

[15] The submodel is obtained by removing $\mathsf{J} - \mathsf{I}$ modalities from the J existing modalities of the initial model.

[16] See Appendix 2 for details. Hastie and Tibshirani (1987) used the method of k-nearest symmetric neighborhoods instead.

qualitatively similar, but the predictions from the semiparametric model are uniformly slightly worse.

The semiparametric model authorizes a much more flexible structure of the variable LSIZE, as documented in Figures 2 and 3, which show the estimated functions $\hat{f}$ for arrival states 2 and 3, respectively. The indicated confidence bands are pointwise estimates. The straight lines depict the slopes estimated in the linear index specification. In pictures (2a), (2c), and (3a), (3c) the results from the two specifications appear compatible, but pictures (2b) and (3b) show different results. However the estimated slope in Figure (3b) is not significantly different from zero, so that the only striking difference concerns the transition up-up.

Figure 2

Figure 3

6 Conclusion

This study analyzes the performance of German business-related service firms. We use panel data taken from a quarterly business survey in this sector in the empirical investigation. The data are collected since the second quarter of 1994 and cover 20 waves. Our measure of firm performance is the change in sales depicted on an ordinal three-point-scale in the present quarter with respect to the previous quarter. We control for seasonal and business cycle effects.

We use a model combining a first order Markov chain and a multinomial logit specification of the probabilities of transition in order to study the relationship between firm performance and firm characteristics. Three different versions of the econometric model are compared in this paper: a linear index model without unobserved heterogeneity, its extension to deal with unobserved heterogeneity, and a semiparametric (generalized additive) model. Within the linear index model, neither the assumption of absence of unobserved heterogeneity nor the linearity in the continuous variable *ln(firm size)* could be rejected. Moreover, a LR test does not reject the linear index model against the semiparametric model, and the multinomial specification is not rejected either. The qualitative implications for the sector of business-related services remain the same across the specifications, so that they present some robustness to specification changes.

These substantive results can be summarized as follows. First, firm size has a positive, but weak, effect on firm performance. Second, young firms outperform old firms. Third, a relationship with one creditor has a stabilizing effect on firm performance. Finally, diversification has a negative effect on firm performance, but the legal status of the firm appears to have none: this is possibly due to the fact that SMEs with the *GmbH* form dominate in our sample, but it may also suggest that the possible risks associated with various legal forms are not a major concern for entrepreneurs of the business-related service sectors. Moreover, the data point to optimistic perspectives: the business-related service sectors appear as high-performers, since the number of observations in the 'up' state is much larger than that in the 'down' state.

Interesting extensions of our analysis would be to compare the results found with *actual* changes in sales to results obtained using *expected* changes instead. Yet potential endogeneity problems, concerning firm size or legal status, may deserve more immediate attention.

7 Appendix 1: Data

Table A1: Distribution by wave.

wave	# obs	%	cum. %
1	500	4.4	4.4
2	448	3.9	8.3
3	552	4.8	13.1
4	362	3.2	16.3
5	564	4.9	21.2
6	508	4.4	25.6
7	481	4.2	29.8
8	523	4.6	34.4
9	525	4.6	39.0
10	468	4.1	43.1
11	431	3.8	46.8
12	412	3.6	50.4
13	730	6.4	56.8
14	719	6.3	63.1
15	673	5.9	68.9
16	692	6.0	75.0
17	718	6.3	81.2
18	653	5.7	86.9
19	796	7.0	93.9
20	700	6.1	100
Total	11455	100	

Table A2: Distribution of firms between sectors.

sector	# obs.	%
ACCOUN	1055	9.21
ADVERT	813	7.10
ARCHIT	1102	9.62
CAR	586	5.11
CONSUL	1166	10.18
MACHIN	852	7.44
PLANNI	1953	17.05
SOFTWA	1394	12.17
TRANSP	920	8.03
WASTE	1614	14.09
Total	11455	100

Figure Al displays the distribution of the year of foundation by wave, for the sector of machine renting. A distribution for all observations of this sector is also presented. The distribution of the age is more or less stable over time, while we would have expected to see an increase in the proportion of young firms (and thus an upward sloping graph). The value of the first quartile corresponds approximately to 1978 for all waves, that of the third quartile to 1990. We thus consider a firm as young (YOUNG = 1) in the sector of machine renting if it was founded after 1990, as old (OLD=1) if it was founded before 1978. The interval 1978-1990 corresponds to the reference category (MIDDLE).

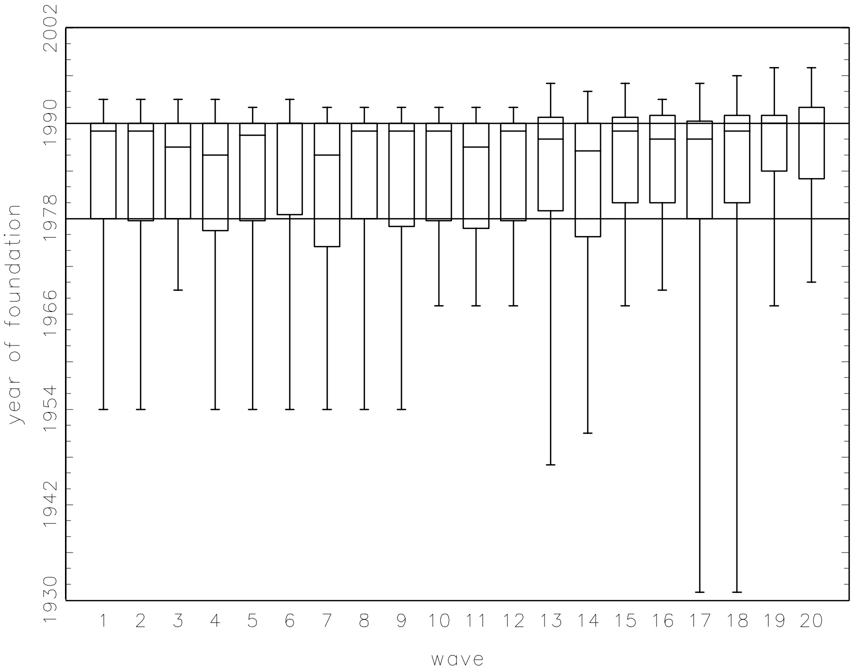

Figure A1: Age definition: Machine Renting sector.

Table A3: Variable definition

	variable	meaning	type	Source
performance	n(jj′), j,j′=1, 2, 3	state of sales (change)	discr.	1
size	LSIZE	log. of number of employees	cont.	2
age (related to sector)	YOUNG	young firm	dum.	2
	MIDDLE	adult firm (reference)	dum.	2
	OLD	old firm	dum.	2
region	EAST	region (East-West)	dum.	2
number of banks	BANK	relationship with banks	dum.	2
diversification	DIVERS	number of activity fields	dum.	2
legal status	SINGPART	single person (Einzelperson)	dum.	2
		business establishment (Gewerbebetrieb)	dum.	2
		sole proprietorship (Einzelfirma)	dum.	2
		civil law association (BGB-Gesellschaft)	dum. dum.	2
		civil law association (working party) (BGB-Gesellschaft-Arbeistgemeinshaft)	dum.	2
		general commercial parnership (OHG)	dum.	2
		limited commercial partnership (KG)	dum.	2
	LIMSTOCK (reference)	limited liability company (GmbH)	dum.	2
		company in the mixed form (GmbH&Co.KG)	dum.	2
		stock corporation (AK)	dum.	2
sector	ACCOUN	accounting	dum.	2
	ADVERT	advertising	dum.	2
	ARCHIT	architecture	dum.	2
	CAR	vehicle renting	dum.	2
	CONSUL	management consulting	dum.	2
	MACHIN	machine renting	dum.	2
	PLANNI	technical planning (reference)	dum.	2
	SOFTWA	software	dum.	2
	TRANSP	transport	dum.	2
	WASTE	waste disposal	dum.	2
time	Y94-Y99	year (reference: Y95=1995)	dum.	1
	Q1-Q4	quarter (reference: Q1)	dum.	1

Note: 1: SSBS, 2: MARKUS.

Table A4: Descriptive statistics.

group	variable	mean	std.dev.	min.	max.
performance	*n(11)*	.248		0	1
	n(12)	.085		0	1
	n(13)	.080		0	1
	n(21)	.106		0	1
	n(22)	.212		0	1
	n(23)	.042		0	1
	n(31)	.072		0	1
	n(32)	.039		0	1
	n(33)	.116		0	1
size	LSIZE	3.572	1.288	0	9.469
age	YOUNG	.231		0	1
	MIDDLE	.596		0	1
	OLD	.173		0	1
region	EAST	.403		0	1
# banks	BANK	.463		0	1
diversification	DIVERS	.379		0	1
legal status	SINGPART	.337		0	1
	LIMSTOCK	.663		0	1
sector	ACCOUN	.092		0	1
	ADVERT	.061		0	1
	ARCHIT	.094		0	1
	CAR	.049		0	1
	CONSUL	.103		0	1
	MACHIN	.070		0	1
	PLANNI	.188		0	1
	SOFTWA	.115		0	1
	TRANSP	.082		0	1
	WASTE	.146		0	1
time	1994	.072		0	1
	1995	.177		0	1
	1996	.209		0	1
	1997	.217		0	1
	1998	.257		0	1
	1999	.068		0	1
	Q1	.264		0	1
	Q2	.202		0	1
	Q3	.272		0	1
	Q4	.262		0	1

Note: number of obs.= 6859.

8 Appendix 2: Estimation method for the semi-parametric model

Hastie and Tibshirani (1987, 1990) proposed the local scoring algorithm to estimate $f(.)$ and b in a binary generalized additive model. Abe (1999) generalized it to the multinomial case. The basic idea is akin to an iterated version of Robinson's (1988) estimator for the semilinear model. The core of this algorithm is the backfitting algorithm, which is described in Härdle (1989). We briefly present the version of Abe (1999) below (indices denoting the arrival state, the firm and the time period are omitted to simplify the presentation).

Generalized algorithm

• Initialization: Use the initial value from the parametric model given by (1) to obtain $\hat{\eta}_j(x) = x\hat{b}_j$ (and set $\hat{\eta}_1(.) = 0$ due to the identifying restrictions).

• Repeat the following steps until the increase in the log-likelihood function is sufficiently small:

(i) Compute the running estimator of the transition probability:

$$\mu_j = \frac{\exp\left[\hat{\eta}_j(x)\right]}{1+\sum_{l=2}^{J}\exp\left[\hat{\eta}_l(x)\right]}$$

(ii) Calculate the adjusted dependent variable v_j and the associated weight ρ_j :

$$v_j = \hat{\eta}_j(x) + \frac{n(j)-\mu_j}{\rho_j}$$

$$\rho_j = \mu_j(1-\mu_j)$$

(iii) Obtain $\hat{f}_j^k(w^k)$ by the *backfitting algorithm* with weight ρ_j, and $\hat{b}$ by ML.

Backfitting algorithm

• Initialization: Use the parametric model to calculate $\hat{f}_j^k(w^k) = \hat{b}_j^k w^k$ for every k.

• Repeat the following steps until the variation of $\hat{f}(.)$ is small enough:

(i) Compute the residual r_j

$$r_j = v_j - z\hat{b}_j - \sum_{m\neq k}^{q} \hat{f}_j^m(w^m)$$

and regress it non-parametrically on w^k with weight ρ_j to obtain $\hat{f}_j^k(.)$. The residual r_j is required to have zero mean.

Hastie and Tibshirani (1987) use the k-nearest symmetric neighborhood in stage (i) to find $\hat{f}_j^k(.)$. For simplification, we use the weighted kernel method with a normal kernel smoother (see Baltagi, Hidalgo and Li, 1996, for the panel data case, see also Lee, 1996). According to Hastie and Tibshirani (1990, pp. 72-74), in order to implement this weighted estimation, the sequence $\{\rho r\}$ as well as $\{\rho\}$ can be smoothed and then be used to form the pointwise ratio of the results. The kernel smoothing of y on z by the normal kernel at the point x_0 is given by (assuming a balanced panel for ease of notation)

$$E(y|z_0) = \sum_{l=1}^{NT} \frac{K\left[(z_l - z_0)/h\right] y_l}{\sum_{l=1}^{NT} K\left[(z_l - z_0)/h\right]}$$

where K is the kernel of the standard normal density, and h is the smoothing parameter. The smoothing parameter h was chosen by eye-balling. As S is the smoothing matrix of which the lkth element is

$$K\left[(z_l - z_k)/h\right] / \sum_{l=1}^{NT} K\left[(z_l - z_k)/h\right],$$

the trace of S, $tr(\mathsf{S})$, is equal to $\sum_{k=1}^{NT} \left\{K(0) / \sum_{l=1}^{NT} K\left[(z_l - z_k)/h\right]\right\}$. The generalized algorithm typically converges in 3 or 4 iterations.

9 Appendix 3: Hausman test correction

In this appendix, we propose a correction which makes the Hausman test statistic always positive. In a way similar to the solution proposed by Lee (1996, p. 20-21), for $j = 1, 2, 3$, and $r = I, J$, we have:

$$\begin{aligned}
\hat{\boldsymbol{\theta}}_r - \boldsymbol{\theta} &= \left[-\frac{\partial^2 \sum_{j'=1}^{J} \log L_{jj'}}{\partial \boldsymbol{\theta} \partial \boldsymbol{\theta}'} \right]^{-1}_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}_r} \left[\frac{\partial \sum_{j'=1}^{J} \log L_{jj'}}{\partial \boldsymbol{\theta}} \right]_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}_r} \\
&= \mathsf{A}_r \sum_{i=1}^{N} \sum_{t=1}^{T} \left[\frac{\partial \sum_{j'=1}^{J} n_{i,t-1,t}(jj') \log P_{ijj'}(t)}{\partial \boldsymbol{\theta}} \right]_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}_r}
\end{aligned}$$

$$= \sum_{i=1}^{N}\sum_{t=1}^{T} A_r \left[\frac{\partial \sum_{j'=1}^{J} n_{i,t-1,t}(jj') \log P_{ijj'}(t)}{\partial \boldsymbol{\theta}} \right]_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}_r} = \sum_{i=1}^{N}\sum_{t=1}^{T} \boldsymbol{\psi}_{it}^{r}.$$

where

$$A_r \equiv \left[-\frac{\partial^2 \sum_{j'=1}^{J} \log L_{jj'}}{\partial \boldsymbol{\theta} \partial \boldsymbol{\theta}'} \right]_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}_r}^{-1},$$

$$\left[\frac{\partial \sum_{j'=1}^{J} \log L_{jj'}}{\partial \boldsymbol{\theta}} \right]_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}_r} = \sum_{i=1}^{N}\sum_{t=1}^{T} \left[\frac{\partial \sum_{j'=1}^{J} n_{i,t-1,t}(jj') \log P_{ijj'}(t)}{\partial \boldsymbol{\theta}} \right]_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}_r}.$$

The expression $\partial \sum_{j'=1}^{J} n_{i,t-1,t}(jj') \log P_{ijj'}(t) / \partial \boldsymbol{\theta}$ is the score for a single observation.

Consequently,

$$\begin{aligned} \hat{V}\left(\hat{\boldsymbol{\theta}}_I - \hat{\boldsymbol{\theta}}_J\right) &= V\left[\sum_{i=1}^{N}\sum_{t=1}^{T} \boldsymbol{\psi}_{it}^{I} - \sum_{i=1}^{N}\sum_{t=1}^{T} \boldsymbol{\psi}_{it}^{J}\right] \\ &= V\left[\sum_{i=1}^{N}\sum_{t=1}^{T} \left(\boldsymbol{\psi}_{it}^{I} - \boldsymbol{\psi}_{it}^{J}\right)\right] \\ &=^{p} \sum_{i=1}^{N}\sum_{t=1}^{T} \left(\boldsymbol{\psi}_{it}^{I} - \boldsymbol{\psi}_{it}^{J}\right)\left(\boldsymbol{\psi}_{it}^{I} - \boldsymbol{\psi}_{it}^{J}\right)'. \end{aligned}$$

This form of the H statistic is obviously always positive.

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Table 1: Number of participations in the SSBS.

# waves present	# firms	%	cum. %
1	772	30.6	30.6
2	482	19.1	49.8
3	255	10.1	59.9
4	210	8.3	68.2
5	133	5.3	73.5
6	107	4.3	77.7
7	94	3.7	81.5
8	74	2.9	84.4
9	45	1.8	86.2
10	43	1.7	87.9
11	22	0.9	88.8
12	26	1.0	89.8
13	39	1.6	91.4
14	33	1.3	92.7
15	33	1.3	94.0
16	37	1.5	95.4
17	31	1.2	96.7
18	31	1.2	97.9
19	33	1.3	99.2
20	20	0.8	100.0
Total	2520	100	

Table 2: Definition of firm age variables for each sector.

variable	OLD	MIDDLE	YOUNG
ACCOUN	before 1975	1975-1990	after 1990
ADVERT	1978	1978-1990	1990
ARCHIT	1983	1983-1991	1991
CAR	1978	1979-1990	1990
CONSUL	1979	1979-1991	1991
MACHIN	1978	1978-1990	1990
PLANNI	1987	1987-1991	1991
SOFTWA	1985	1985-1991	1991
TRANSP	1981	1981-1991	1991
WASTE	1988	1988-1991	1991

Table 3: Distribution of observations by transition type and by variable.

variable	n(11)	n(12)	n(13)	n(21)	n(22)	n(23)	n(31)	n(32)	n(33)	Total
YOUNG	378	168	106	180	337	67	106	54	188	1584
MIDDLE	1077	303	357	411	802	164	310	154	507	4085
OLD	245	112	87	135	318	56	76	58	103	1190
EAST=1	716	197	283	276	437	122	239	125	366	2761
EAST=0	984	386	267	450	1020	165	253	141	432	4098
BANK=1	806	278	264	350	664	115	235	104	362	3178
BANK=0	894	305	286	376	793	172	257	162	436	3681
DIVERS=1	588	220	227	268	580	124	182	104	308	2601
DIVERS=0	1112	363	323	458	877	163	310	162	490	4258
SINGPART	561	180	185	243	517	102	161	84	279	2312
LIMSTOCK	1139	403	365	438	940	185	331	182	519	4547
ACCOUN	203	54	36	87	135	23	34	21	36	629
ADVERT	86	33	34	51	109	20	22	27	39	421
ARCHIT	176	44	62	54	66	29	66	16	134	647
CAR	56	32	27	44	74	16	24	17	42	332
CONSUL	158	66	36	66	237	32	35	24	53	707
MACHIN	94	32	44	36	123	20	36	24	71	480
PLANNI	397	112	120	128	176	44	103	46	183	1291
SOFTWA	165	79	51	85	243	36	44	29	59	791
TRANSP	132	56	44	71	120	26	39	25	50	563
WASTE	51	75	96	104	174	41	89	37	131	998
Y94	99	56	19	67	148	15	32	26	33	495
Y95	312	116	82	158	295	46	69	40	99	1217
Y96	375	112	131	145	224	73	119	71	180	1430
Y97	365	127	137	126	297	56	116	49	217	1490
Y98	449	148	122	164	405	61	129	73	209	1760
Y99	100	24	59	66	88	36	27	7	60	467
Q1	414	127	206	209	342	157	101	42	215	1813
Q2	347	119	85	115	266	27	136	100	188	1383
Q3	472	156	138	219	425	63	124	48	220	1865
Q4	467	181	121	183	424	40	131	76	175	1798

Note: The total number of observations is 6859. For the transition indicators n(jj'), the first digit, j, corresponds to the departure state, the second, j', to the arrival state: 'unchanged':1, 'up':2, 'down':3.

Table 4a: Estimation results for the linear index model without unobservable heterogeneity: arrival state 2 ('up').

	Starting state					
	1		2		3	
variable	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.
LSIZE	.047	1.2	**.183**	4.9	.075	1.1
OLD	**.314**	2.4	**-.348**	-2.7	-.133	-0.5
YOUNG	**.505**	3.7	.196	1.5	**.479**	2.3
EAST	**-.283**	-2.4	**-.321**	-2.8	-.034	-0.2
BANK	.063	0.6	-.101	-1.0	**-.390**	-2.3
DIVERS	.067	0.6	.029	0.3	-.015	-0.1
SINGPART	.613	1.3	.007	0.0	-.080	-0.1
ACCOUN	-.155	-0.8	.080	0.4	.597	1.7
ADVERT	.181	0.8	.347	1.6	**1.101**	3.1
ARCHIT	-.223	-1.1	-.099	-0.4	-.478	-1.4
CAR	**.579**	2.2	.163	0.6	.575	1.5
CONSUL	.268	1.5	**.847**	4.4	.579	1.7
MACHIN	.037	0.2	**.891**	3.9	.542	1.6
SOFTWA	**.440**	2.5	**.707**	4.1	.532	1.7
TRANSP	.341	1.7	.199	1.0	.475	1.5
WASTE	-.086	-0.5	.102	0.6	.001	0.0
1994	.357	1.7	.180	1.0	.489	1.4
1996	-.283	-1.8	-.238	-1.6	.073	0.3
1997	-.137	-0.9	.132	0.9	-.352	-1.3
1998	-.834	-1.7	.130	0.3	.016	0.0
1999	**-1.206**	-2.2	-.395	-1.0	-.523	-0.6
Q2	.043	0.3	.240	1.5	.485	1.9
Q3	-.078	-0.5	.058	0.4	-.263	-0.9
Q4	.061	0.4	.246	1.7	.713	0.7
intercept	**-1.310**	-5.1	-.254	-1.0	**-1.136**	-2.5

Note: significative estimates at the 5% level in bold.

Table 4b: Estimation results for the linear index model without unobservable heterogeneity: arrival state 3 ('down') and summary statistics.

	Starting state					
	1		2		3	
variable	coef.	t-stat.	coef.	t-stat	coef.	t-stat.
LSIZE	**-.114**	-2.5	.094	1.6	**-.116**	-2.2
OLD	.143	1.0	.005	0.0	.132	0.8
YOUNG	-.001	-0.0	.101	0.5	-.229	-1.3
EAST	**.478**	3.9	.263	1.5	-.034	-0.2
BANK	.016	0.2	**-.318**	-2.2	.119	1.0
DIVERS	**.265**	2.5	.249	1.7	.123	1.0
SINGPART	-.103	-0.2	.282	0.5	.416	0.8
ACCOUN	**-.510**	-2.4	-.068	-0.2	**-.632**	-2.3
ADVERT	.311	1.3	.221	0.7	-.106	0.3
ARCHIT	.106	0.6	**.686**	2.3	.076	0.4
CAR	.390	1.5	.155	0.4	-.202	-0.7
CONSUL	-.261	-1.2	.487	1.6	-.204	-0.8
MACHIN	**.470**	2.1	.581	1.7	.028	0.1
SOFTWA	-.102	-0.5	.171	0.6	-.342	-1.4
TRANSP	-.026	-0.1	.106	0.4	-.326	-1.3
WASTE	.154	0.9	.233	0.9	-.238	-1.3
1994	-.166	-0.6	.159	0.5	-.359	-1.2
1996	.317	1.9	**.548**	2.4	.050	0.3
1997	**.395**	2.4	**.578**	2.4	.287	1.4
1998	.177	0.3	.013	0.0	-.286	-0.5
1999	.567	0.9	-.304	-0.5	-.242	-0.4
Q2	**-.601**	-3.8	**-1.294**	-5.2	**-.409**	-2.2
Q3	**-.427**	-3.0	**-1.028**	-5.2	-.096	-0.5
Q4	**-.553**	-3.8	**-1.314**	-6.0	**-.410**	-2.2
intercept	**-.976**	-3.7	**-1.199**	-3.3	**1.161**	3.5
Log-likelihood	-2590.71		-2138.33		-1494.85	
N	2833		2470		1556	
χ^2 (d.o.f.=48)	187.97		248.03		125.20	

Note: significative estimates at the 5% level in bold.

Table 5: Actual and predicted outcomes (parametric model).

				Start					
	Actual	1		2		3		Total	
	Predicted								
	1	1700		726		492		2918	
			2799		183		111		3078
Arrival	2	583		1457		266		2306	
			14		2247		97		2331
	3	550		287		798		1635	
			20		40		1348		1450
	Total	2833		2470		1556		6859	
			2833		2470		1556		6859

Note: i predicted to make the transition from j to j' if $P_{ijj'}(t)$ is max of $P_{ijl}(t)$, l=1,2,3.

Table 6a: Estimation results for the semiparametric model: arrival state 2 ('up').

	Starting state					
	1		2		3	
variable	coef.	t-stat.	coef.	t-stat.	coef.	t-stat.
OLD	**.316**	2.4	**-.328**	-2.6	-.123	-0.5
YOUNG	**.498**	3.7	.179	1.4	**.470**	2.2
EAST	**-.284**	-2.4	**-.327**	-2.8	-.023	-0.1
BANK	.073	0.7	-.124	-1.3	**-.407**	-2.4
DIVERS	.072	0.7	.034	0.4	-.014	-0.1
SINGPART	.626	1.3	.012	0.0	-.067	-0.1
ACCOUN	-.143	-0.7	.054	0.3	.572	1.6
ADVERT	.174	0.7	.350	1.6	**1.098**	3.1
ARCHIT	-.226	-1.1	-.127	-0.6	-.485	-1.4
CAR	**.593**	2.3	.125	0.5	.550	1.4
CONSUL	.273	1.5	**.844**	4.4	.581	1.8
MACHIN	.042	0.2	**.880**	3.9	.533	1.6
SOFTWA	**.441**	2.5	**.712**	4.1	.521	1.7
TRANSP	.344	1.7	.206	1.1	.465	1.4
WASTE	-.078	-0.4	.125	0.7	.004	0.0
1994	.357	1.7	.190	1.0	.496	1.4
1996	-.284	-1.8	-.238	-1.6	.070	0.3
1997	-.136	-0.9	.119	0.8	-.357	-1.3
1998	-.844	-1.7	.115	0.3	.003	0.0
1999	**-1.210**	-2.2	-.415	-1.0	-.539	-0.6
Q2	.047	0.3	.241	1.5	.482	1.9
Q3	-.078	-0.5	.056	0.4	-.264	-0.9
Q4	.062	0.4	.240	1.7	.171	0.7
intercept	**-1.166**	-5.4	**.455**	-2.3	**-.842**	-2.2

Note: significative estimates at the 5% level in bold.

Table 6b: Estimation result of the semiparametric model: arrival state 3 (down) and summary statistics.

	Starting state					
	1		2		3	
variable	coef.	t-stat.	coef.	t-stat	coef.	t-stat.
OLD	.124	0.8	.035	0.2	.126	0.7
YOUNG	-.013	-0.1	.092	0.5	-.232	-1.4
EAST	**.476**	3.9	.262	1.5	-.036	-0.3
BANK	.043	0.4	**-.351**	-2.4	-.115	-0.9
DIVERS	**.258**	2.4	.249	1.7	.112	0.9
SINGPART	-.042	-0.1	.331	0.6	.426	0.8
ACCOUN	**-.501**	-2.4	-.111	-0.4	**-.621**	-2.2
ADVERT	.325	1.4	.233	0.7	-.106	-0.3
ARCHIT	.127	0.7	**.653**	2.2	.075	0.4
CAR	.422	1.6	.101	0.3	-.189	-0.6
CONSUL	-.237	-1.1	.484	1.6	-.204	-0.8
MACHIN	**.499**	2.3	.573	1.7	.026	0.1
SOFTWA	-.080	-0.4	.182	0.7	-.341	-1.4
TRANSP	-.039	-0.2	.116	0.4	-.343	-1.3
WASTE	.159	1.0	.276	1.1	-.241	-1.3
1994	-.182	-0.6	.179	0.5	-.354	-1.2
1996	**.313**	1.9	**.544**	2.4	.055	0.3
1997	**.395**	2.4	**.554**	2.3	.289	1.5
1998	.117	0.2	-.052	-0.1	-.296	-0.5
1999	.515	0.8	-.377	-0.6	-.244	-0.4
Q2	**-.600**	-3.8	**-1.283**	-5.1	**-.406**	-2.2
Q3	**-.426**	-3.0	**-1.031**	-5.2	-.094	-0.5
Q4	**-.551**	-3.8	**-1.322**	-6.1	**-.410**	-2.2
intercept	**-1.381**	-6.5	**-0.817**	-2.8	**-761**	2.8
Log-likelihood	-2587.77		-2130.69		-1493.39	
N	2833		2470		1556	
# equiv. param.	9.2		12.4		8.4	

Note: significative estimates at the 5% level in bold.

Table 7: Actual and predicted outcomes (semiparametric model).

					Start					
	Actual		1		2		3		Total	
		Predicted								
	1		1700		726		492		2918	
				2808		154		106		3068
Arrival	2		583		1457		266		2306	
				14		2272		92		2376
	3		550		287		798		1635	
				11		44		1358		1413
	Total		2833		2470		1556		6859	
				2833		2470		1556		6859

Note: see table 5.

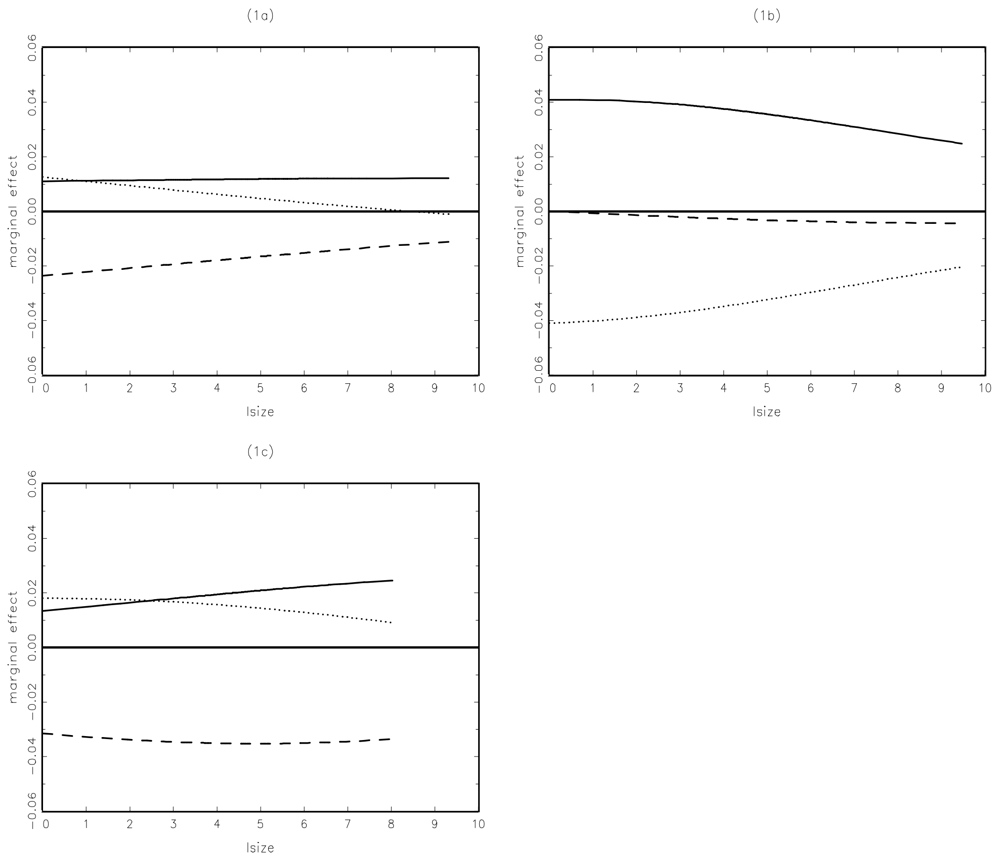

Figure 1: Marginal effect of LSIZE. Fig 1a, 1b, and 1c correspond to the departure state $j = 1, 2, 3$, respectively. The dotted, solid, and dashed curves represent $\hat{\delta}_{j1}, \hat{\delta}_{j2}$, and $\hat{\delta}_{j3}$, respectively (see equation (5)).

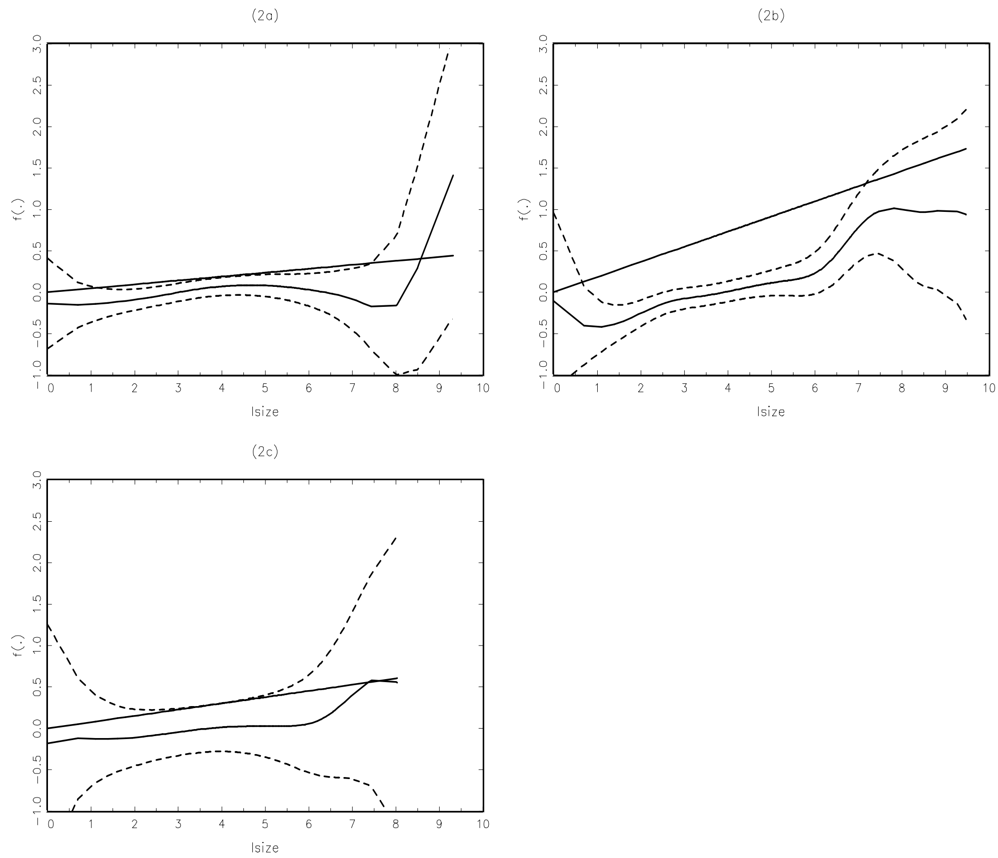

Figure 2: Nonparametric estimation for $f\,(.)$, arrival state 2 (up). Fig 2a, 2b, and 2c correspond to the departure state $j\ =\ 1, 2, 3,$ respectively. The solid curves are the nonparametric fits $\hat{f}\,(.)$. The dashed curves are the 95% pointwise confidence intervals. The straight solid lines represent the slope for LSIZE in the parametric model.

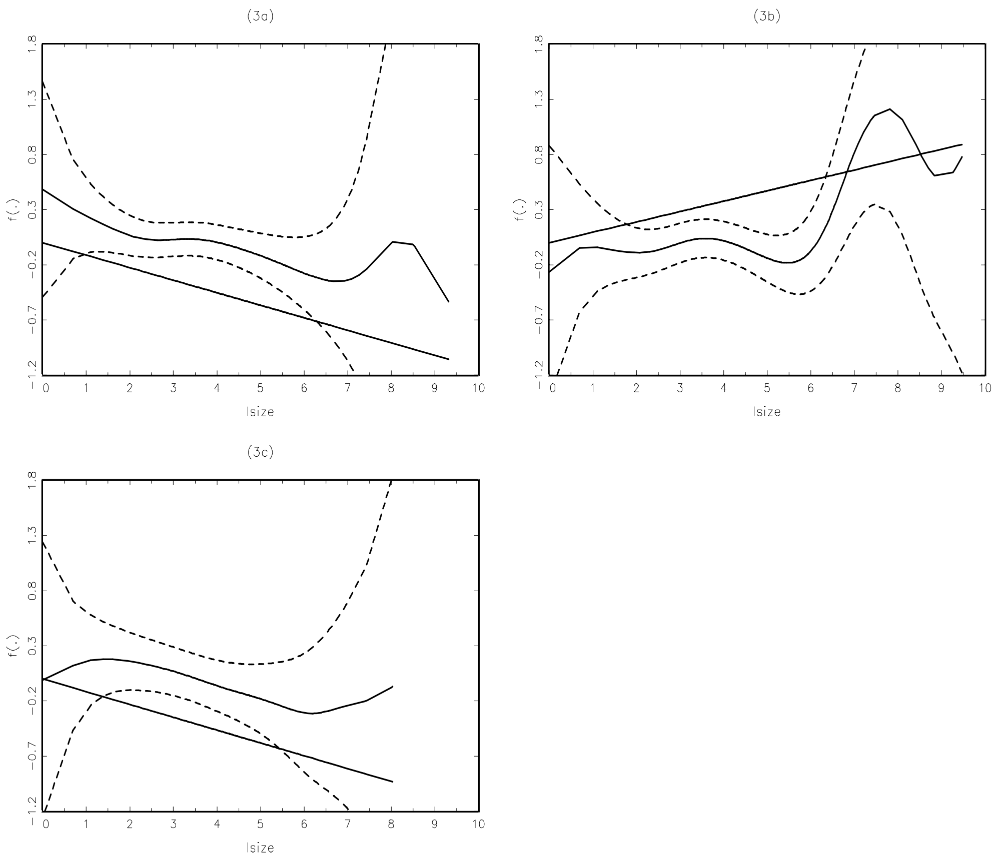

Figure 3: Nonparametric estimation for $f\,(.)$, arrival state 3 (down). Fig 3a, 3b, and 3c correspond to the departure state $j = 1, 2, 3$, respectively. The solid curves are the nonparametric fits $\hat{f}\,(.)$. The dashed curves are the 95% pointwise confidence intervals. The straight solid lines represent the slope for LSIZE in the parametric model.