DISCUSSION PAPER SERIES

IZA DP No. 307

Downsizing

Gerard A. Pfann

June 2001

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

Downsizing

Gerard A. Pfann
Business Investment Research Center, Maastricht University, University of Chicago, C.E.P.R. and IZA, Bonn

Discussion Paper No. 307
June 2001

IZA

P.O. Box 7240
D-53072 Bonn
Germany

Tel.: +49-228-3894-0
Fax: +49-228-3894-210
Email: iza@iza.org

IZA Discussion Paper No. 307
June 2001

ABSTRACT

Downsizing[*]

Optimal layoff rules in closed form are derived for all workers in a firm that downsizes under uncertainty and faces heterogeneous firing costs. The theoretical model predicts that the firm displaces workers with low firing costs, low expected future productivity growth, and low layoff option values. The empirical analysis based on personnel records from a Dutch aircraft building company that went bankrupt in 1996 shows that workers with high uncertainty associated with higher than average expected productivity growth are most likely to be retained.

JEL Classification: J33, J63

Keywords: Layoff rules, firing costs, uncertainty, heterogeneity

Gerard A. Pfann
Business Investment Research Center
University of Maastricht
P.O. Box 616
6200 MD MAASTRICHT
The Netherlands
Tel.: +31-43-388 3832
Fax: +31-43-388 4856
Email: G.Pfann@KE.UniMaas.NL
gpfann@uchicago.edu

[*] I gratefully acknowledge Fokker's bankruptcy trustees, especially Ben Knüppe, for making the personnel data available to me. I thank the N.W.O. PIONIER program for financial support. Fruitful discussions with Joe Altonji, Jan Eberly, Mike Gibbs, Dan Hamermesh, Boyan Jovanovic, Bob LaLonde, and Dale Mortensen helped me shape this paper. I also thank seminar participants at Northwestern University and the University of Chicago Graduate Schools of Business and Public Policy for helpful comments.

I. Introduction

One of the most disputed focal points of European employment policies is the protection of jobs through layoff deterrence legislation that intends to raise firing costs and forestall layoffs (Nickell, 1978). Macroeconomic studies find modest evidence of firing costs upholding the equilibrium level of aggregate employment (Bentolila and Bertola, 1990). At the industry level firing costs are found to lengthen the equilibrium adjustment process of labor demand (Pfann and Palm, 1993). Direct measurements of adjustment costs at the establishment level have shown that firing costs differ among types of workers as well as among production technologies (Pfann and Verspagen, 1989).

Firing costs are not exclusive to European labor markets. Microeconomic labor demand studies in the US find that adjustment costs are fixed at the firm level, rendering a firm's optimal upward and downward adjustment processes lumpy (Hamermesh, 1989). A firm that is engaged in optimally designing displacement policies during bad times, and accounts for differences in firing costs between workers performs better in the future and lives longer (McLaughlin, 1991). There is also evidence showing that rising firing costs in the US related to litigation instigate a process of substitution of individual firings by mass layoffs (Oyer and Schaefer, 2000).

But what is not known -- and what is crucial to understand the influences of employment protection policies on the value of the firm -- is how variations in firing costs among workers translate into differences in personnel policy rules. Heterogeneous differences in adjustment costs not only affect the wage distribution inside a firm, they lead to differences in recruitment and layoff probabilities as well. In this paper I take a microscopic look at the layoff policy of a firm in demise, and study the actual displacements to learn more about the effects variations in firing costs have on the firm’s value, and how these differences are reflected in decisions about which workers will be displaced or retained.

Although the most sizable labor force reductions occur during recessions, cutbacks in establishments happen frequently in emerging industries as well (Jovanovic, 1982). The increases in business failures and mass layoffs that characterize the booming economies of the late 1990's are a good illustration thereof. The explicit formulation of optimal downsizing rules for heterogeneous workers thus speaks to all firms facing imperative workforce reorganizations. Thinking about heterogeneity in firing costs also vouches workers' continuing but unequal risks of getting fired for reasons of economic redundancy. In fact, over the period 1981-1995 a steady annual 1.25 percent of job loss is caused by plant closing (Farber, 1997). In 1999, the US manufacturing employed 18.4 million workers. This implies that 230.4 thousand workers were facing job losses due to plant closing that year[1]. The losses foreseen by displaced workers are considerable (Hamermesh, 1987), and most enduring (Jacobson, *et al.* 1993). When better layoff policies can be designed, firms may survive longer and more jobs can be saved, while less firm-specific human capital is wasted. In this paper I study how a firm in demise formulates its employment policy while maximizing under uncertainty the present value of the expected future stream of profits from each retained worker individually.

In a recent survey of the literature, Hamermesh and Pfann (1996) showed that fixed costs regimes at the firm level have only been analyzed empirically under the assumption of myopic foresight. A novelty put forward in this paper is the derivation of idiosyncratic optimal displacement rules in closed form for a firm that reduces its workforce under uncertainty and faces heterogeneous firing costs. Due to the fixed nature of firing costs through time, a downsizing firm is most likely to adjusts its workforce in a lumpy fashion. Two-sided employer-employee learning makes it worthwhile though to outspread a sizable workforce reduction over a sequence of lumps rather than

[1] This number comprises only a part of all layoffs. Farber includes only workers with at least three years of tenure with the shutdown firm. So this number is a lower bound.

carry out one big mass displacement at once (Pfann and Hamermesh, 2001). As soon as a firm has reached a state of insolvency, however, the option to choose the optimal size and time to downsize has expired. This is the situation analyzed in this paper. I find that once workforce reduction is immediate, three individual worker characteristics are crucial for the firm's choice to decide which workers to retain or to layoff. These are a worker's firing costs, the idiosyncratic expected productivity growth, and the idiosyncratic uncertainty of the expected growth in productivity. The theory presented in this paper predicts that a downsizing firm displaces workers with low firing costs, low productivity growth, and low uncertainty about future productivity growth.

Testing these predictions is based on a case of bankruptcy in the European aircraft industry. The Dutch aircraft manufacturer Fokker, with headquarters based in Amsterdam, went bankrupt on March 15th, 1996. Directly after the bankruptcy, the trustees restructured Fokker before selling the company's parts that were still considered viable. The bankruptcy trustees increased the efficiency of the production process and closed down the divisions responsible for the design, development, and production of new aeroplanes. At the time of the bankruptcy the company employed 6,970 workers, divided over six geographically dispersed divisions.

A new company, created right after the bankruptcy, employed only 2,420 workers, while 900 others remained working for the trustees to finish off products already ordered. A total of 3,650 workers were permanently discharged. On July 17th, 1996 the trustees sold the firm they created for 300 million guilders to Stork, another Dutch manufacturer (Deterink *et al.* 1997). I estimated the value gained from accounting for worker specific firing costs, idiosyncratic future productivity growth, and individual firing option values to yield 4.5 percent of every retained worker's annual earnings.

The paper is organized as follows. Section 2 presents the theoretical model of downsizing a workforce under uncertainty. Theoretical predictions are derived about worker characteristics that affect the firm's propensity to fire. Section 3 portrays the data used for the empirical analysis. In section 4, the structural econometric model is derived from the theory and is estimated using the Fokker personnel data set. Section 5 sets out in detail the procedure of how to calculate the value added to a firm, when in the process of downsizing worker variety in firing costs as well as expected heterogeneous future productivity growth and idiosyncratic uncertainty are integrated into the firm's layoff contingency plans. Section 6 discusses possible generalizations of the analysis and policy implications. Section 7 concludes.

II. A Theoretical Model of Downsizing the Workforce of a Firm under Uncertainty

Consider a risk-neutral firm that maximizes its expected net present value of profits. The firm can hire a worker with a bundle of characteristics X and general productivity $Y_G(X)$. If the labor market is perfectly competitive and transparent with respect to X and $Y_G(X)$, then in the absence of hiring and firing costs the general productivity of each worker with characteristics X is equal to the wage $W_G(X)$ offered in the labor market, or $Y_G(X)= W_G(X)$.

A declining firm faces firing costs when reducing the size of its workforce, then for every worker in equilibrium it holds that $Y_G(X)=W_G(X)+F$, where F are firing costs. Firing costs are irreversible, meaning that rehiring is equivalent to new hiring. Firing costs differ among workers. The assumption of heterogeneous firing costs is a novelty in models of workforce adjustment that makes it possible to investigate the selection process of a firm when making choices about which workers to fire. In addition to worker-specific firing costs, idiosyncratic productivity growth and the accompanying uncertainty determine the firm's optimal layoff decisions under uncertainty.

An expanding firm can invest Q to bud a new worker's talents to produce a firm-specific $Y_S(X,Q)$ in addition to $Y_G(X)$, for which the firm pays an additional $W_S(X,Q)$ in return (Oi, 1962). I assume asymmetric adjustment, so that $Q>F$ (Pfann and Verspagen, 1989). If the firm has monopolistic power with respect to its own firm-specific technology Y_S, then at the onset of the worker-firm's relationship it holds that $Y_S(X,Q)> W_S(X,Q)>0$ for all X and $Q>0$. The possibility for a worker to receive stocks and bonds as part of the employment contract is not considered in this model. The firm's share of returns from firm specific human capital is $S(X,Q) = (Y_S(X,Q) - W_S(X,Q))/Y_S(X,Q)$, and $0 < S(X,Q) < 1$ for this worker. The instant return a firm can obtain from investing Q is defined as

(2.1) $\Pi^*(X,Q) = Y_G(X) - W_G(X) + Y_S(X,Q) - W_S(X,Q)$,

with $\Pi^*(X,Q) \geq 0$ for all X iff $Q>0$. The return is concave in the number of workers hired, which is the standard assumption in dynamic labor demand models (see Nickell, 1986). Moreover, the specific profit structure is such that the returns per worker are maximized at some optimal investment level $Q^* < \propto$, so that $\partial\Pi^*(X,Q)/\partial Q \geq 0$ and $\partial^2\Pi^*(X,Q)/\partial Q^2 < 0$.

Once the firm has invested Q, the current profit stream of the marginal worker is known with certainty. Since $W_S(X) > 0$, the worker faces quitting costs, which I assume are constant. Consequently, the firm has obtained wage bargaining power, so that $Y_G(X) - W_G(X) - F > 0$ in the future, if $Y_G(X)$ grows through time. The stochastic part of the worker's future returns for the firm is defined as

(2.2) $\Pi(X,Q) = Y_G(X) - W_G(X,Q) + Y_S(X,Q)$,

which becomes more uncertain the farther in time lies the horizon over which the returns of the investment will be discounted. This uncertainty emanates from the possibility of exogenous shocks in the demand for the firm's product or unforeseen idiosyncratic or economy wide technology shocks.

The stochastic part of the worker-specific profit, Π (omitting the *addenda* X and Q for notational convenience), is assumed to evolve randomly but exogenously over time as a geometric Brownian motion with the following continuous time representation

(2.3) $\mathbf{d}\Pi / \Pi = m\mathbf{d}t + \sqrt{s^{m}}\,\mathbf{d}z$, $\qquad s^{m} > 0$,

where $\mathbf{d}z$ is the increment to a standard Wiener process, with

(2.4) $E[\mathbf{d}z] = 0$, $E[\mathbf{d}z^2] = \mathbf{d}t$.

At $t=0$, $\Pi_0 > 0$ and known with certainty. The random profit Π_t at time $t>0$ is log-normally distributed with mean $\ln(\Pi_0) + (m - \frac{1}{2}s^{m})t$, variance $s^{m}t$, and $E[\Pi_t \mid \Pi_0] = \exp(mt)$, so that m is the trend growth of the profit stream the firm expects in return of having invested Q in the worker's firm-specific human capital. And if W_G is sticky or not downward adjustable, then all the growth in profits comes from the worker's general or specific productivity growth.

I assume the size of the downward adjustment to be predetermined[2]. The downsizing firm's firing decisions are all solutions of stochastic dynamic programming problems. There is only one discount rate $r > 0$[3]. Each worker's value $V(\Pi)$ changes with Π and the expected future returns $E[\mathbf{d}V(\Pi)/\mathbf{d}t]$ are equal to the normal returns $rV(\Pi)$. The flow of profits when retaining the worker yields Π, so that $V(\Pi)$ must satisfy

(2.5) $\frac{1}{2}s^{m}\Pi^2(\mathbf{d}^2V(\Pi)/\mathbf{d}\Pi^2) + m\,\Pi(\mathbf{d}V(\Pi)/\mathbf{d}\Pi) - rV(\Pi) = W_S - \Pi$.

The general solution to the homogeneous part of this second order differential equation can be found by substitution of a general solution in the form

(2.6) $V(\Pi) = \Pi^{l}$; $\mathbf{d}V(\Pi)/\mathbf{d}\Pi = l\Pi^{l-1}$; $\mathbf{d}^2V(\Pi)/\mathbf{d}\Pi^2 = l^2\Pi^{l-2}$.

into (2.5). This yields

(2.7) $\frac{1}{2}s^{m}l(l-1) + ml - r = 0$,

that has two solutions, one being negative and one positive and outside the unit circle. More explicitly,

[2] In the case of a through-start after a bankruptcy the new firm's size is most likely to be determined by the constraints imposed upon by the financial institutions financing it.

[3] I assume that the financial market trades only one product for which the firm can receive a constant and certain return $r > m$ each period of time.

(2.8a) $l_0 = -\left(\frac{m}{s^m} - \frac{1}{2}\right) - \sqrt{\left(\frac{m}{s^m} - \frac{1}{2}\right)^2 + \frac{2r}{s^m}}$, with $l_0 < 0$

and

(2.8b) $l_1 = -\left(\frac{m}{s^m} - \frac{1}{2}\right) + \sqrt{\left(\frac{m}{s^m} - \frac{1}{2}\right)^2 + \frac{2r}{s^m}}$, with $l_1 > 0$.

A particular solution of the inhomogeneous part of the differential equation (2.5) is found in linear form as

(2.9) $V(\Pi) = \Pi/(r - m) - W_S / r$.

This can be interpreted as the firm's net present value of expected profits from the ongoing production of the worker under consideration to be perpetually retained. The general solution of the inhomogeneous differential equation (2.5) yields

(2.10) $V(\Pi) = \Lambda_0 \Pi^{l_0} + \Lambda_1 \Pi^{l_1} + \Pi/(r - m) - W_S / r$,

where Λ_0 and Λ_1 are constants.

The downsizing firm can fire or retain the worker. When firing a worker, it can rehire a similar worker at the costs of Q to bud firm-specific talents in case that the expected returns rise above some point Π_H . The option value of this decision yie lds $\Lambda_1 \Pi^{l_1}$. Alternatively, the firm can retain the worker, keeping the layoff option open that is worth $\Lambda_0 \Pi^{l_0}$, but discharge the worker once Π falls below some point Π_L . In many other investment decisions this aspect is found to be quantitatively important (Dixit and Pindyck, 1994). The firm's tardiness (hysteresis) in changing the size of the workforce depends on the distance $\|\Pi_H - \Pi_L\|$ that arises from Q and F, the option values associated with these adjustment costs, and the growing uncertainty surrounding Π . The value of accounting for this uncertainty in future productivity growth of each incumbent worker can be derived in the closed form solution as follows.

Opposite to a growing firm, the firm in demise faces rather small $\Pi's$ for most of its incumbent workers. Given this, the firm's option value of workforce expansion is negligible, or $\Lambda_1 = 0$. Meanwhile the option values of workforce reduction can become quite large, or $\Lambda_0 > 0$. Then the value of the troubled firm's marginal worker yields[4]

(2.11) $V(\Pi_L) = \Lambda_0 \Pi_L{}^{l_0} + \Pi_L / (r - m) - W_S / r$.

If the firm fires this worker, when $V(\Pi_L) + F < 0$, it is giving up the discounted value of perpetual returns from the worker's firm-specific capital plus the option value to fire later. An optimal layoff policy complies with the two boundary conditions for Π_L (Bentolila and Bertola, 1990):

(2.12) $\Lambda_0 \Pi_L{}^{l_0} + \Pi_L / (r - m) - W_S / r = -F$, -- a worker's value matching condition --

and

(2.13) $l_0 \Lambda_0 \Pi_L{}^{l_0 - 1} + 1/(r - m) = 0$. -- a worker's smooth pasting condition --

The expression for Π_L in closed form then becomes (*cf*. Dixit, 1989)

(2.15) $\Pi_L = \left(\frac{r - m}{r} \right) \left(\frac{l_0}{l_0 - 1} \right) (W_S - rF)$.

Equation (12) is a useful expression to predict when a firm downsizes, and if so, which type of workers it is most likely to retain. Since $r > m$ and $l_0 < 0$, the first two terms on the right hand side are positive. The last term must be positive for all incumbent workers as well, since $Q > F$, and the worker would otherwise not have been hired. Thus the boundary value Π_L is always positive and can be interpreted as the firm's inclination to retain a worker: the lower Π_L, the more reluctant the firm is to fire this worker, and *vice versa*. It is now possible to predict how changes in r , m , s^m , W_S, and F separately would alter Π_L . The predictions are:

[4] Similarly, the value of an expanding firm's marginal worker yields $V_H(\Pi) = \Lambda_1 \Pi^{l_1}$.

Prediction 1: $\partial\Pi_L / \partial r > 0$

When the real interest rate is higher a firm downsizes faster. This result corresponds with the general finding from the investment literature that overall investment decreases if the interest rate rises. It also points at a microeconomic rationalization of the macroeconomic relationship between the real rate of interest and the natural rate of unemployment (Sargent, 1973).

Prediction 1 emphasizes the importance of risk-adjusted discounting when insolvency risk jeopardizes the future of the firm: a larger part of the workforce is discharged when the chance of bankruptcy is larger. This result draws on the contribution by Merton (1979) on the possibility of a 'complete ruin'. The process for $\mathbf{d}\Pi / \Pi$ could be extended with an exponentially distributed Poisson process $\mathbf{d}n$ with mean $1/_t$. The probability of a 'complete ruin' -- $\mathbf{d}n = -1$ -- is equal to $t\ \mathbf{d}t$. Equation (2.3) then becomes

$$\text{(2.3')}\quad \mathbf{d}\Pi / \Pi = m\mathbf{d}t + \sqrt{s^{m}}\,\mathbf{d}z + \mathbf{d}n\,.$$

An increase in the jump probability t is coherent with an increase in the discount rate. All of the above results remain unaltered except that the interest rate r is replaced by $(r + t)$ with $t > 0$.

<u>*Prediction 2:*</u> $\partial\Pi_L / \partial m < 0$ (Figure 1, Graph A)

The downsizing firm is more likely to retain workers with higher expected within-firm productivity growth. This is an appreciated result in the literature of worker turnover that is related to the fact that higher valued worker-employer matches are more likely to survive (Topel and Ward, 1992).

Prediction 3: $\partial \Pi_L / \partial s^m < 0$ (Figure 1, Graph B)

The downsizing firm prefers workers with more uncertain future productivity growth for the same reason why growing firms like these workers: the chance of higher productivity also increases the firm's share in this worker's expected future returns and is therefore more likely to be retained. This is a new result that refutes the proposition put forward by Lazear (1995) that a declining firm prefers risk-free workers to 'risky' workers. Even a firm in demise can benefit from the uncertainty of a worker's future productivity growth.

Prediction 4: $\partial \Pi_L / \partial W_S > 0$

Holding constant the firm's share, S, of returns on investing Q in a worker's firm-specific human capital, a worker with higher Q has a higher productivity while earning the same W_S, and thus has a higher likelihood of being retained upon a reorganization (Jovanovic (1979)). Since W_S is an equilibrium outcome, the firm may pay more to one worker with the same amount of Q than to another. This means that S is lower for this worker and so is this worker's value to the firm. Thus, holding Q constant, the firm is inclined to layoff workers with a high W_S (Mortensen and Pissarides, 1994).

Prediction 5: $\partial \Pi_L / \partial F < 0$ (Figure 1, Graph C)

A worker with high firing costs is less likely to get displaced by the firm. This result compares to that of Bentolila and Bertola (1990) for aggregate employment. Examples are unionized or insider workers are being fired later than outsider workers. At the individual worker level, statutory replacement costs born by the firm are often determined as a function of a worker's last earnings. This points at a negative relationship between a worker's earnings and the risk of layoff.

Summarizing all of the above results, the theory of downsizing with heterogeneous firing costs and uncertainty encompasses the earlier structural models of worker turnover under rational expectations. A new result is that the higher-variance productivity growth people are the ones who are less likely to be fired (more likely to be retained) when the reorganization is imminent. Hence, a downsizing firm can be defined as a firm that has access to a specific production technology and displaces workers with the least firing costs, the lowest productivity growth, and the smallest layoff option value. The layoff option value results from the idiosyncratic uncertainty about the future development of a worker's productivity growth. The importance of this value for a downsizing firm that maximizes the expected future returns under uncertainty from investments in firm-specific productive capacity of its retained workers will be investigated in the sequel of this paper.

III. Fokker Aircraft (old) and Fokker Aviation (new)

To test the theoretical predictions of the downsizing model data will be used from personnel records of a Dutch aircraft manufacturer, Fokker. The company was founded in 1919 and went bankrupt in 1996. Before the bankruptcy the firm went through a series of mass lay-offs that started in 1991 with the installation of a new early retirement plan for 55 years and older workers and ended with the firm's bankruptcy on Friday, March 15th, 1996. The data used in this paper consist of all tenured workers' personnel records at the time of the bankruptcy, excluding those working at the Fokker Aircraft headquarters (780 employees) in Amsterdam and of the management team (5 employees).

3.1 How Wages Are Set in the Firm

For each employee the data record any wage change and the date of the wage change. In general, most of the observed changes in wages of workers are mass mutations that result from contractual periodical -- mostly annual -- increases or collectively negotiated wage increases including price compensation. Idiosyncratic wage changes can result from promotions or extra periodical increases.

Table 1A shows how the average hourly wage inside the firm changes during the last half decade of the firm for workers that are retained or displaced after the 1996 bankruptcy. Reported are average hourly wages (in 1995 Dutch Guilders), and the percentages of wage growth during three different spells: 1991-1996, the complete spell of firm demise that includes the first years of the new early retirement scheme and end at the day of the bankruptcy; 1993-1996, the spell of structural reorganization, when not only elderly workers and production workers were laid off, but when managers were fired as well; and 1995-1996 the last ten months of the firm's existence. On average real wages were growing with 2 percent points per year and this rate of growth was slightly larger for those workers that were eventually retained. During the final year there is hardly any noticeable change in the firm's wage distributions.

Table 1B zooms in on the compositional change of the wage distribution among incumbent workers during the company's last year. It shows that especially at the distribution's extremes changes occur for a limited number of people. These changes give rise to an increased variance and positive skewness, suggesting most changes occurred at the upper tail of the wage distribution.

3.2 Six Plants

Before the bankruptcy the firm existed of six geographically dispersed divisions or 'plants' that were all part of the reorganization by the bankruptcy trustees. After the bankruptcy, the trustees created a new company, Fokker Aviation, that contained all the viable parts of the bankrupt Fokker Aircraft. Three divisions that existed before the bankruptcy carried on practically unaltered. They were Fokker Special Products B.V. in Hoogeveen (*plant 1*), Fokker ELMO B.V. in Woensdrecht (*plant 2*), that specialized in the design and production of electronic systems for civil and military aircraft industry, and Fokker Aircraft Services B.V. also in Woensdrecht (*plant 3*). The three other divisions, one in Ypenburg (*plant 4*), one in Papendrecht (*plant 5*), and one at Schiphol Amsterdam (*plant 6*) together with the headquarters in Amsterdam formed the holding Fokker Aircraft employing 5,200 workers at the day of bankruptcy. This holding designed, developed, and built new aircrafts. After the bankruptcy, two new divisions were created out of this holding: Fokker Aerostructures B.V. and Fokker Product Support B.V. that employed only 950 workers. The five divisions that continued to exist together formed Fokker Aviation B.V. that employed 2,420 workers. In addition, the trustees selected 900 workers to continue finishing unfinished products and to help wrapping up the parts of the firm that were closed down. In total of 3,650 workers were permanently discharged (see Chart 1). On July 17th, 1996, Fokker Aviation B.V. was sold for 300 million guilders to another Netherlands manufacturing company, Stork B.V., after negotiations with the Canadian aircraft manufacturer Bombardier had failed.

On Monday, March 18th, 1996, the first working day after the company filed for bankruptcy, all workers employed at the day of the bankruptcy received an envelope from the trustees that contained either one or two letters: the data set includes 2578 workers who certainly received a single letter announcing the displacement to the addressee, and 2619 workers that also received a second letter stating a new one-year contract to work in the same job and the same wage for the newly created Fokker Aviation B.V. or for the bankruptcy trustees. The discrepancy between the numbers in the sample and the true numbers is due to incomplete information in the personnel files being the most relevant cause of missing data and due to the fact that the file didn't include information on the management team. Throughout the paper I assume that the sample is representative for the entire productive workforce, and that the missing of data is random and uncorrelated to any of the decision processes described here.

Table 2 presents for each of the company's six divisions in increasing order of workforce reductions the number of workers at the day of the bankruptcy. Each plant's workforce is divided into a group of workers that were retained after the bankruptcy, and a group of displaced workers. For all workers together and for each group separately I report their respective sizes, the layoff incidence, the average hourly wages at the day of the bankruptcy (in 1995 Dutch Guilders), and the percentages of wage growth during the three different spells: 1991-1996; 1993-1996; and 1995-1996.

Layoff rates differ substantially among the six plants. The plants involved with aircraft construction, plants 4, 5 and 6 lost 61, 64 and 66 percent of their workers, respectively. For the service and parts plants 2 and 3 only 12 percent of their workers were forced to go, while the special products plant 1 remained virtually unchanged. Especially for the plants with the largest lyoff rates, it is found that since 1993 retained workers saw their real hourly earnings grow more rapidly than those who were fired in the end.

3.3 Worker Characteristics

Three types of selection criteria were used in the layoff procedure. The list of *social* criteria or 'fairness quota' included disabled workers, minority groups, single mothers, families with husband and wife both working for Fokker, workers of 50 years or older, and the age distribution in general. The list of *behavioral* characteristics included mental flexibility, creativity, communication skills, interest in other people, need for structure, emotional stability, self-confidence, frustration tolerance, team-worker, leadership, and learning capacity. The list of *performance* characteristics included education and social background, experience, responsibility, language skills, proved performance, ability to delegate, and organizational skills. Selection teams existed of group-leaders or group-superiors that had been selected using the same selection procedure before. External observers were assigned to each selection team to reduce the risk of maintaining 'old-boys-networks', to control the use of the selection criteria in relation to the company's goals, and to verify the quota system.

The characteristics observed by the econometrician are the same as commonly used in worker displacement studies (Kletzer, 1998), such as age, tenure, gender, educational level and sort (general vs. vocational/technical), hours worked, and marital status. In addition, information is available for each worker about the number of internal training courses (paid and provided by the company), the number of external courses (paid by the company, but provided by private training agencies), and the last annual performance evaluation outcome.

3.3.1 Age

Figure 2 shows the age distribution of the whole workforce at the day of the bankruptcy (Graph A), as well as for retained workers (Graph B) and layoffs (Graph C). I divided age into 7 different categories. These are $\leq$ 24 years ; 25-29 years; 30-34 years; 35-39 years; 40-44 years; 45-49 years; and 50-54 years of age. Tabel 3.1 presents the within age group averages of wage levels, percentage growth, and the 95% confidence intervals for wage growth for the three periods. The oldest workers faced the highest layoff risk. Layoffs with ages ranging between 25 and 49 years old were high wage earners. And except for the middle age groups 30-34 and 35-39, all layoffs had lower wage growth since 1993, and with less dispersion.

3.3.2 Tenure

Figure 3 presents the tenure distribution. It is different from the age distribution and shows the existence of vintages reflecting previous cycles of expansion and decline. Tenure is divided into 6 different groups according to the modalities in the tenure distribution of the workforce (see Figure 3.2, Graph A). The groups are $\leq$ 7 years ; 8-11 years; 12-17 years; 18-22 years; 23-29 years; and $\geq$ 30 years of tenure. Graphs B and C of Figure 3 show that the firm's selection of workers was done in such a way that the tenure distribution did not change by much.

In Table 3.2 within group averages of wages and wage growth rates for all tenure groups are presented. Workers with the highest tenure are least likely to get displaced. Workers with up to 22 years of service with the firm and who were retained after the bankruptcy earned generally less than their displaced colleagues. Since 1993, however, for retained workers in all tenure groups, wages grew faster and the growth was also more dispersed.

3.3.3 General versus Vocational Schooling

The traditional industrial character of the firm's production technology comes to the fore when taking a closer look at the workforce's education composition. Making the simple distinction between general and vocational schooling, it turns out that 73.5 percent of all workers have a vocational background. Later on, in the econometric analysis, schooling will be further subdivided between different educational levels as well. But for the purpose of this section the partition into two parts suffices.

In Table 3.3 within group averages of wages and wage growth for workers with general and vocational schooling are presented. For both schooling types, but especially for workers with a general educational background, the downsizing firm decided to keep low wage earners with high and variable hourly wage growth.

3.3.4 Type of Job

Two types of jobs are distinguished, production workers and managers. This distinction is equivalent to the different representations of workers inside the firm. Wage contracts of production workers are collectively negotiated in a committee of union members, employer representatives, and governmental officials that sets new contracts annually. The unions are also important players in the determination of the size of layoffs. Unions do not represent the firm's managers. Their wage changes are determined in a less formal manner annually by the firm. In setting wages of managers more room exists for individual negotiations.

The firm displaced 46.9 percent of its production workers and 55.3 percent of its managers (Table 3.4). Before the bankruptcy there were 2.1 production workers to every manager. After the reorganization the ratio increased to 2.5. Both types of jobs do not show a difference in wage levels between retained workers and layoffs. However, the wage of retained production workers and managers grew significantly faster, and that growth was significantly more dispersed as well. The wage growth of retained managers was particularly large and became more dispersed after 1993.

3.3.5 Internal and External Training Courses

On-the-job training is provided in two ways. The firm invested in firm-specific productivity in the form of the provision of *internal* training courses. The median worker followed 5 internal courses: 45 percent of all workers took more than 5. The firm adjusted its workforce to general technology shocks by means of investing in the expansion of workers' general productivity through financing *external* courses provided by outside training agencies. Most workers were offered one such course only; 24.7 percent had 2 or more.

In Table 3.5, for each of the two types of training courses the workforce was split into two parts: one part had been trained more, the other part less than or equal to the median worker. Within group averages of wage levels and wage growth rates are presented for workers with below or above median internal and external training courses. The firm retained most workers that had followed above median internal training courses. With the exception of workers with more than the median number of external courses, all retained workers' wages grew at a faster pace than that of the displaced workers.

3.3.5 Performance Evaluation

Table 3.6 shows similar statistics as the previous ones but now for workers with high or low performance evaluation scores. Workers' job performance was evaluated annually and the scores they received ranged between 1 (bad) and 6 (excellent). With a sample mean of 3.5, low scores are

1,2 and 3, while high scores are 4,5, and 6. The firm retained more workers with high evaluations scores. As of 1993, wages of retained workers grew faster in both categories.

3.3.7 Gender

At the time of bankruptcy the firm employed 10.9 percent female worker. Table 3.7 shows that just as their male counterparts, the retained female workers were low wage earners, whose wages started rising faster after 1993.

3.3.8 Marital Status

Being married to another Fokker employee was one criterion used in the trustees' quota system to be selected to stay. Table 3.8 shows that the downsizing firm indeed preferred to keep married workers. Although wage levels were generally lower at the time of the bankruptcy, wages grew faster of married as well as unmarried workers who were retained.

By and large, most of the observable characteristics used as selection criteria in the layoff procedure used by the bankruptcy trustees show an equal division between retained workers and layoffs. The differences found between retained workers and layoffs are remarkably similar along practically all observed characteristics. These differences are that layoffs earned significantly higher hourly wages, experienced less wage growth, and the wage change was less widely dispersed.

IV. The Econometric Model

When the size of the layoffs is predetermined and equals *N-M*, the firm seeks *M* out of *N* workers as to maximize the sum of discounted future values $V(\Pi_{Li})$, *i=1,..,M,* of all expected returns from its investment *Q* in each worker, with Π_{Li} being the firm's layoff boundary for worker *i*. The downsizing problem under uncertainty then yields

(4.1) $$Max V(\Pi_L^M) = Max \sum_{i=1}^{M} V(\Pi_{Li}) .$$

$V(\Pi_{Li})$ is monotonous in Π_{Li}, so that we would only need to be able to observe Π_{Li} for all workers, order all workers by its size, and select the smallest M from the sorted array. However, the non-linearity of equation (2.15) in r, m, and s^m makes it cumbersome to analyze every worker's layoff boundary Π_{Li}. I suggest to use a linearized decision rule instead, writing Π_{Li} in linear form as follows

$$(4.2) \qquad \Pi_{Li} = \underset{(+)}{\frac{\partial \Pi}{\partial r}} r + \underset{(-)}{\frac{\partial \Pi}{\partial m}} m_i + \underset{(-)}{\frac{\partial \Pi}{\partial s^m}} s_i^m + \underset{(+)}{\frac{\partial \Pi}{\partial W_S}} W_{Si} + \underset{(-)}{\frac{\partial \Pi}{\partial F}} F_i + \mathrm{O}(p_i^2),$$

with $\mathrm{O}(p_i^2)$ being a zero mean error term with standardized unit variance. Jointly the partial derivatives form the firm's layoff policy that is assumed to be the same for all workers.

4.1 Measuring the Explanatory Variables

The variables r, m_i, s^m_i, W_{Si}, and F_i need to be measured from the data set. Π_{Li} is not observed, but it is known which workers are retained and which are not. This gives the following employment decision rules

(4.3a) *Retain worker i, or* $\quad I\Pi_{Li} = 0 \quad$ *iff* $\quad \Pi_{Li} \leq C$, and

(4.3b) *Layoff worker i, or* $\quad I\Pi_{Li} = 1 \quad$ *iff* $\quad \Pi_{Li} > C$.

$I\Pi_{Li}$ is a layoff indicator variable, and C is an unknown constant used by the firm to determine the cut-off point above which N-M workers will be displaced. For each worker, the layoff expectation yields

$$(4.4) \qquad E\{\Pi_{Li} - C > 0\} = p^r r + p^m m_i + p^s s_i^m + p^{W_S} W_{Si} + p^F F_i - C \equiv p \ \Lambda_i,$$

with the lower case p's denoting the respective partial derivatives given in (4.2). If $\mathrm{O}(p_i^2)$ is standard normally distributed, a worker's layoff probability becomes

(4.5) $\Pr(\Pi_{Li} - C > 0) = \Pr(I\Pi_{Li} = 1) = \Phi(p \quad \Lambda_i)$.

The next step is to obtain observations on r , m_i , $s^m{}_i$, W_{Si} , and F_i for all workers.

Measuring r

The interest rate itself is firm-specific and constant for all workers. But the probability of a division closure turned out not to be the same across the six different plants. This can be modeled by allowing for differences in dismantling probabilities -- different t's for each plant -- among the six existing plants. One way to control for these differences is to include plant specific dummy variables. The largest plant, no. 6, is chosen as the reference plant. Risk adjusted discount rates for plants 2, 3, 4, and 5 (plant 1 has too few layoffs to be included) are incorporated into the model as: $p^r\, r = \sum_{j=2}^{5} p^j D_j$.

Measuring m_i

Under rational expectations, the observed real hourly wage growth during the period preceding the bankruptcy should reflect the expected future productivity growth most accurately. Suppose that together with a common component C for all workers, individual productivity characteristics Y_i measured at the time of layoff determine the individual worker's future wage growth. The real hourly wage growth equation for worker *i* then yields

(4.6) $\Delta \ln W(C, Y_i) = a \quad C + h \quad Y_i + e_i^W$,

where a , h are constant parameter vectors and e_i^W is a worker specific component.[5] The expected wage growth given the current set of available information Ω_t is

(4.7) $E[\Delta \ln W(C, Y_i) \mid \Omega_t] = a \quad C + h \quad Y_i$.

---

[5] The data generating process of real industry wages is usually found to be an ARI(1,1) process (see Pfann and Palm, 1993). After detrending, AR(2) processes for real wage dynamics are also found (Sargent, 1978).

The vector Y_i contain the seven age groups -- using the actual age rather than a dummy allows for within group age variation and uses the available information more efficiently. Also included in Y_i are seven (out of eight mutually exclusive) schooling variables: four general levels and three technical schooling levels. The reference group is the lowest vocational schooling level that is assigned to 38.5 percent of the firm's total workforce. The last performance evaluation score, a job-type dummy for managers, a female dummy, and a dummy variable for being married are also included in Y_i. In addition Y_i contains the six tenure groups -- as with the age groups within group variation is allowed for as well --, the number of external training courses, and the number of internal training courses.

Measuring s_i^m

An accurate way to measure s_i^m that captures idiosyncratic differences in the uncertainty of future changes in productivity or the layoff option value when retaining a worker is to directly estimate the heterogeneous uncertainty using equation (4.6). The heterogeneous component e_i^W is known by the firm and determines the option value of worker *i*, or

(4.8) $\hat{s}_i^m = \hat{s}_i^m \equiv (\hat{e}_i^W)^2$,

where $\hat{e}_i^W$ is the observed residual after equation (4.6) has been fitted to the data. In order to obtain an unbiased estimate of $\hat{e}_i^W$ the worker's decision process to stay with the firm until the end must be modeled explicitly, for the decision to stay or not to stay is the outcome of a non-random selection problem (Pfann, 2001). The decision to stay and $\Delta \ln W_i$ are most likely correlated, so that a straightforward estimation of (4.6), without controlling for a selection mechanism, would provide biased estimates for $\hat{e}_i^W$.

To obtain unbiased estimates of $\hat{e}_i^W$ the worker's decision process must thus be modeled explicitly. Suppose that a worker's unobserved separation propensity Q_i^*, based on a comparison of the expected stream of future earnings inside the firm and the expected stream of alternative earnings elsewhere. The separation decision under uncertainty is written as

(4.9) $Q_i^* = g \;\; Z_i + u_i$,

Z_i is a vector of individual characteristics explaining Q_i^* at the beginning of the episode in which the observed quit occurs, g is a vector of unknown parameters, and u_i is a worker-specific normally distributed zero mean error with variance $s^{\,Q}$. A worker's separation propensity is not observed, but the actual outcome, Q_i, is. The worker's propensity to stay with the firm until the end is equal to

(4.10) $\Pr(Q_i = 0) = 1 - \Phi(g \;\; Z_i)$,

with $\Phi(\cdot)$ being the standard normal cumulative distribution function.

The correlation between the quit decision and the wage growth is defined as:

(4.11) $r_{QW} = corr(u_i, e_i^W)$.

If $r_{QW} \neq 0$, then the regression equation that produces unbiased estimates for a and k, and consequently for e_i^W, yields

(4.6′) $\Delta \ln W(C, Y_i) = a \;\; C + h \;\; Y_i + r_{QW} \;\; l_i^{\,Q} + e_i^{\,W}$, with $l_i^{\,Q} = f(\hat{g} \;\; Z_i)/(1 - \Phi(\hat{g} \;\; Z_i))$.

The residuals $e_i^{\,W}$ from this regression are used as the measure for heterogeneous uncertainty about future productivity growth and $\hat{s}_i^m$ as in (4.8).

I propose to obtain estimates for s_i^m for the three episodes 1995-1996, 1993-1996, and 1991-1996 independently. The first measurement of the observed variation in residual wage growth, $\hat{s}_i^{95-96}$, covers the last year of the firm before bankruptcy. The uncertainty $\hat{s}_i^{91-96}$ measures the observed variation in residual wage growth during period since the firm started its first attempt to downsize in 1991 when it introduced an early retirement plan for 55 years and older workers. Using all the information that is available on these workers, $\hat{s}_i^{91-96}$ differs from $\hat{s}_i^{95-96}$ as it also includes a period when the demise of the firm was not expected to be permanently ending up in the firm's bankruptcy (see Deterink, *et al.*, 1997). Moreover, 273 workers are observed to have entered the workforce since 1991. The company's structural decline started in 1993. To allow for differences between cyclical and structural adjustments I also include $\hat{s}_i^{93-96}$ as a separate measure of idiosyncratic productivity growth uncertainty estimated for the period 1993-1996. The results from the estimation procedures to compute $\hat{s}_i^{95-96}$, $\hat{s}_i^{93-96}$, and $\hat{s}_i^{91-96}$ are not reported here. The technique is straightforward and has been used numerous times before. The results can be obtained upon request.

Table 4 presents a summary of the outcomes for the three different measures of $\hat{s}_i^m$ divided between retained and displaced workers. For all time spells the average option value for retained workers exceed that of displaced workers, just as the theory predicts. Expectedly, the further back into the past, the closer the option values ratio between the two groups of workers is to one. The residual wage growth variance in the final year is rather small. The information content of this episode in terms of differences in option values among workers is therefore expected to be limited.

Measuring W_{Si}

The idiosyncratic premium that the firm pays a worker each period for firm-specific productivity cannot be determined independently from the worker's overall productivity. W_{Si} determines the share of return to the firm on firm-specific investment at the time of hiring. At that stage the negotiating power is limited for any worker. I assume that share is constant for all workers.

Measuring F_i

Statutory replacement costs are the most important firing costs faced by the firm. Replacement costs are best estimated as being proportional to a worker's annual earnings and to a worker's tenure within the firm. Tenure is already included in the vector of productivity characteristics Y_i. Moreover, tenure has been one of the variables of the 'quota-system' used by the trustees to select workers to stay. The interpretation of the tenure effect in the layoff probability is thus a combination of expected future productivity, replacement costs, and 'fairness'.

Although the law applies to all workers in a similar manner, and given workers' differences in tenure structures, wages differ and therefore so do firing costs among workers. In equilibrium the expected firing costs are the difference between productivity and earnings. But I do not observe productivity and therefore suggest using the residual annual earnings distribution at the time of bankruptcy as a proxy of the distribution of heterogeneous firing costs among all workers. Thus, $F_i = j\ (\mathbf{w}_i)$, with $\partial j\ / \partial \mathbf{w}_i > 0$, where $\mathbf{w}_i$ denotes worker i's residual of the annual wage equation at the day of the bankruptcy. In linear form, this produces the result that $p^{F} F_i = p^{Fw} \mathbf{w}_i$, with $p^{Fw} = j\, p^{F}$.

4.2 Estimation Results

A worker's layoff probability written in terms of observable variables then yields

(4.12) $\Pr(I\Pi_{Li} = 1) = \Phi(p\ \hat{\Lambda}_i)$,

where

(4.13) $p\ \hat{\Lambda}_i = p^{C} C + \sum_{j=2}^{5} p^{j} D_j + p^{m} Y_i + p^{s} \hat{s}_i^{m} + p^{Fw} \mathbf{w}_i$.

The estimation results for this structural probit model are given in Tables 5 and 6.

Firing costs

The distribution of statutory replacement costs among workers has been measured as the residual annual earnings distribution at the time of bankruptcy. At the time of the bankruptcy these firing costs were fixed for each worker, but varied among workers. The estimation results presented in the first row of Table 5 show that, irrespective of the chosen specification for the worker's option value of future productivity growth, workers with higher firing costs were more likely to be retained by the downsizing firm, or $\hat{p}^{Fw} < 0$. This is evidence in favor of *Prediction 5* from the theory, and corroborates with the results found in the existing literature on firing costs and worker turnover initiated by the firm.

Idiosyncratic uncertainty of future productivity change

Table 5 presents a base-line model (Column **I**) and the results for the three different measures of uncertainty of worker specific future productivity change: the residual wage change squared, $\hat{s}_i^m$, for the respective periods 1991-1996, 1993-1996, and 1995-1995. When each measure is used individually, the option value over the entire period of the firm's demise, 1991-1996, is practically zero (Column **II**). The period of six years is seemingly too long to carry worthwhile information of future option values of individual workers in the case of downsizing. For the periods 1993-1996 and 1995-1996 the parameters are both negative and significant (Columns **III** and **IV**). The implication is that workers with higher layoff option values are less likely to be displaced. This is consistent with the theory and confirms *Prediction 3.* When all option values are combined, the 1993-1996 effect is the strongest, while the 1995-1996 effect disappears as well (Column **V**). This is not surprising given the minimal change observed in the wage distribution during the last months of the firm's existence.

The results suggest that uncertainty is good, because for a given average it increases the mass in the upper tail. Using $\hat{s}_i^m$ as the measure of heterogeneous uncertainty, workers with less than average residual productivity growth are treated equally as workers with high residuals. But greater mass in the lower tail can always be taken care off by firing workers who reveal themselves as low productivity workers. Therefore I also investigated the possibility of an asymmetry of response of the layoff probability around zero (Columns **VI-VIII**). The results show indeed that the responsiveness is different to a squared positive residual than to a squared negative residual. In fact, mass in the lower tail is diminished by increased displacement probabilities of those workers that revealed a less than average residual productivity growth. More than average productive workers with a high option value had a significantly higher probability to be retained. The symmetric value model is inferior to the asymmetric one, which distinguishes between otherwise observably identical workers with option values associated with high residual productivity growth and low residual productivity decline. Clearly, the period 1993-1996 carries most of the information over which the firm computed these values. The asymmetric model, reported in Column **VII** and includes the 1993-1996 period alone, is the specification that prevails over all others reported in Table 5, including the one that includes uncertainty measured asymmetrically over the period 1991-1996 as well. The estimation outcomes of the remaining explanatory variables of specification **VII** are presented in Table 6.

Risk adjusted discount rates

The plant-dummies in Table 6 show that working in a plant with a smaller shut-down probability reduced the risk of layoff. The coefficients are ordered accordingly to the *ex post* downsizes, which can be interpreted as support for *Prediction 1*, stating that plants with a higher risk adjusted discount rate are more likely to layoff workers.

Age and tenure

Workers between 50 and 54 years of age are the only workers that have a marginally significant higher layoff probability than all other workers. This is largely driven by the fact that workers of 54 years old, almost eligible to enroll into the early retirement plan were not retained (see Figure 3.1.C). Workers with 23 to 29 years of tenure within the firm are found to have a significantly lower risk of being displaced. This is in accordance with the trustees prescribed layoff policy to reduce the displacement risk for workers that have been with the company for almost all their working lives. The likelihood function is flat with respect to all other variables measuring age and tenure. This is due to the successful implementation of the trustees' quota system.

Education

Workers with basic and higher general schooling were less likely to be displaced, compared to those with a basic vocational schooling level. But workers with a higher technical educational background faced a significantly higher layoff probability.

Training courses

Workers that had more internal training courses had a significantly higher probability of being retained, while workers with more external training did not. This result corresponds with the notion that firm-specific human capital investments remain valuable to the firm during times of structural corporate demise. External training courses, provided by agencies not owned by the company itself, increased a worker's productivity, but this increase i not firm specific and therefore transferable in the labor market. Internal training courses, on the other hand, being provided by the company itself, are not transferable. When not retained, this idiosyncratically embodied productivity would otherwise be lost to the firm.

Performance evaluation

Performance evaluations inform the firm about a worker's citizenship. It is an instrument to learn about a worker's performance over time. It also provides the firm with distributional information about all workers' productivity. The results show that workers with higher evaluation scores were less likely to be displaced.

Type of job, gender, and marital status

Other things equal, the fact that a worker performed managerial tasks in the firm increased the likelihood of being retained significantly. Gender was no issue at all during the final reorganization. But being married contributed significantly to the propensity of being retained. This was partly due to the quota system obtained by the trustees, determining couples both working at Fokker to be retained. Moreover, the fact that, generally, married workers are considered to be less likely to quit also increase their present value to the firm.

V. The Value of Productivity Uncertainty when Firing Costs are Heterogeneous

If the downsizing firm uses all available information efficiently, one element not yet considered that may be relevant is the firm's believes about each worker's productivity. Farber and Gibbons (1996) provided empirical evidence that a firm revises these believes when more information becomes available while working longer on the job. Employer learning implies that the uncertainty about a worker's productivity and future productivity growth is expected to decline with tenure.

Figure 4 shows the relation between the uncertainty about wage growth and tenure of all Fokker's employees, retained workers, and displaced workers at the time of bankruptcy. At that time the workers have at least three years of tenure. Even after three years the decline is still sharp at the early years of tenure but there is no cut-off point. In fact, Figure 4 suggests that employer learning is an ongoing process until a worker retires. It also shows that for all years of tenure, the firm prefers workers with more uncertainty rather than less.

Altonji and Pierret (2001) argue that if a firm acquires more information about a worker indeed, pay becomes more dependent on productivity and less dependent on easily observable characteristics or credentials. A direct test would be to include into the empirical model interaction terms between $\hat{s}_i^{93-96}$ and the six tenure groups. I find that not one single interaction term is significantly different from zero, and the overall test equals $c^2(6) = 4.65$. This implies that for the downsizing firm, employing workers with at least three years of tenure and many observable characteristics to rely upon including performance evaluations and on the job training, the unobserved heterogeneity with respect to productivity does not play an important role in the layoff decision.

Another economically relevant question yet unanswered is concerned with the marginal effects of how much these variables add in terms of extra value to the firm. The estimation results showed that r , m_i , $s^m{}_i$, and F_i are crucial factors to describe a firm' layoff policy under uncertainty, that must be included in firm-level analyses of mass displacement. But how much is the reorganized firm worth more when future productivity of its workers, the corresponding uncertainty, and idiosyncratic firing costs are explicit subjects of the design of optimal downsizing policy under uncertainty?

The overall layoff probability is equal to .512 for all 4,683 workers included in the econometric analysis. From this sample 2284 workers were retained and 2399 workers were displaced. The estimated model's pseudo-R^2 = .164 for the preferred specification. Given the results reported in Tables 5 and 6, it is possible to assess which workers the model correctly predicts to be retained or displaced. This is done as follows. First, all workers in the sample are ordered from low to high layoff probabilities predicted by the model. The first M (=2284) workers are the ones that would select to stay according to the model's linearized decision rule. It is then possible to match this prediction with each worker's actually observed outcome of the firm's layoff decision. The ratio of the number of correctly predicted and the actual number of retained workers (M) provides a first sense of the model's performance to describe the firm's layoff policy at the individual worker's level. The model correctly predicts 1522 out of 2284 workers or 66.6 percent of all retained workers.

The estimated mean $\hat{p}\Lambda_i$ for layoffs is equal to .294 with a 95% confidence interval of $[.278\ ;\ .312]$; the estimated mean $\hat{p}\Lambda_i$ for retained workers is equal to $-.338$ with a 95% confidence interval of $[-.370\ ;\ -.306]$. The expected value of all the firm's correctly predicted retained workers can be computed as

$$(4.12)\quad V(\hat{\Pi}_M^L) = \sum_{i \in \Psi} \overline{\Pr(I\Pi_{Li} = 0)}\ \mathbf{W}_i \left(\frac{S_i}{1 - S_i} \right) / \Pr(Stay),$$

where Ψ is the set of all correctly predicted retained workers, $\overline{\Pr(\cdot)}$ is the estimated probability to stay for each worker, $\mathbf{W}_i$ is the worker's annual earnings at the time of the bankruptcy, S_i is the firm's share of firm-specific human capital invested in worker *i*, and Pr($Stay$) is the overall probability to stay. Assuming $S_i = 1/2$ for all workers, I find that $V(\hat{\Pi}_L^M) = \mathbf{D}fl\ 111.6$ million guilders, which is the equivalent of 63.8 million U$ 1995 dollars for 2284 workers.

The 'baseline NPV' model, that is encompassed by the option model of downsizing and represented in Column **I** in Table 5, is a structural net present value model of turnover with firing costs being fixed and equal for all workers and does not include uncertainty about individual worker's future productivity growth. This model is strongly rejected against the model with heterogeneous firing costs and idiosyncratic uncertainty. The joint hypothesis is $H_{NPV} : \{p^{s:93-96} \mid e_i^w \geq 0\} \wedge \{p^{s:93-96} \mid e_i^w < 0\} \wedge \{p^{Fw} = 0\}$, and the test statistic is $c^2(3) = 22.6$. The NPV model predicts 1465 or 64.1% of the retained workers correctly. Using the NPV rule, the expected value of all the firm's correctly predicted retained workers can be computed as

$$(4.13)\quad V(\hat{\Pi}_{NPV}^M) = \sum_{i \in \Psi} \overline{\overline{\Pr(I\Pi_{Li} = 0)}}\ \mathbf{W}_i \left(\frac{S_i}{1 - S_i} \right) / \Pr(Stay),$$

where $\overline{\overline{\Pr(\cdot)}}$ is the estimated probability to stay under H_{NPV}. I find $V(\hat{\Pi}_{NPV}^M) = \mathbf{D}fl\ 106.2$ million guilders, or 60.7 million U$ dollars for 2284 workers.

Even though the average difference in fitting the data between the two models seems modest, on an individual worker basis the difference in predictability between the two models is found to be quite distinct. Per retained worker the estimated difference between $V(\hat{\Pi}_L^M)$ and $V(\hat{\Pi}_{NPV}^M)$ amounts to 2,364 **D***fl* or 1,351 U$ on average. Given the average annual earnings of retained workers of 52,078 D*fl* or 29,759 U$, the per worker value gained from accounting for heterogeneous firing costs and uncertainty of future productivity growth is estimated to yield 4.5 percent of every retained worker's annual earnings. The total number of workers retained by Fokker was 2,420 (and not 2,284 as in the econometric analysis). Consequently, the total value gain for this firm is estimated to be equal to 5.7 million Dutch guilders or 3.2 million U$ dollars, or 2 percent of the price for which Fokker Aviation was sold to Stork. If the firm's share of the returns to firm-specific training exceeds $\frac{1}{2}$, its monetary gains would still be greater.

VI. Generalizations and Personnel Policy Implications

The theory presented in this paper is a general theory for an insolvent firm with an immediate need to layoff part of its workforce following from a survival contingency plan. The empirical results are for one bankrupt aircraft building company in the small open economy of the Netherlands. Whether they hold true for an economy as a whole is a relevant question, but can't be addressed here. The theoretical model can be applied such that generalizations of the empirical findings could be achieved in a variety of ways. First, the study could be replicated using personnel data from other firms, in other sector, and in other countries. The outcomes thereof can be compared. Second, a worthwhile extension of the model is to allow for more than the two different job levels considered here. This would provide an opportunity to investigate the existence of "ports of exit" for layoffs in the case of downsizing. Third, the model could be extended with the outcome of a Nash bargaining equilibrium between each worker and the employer. Empirically this would entail to compute for every worker at the time of hiring the outside reservation wage W_S based on the worker's and the firm's observable characteristics and the worker specific unemployment rate. Fourth, the theoretical model of downsizing is easily combined with a reverse model of firm's growth (see footnote 3). The econometric model associated with such a expansionary firm model would be a duration model where the timing of the hiring decision is endogenous and the resulting expansion hazards are the crucial decision parameters. That model can be empirically tested using the firm specific data of growing firms. Such data seem to be more easily obtainable probably because managers' interests are more appealed by designing better expansionary than contractionary personnel policy. A comparable model of firm growth could, for example, shed more light on the existence of promotion "fast tracks" (Baker *et al.,* 1994).

From a downsizing personnel policy point of view this paper shows that the history of a worker in the firm contains valuable information, not because the firm knows more about initially unobserved productivity, but because the firm is able to maximize future profits by accounting for uncertainty about future productivity growth. This provides an explanation of the question why hiring occurs so lttle in firms in demise even during recessions. One could argue that downsizing is only about cutting the firm's total wage bill. But then it is not immediately obvious why declining firms are not replacing incumbent workers by new workers. The answer provided in this paper is not so much one that stresses the reputation or unobserved ability arguments, but extends the long used theory of the firm's invested interest in firm specific human capital. Although new workers tend to be less expensive, the value of incumbent workers exceeds that of new workers and that value is most important for a firm that seeks an optimal survival strategy under uncertainty.

From an overall employment policy point of view this paper stresses once more the importance of the role of firing costs. However, it shows a different role of firing costs than has been debated about so far. If the level of firing costs is higher in general, a firm will wait longer to reduce its workforce (Figure 1, Graph C). This tendency increases the insolvency risk, and provides a theoretical explanation for the observed substitution of individual firings by mass layoffs (Oyer and Schaefer, 2000). The differences of firing costs among workers is another important new element that can add to the discussion of designing employment policies directed at the protection of the most vulnerable workers (low firing costs, low productivity growth, low uncertainty) from being displaced.

VII. Conclusions

In this paper optimal layoff rules in closed form have been derived for all workers of a downsizing firm that operates under uncertainty and faced heterogeneous firing costs. The theoretical model predicts that the firm displaces workers with the lowest firing costs, the lowest expected future productivity growth, and the lowest layoff option value. A declining firm prefers workers with more uncertainty about future productivity growth for the same reason why growing firms like these workers: the chance of higher productivity also increases the firm's share in this worker's expected future returns and is therefore more likely to be retained. The theory also predicts that when interest rates are higher a firm downsizes faster. This corresponds with a general finding in the investment literature that overall investment decreases if the interest rate rises. But it also explains why a firm cuts a larger chunk of its workforce when the chance of bankruptcy is higher.

The predictions are tested and supported empirically using personnel data of a Dutch aircraft manufacturer that went bankrupt in 1996. The bankruptcy trustees closed down parts of the company that were involved in developing and building new aircrafts. From the remainders a new firm was created and sold. The outcomes of the selection process to retain some workers and layoff others provided the relevant empirical material to test the model's predictions and provided the opportunity to compute the additional firm's value when heterogeneous firing costs and idiosyncratic uncertainty about future productivity growth are built into the firm's layoff contingency plan.

The analysis can be extended in a variety of ways. First, the empirical study can be replicated using personnel data from other firms, in other sector, or in other countries. The outcomes thereof could be compared to find confirmation or refutation of the generality of the results presented here. Second, the model can be extended to allow for more than two job levels in order to investigate the importance of "ports of exit". Third, the model can be extended with the outcome of a Nash bargaining equilibrium between each worker and the employer. Fourth, the theoretical model of downsizing can easily be transformed into a theoretical model of heterogeneous fixed costs expansionary model of personnel policy under uncertainty. Rather than the structural probit model, this would entail a duration model of optimal hiring decisions.

REFERENCES

Altonji, Joseph and Pierret, Charles. "Employer Learning and Statistical Discrimination," *Quarterly Journal of Economics* (Forthcoming, 2001).

Baker, George, Micheal Gibbs, and Bengt Holmstrom. "The Internal Economics of the Firm: Evidence from Personnel Data," *Quarterly Journal of Economics*, 109 (November 1994): 881-919.

Bentolila, Samuel and Guiseppe Bertola. "Firing Costs and Labour Demand: How Bad Is Eurosclerosis?" *Review of Economic Studies*, 57 (July 1990): 381-402.

Deterink, Louis, Robert Schimmelpenninck, Arnold Leufting, and Ben Knüppe, "*Bankruptcy Trustees' Investigation of the Causes of the Bankruptcy of N.V. Koninklijke Nederlandse Vliegtuigfabriek Fokker, Fokker Aircraft B.V. and Fokker Administration B.V.*." Deventer: Kluwer Publishers (1997).

Dixit, Avinash, "Entry and Exit Decisions under Uncertainty," *Journal of Political Economy*, 97 (June 1989): 620-638.

-------------------, and Robert S. Pindyck. *Investment under Uncertainty*. Princeton: Princeton University Press, 1994.

Farber, Henry. "The Changing Face of Job Loss in the United States, 1982-1995," *Brookings Papers on Economic Activity* (1977): 55-128.

-----------------, and Robert Gibbons. "Learning and Wage Dynamics," *Quarterly Journal of Economics*, 111 (November 1996): 1007-47.

Hamermesh, Daniel. "The Costs of Worker Displacement," *Quarterly Journal of Economics*, 102 (February 1987): 51-75.

--------------------------. "Labor Demand and the Structure of Adjustment Costs," *American Economic Review*, 79 (September 1989): 674-89.

--------------------------, and Gerard Pfann. "Adjustment Costs in Factor Demand," *Journal of Economic Literature*, 34 (September 1996): 1264-92

Jacobson, Louis, Robert LaLonde, and Daniel Sullivan. "Earnings Losses of Displaced Workers," *American Economic Review*, 83 (September 1993): 685-709.

Jovanovic, Boyan. "Firm-specific Capital and Turnover." *Journal of Political Economy* 87 (December 1979): 1246-60.

----------------------. "Selection and the Evolution of Industry," *Econometrica*, 50 (May 1982): 649-70.

Kletzer, Lori. "Job Displacement," *Journal of Economic Perspectives*, 12 (Winter 1998): 115-36.

Lazear, Edward. "Hiring Risky Workers." NBER WP No. 5334 (November 1995).

McLaughlin, Kenneth. "A Theory of Quits and Layoffs with Efficient Turnover," *Journal of Political Economy*, 99 (February 1991): 1-29.

Merton, Robert. "Option Pricing when Underlying Stock Returns are Discontinuous," *Journal of Financial Economics*, 3 (1979): 125-44.

Mortensen, Dale, and Christopher Pissarides. "Job Creation and Job Destruction in the Theory of Unemployment," *Review of Economic Studies*, 61 (July 1994): 397-415.

Nickell, Stephen. "Fixed Costs, Employment and Labour Demand over the Cycle," *Economica* 45 (Nov. 1978): 329-45

-------------------. "Dynamic Models of Labour Demand." In *Handbook of Labor Economics. Volume 1* edited by Orley Ashenfelter and Richard Layard. Amsterdam: North-Holland, 1986.

Oyer, Paul, and Scott Schaefer. "Layoffs and Litigation," *RAND Journal of Economics*, 31 (Summer 2000): 345-58.

Oi, Walter. "Labor as a Quasi-Fixed Factor", *Journal of Political Economy*, 70 (December 1962): 538-555

Pfann, Gerard. "Options to Quit," *Economics Letters*, 70 (January 2001): 259-265.

----------------, and Daniel Hamermesh, "Two-Sided Learning, Labor Turnover and Worker Displacement." University of Chicago Harris School Working Paper # W21 (January 2001).

----------------, and Franz Palm. "Asymmetric Adjustment Costs in Non-linear Labour Demand Models for the Netherlands and U.K. Manufacturing Sectors," *Review of Economic Studies*, 60 (April 1993): 397-412.

----------------, and Bart Verspagen. "The Structure of Adjustment Costs for Labour in the Dutch Manufacturing Sector," *Economics Letters* 29, (1989): 365-71.

Sargent, Thomas. "Rational Expectations, the Real Rate of Interest, and the Natural Rate of Unemployment," *Brookings Papers of Economic Activity* 2 (1973): 429-80.

--------------------. "Estimation of Dynamic Labor Demand Schedules under Rational Expectations," *Journal of Political Economy* 86 (December 1978): 1009-44.

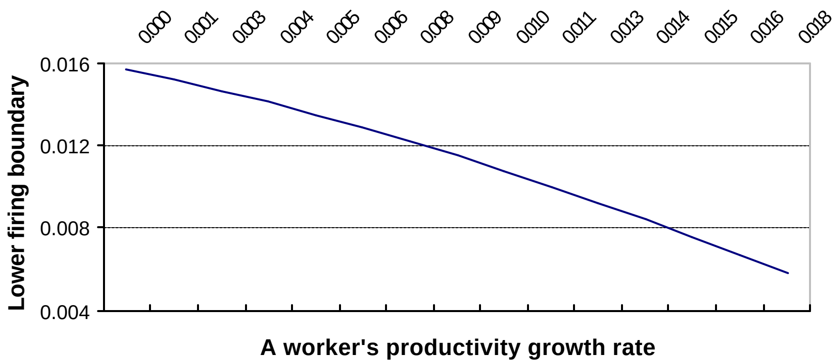
Topel, Robert, and Michael Ward. "Job Mobility and the Careers of Young Men." *Quarterly Journal of Economics* 107, (May 1992): 439-79.

Figure 1

Effects on Π_L from changes in *F*, m, and s

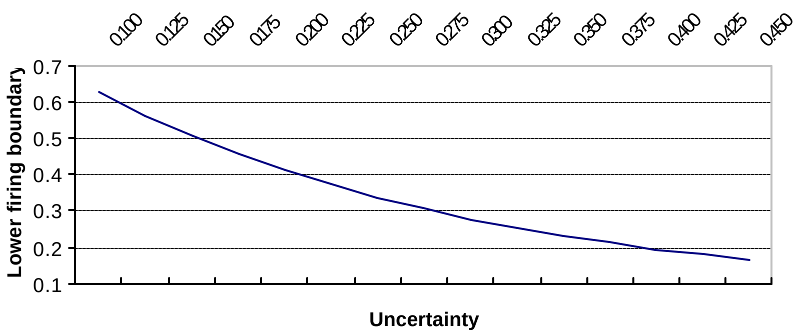
Graph A: Changes in Productivity Growth

$(r = .025; \sqrt{s} = .1; W = 1; F = 1)$



Graph B: Changes in Uncertainty

$(m = 0; r = .025; W = 1; F = 1)$



Graph C: Changes in Firing Costs

$(m = 0; r = .025; \sqrt{s} = .1; W = 1)$

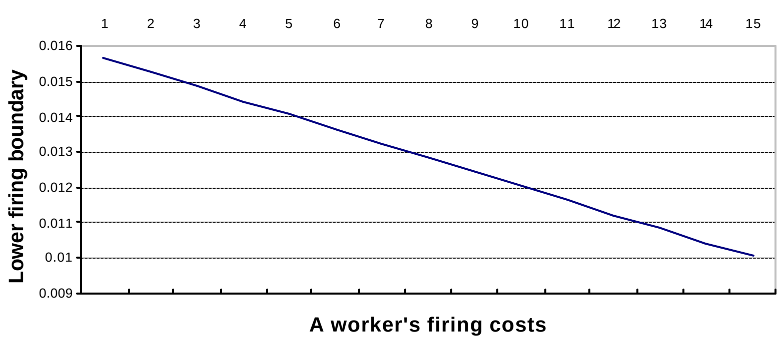
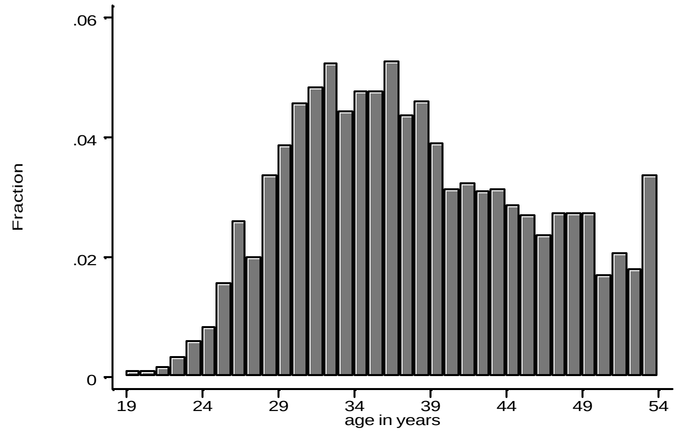


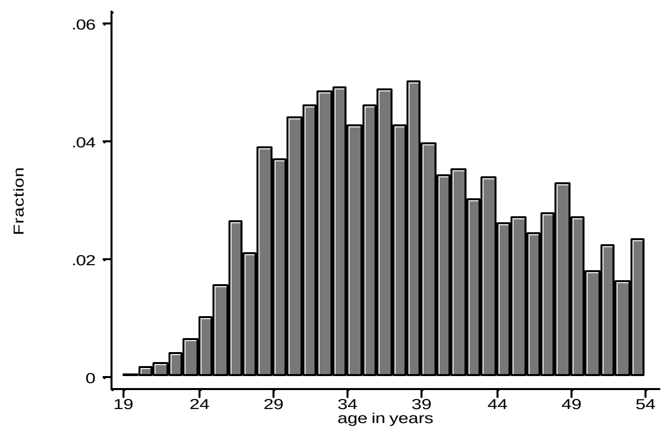
Figure 2

Age Distributions in Years

Graph A: All Workers



Graph B: Retained Workers



Graph C: Layoffs

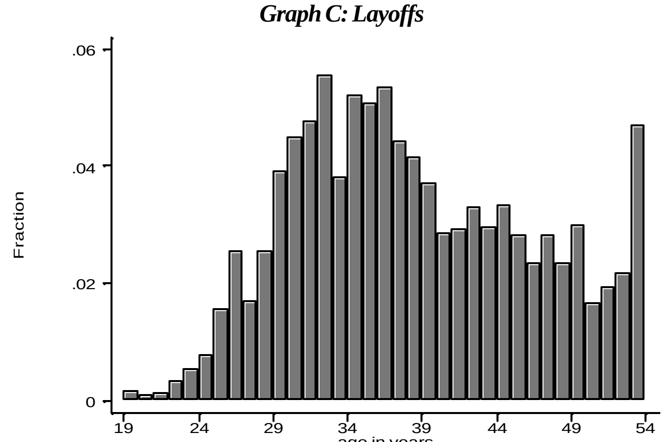
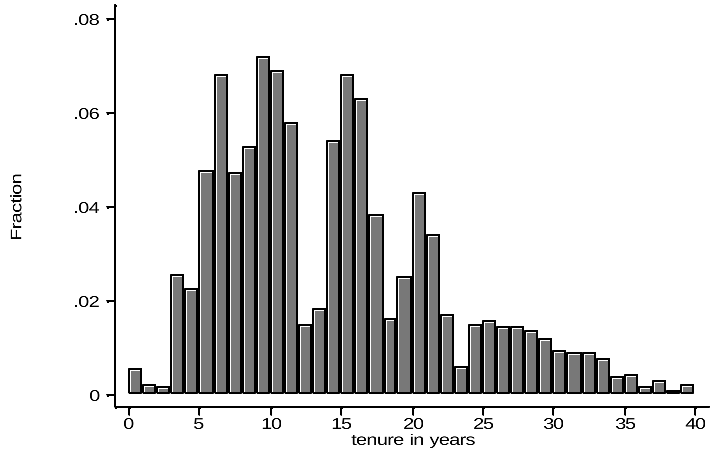


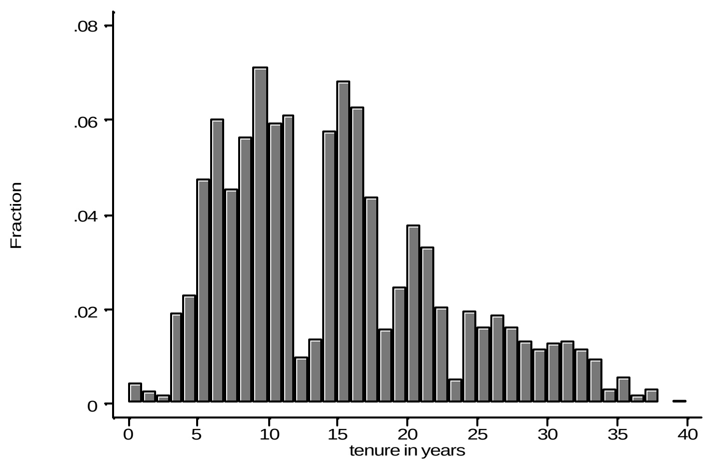
Figure 3

Tenure Distributions in Years

Graph A: All Workers



Graph B: Retained Workers



Graph C: Layoffs

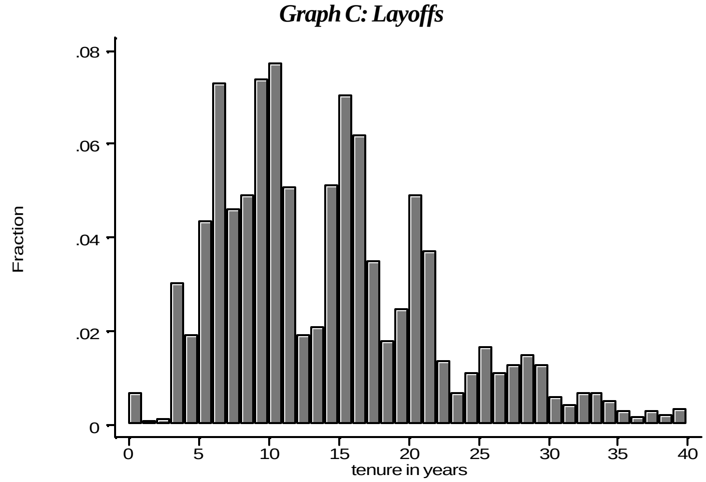


Figure 4

Productivity Growth Uncertainty and Tenure

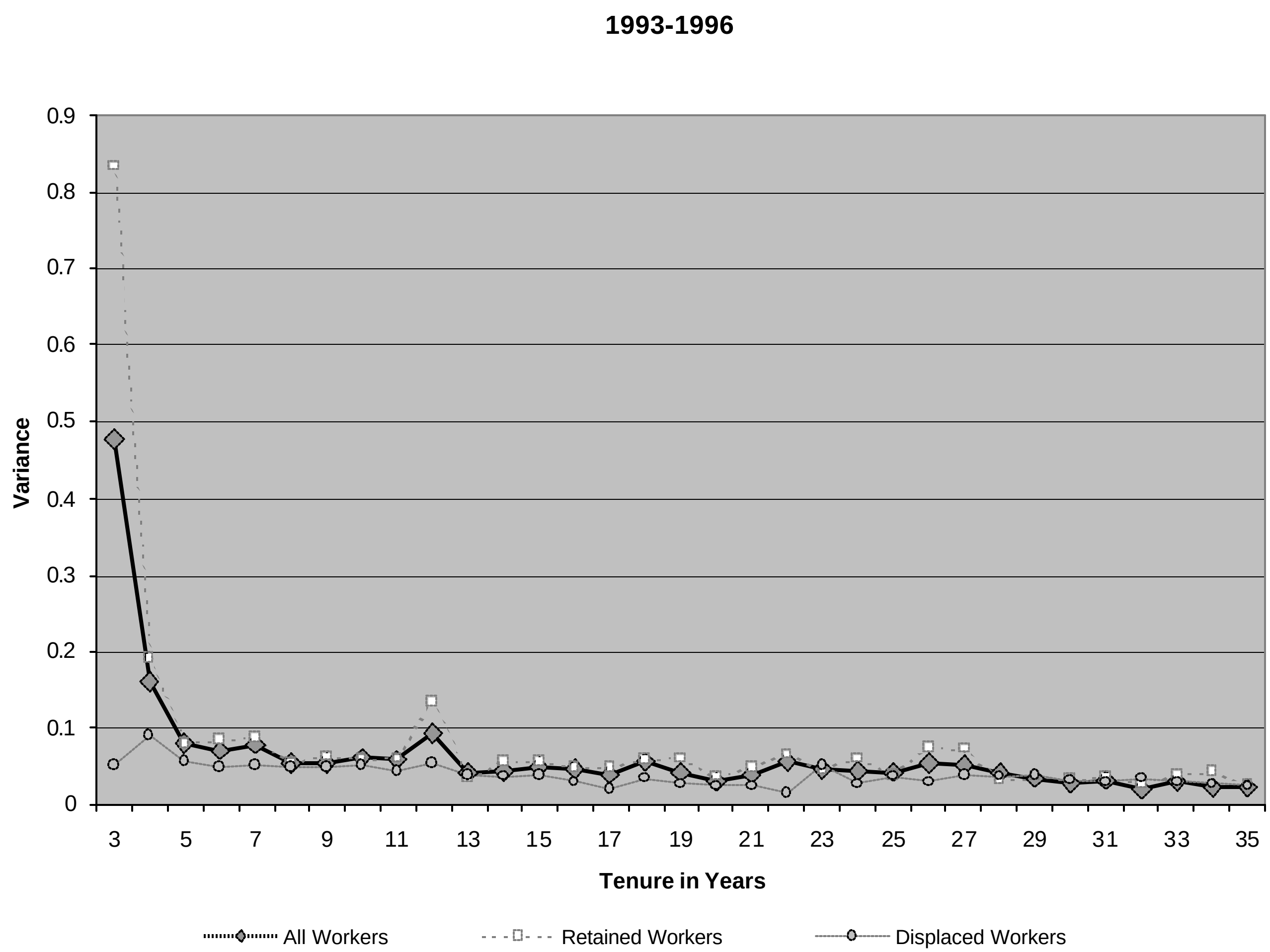
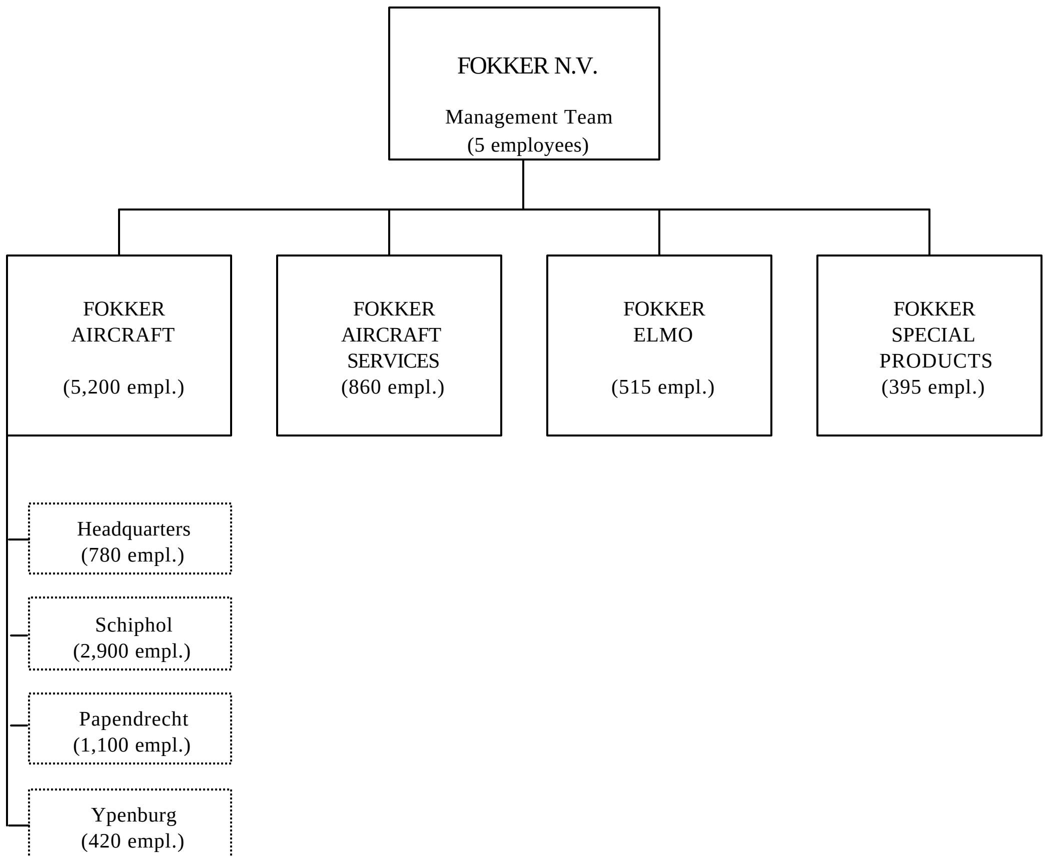


Chart 1

The Reorganization of a Bankrupt Company

Organizational Structure of FOKKER on January 23rd, 1996
(surseance of payments)



Organizational Structure of FOKKER on March 18th, 1996
(after the bankruptcy)

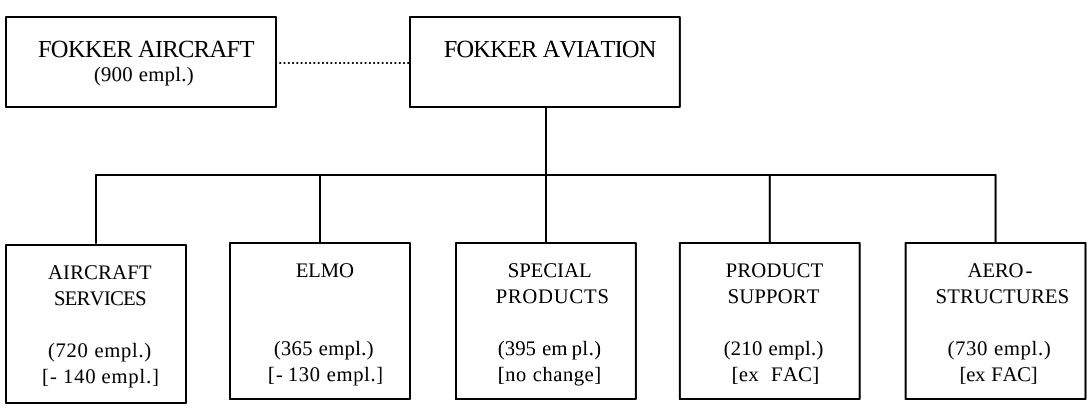


Table 1A

Hourly Wage and Wage Changes of Retained and Displaced Workers

Period	All Workers		Retained Workers		Displaced Workers	
	Level (in 1995 D*fl*)	% Change	Level (in 1995 D*fl*)	% Change	Level (in 1995 D*fl*)	% Change
1991-1996	24.27 (.12)[1]	10.26 (.13)	23.72 (.16)	10.28 (.19)	24.84 (.19)	10.23 (.19)
1993-1996	25.51 (.13)	4.69 (.05)	24.88 (.17)	4.86 (.07)	26.14 (.19)	4.51 (.07)
1995-1996	26.63 (.13)	.14 (.01)	26.05 (.18)	.19 (.02)	27.22 (.19)	.10 (.01)

[1] Standard errors of means are given in parentheses.

Table 1B

Hourly Wage Distributions in 1995 and 1996 for All Workers

	Hourly wage		Wage change	
Percentiles	**June 18, 1995**	**March 15, 1996**	**Levels**	**%**
			smallest	*smallest*
1%	15.2	15.2	-1.20	-6.43
5%	17.2	17.2	-.68	-3.00
10%	18.4	18.4	-.08	-.308
25%	21.1	21.1	.009	.087
50%	23.5	23.5	.021	.088
			largest	*largest*
75%	30.1	30.2	9.39	11.2
90%	39.1	39.4	9.50	16.6
95%	45.7	45.8	17.2	18.7
99%	61.7	64.7	18.9	31.6
Mean	26.6	26.8	.050	.145
(s.d)	(9.4)	(10.1)	(.44)	(.76)
Variance	89.1	102.1	.196	.57
Skewness	2.15	2.61	30.3	22.2

<u>**Table 2**</u>

Workers, Wage, Wage Growth and Dispersion of a Downsizing Firm and its Plants

	All plants FOKKER	**Plant 1 FSP**	**Plant 2 ELMO**	**Plant 3 FAS**	**Plant 4 Ypenburg**	**Plant 5 Papendrecht**	**Plant 6 Schiphol**
<u>**All workers**</u>	***5197***	***357***	***357***	***700***	***367***	***957***	***2459***
Layoffs (in %)	**49.6**	**0.8**	**11.8**	**12.3**	**.607**	**.635**	**.659**
Hourly wage	**26.8**	**24.9**	**22.0**	**24.1**	**23.2**	**22.8**	**30.6**
	(10.1)[1]	(7.5)	(7.7)	(7.7)	(5.8)	(5.6)	(11.4)
Wage change (in %)	**4.7**	**4.1**	**4.6**	**5.2**	**4.1**	**3.9**	**5.0**
1993-96	[4.6 ; 4.8][2]	[3.7 ; 4.5]	[4.2 ; 5.0]	[4.9 ; 6.0]	[3.7 ; 4.4]	[3.7 ; 4.1]	[4.9 ; 5.2]
<u>**Retained workers**</u>	***2619***	***354***	***315***	***614***	***144***	***349***	***843***
Hourly wage	**26.4**	**24.9**	**22.1**	**24.4**	**24.0**	**23.8**	**31.2**
	(9.9)	(7.5)	(8.0)	(7.9)	(5.6)	(6.4)	(11.8)
Wage change (in %)	**4.9**	**4.1**	**4.6**	**5.2**	**4.5**	**4.2**	**5.3**
1993-96	[4.7 ; 5.0]	[3.7 ; 4.5]	[4.2 ; 5.0]]	[4.9 ; 5.5]	[3.9 ; 5.1]	[3.9 ; 4.4]	[5.1 ; 5.6]
<u>**Displaced workers**</u>	***2578***	***3***	***42***	***86***	***223***	***608***	***1616***
Hourly wage	**27.3**	**23.8**	**21.1**	**22.1**	**22.7**	**22.2**	**30.4**
	(10.2)	(.27)	(4.9)	(6.0)	(5.9)	(5.0)	(11.2)
Wage change (in %)	**4.5**	**1.4**	**4.7**	**5.1**	**3.8**	**3.8**	**4.9**
1993-96	[4.4 ; 4.6]	[1.4 ; 1.5]	[3.6 ; 5.7]	[4.2 ; 6.0]	[3.4 ; 4.2]	[3.5 ; 4.0]	[4.7 ; 5.1]

[1] standard deviations in round parentheses; [2] 95%-confidence intervals in squared brackets.

Table 3.1

Wages, Wage Growth and Dispersion among Age Groups

AGE:	≤ 24	25-29	30-34	35-39	40-44	45-49	50-54
All workers	*116*	*681*	*1218*	*1182*	*814*	*708*	*478*
Layoffs (in %)	**44.8**	**46.5**	**50.4**	**49.6**	**48.6**	**48.4**	**56.5**
Retained workers							
Hourly wage	**15.6**	**19.6**	**23.5**	**26.8**	**29.0**	**30.9**	**35.2**
	(2.1)[1]	(3.1)	(4.7)	(6.9)	(10.5)	(11.6)	(17.5)
Wage change (in %)	**11.3**	**7.7**	**6.0**	**4.3**	**3.5**	**3.0**	**2.6**
1993-96	[10.4 ; 12.3][2]	[7.3 ; 8.0]	[5.7 ; 6.3]	[4.0 ; 4.6]	[3.2 ; 3.7]	[2.8 ; 3.3]	[2.3 ; 2.9]
Displaced workers							
Hourly wage	**15.3**	**20.0**	**24.1**	**28.2**	**31.4**	**32.4**	**31.3**
	(2.0)	(3.7)	(5.6)	(8.0)	(11.6)	(12.9)	(13.3)
Wage change (in %)	**9.8**	**7.3**	**6.0**	**4.4**	**3.2**	**2.3**	**2.1**
1993-96	[8.5 ; 11.1]	[7.0 ; 7.6]	[5.7 ; 6.3]	[4.1 ; 4.7]	[3.0 ; 3.4]	[2.1 ; 2.5]	[1.9 ; 2.3]

[1] standard deviations of mean in round parentheses; [2] 95%-confidence intervals in squared brackets

<u>**Table 3.2**</u>

Wages, Wage Growth and Dispersion among Tenure Groups

TENURE:	**≤ 7**	**8-11**	**12-17**	**18-22**	**23-29**	^{3} **30**
<u>**All workers**</u>	***864***	***1531***	***1336***	***712***	***485***	***269***
Layoffs (in %)	52.0	50.0	49.9	51.7	45.8	39.8
<u>**Retained workers**</u>						
Hourly wage	**22.7**	**24.0**	**26.8**	**28.8**	**33.0**	**29.1**
	(8.4)[1]	(8.1)	(9.6)	(10.1)	(13.8)	(7.5)
Wage change (in %)	**8.8**	**5.6**	**3.9**	**3.0**	**2.9**	**2.7**
1993-96	[8.3 ; 9.3][2]	[5.4 ; 5.9]	[3.6 ; 4.1]	[2.7 ; 3.3]	[2.6 ; 3.3]	[2.3 ; 3.0]
<u>**Displaced workers**</u>						
Hourly wage	**24.3**	**25.6**	**28.6**	**29.7**	**32.0**	**28.1**
	(8.1)	(8.8)	(11.4)	(11.2)	(11.1)	(6.7)
Wage change (in %)	**7.8**	**5.5**	**3.5**	**2.6**	**2.2**	**2.0**
1993-96	[7.4 ; 8.2]	[5.3 ; 5.7]	[3.3 ; 3.7]	[2.4 ; 2.8]	[2.0 ; 2.4]	[1.7 ; 2.3]

[1] standard deviations of mean in round parentheses; [2] 95% confidence intervals in squared brackets.

Table 3.3

Wages, Wage Growth, and Dispersion between Educational Groups

		Vocational Schooling	**General Schooling**
All workers		***3821***	***1376***
Layoffs (in %)		50.4	47.3
Retained workers			
Hourly wage		**26.2** (8.6)[1]	**26.7** (12.9)
Wage change (in %):	1993-96	**4.8** [4.6 ; 4.9][2]	**5.1** [4.8 ; 5.4]
Displaced workers			
Hourly wage		**27.1** (9.7)	**28.0** (11.6)
Wage change (in %):	1993-96	**4.6** [4.4 ; 4.7]	**4.3** [4.0 ; 4.6]

[1] standard deviations of mean in round parentheses
[2] 95% confidence intervals in squared brackets.

Table 3.4

Wage, Wage Growth, Dispersion, and Type of Job

		Production Workers	Managers
All workers		***3542***	***1655***
Layoffs (in %)		46.9	55.3
Retained workers			
Hourly wage		**21.8**	**37.8**
		(3.1)[1]	(12.0)
Wage change (in %)	1993-96	**4.2**	**6.6**
		[4.0 ; 4.3][2]	[6.3 ; 7.0]
Displaced workers			
Hourly wage		**21.8**	**37.3**
		(3.2)	(11.0)
Wage change (in %)	1993-96	**3.7**	**6.0**
		[3.6 ; 3.8]	[5.7 ; 6.2]

[1] standard deviations of mean in round parentheses
[2] 95% confidence intervals in squared brackets.

Table 3.5

Wages, Wage Growth, Dispersion, and On-the-Job-Training

	Internal Courses		External Courses	
	Below median (≤ 5)	**Above median (> 5)**	**Below median (≤ 1)**	**Above median (> 1)**
All workers	***2853***	***2344***	***3911***	***1286***
Layoffs (in %)	53.9	44.3	49.5	49.8
Retained workers				
Hourly wage	**27.9** (12.7)[1]	**24.8** (5.7)	**25.8** (10.4)	**28.0** (8.4)
Wage change (in %) 1993-96	**5.1** [4.9 ; 5.3] [2]	**4.6** [4.4 ; 4.8]	**4.6** [4.5 ; 4.8]	**5.6** [5.3 ; 5.8]
Displaced workers				
Hourly wage	**28.6** (11.9)	**25.5** (6.7)	**26.6** (10.6)	**29.7** (8.4)
Wage change (in %) 1993-96	**4.6** [4.4 ; 4.8]	**4.4** [4.2 ; 4.6]	**4.2** [4.0 ; 4.3]	**5.5** [5.2 ; 5.8]

[1] standard deviations of mean in round parentheses; [2] 95% confidence intervals in squared brackets.

Table 3.6

Wages, Wage Growth, Dispersion, and Job Performance Evaluation

	Low Scores (1,2,3)	High Scores (4,5,6)
All workers	***2789***	***2407***
Layoffs (in %)	.541	.444
Retained workers		
Hourly wage	**28.3** (11.7)[1]	**24.5** (7.4)
Wage change (in %) 1993-96	**5.8** [5.5 ; 6.0][2]	**4.0** [3.8 ; 4.2]
Displaced workers		
Hourly wage	**29.3** (11.3)	**24.6** (7.6)
Wage change (in %) 1993-96	**5.1** [4.9 ; 5.3]	**3.7** [3.5 ; 3.9]

[1] standard deviations of mean in round parentheses
[2] 95% confidence intervals in squared brackets.

Table 3.7

Wages, Wage Growth, and Dispersion for Women and Men

		Females	Males
All workers		***568***	***4629***
Layoffs (in %)		40.7	50.7
Retained workers			
Hourly wage		**20.5**	**27.2**
		(5.3)[1]	(10.2)
Wage change (in %)	1993-96	**5.0**	**4.8**
		[4.5 ; 5.6][2]	[4.7 ; 5.0]
Displaced workers			
Hourly wage		**23.4**	**27.7**
		(6.7)	(10.4)
Wage change (in %)	1993-96	**4.6**	**4.5**
		[4.0 ; 5.3]	[4.4 ; 4.6]

[1] standard deviations of mean in round parentheses
[2] 95% confidence intervals in squared brackets.

Table 3.8

Wage, Wage Growth, Uncertainty, and Marital Status

		Unmarried (incl. Divorced)	Married
All workers		***1906***	***3287***
Layoffs (in %)		55.1	46.4
Retained workers			
Hourly wage		**23.8** (8.1)	**27.6** (10.5)
Wage change (in %)	1993-96	**5.9** [5.7 ; 6.2]	**4.3** [4.2 ; 4.5]
Displaced workers			
Hourly wage		**25.2** (8.3)	**28.8** (11.1)
Wage change (in %)	1993-96	**5.6** [5.4 ; 5.9]	**3.8** [3.6 ; 3.9]

[1] standard deviations of mean in round parentheses
[2] 95% confidence intervals in squared brackets.

Table 4

Residual Wage Growth Variances Through Time

	Residual Wage Growth Variance		
	1991-1996	**1993-1996**	**1995-1996**
Retained workers			
Mean	**25.9**	**7.66**	**.98**
Std.Err.	1.09	.98	.42
[95% Conf. Interval]	[23.8 ; 28.0]	[5.7 ; 9.6]	[.15 ; 1.8]
Displaced workers			
Mean	**24.2**	**5.45**	**.21**
Std.Err.	.91	.64	.14
[95% Conf. Interval]	[22.5 ; 26.0]	[4.2 ; 6.7]	[.00 ; .48]
Option Value Ratio	**1.07**	**1.41**	**4.67**

Table 5

Heterogeneous Firing Costs, Productivity Growth Uncertainty, and Layoff Probabilities

	I	II	III	IV	V	VI	VII	VIII
	Baseline Model		Symmetric Value Models				Asymmetric Value Models	
Firing Costs:								
$\mathbf{W}_i$		-.076 * (.021)	-.071 * (.021)	-.074 * (.021)	-.074 * (.022)	-.071 * (.022)	-.070 * (.022)	-.073 * (.022)
Uncertainty: ***1991-1996***								
$\hat{s}_i^m$		-.001 (.044)			.076 (.053)			
$\hat{s}_i^m \mid \hat{e}_i^m < 0$						.150 * (.074)		.040 (.089)
$\hat{s}_i^m \mid \hat{e}_i^m \geq 0$						-.055 (.049)		.080 (.063)
Uncertainty: ***1993-1996***								
$\hat{s}_i^m$			-.377 * (.158)		-.475 * (.204)			
$\hat{s}_i^m \mid \hat{e}_i^m < 0$							1.135 * (.394)	1.075 * (.461)
$\hat{s}_i^m \mid \hat{e}_i^m \geq 0$							-.549 * (.171)	-.691 * (.228)
Uncertainty:(1) ***1995-1996***								
$\hat{s}_i^m$				-.472 + (.270)	-.158 (.307)			.015 (.316)
Pseudo-R^2	.158	.160	.161	.161	.162	.161	.164	.164
Log L	-2730.5	-2724.1	-2721.1	-2722.6	-2719.8	-2721.1	-2712.9	-2712.0
# Observations	4683	4683	4683	4683	4683	4683	4683	4683

* Coefficients (std.err.) reported; p -value of z-score < .05

\+ p-value of z-score < .10

(1) Variation of $\hat{s}_i^{95-96}$ insufficiently large to warrant asymmetric effects.

Table 6

Workers' Characteristics and Layoff Probabilities

	Mean (Std.Dev.)	**Coefficient** (Std.Err.)	**Marginal Change** (Std.Err.)	**z-score** [p-value]
Plants				
ELMO: Plant 2	.071 (.26)	-1.59 (.103)	-.472 (.016)	-15.5 [.000]
FAS: Plant 3	.138 (.34)	-1.58 (.076)	-.498 (.014)	-20.9 [.000]
FAC Ypenburg: Plant 4	.070 (.25)	.009 (.079)	.004 (.032)	.116 [.908]
FAC Papendrecht: Plant 5	.201 (.40)	-.044 (.060)	-.018 (.024)	-.731 [.465]
Age (in years)				
≤ 24	22.7 (1.41)	.299 (.236)	.119 (.094)	1.27 [.204]
25-29	27.4 (1.39)	.211 (.191)	.084 (.077)	1.10 [.270]
30-34	32.0 (1.40)	.184 (.166)	.074 (.066)	1.14 [.265]
35-39	36.9 (1.39)	.186 (.146)	.074 (.058)	1.27 [.203]
40-44	42.0 (1.40)	.164 (.129)	.066 (.051)	1.28 [.202]
45-49	47.0 (1.42)	.153 (.116)	.061 (.046)	1.32 [.186]
50-54	52.0 (1.39)	.191 (.106)	.076 (.042)	1.82 [.069]
Tenure (in years)				
≤ 7	4.90 (1.19)	-.383 (.356)	-.153 (.142)	-1.08 [.281]
8-11	9.12 (1.33)	-.308 (.213)	-.122 (.085)	-1.45 [.148]
12-17	15.0 (1.36)	-.225 (.135)	-.090 (.054)	-1.67 [.096]
18-22	20.1 (1.19)	-.155 (.106)	-.062 (.042)	-1.47 [.143]
23-29	26.1 (1.82)	-.170 (.084)	-.068 (.033)	-2.03 [.042]
≥ 30	32.9 (2.48)	-.110 (.071)	-.044 (.028)	-1.55 [.121]

Table 6 *(continued)*

	Mean (Std.Dev.)	Coefficient (Std.Err.)	Marginal Change[1] (Std.Err.)	z-score [p-value]
Education[2]				
Reference group: vocational schooling basic level				
General schooling:				
Basic Level	.144	-.173	-.069	-2.41
	(.35)	(.072)	(.028)	[.016]
Lower Level	.081	-.083	-.033	-.95
	(.27)	(.088)	(.035)	[.343]
Medium Level	.024	-.020	-.008	-.140
	(.15)	(.144)	(.058)	[.888]
Higher Level	.016	-.339	-.133	-1.98
	(.13)	(.171)	(.064)	[.047]
Vocational schooling:				
Lower Level	.196	-.024	-.010	-.41
	(.40)	(.059)	(.024)	[.683]
Medium Level	.105	.065	.026	.72
	(.31)	(.090)	(.036)	[.471]
Higher Level	.036	.436	.170	3.31
	(.46)	(.132)	(.048)	[.001]
Performance evaluation	3.57	-.236	-.094	-7.48
	(.72)	(.032)	(.012)	[.000]
Training Courses				
Internal courses	7.05	-.017	-.007	-5.23
	(6.82)	(.003)	(.001)	[.000]
External courses	1.04	.010	.004	.72
	(1.48)	(.014)	(.005)	[.471]
Manager	.306	-.330	-.131	-4.78
	(.46)	(.069)	(.027)	[.000]
Male	.888	.004	.001	.05
	(.31)	(.082)	(.033)	[.961]
Married	.641	-.115	-.046	-2.88
	(.48)	(.044)	(.018)	[.010]
Regression statistics	# Obs: 4683	Log ***L***: -2713	Pseudo-R^2:	.164

[1] Unit change for dummy variables.

[2] The basic level of vocational schooling (the reference group) refers to secundary schooling only extended with an apprenticeship program (*leerlingwezen*) enforced by Dutch law for people of ages 16 or below. Lower level vocational schooling refers is *lager beroepsonderwijs*. Medium level vocational schooling refers to *middelbaar beroepsonderwijs*. Higher level vocational schooling level 4 refers to *hoger beroepsonderwijs* of *technische universiteit.* The basic level of general schooling refers to secundary schooling only extended with a general learning program enforced by Dutch law for people of ages 16 or below. Lower level general schooling refers to *mavo.* Medium level general schooling level 3 refers to *havo/vwo*. Higher level general schooling refers to non-technical university.

IZA Discussion Papers

No	Author(s)	Titel	Area	Date
221	C. Grund	Wages as Risk Compensation in Germany	5	12/00
222	W.P.M. Vijverberg	Betit: A Family That Nests Probit and Logit	7	12/00
223	M. Rosholm M. Svarer	Wages, Training, and Job Turnover in a Search-Matching Model	1	12/00
224	J. Schwarze	Using Panel Data on Income Satisfaction to Estimate the Equivalence Scale Elasticity	3	12/00
225	L. Modesto J. P. Thomas	An Analysis of Labour Adjustment Costs in Unionized Economies	1	12/00
226	P. A. Puhani	On the Identification of Relative Wage Rigidity Dynamics: A Proposal for a Methodology on Cross-Section Data and Empirical Evidence for Poland in Transition	4/5	12/00
227	L. Locher	Immigration from the Eastern Block and the former Soviet Union to Israel: Who is coming when?	1	12/00
228	G. Brunello S. Comi C. Lucifora	The College Wage Gap in 10 European Countries: Evidence from Two Cohorts	5	12/00
229	R. Coimbra T. Lloyd-Braga L. Modesto	Unions, Increasing Returns and Endogenous Fluctuations	1	12/00
230	L. Modesto	Should I Stay or Should I Go? Educational Choices and Earnings: An Empirical Study for Portugal	5	12/00
231	G. Saint-Paul	The Economics of Human Cloning	5	12/00
232	E. Bardasi M. Francesconi	The Effect of Non-Standard Employment on Mental Health in Britain	5	12/00
233	C. Dustmann C. M. Schmidt	The Wage Performance of Immigrant Women: Full-Time Jobs, Part-Time Jobs, and the Role of Selection	1	12/00
234	R. Rotte M. Steininger	Sozioökonomische Determinanten extremistischer Wahlerfolge in Deutschland: Das Beispiel der Europawahlen 1994 und 1999	3	12/00

235	W. Schnedler	Who gets the Reward? An Empirical Exploration of Bonus Pay and Task Characteristics	5	12/00
236	R. Hujer M. Caliendo	Evaluation of Active Labour Market Policy: Methodological Concepts and Empirical Estimates	6	12/00
237	S. Klasen I. Woolard	Surviving Unemployment without State Support: Unemployment and Household Formation in South Africa	3	12/00
238	R. Euwals A. Börsch-Supan A. Eymann	The Saving Behaviour of Two Person House-holds: Evidence from Dutch Panel Data	5	12/00
239	F. Andersson K. A. Konrad	Human Capital Investment and Globalization in Extortionary States	5	01/01
240	W. Koeniger	Labor and Financial Market Interactions: The Case of Labor Income Risk and Car Insurance in the UK 1969-95	5	01/01
241	W. Koeniger	Trade, Labor Market Rigidities, and Government-Financed Technological Change	2	01/01
242	G. Faggio J. Konings	Job Creation, Job Destruction and Employment Growth in Transition Countries in the 90's	4	01/01
243	E. Brainerd	Economic Reform and Mortality in the Former Soviet Union: A Study of the Suicide Epidemic in the 1990s	4	01/01
244	S. M. Fuess, Jr. M. Millea	Pay and Productivity in a Corporatist Economy: Evidence from Austria	5	01/01
245	F. Andersson K. A. Konrad	Globalization and Human Capital Formation	5	01/01
246	E. Plug W. Vijverberg	Schooling, Family Background, and Adoption: Does Family Income Matter?	5	01/01
247	E. Plug W. Vijverberg	Schooling, Family Background, and Adoption: Is it Nature or is it Nurture?	5	01/01
248	P. M. Picard E. Toulemonde	The Impact of Labor Markets on Emergence and Persistence of Regional Asymmetries	2	01/01
249	B. M. S. van Praag P. Cardoso	"Should I Pay for You or for Myself?" The Optimal Level and Composition of Retirement Benefit Systems	3	01/01
250	T. J. Hatton J. G. Williamson	Demographic and Economic Pressure on Emigration out of Africa	1	01/01

251	R. Yemtsov	Labor Markets, Inequality and Poverty in Georgia	4	01/01
252	R. Yemtsov	Inequality and Income Distribution in Georgia	4	01/01
253	R. Yemtsov	Living Standards and Economic Vulnerability in Turkey between 1987 and 1994	4	01/01
254	H. Gersbach A. Schniewind	Learning of General Equilibrium Effects and the Unemployment Trap	3	02/01
255	H. Gersbach A. Schniewind	Product Market Reforms and Unemployment in Europe	3	02/01
256	T. Boeri H. Brücker	Eastern Enlargement and EU-Labour Markets: Perceptions, Challenges and Opportunities	2	02/01
257	T. Boeri	Transition with Labour Supply	4	02/01
258	M. Rosholm K. Scott L. Husted	The Times They Are A-Changin': Organizational Change and Immigrant Employment Opportunities in Scandinavia	1	02/01
259	A. Ferrer-i-Carbonell B. M.S. van Praag	Poverty in the Russian Federation	4	02/01
260	P. Cahuc F. Postel-Vinay	Temporary Jobs, Employment Protection and Labor Market Performance	1/3	02/01
261	M. Lindahl	Home versus School Learning: A New Approach to Estimating the Effect of Class Size on Achievement	5	02/01
262	M. Lindahl	Summer Learning and the Effect of Schooling: Evidence from Sweden	5	02/01
263	N. Datta Gupta N. Smith	Children and Career Interruptions: The Family Gap in Denmark	5	02/01
264	C. Dustmann	Return Migration, Wage Differentials, and the Optimal Migration Duration	1	02/01
265	M. Rosholm M. Svarer	Structurally Dependent Competing Risks	1	02/01
266	C. Dustmann O. Kirchkamp	The Optimal Migration Duration and Activity Choice after Re-migration	1	02/01

267	A. Newell	The Distribution of Wages in Transition Countries	4	03/01
268	A. Newell B. Reilly	The Gender Pay Gap in the Transition from Communism: Some Empirical Evidence	4	03/01
269	H. Buddelmeyer	Re-employment Dynamics of Disabled Workers	3	03/01
270	B. Augurzky C. M. Schmidt	The Evaluation of Community-Based Interventions: A Monte Carlo Study	6	03/01
271	B. Augurzky C. M. Schmidt	The Propensity Score: A Means to An End	6	03/01
272	C. Belzil J. Hansen	Heterogeneous Returns to Human Capital and Dynamic Self-Selection	5	03/01
273	G. Saint-Paul	Distribution and Growth in an Economy with Limited Needs	5	03/01
274	P. J. Pedersen N. Smith	Unemployment Traps: Do Financial Dis-incentives Matter?	3	03/01
275	G. S. Epstein T. Lecker	Multi-Generation Model of Immigrant Earnings: Theory and Application	1	03/01
276	B. Amable D. Gatti	The Impact of Product Market Competition on Employment and Wages	5	03/01
277	R. Winter-Ebmer	Evaluating an Innovative Redundancy-Retraining Project: The Austrian Steel Foundation	6	03/01
278	T. M. Andersen	Welfare Policies, Labour Taxation and International Integration	2	04/01
279	T. M. Andersen	Product Market Integration, Wage Dispersion and Unemployment	2	04/01
280	P. Apps R. Rees	Household Saving and Full Consumption over the Life Cycle	7	04/01
281	G. Saint-Paul	Information Technology and the Knowledge Elites	5	04/01
282	J. Albrecht A. Björklund S. Vroman	Is There a Glass Ceiling in Sweden?	5	04/01

283	M. Hagedorn A. Kaul V. Reinthaler	Welfare Analysis in a Schumpeterian Growth Model with Capital	7	04/01
284	H. Rapoport A. Weiss	The Optimal Size for a Minority	1	04/01
285	J. Jerger C. Pohnke A. Spermann	Gut betreut in den Arbeitsmarkt? Eine mikroökonometrische Evaluation der Mannheimer Arbeitsvermittlungsagentur	5	04/01
286	M. Fertig C. M. Schmidt	First- and Second-Generation Migrants in Germany –What Do We Know and What Do People Think	1	04/01
287	P. Guggenberger A. Kaul M. Kolmar	Efficiency Properties of Labor Taxation in a Spatial Model of Restricted Labor Mobility	3	04/01
288	D. A. Cobb-Clark	Getting Ahead: The Determinants of and Payoffs to Internal Promotion for Young U.S. Men and Women	5	04/01
289	L. Cameron D. A. Cobb-Clark	Old-Age Support in Developing Countries: Labor Supply, Intergenerational Transfers and Living Arrangements	3	04/01
290	D. A. Cobb-Clark M. D. Connolly C. Worswick	The Job Search and Education Investments of Immigrant Families	1	04/01
291	R. T. Riphahn	Cohort Effects in the Educational Attainment of Second Generation Immigrants in Germany: An Analysis of Census Data	1	05/01
292	E. Wasmer	Between-group Competition in the Labor Market and the Rising Returns to Skill: US and France 1964-2000	5	05/01
293	D. Cobb-Clark T. F. Crossley	Gender, Comparative Advantage and Labor Market Activity in Immigrant Families	1	05/01
294	Š. Jurajda	Estimating the Effect of Unemployment Insurance Compensation on the Labor Market Histories of Displaced Workers	3	05/01
295	F. Duffy P. P. Walsh	Individual Pay and Outside Options: Evidence from the Polish Labour Force Survey	4	05/01
296	H. S. Nielsen M. Rosholm N. Smith L. Husted	Intergenerational Transmissions and the School-to-Work transition of 2^{nd} Generation Immigrants	1	05/01

297	J. C. van Ours J. Veenman	The Educational Attainment of Second Generation Immigrants in The Netherlands	1	05/01
298	P. Telhado Pereira P. Silva Martins	Returns to Education and Wage Equations	5	06/01
299	G. Brunello C. Lucifora R. Winter-Ebmer	The Wage Expectations of European College Students	5	06/01
300	A. Stutzer R. Lalive	The Role of Social Work Norms in Job Searching and Subjective Well-Being The Role of Social Work	5	06/01
301	J. R. Frick G.G. Wagner	Economic and Social Perspectives of Immigrant Children in Germany	1	06/01
302	G. S. Epstein A. Weiss	A Theory of Immigration Amnesties	1	06/01
303	G. A. Pfann B. F. Blumberg	Social Capital and the Uncertainty Reduction of Self-Employment	5	06/01
304	P. Cahuc E. Wasmer	Labour Market Efficiency, Wages and Employment when Search Frictions Interact with Intra-firm Bargaining	2	06/01
305	H. Bonin	Fiskalische Effekte der Zuwanderung nach Deutschland: Eine Generationenbilanz	1	06/01
306	H. Bonin G. Abío E. Berenguer J. Gil C. Patxot	Is the Deficit under Control? A Generational Accounting Perspective on Fiscal Policy and Labour Market Trends in Spain	2	06/01
307	G. A. Pfann	Downsizing	1/5	06/01

An updated list of IZA Discussion Papers is available on the center‘s homepage *www.iza.org*.