

Downsizing

Gerard A. Pfann*

ABSTRACT: This paper suggests that in order to optimally reorganize its workforce a firm sorts all incumbent workers according to each worker's expected future value. Once the size of the reorganization has been determined, the lowest value workers will be dismissed. A structural labor demand model with menu costs derived from heterogeneous irreversible firing costs is presented to determine a worker's idiosyncratic value to the firm. An econometric analysis using personnel records from a European aircraft building firm shows that a reorganizational design that accounts for idiosyncratic firing costs reduces the total downsizing costs by more than 25 percent.

Keywords: Firing costs; menu costs; value of the firm

JEL Codes: J61

* Business Investment Research Center, Maastricht University, The Netherlands; IZA, Bonn, Germany; and C.E.P.R., U.K. I gratefully acknowledge Fokker's bankruptcy trustees, especially Ben Knüppe, for making the personnel data available to me, and Louis Deterink for sharing with me his profound knowledge and insights on corporate through-starts. I thank the N.W.O. PIONIER program for financial support. I thank Joe Altonji, Jan Eberly, Mike Gibbs, Dan Hamermesh, Boyan Jovanovic, Bob LaLonde, and Dale Mortensen for fruitful discussions, and seminar participants at Northwestern University, the University of Chicago Graduate Schools of Business and Public Policy, and Bonn University for helpful comments. All errors are my own.

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 dismissal 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 also lead to differences in recruitment and layoff probabilities. In this paper I take a microscopic look at the layoff policy of a firm in demise, and study the actual layoffs to learn more about the

impact of heterogeneous variations in firing costs on the value of the firm, and how observed 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). 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 probabilities also vouches workers' continuing but unequal displacement risks due to economic redundancy. In fact, for the U.S. 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 year¹. The losses foreseen by displaced workers are considerable (Hamermesh, 1987), and 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 optimally formulates its downsizing 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 dynamic labor demand under fixed costs regimes at the firm level have only been analyzed empirically under the assumption of myopic foresight. This paper estimates a structural forward looking model in closed form that is derived from displacement rules of a firm that reduces its workforce under uncertainty while facing heterogeneous irreversible firing costs. Due to the nature of firing costs, workforce reductions are often lumpy. Optimal rules are cast in terms of

cut-off values for expected profit levels of individual workers. A worker with an estimated high cut-off point will be dismissed, while a worker with an estimated low cut-off point will be kept. The breaking point is predetermined by the anticipated monetary savings of the reorganization and hence by the size of the mass displacement. Other things equal, workers that have different values of uncertainty attached to their current profit estimates by the firm have different probabilities of being retained. Two-sided employer-employee learning makes it worthwhile though to outspread a sizable workforce reduction over a sequence of lumps rather than 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. Once workforce reduction is immediate, the menu costs rules apply but the waiting time is foregone. This opens up the possibility to study the workings of the menu costs rules in a downsizing firm from observed retaining and dismissal decisions at the instant of reorganization.

The empirical application is based on a case of bankruptcy in the European aircraft industry. The model produces sharp predictions on how individual worker characteristics affect cutoffs. These predictions are comparable to those derived from (S,s) rules for durable and investment goods (Eberly (1994), Caballero and Engel (1999)). I simply ask whether the bankruptcy trustees in charge of creating a new viable firm out of an old bankrupt one are applying such rules when deciding which workers to select for the new company. The alternative model -- used to test the menu costs model -- is the standard net present value model that would result if firing costs would not depend on the individual worker but would be fixed and depend on the overall reduction of the workforce. That model has often been suggested for macroeconomic policy analysis of the role of firing costs on the overall

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.

employment, and primarily tested empirically with aggregate labor market data (Bentolila and Bertola, 1990).

The Dutch aircraft manufacturer Fokker, with headquarters based in Amsterdam, went bankrupt on March 15th, 1996. The trustees restructured Fokker directly after the bankruptcy, and created a new company from the old ones' viable parts. At the time of the bankruptcy the company employed 6,970 workers, divided over six geographically dispersed divisions. The new company, created within 48 hours 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). The proceeds of this transaction were used to pay off the -- preferred -- creditors. The estimated value gained from using the menu costs model with heterogeneous firing costs rather than the prevalent fixed costs model prevalent added up to more than 25 percent of total firing costs.

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 workers' variety in firing costs as well as expected heterogeneous future profit growth and idiosyncratic uncertainty are integrated into the new company's expected present value. Section 6 discusses possible generalizations of the analysis and policy implications. Section 7 concludes.

II. Reorganization under Heterogeneous Irreversible Firing Costs and 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 $Y_G(X)$. The hiring firm can invest Q to sprout a new worker's firm-specific talents to produce $Y_S(X, Q)$ 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 costs, 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 firing firm faces firing costs when reducing the size of its workforce. 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 allows for the in-depth investigation of the selection process of a firm when making choices about which workers to fire. In addition to worker-specific firing costs, idiosyncratic profit growth and the accompanying uncertainty determine the firm's optimal layoff decisions under uncertainty. 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 $0 < 1 - S(X, Q) < 1$ for the worker. The stochastic profit that a firm can obtain from investing Q is defined as

$$(1) \quad \Pi^*(X, Q) = Y_G(X) - W_G(X) + Y_S(X, Q) - W_S(X, Q),$$

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 $Q^* < \infty$, 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. If $Y_G(X)$ grows through time, then $Y_G(X) - W_G(X) - F > 0$ in the future. The stochastic part of the future profits of a worker for the firm is defined as

$$(2) \quad \Pi(X, Q) = Y_G(X) - W_G(X, Q) + Y_s(X, Q).$$

The stochastic part of the worker-specific profit, $\Pi(X, Q)$, becomes more uncertain the farther in time lies the horizon over which the returns of the investment will be discounted. The optimal rules for downsizing are cast in terms of cut-off values Π_L for current profit levels. The expression for Π_L in closed form is derived in Appendix I and yields

$$(3) \quad \Pi_L = \left(\frac{\rho - \mu}{\rho} \right) \left(\frac{\lambda_0}{\lambda_0 - 1} \right) (W_s - \rho F).$$

Equation (3) predicts which workers a downsizing firm is most likely to retain. Since $\rho > \mu$ and $\lambda_0 < 0$, the first two terms on the right hand side are positive. The last term must be positive for all incumbent workers as well, since $Q > F$, so that the worker would otherwise not have been hired. Thus the cut-off value Π_L is always positive and can be interpreted as the firm's inclination to retain workers: the lower Π_L , the more reluctant the firm is to fire workers, and *vice versa*. It is now possible to predict how changes in ρ , μ , σ^μ , W_s , and F separately would alter Π_L . The predictions are as follows.

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

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 $d\Pi/\Pi$ could be extended with an exponentially distributed Poisson process dn with mean λ_0/τ . The probability of a bankruptcy ($dn = -1$) is equal to τdt . Equation (3) then becomes

$$(3') \quad \Pi_L = \left(\frac{\rho + \tau - \mu}{\rho + \tau} \right) \left(\frac{\lambda_0}{\lambda_0 - 1} \right) (W_S - (\rho + \tau)F).$$

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

Prediction 2: $\partial\Pi_L / \partial\mu < 0$ (Figure 1, Graph A)

The downsizing firm is more likely to retain workers with higher expected within-firm profit 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: $\partial\Pi_L / \partial\sigma^\mu < 0$ (Figure 1, Graph B)

The downsizing firm prefers workers with more uncertain future profit growth for the same reason why growing firms like these workers: the chance of higher profit also increases the firm’s share in this worker’s expected future returns and is therefore more likely to be retained. This result refutes the proposition put forward by Lazear (1995) that a declining firm prefers risk-free workers to ‘risky’ workers. The model with irreversibility and uncertainty predicts that even a firm in demise can benefit from the uncertainty of a worker’s future profit 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 this worker's S is lower for the firm and so is her or his value to the firm. I refer to a high S as a better quality of the match. 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 Nickell (1978) and Bentolila and Bertola (1990) for aggregate employment. At the individual worker level statutory replacement costs are born by the firm. It is therefore that idiosyncratic firing costs enter the firm's strategic decision making process of designing an optimal contingency plan to reduce its workforce.

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 profit 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 expected profit growth, and the smallest layoff option value. The idiosyncratic layoff option value results from the irreversible character of heterogeneous firing costs and future uncertainty about each worker's profit growth. The importance of firing costs 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 The Wage Policy of 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 1 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.

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 (see Chart 1). 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 the newly created company named Fokker Aviation B.V., which 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. 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 dismissal 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 annual performance evaluation outcomes.

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 ≤ 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 eldest 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 ≤ 7 years ; 8-11 years; 12-17 years; 18-22 years; 23-29 years; and ≥ 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 be dismissed. 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 had 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 kept 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 dismissed 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 considerably more variation 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*

Information on 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

The company evaluated each worker's job performance every year. The scores ranged between 1 (bad) and 6 (excellent). Table 3.6 shows statistics similar as the ones before but now for workers with high or low performance evaluation scores. With a sample mean of 3.5, low scores are 1,2 and 3, and high scores are 4,5, and 6. It appears that 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 of the 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

Once the size of the restructuring is determined, and consequently $N-M$ and Π_L , the firm seeks M out of N workers to keep as to maximize the sum of discounted future values $V(\Pi_{Li})$, $i=1, \dots, M$, of all expected returns from its investment Q in each worker, with Π_{Li} being the firm's idiosyncratic cut-off boundary for worker i . The downsizing problem under uncertainty then yields

$$(4) \quad \text{Max} V(\Pi_L^M) = \text{Max} \sum_{i=1}^M V(\Pi_{Li}).$$

$V(\Pi_{Li})$ is monotonous in Π_{Li} , so that we would only need to know Π_{Li} for all workers, order all workers by the size of Π_{Li} , and then, since a lower boundary implies a higher expected future profit and a lower likelihood of being dismissed, select the smallest M from the sorted array. However, the non-linearity of equation (3) in ρ , μ , and σ^μ makes it cumbersome to analyze every worker's layoff boundary Π_{Li} . I suggest using linearized decision rules instead, and express Π_{Li} in linear form as follows

$$(5) \quad \Pi_{Li} = \frac{\partial \Pi}{\partial \rho} \rho + \frac{\partial \Pi}{\partial \mu} \mu_i + \frac{\partial \Pi}{\partial \sigma^\mu} \sigma_i^\mu + \frac{\partial \Pi}{\partial W_s} W_{si} + \frac{\partial \Pi}{\partial F} F_i + O(\pi_i^2),$$

(+) (-) (-) (+) (-)

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

4.1 Cut-off Rules

Π_L and Π_{Li} are not observed. But what is known is how many and which workers are retained or dismissed. This gives the following employment decision rules

Retain worker i, or $\mathbb{I}\Pi_{Li} = 0$ *iff* $\Pi_{Li} \leq \Pi_L$, *and*

Dismiss worker i, or $\mathbb{I}\Pi_{Li} = 1$ *iff* $\Pi_{Li} > \Pi_L$.

$\mathbb{I}\Pi_{Li}$ is a layoff indicator variable. For each worker, the layoff expectation yields

$$(6) \quad E\{\Pi_{Li} > \Pi_L\} = \pi^\rho \rho + \pi^\mu \mu_i + \pi^\sigma \sigma_i^\mu + \pi^{W_s} W_{Si} + \pi^F F_i + \Pi_L \equiv \pi \Lambda_i,$$

with the lower case π 's denoting the respective partial derivatives given in (5). If $O(\pi_i^2)$ is standard normally distributed, a worker's layoff probability becomes

$$(7) \quad \Pr(\Pi_{Li} > \Pi_L) = \Pr(\mathbb{I}\Pi_{Li} = 1) = \Phi(\pi \Lambda_i).$$

Next, the quest is to obtain observations on ρ , μ_i , σ_i^μ , W_{Si} , and F_i for all workers.

4.2 A Direct Measure of Idiosyncratic Firing Costs (F_i)

Firing costs are associated with the period of notice to terminate a job contract. Job contracts may be cancelled either by the employer or the employee. Employment contracts in bankruptcies are discontinued as an act of the designated trustees. The employer's term of notice (ToN) is legally defined in Articles 1639i and 1639j of the Netherlands Civil Code and Article 40.3 of the Bankruptcy Act. The ToN is usually equal to the time that passes between two consecutive earnings installments but not more than 6 weeks (Fokker had a monthly earnings payment scheme). For tenured employees the ToN is at least as many weeks as the number of years the employee has worked full time for the same employer since adulthood (18 years and older), but not more than 13 weeks. The employer's ToN is extended with one week for every full year during which an employee, after becoming 45 years of age, has been employed. This extension can never be more than 13 weeks. As of the day of bankruptcy all earnings payments and other associated costs are considered bankruptcy dept and the employees – or their collective representatives - are legal primary claimants.

Example 1: A 25 years old worker earns a gross monthly salary of 3,500 guilders. At the day of the bankruptcy he has worked three years and 5 months as a tenured employee for the firm. His *ToN* is 1 month and the firing costs the bankruptcy trustee is facing is equal to his monthly wage costs that is equal to 3,500 guilders plus the associated employer labor costs.

Example 2: A 49 years old worker earns a gross monthly salary of 7,800 guilders. At the day of the bankruptcy she has worked 21 years and 9 months in tenured positions at the firm. Her maximum tenure *ToN* is equal to 13 weeks plus an age extension of 4 weeks. The firing costs for her are $(13+3)*(12/52)*7,800=28,800$ guilders plus associated costs.

The *ToN* lasts only until the day of retirement. Since 1991 Fokker had installed an early retirement plan for workers being 55 years or older. So the firing costs for workers of 54 years of age can be lower than for workers who are 53 years old.

Example 3: A 54 years old worker earns a gross monthly salary of 5,200 guilders. At the day of the bankruptcy he has worked 32 years and two months for the firm. At the day of the bankruptcy he is only 6 weeks away from his 55th birthday. Without the early retirement plan, the *ToN* would have been $13+9=22$ weeks. But as a result of the retirement plan, the *ToN* is now only 6 weeks and the firing costs the firm faces for this worker yields $6*(12/52)*5,200=7,200$ guilders plus associated costs.

Firing costs are different for each worker. The idiosyncratic firing costs F_i for worker i at the day of the bankruptcy are computed in accordance with the legal definitions but excluding the unobserved associated employer labor costs. I do not consider the fact that this part of the

costs is not included in the computation of F_i as indispensable, since they constitute a fraction of F_i , which is virtually constant for all workers. Therefore the omission of the unobserved part of employer costs is not expected to distort the distribution of F_i among all workers in any way.

Figure 4 shows the distribution of worker specific firing costs aggregated per year of age for all tenured, retained and displaced workers. Firing costs increase with age up to the last year before the early retirement scheme starts. Firing costs for workers of age 54 are low compared to their 53 years old counterparts. For this sample the minimum is **Dfl** 1,235 and the maximum **Dfl** 94,284. The average costs per dismissed worker are somewhat higher than of a retained worker. The total firing costs for all -- 2578 -- workers in the sample that were displaced after the bankruptcy are equal to **Dfl** 31.5 million Dutch guilders, which is the equivalent of 18 million 1995 US dollars.

4.3 *Expected Idiosyncratic Profit Growth (μ_i)*

When all available information is used optimally, the observed real hourly wage growth during the period preceding the bankruptcy should contain most of the relevant information on the expected future profit growth. Assume that together with a common component C for all workers, individual characteristics Y_i measured at the time of layoff determine the individual worker's real hourly wage growth for worker i then yields

$$(8) \quad \Delta \ln W(C, Y_i) = \alpha C + \eta Y_i + \varepsilon_i^W,$$

where α, η are constant parameter vectors and ε_i^W is a worker specific component.² The expected profit growth given the current set of available information Ω_t is

$$(9) \quad \hat{\mu}_i \equiv -E[\Delta \ln W(C, Y_i) | \Omega_t] = -\hat{\alpha}C - \hat{\eta}Y_i.$$

² 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). Note that the idiosyncratic match quality (W_{Si}) does not enter this equation as it is assumed to be negotiated at the beginning of a contract and held constant through time.

where $\hat{\alpha}$ and $\hat{\eta}$ are parameter estimates and Δ is the lag operator. Equation (9) says that for two otherwise observably identical workers the one with the lowest wage growth has the highest expected future profit growth for the firm. How to obtain unbiased estimates for $\hat{\alpha}$ and $\hat{\eta}$ is discussed in Appendix II. The vector Y_i contains six (out of seven) age groups, five (out of six) tenure groups, and 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 available 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 number of external training courses, and the number of internal training courses.

4.4 *Idiosyncratic Uncertainty (σ_i^{μ})*

The idiosyncratic uncertainty, σ_i^{μ} , is a holy grail for the empirical analysis of dynamic irreversible adjustment models. I propose two measurements. One is obtained from the variation over time of worker specific performance evaluations, the other is the squared residual of the wage growth regression over different time spells.

The first measurement of uncertainty is derived from the variation over time of the performance evaluation scores. A worker with a large variation in evaluation scores is assumed to be a riskier worker. During the period 1991 through 1996 for each worker a maximum number of 5 annual performance evaluation scores are available. For each worker I computed the standard deviation of the available time series of scores across all observed scores ignoring missing values. This measure, $\hat{\sigma}_i^{Perf}$, is used as a measurement of idiosyncrasy of workers' uncertainty. A drawback of this measurement is that it only carries limited information as 46.6 percent of all observations' evaluation scores do not vary through time.

The second measurement of uncertainty is the worker specific residual of the wage growth equation, the component ε_i^W , that is known by the firm and yields

$$(10) \quad \hat{\sigma}_i^\mu = (\hat{\varepsilon}_i^W)^2.$$

$\hat{\varepsilon}_i^W$ is observed residual after equation (9) has been fitted to the data. The immediate need arises to set out a warning to linking $\hat{\sigma}_i^\mu$ to the *option value* of retaining worker i . Apart from the fact that it is tedious to obtain an unbiased estimate of $\hat{\varepsilon}_i^W$ (see Appendix II for an explanation how this is done), an observed effect of $\hat{\sigma}_i^\mu$ on the layoff decision may even be only distantly related to future uncertainty; it may just capture nonlinear effects that are important and not accounted for in the linearized empirical specification. Or the relationship may depend on several years of history, and the additional time-series information in $\hat{\sigma}_i^\mu$ helps capture this. It will thus be difficult to univocally interpret the meaning of $\hat{\sigma}_i^\mu$ in the cutoff equation as the option value of retaining a worker.

Next I will discuss empirical argumentations of why $\hat{\sigma}_i^\mu$ may indeed be a good candidate to approximate idiosyncratic uncertainty of future profit growth of workers. Table 4 presents a summary of the outcomes for the three different measures of $\hat{\sigma}_i^\mu$ for three different time periods divided between retained and displaced workers. These are the episodes 1991-1996; 1993-1996; and 1995-1996. 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 small. The informational contents of the episodes 1991-1996 and of 1995-1996 in terms of differences in option values among workers are thus negligible. In the sequel of this analysis I will only be using $\hat{\sigma}_i^{\mu: 1993-1996}$, as well as $\hat{\mu}_i^{1993-1996}$.

If the downsizing firm uses all available information efficiently, the relevant element is the firm's beliefs about each worker's profits. Farber and Gibbons (1996) provided empirical evidence that a firm revises these beliefs when more information becomes available when workers spent more time on the job. Employer learning implies that the uncertainty about a worker's future profit growth is expected to decline with tenure. Figure 5 shows the relation between the uncertainty measure $\hat{\sigma}_i^{\mu: 1993-1996}$ and tenure of all Fokker's employees, retained workers, and displaced workers at the time of bankruptcy. All workers in the sample 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 5 suggests that employer learning is an ongoing process until a worker retires. It also shows that for all years of tenure, the firm prefers "riskier" workers.

4.5 *The Quality of the Match (W_{Si})*

Factors that affect the contracted wage W_{Si} , may not all be included or properly modeled in a wage regression in levels (N.B.:not in first differences!). Some workers are still more productive than their pay indicates and, when forced to let some people go, the firm keeps those workers. If that's right, then the wage residual indicates worker-specific profit. The firm wants to preserve its best matches, and high wage residuals are good matches that the firm wants to retain.

As a measurement of the quality of the match I suggest the use of the residual annual earnings distribution at the time of bankruptcy. Thus, $W_{Si} = \varphi(\hat{\mathbf{w}}_i)$, with $\varphi' \leq 0$, where $\hat{\mathbf{w}}_i$ denotes worker i's residual of the annual wage equation at the day of the bankruptcy. In

linear form, this gives $\pi^{W_s} W_{Si} = \pi^{W_\omega} \hat{\mathbf{w}}_i$, with $\pi^{W_\omega} = \frac{\partial \Pi}{\partial W_s} \cdot \frac{\partial \varphi}{\partial \mathbf{w}_i} = \varphi \pi^{W_s}$. Since $\frac{\partial \Pi}{\partial W_s} > 0$

and $\frac{\partial \varphi}{\partial \mathbf{w}_i} \leq 0$, we expect the overall effect of $\hat{\mathbf{w}}_i$ to be negative.

4.6 Plant Dummies: Risk Adjusted Discount Rates (ρ)

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 bankruptcy probabilities or different τ 's for each plant imply a plant-specific risk-adjusted interest rate (equation (3')) -- among the six existing plants. I control for these differences by simply including plant specific dummy variables. The largest plant (plant 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: $\pi^\rho \rho = \sum_{j=2}^5 \pi^j D_j$.

4.7 Estimation Results

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

$$(11) \quad \Pr(\Pi_{Li} = 1) = \Phi(\pi \hat{\Lambda}_i),$$

where

$$(12) \quad \pi \hat{\Lambda}_i = \beta X_i + \pi^F F_i + \pi^\mu \hat{\mu}_i^{1993-1996} + \pi^\sigma \hat{\sigma}_i^{Perf} + \pi^{W\omega} \mathbf{w}_i + \sum_{j=2}^5 \pi^j D_j,$$

or

$$(13) \quad \pi \hat{\Lambda}_i = \beta X_i + \pi^F F_i + \pi^\mu \hat{\mu}_i^{1993-1996} + \pi^\sigma \hat{\sigma}_i^{\mu: 1993-1996} + \pi^{W\omega} \mathbf{w}_i + \sum_{j=2}^5 \pi^j D_j,$$

depending of the choice of the uncertainty measurement. According to equation (5) and the

fact that $\frac{\partial \varphi}{\partial \mathbf{w}_i} \leq 0$, the expected signs of the structural parameters are as follows: $\hat{\pi}^F < 0$;

$\hat{\pi}^\mu < 0$; $\hat{\pi}^\sigma < 0$; and $\hat{\pi}^{W\omega} < 0$. Vector X_i contains individual worker characteristics upon

which the initial decision of the size of the reorganization was based, or $\Pi_L \equiv \beta X_i$. The

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

In general, the results tell an interesting story. The firm chose to keep the more tenured and for the most part older workers. People's outcomes were related to the luck of which plant

they worked at. The firm seems to have kept the people with the most general schooling, possibly indicating that its needs were changing and it required workers who were open to and capable of performing and managing new tasks. However, it still valued old skills in that those who had been trained in firm-specific courses were more likely to be kept. These are informative results. I will now comment on some variables more specifically.

Firing costs ($\hat{\pi}^F$)

The estimation results presented in the first row of Table 5 show that, irrespective of the chosen specification of the uncertainty of future profit growth, workers with higher firing costs faced a significantly lower chance to be dismissed, or $\hat{\pi}^{Fw} < 0$. This is an important result. Not only is it consistent with *Prediction 5* of the structural model, it also shows that firing costs play a crucial role in understanding the characteristics of worker turnover, and how they set out incentives for employers to account for idiosyncratic firing costs when designing optimal rules of dismissal as they effect the value of the firm. Moreover, the results shed new light on a long lasting debate in Europe on the role of firing costs. People with the lowest firing costs have the weakest employment protection inside a firm.

Idiosyncratic expected profit growth and uncertainty ($\hat{\pi}^\mu; \hat{\pi}^\sigma$)

Columns two and three of Table 5 present the results for the two different measures of idiosyncratic uncertainty of expected worker profit. Both measurements show that riskier workers are less likely to be dismissed. This is consistent with the theory and confirms *Prediction 3*. 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' loyalty. The results show that workers with higher evaluation scores were less likely to be dismissed. The variation in performance evaluation negative but insignificant, which is not surprising given the large number of zero observations in this variable. The implication of the estimated parameter on the variation in

wage growth is that workers with more variation in wage growth are more likely to be kept during reorganization. The results suggest that uncertainty is good, because for a given average it increases the mass in the upper tail.

The use of $\hat{\sigma}_i^\mu$ as a measure of idiosyncratic worker uncertainty suggests that workers with less than average expected profit growth are treated equivalent to more than average workers. 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. The results are presented in the fourth and last column of Table 5, and show that the responsiveness is indeed different. In fact, mass in the lower tail is diminished by an increased dismissal probability of those workers that revealed a less than average unexplained wage growth. More than average productive workers had a significantly higher probability to be retained. The asymmetric specification prevails over the other ones reported in Table 5, and is my preferred specification. Its parameter estimates of the remaining explanatory variables are given in Table 6.

The Quality of the Match ($\hat{\pi}^{W_\omega}$)

The parameter estimate of $\hat{\pi}^{W_\omega}$ is negative but insignificant for all specifications. The firm preserves its best matches, and high wage residuals signal good matches that the firm wants to retain. The fact that this variable is insignificant may result from the inclusion of other variables that signal and control for the possibility of successfully being kept as a good worker such as the number of internal training courses.

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, may have increased a worker's productivity, but that increase is 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.

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 speaking, married workers are considered to be less likely to quit can also be expected to increase their expected future value to the firm.

V. The Value of a Reorganized Firm when Firing Costs are Heterogeneous

Altonji and Pierret (2001) showed that if a firm acquires more information about a worker, 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 $\hat{\sigma}_i^{\mu: 1993-1996}$ and the six tenure groups. I find that not one single interaction term is significantly different from zero, and the overall test equals $\chi^2(6) = 4.65$. 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.

The Predicted Value of the Firm's Layoff Policy

An economically relevant question yet unanswered is concerned with the marginal effects of how much idiosyncratic firing costs add in terms of extra value to the firm. The estimation results showed that F_i is a crucial variable to explain a firm's layoff policy under uncertainty. But how much is the reorganized firm worth more when heterogeneity in firing costs is explicitly subject to the design of optimal downsizing policy under uncertainty?

The overall layoff probability is equal to .514 for all 4,622 workers included in the econometric analysis. From this sample 2260 workers were retained and 2362 workers were displaced. The estimated model's pseudo- $R^2 = .161$ for the preferred specification with asymmetry in uncertainty. Given the results reported in Tables 5 and 6, it is possible to assess which workers the model correctly predicts to be retained or dismissed. This is done in the following way. First, all workers in the sample are ordered according to the - low to high - layoff probabilities as predicted by the model. The first M ($=2260$: $\Pr(\hat{\Pi}_{L_i} = 1) < .5866$) workers are those that would be selected to stay according to the model with idiosyncratic firing costs, irreversibilities, and uncertainty. I then match this prediction with each worker's observed outcome of the firm's actual 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 1500 out of 2260 workers or 66.4 percent of all retained workers. The average cutoff point, $\hat{\pi}\Lambda_i$, for layoffs is equal to .283 with a 95% confidence interval of [.278 ; .312]; the average cutoff for retained workers is equal to -.325 with a 95% confidence interval of [-.370 ; -.306]. Interestingly, the fact that both confidence intervals are significantly separate indicates the model capability to provide a clear-cut structural distinction between those being kept or dismissed.

The expected value of all the firm's correctly predicted retained workers can be computed as

$$(14) \quad V(\hat{\Pi}_L^M) = \sum_{i \in \Psi} \overline{\Pr(\Pi_{Li} = 0)} \mathbf{W}_i \left(\frac{S_i}{1 - S_i} \right) / \Pr(Stay),$$

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 $V(\hat{\Pi}_L^M) = \text{Dfl } 105.4$ million guilders, which is the equivalent of 60.2 million US\$ 1995 dollars for 2260 workers.

The model's performance is evaluated against an alternative model that is a simple net present value model that would result if the irreversible character of idiosyncratic firing costs would not play a role in the decisive strategy of the decision makers, as suggested by policy analysis based on aggregate data. That model is the "rule-of-thumb", where the ordering of workers is done by means of observable characteristics in the X-vector only. It is the fixed costs model that has often been suggested for macroeconomic policy analysis of the role of firing costs on the overall employment level, and primarily tested empirically with aggregate labor market data. (Bentolila and Bertola, 1990).

The "rule-of-thumb" model is at one end of the spectrum of available empirical models on worker turnover; the model presented in this paper is at the other end. In between are many other interesting structural empirical models of worker turnover such as those suggested by McLaughlin (1991), Topel and Ward (1992), and Lazear (1995). The rule-of-thumb model is strongly rejected against the one with heterogeneous firing costs and idiosyncratic uncertainty. The joint hypothesis is:

$$(15) \quad \text{Rule of Thumb -- } H_0 : \pi^{Fw} = \pi^\mu = \pi^{\sigma^+} = \pi^{\sigma^-} = \pi^{W\omega} = 0,$$

and the LR test statistic is $\chi^2(5) = 367.8$. The restricted model predicts 1389 or 61.5% of retained workers correctly. Under H_0 the expected value of all correctly predicted retained workers can be computed as

$$(16) \quad V(\hat{\Pi}_{Rule-of-Thumb}^M) = \sum_{i \in \Psi} \overline{\Pr(\Pi_{Li} = 0)} \mathbf{W}_i \left(\frac{S_i}{1 - S_i} \right) / \Pr(Stay),$$

where $\overline{\Pr(\cdot)}$ is the estimated probability to stay under $H_{Rule-of-Thumb}$. I find

$$V(\hat{\Pi}_{Rule-of-Thumb}^M) = \mathbf{Dfl} \ 97.9 \text{ million guilders, or } 55.9 \text{ million US dollars for } 2260 \text{ workers.}$$

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 $V(\hat{\Pi}_{Rule-of-Thumb}^M)$ amounts to 3,319 *Dfl* or 1,896 US\$ on average. Given the average annual earnings of retained workers of 52,078 *Dfl* or 29,759 US\$, the per worker value gained from accounting for heterogeneous firing costs and uncertainty of future profit growth is estimated to yield 6.4 percent of every retained worker's annual earnings. The total number of workers retained by Fokker was 2,420 (and not 2,260 as in the econometric analysis). Consequently, the total value gain for this firm is estimated to be equal to 8.0 million Dutch guilders or 4.6 million US\$ dollars. This is 2.7 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.

Is 8 million a lot? I believe it is a substantial amount. Total firing costs are equal to the average firing costs per worker (12,228 *Dfl*) times all 2578 dismissed workers, and amount to 31.5 million *Dfl*, or 18 million US\$ 1995 dollars. So the total amount saved from optimally accounting for heterogeneous firing costs is 25.4 percent of the total firing costs faced had the firm only applied the prevalent rule-of-thumb.

VI. Generalizations and Personnel Policy Implications

The model presented in this paper is derived from 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 has not been addressed here. The theoretical model is such that generalizations 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 structural downsizing model is easily reversed into a menu costs model of firm’s growth. 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 viewpoint the 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 irreversibility of heterogeneous firing costs and uncertainty. This also provides an explanation of the question why hiring occurs so little 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 expected profit growth, low uncertainty) from being dismissed.

VII. Conclusions

This paper has suggested that a firm in order to optimally reorganize its workforce sorts all its incumbent workers according to each worker's expected future net present value. Once the size of the reorganization is determined, the lowest value workers will be dismissed. A structural labor demand model with heterogeneous irreversible firing costs is presented to determine a worker's idiosyncratic value to the firm. Its predictions are tested and confirmed

using the personnel records from a large Dutch aircraft building company. Accounting for idiosyncratic firing costs prescribed by the model reduces total downsizing costs by well over 25 percent when compared to the costs predicted by a commonly used “rule-of-thumb”.

The theoretical model stated that the firm displaces workers with the lowest firing costs. Due to the irreversible nature of these costs a declining firm prefers to keep risky workers for the same reason why growing firms like them: the chance of unexpectedly higher profits increases the worker’s value to the firm as the expected future returns are larger. The risky worker is therefore more likely to be retained.

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 model with irreversibilities and uncertainty, this would result in an equilibrium search model with optimal heterogeneous hiring decisions (Postel-Vinay and Robin, 2001).

REFERENCES

- Altonji, Joseph and Pierret, Charles. "Employer Learning and Statistical Discrimination," *Quarterly Journal of Economics* (Forthcoming, 2001).
- Baker, George, Michael 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 Euroscclerosis?" *Review of Economic Studies*, 57 (July 1990): 381-402.
- Caballero, Ricardo J., and Eduardo M.R.A. Engel. "Explaining Investment Dynamics in U.S. Manufacturing: A Generalized (S,s) Approach". *Econometrica*, 67 (July 1999): 783-826.
- 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.
- Eberly, Janice. "Adjustment of Consumers' Durables Stocks: Evidence from Automobile Purchases," *Journal of Political Economy*, 102 (June 1994): 403-36.
- 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.

Postel-Vinay, Fabienne, and Jean-Marc Robin. "Equilibrium Wage Dispersion with Worker and Employer Heterogeneity." Manuscript. CREST, Paris: 2001.

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.

Appendix I: Menu Costs Rules for Workforce Adjusting Firms

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

$$(A.1) \quad d\Pi / \Pi = \mu dt + \sqrt{\sigma^\mu} dz, \quad \sigma^\mu > 0,$$

where dz is the increment to a standard Wiener process, with

$$(A.2) \quad E[dz] = 0, \quad E[dz^2] = dt.$$

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 $\ln(\Pi_0) + (\mu - \frac{1}{2}\sigma^\mu)t$, variance $\sigma^\mu t$, and $E[\Pi_t | \Pi_0] = \exp(\mu t)$, so that μ 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 predetermined³. The downsizing firm's firing decisions are all solutions of stochastic dynamic programming problems. There is only one discount rate $\rho > 0$ ⁴. Each worker's value $V(\Pi)$ changes with Π and the expected future returns $E[dV(\Pi)/dt]$ are equal to the normal returns $\rho V(\Pi)$. The flow of profits when retaining the worker yields Π , so that $V(\Pi)$ must satisfy

$$(A.3) \quad \frac{1}{2}\sigma^\mu \Pi^2 (d^2V(\Pi)/d\Pi^2) + \mu \Pi (dV(\Pi)/d\Pi) - \rho V(\Pi) = W_S - \Pi.$$

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

$$(A.4) \quad V(\Pi) = \Pi^\lambda; \quad dV(\Pi)/d\Pi = \lambda \Pi^{\lambda-1}; \quad d^2V(\Pi)/d\Pi^2 = \lambda^2 \Pi^{\lambda-2}.$$

³ 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.

into (A.3). This yields

$$(A.5) \quad \frac{1}{2}\sigma^\mu \lambda(\lambda-1) + \mu\lambda - \rho = 0,$$

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

$$(A.6) \quad \lambda_0 = -\left(\frac{\mu}{\sigma^\mu} - \frac{1}{2}\right) - \sqrt{\left(\frac{\mu}{\sigma^\mu} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^\mu}}, \quad \text{with } \lambda_0 < 0$$

and

$$(A.7) \quad \lambda_1 = -\left(\frac{\mu}{\sigma^\mu} - \frac{1}{2}\right) + \sqrt{\left(\frac{\mu}{\sigma^\mu} - \frac{1}{2}\right)^2 + \frac{2\rho}{\sigma^\mu}}, \quad \text{with } \lambda_1 > 0.$$

A particular solution of the inhomogeneous part of the differential equation (A.3) is found in linear form as

$$(A.8) \quad V(\Pi) = \Pi/(\rho - \mu) - W_S/\rho.$$

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 (A.3) yields

$$(A.9) \quad V(\Pi) = \Lambda_0 \Pi^{\lambda_0} + \Lambda_1 \Pi^{\lambda_1} + \Pi/(\rho - \mu) - W_S/\rho,$$

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 yields $\Lambda_1 \Pi^{\lambda_1}$. Alternatively, the firm can retain the worker, keeping the layoff option open that is worth $\Lambda_0 \Pi^{\lambda_0}$, 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)

⁴ I assume that the financial market trades only one product for which the firm can receive a constant and certain

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 profit 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 Π '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 yields⁵

$$(A.10) \quad V(\Pi_L) = \Lambda_0 \Pi_L^{\lambda_0} + \Pi_L / (\rho - \mu) - W_S / \rho.$$

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 (Dixit (1989), Bentolila and Bertola (1990)):

$$(A.11) \quad \Lambda_0 \Pi_L^{\lambda_0} + \Pi_L / (\rho - \mu) - W_S / \rho = -F, \quad \text{-- a worker's value matching condition --}$$

and

$$(A.12) \quad \lambda_0 \Lambda_0 \Pi_L^{\lambda_0 - 1} + 1 / (\rho - \mu) = 0. \quad \text{-- a worker's smooth pasting condition --}$$

The expression for Π_L in closed form then becomes

$$(A.13) \quad \Pi_L = \left(\frac{\rho - \mu}{\rho} \right) \left(\frac{\lambda_0}{\lambda_0 - 1} \right) (W_S - \rho F).$$

Q.E.D.

return $\rho > \mu$ each period of time.

⁵ Similarly, the value of an expanding firm's marginal worker yields $V_H(\Pi) = \Lambda_1 \Pi^{\lambda_1}$.

Appendix II: An Unbiased Measure of Idiosyncratic Uncertainty ($\hat{\sigma}_i^W$)

In order to obtain an unbiased estimate of $\hat{\sigma}_i^W$ 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 equation

$$(8) \quad \Delta \ln W(C, Y_i) = \alpha C + \eta Y_i + \varepsilon_i^W,$$

without controlling for a selection mechanism, would provide biased estimates for α, η , and hence for ε_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

$$(B.1) \quad Q_i^* = \gamma Z_i + u_i,$$

Z_i is a vector of individual characteristics explaining Q_i^* at the beginning of the episode in which the observed quit occurs, γ is a vector of unknown parameters, and u_i is a worker-specific normally distributed zero mean error with variance σ^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

$$(B.2) \quad \Pr(Q_i = 0) = 1 - \Phi(\gamma Z_i),$$

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

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

$$(B.3) \quad r_{QW} = \text{corr}(u_i, \varepsilon_i^W).$$

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

$$(B.4) \quad \Delta \ln W(C, Y_i) = \alpha C + \eta Y_i + r_{QW} \lambda_i^Q + \varepsilon_i^W, \quad \text{with} \quad \lambda_i^Q = \phi(\hat{\gamma}Z_i)/(1 - \Phi(\hat{\gamma}Z_i)).$$

The residuals ε_i^W from this regression can now be used to compute the measure for heterogeneous uncertainty about future profit growth: $\hat{\sigma}_i^\mu = (\hat{\varepsilon}_i^W)^2$

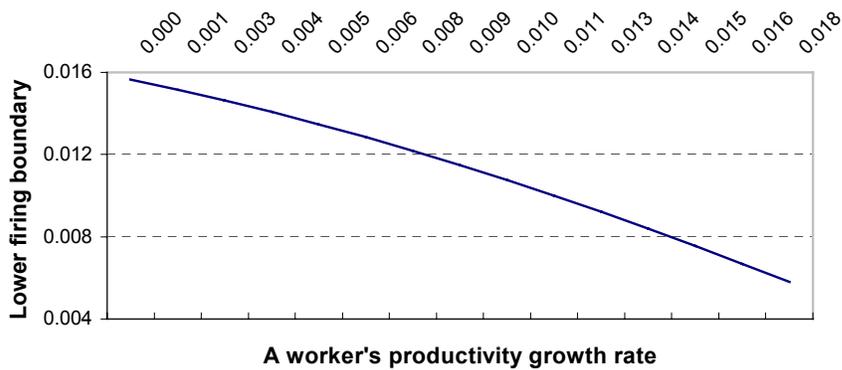
I propose to obtain estimates for σ_i^μ for the three different episodes 1995-1996, 1993-1996, and 1991-1996 independently. The first measurement of the observed variation in residual wage growth, $\hat{\sigma}_i^{\mu: 1995-1996}$, covers the last year of the firm before bankruptcy. The uncertainty $\hat{\sigma}_i^{\mu: 1991-1996}$ measures the observed variation in residual wage growth during period since the firm started its first reorganization 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, $\hat{\sigma}_i^{\mu: 1991-1996}$ differs from $\hat{\sigma}_i^{\mu: 1995-1996}$ 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 measured $\hat{\sigma}_i^{\mu: 1993-1996}$ separately. The results from the estimation procedures to compute $\hat{\sigma}_i^{\mu: 1991-1996}$, $\hat{\sigma}_i^{\mu: 1993-1996}$, and $\hat{\sigma}_i^{\mu: 1995-1996}$ are not reported here. The technique is straightforward and has been used numerous times before. The results can be obtained upon request.

Figure 1

Effects on Π_L from changes in F , μ , and σ

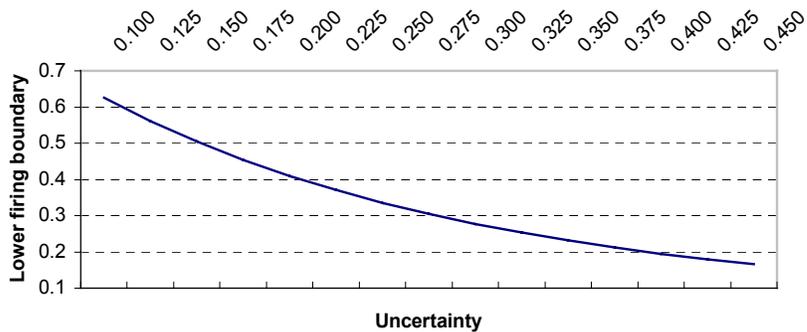
Graph A: Changes in Profit Growth

($\rho = .025; \sqrt{\sigma} = .1; W = 1; F = 1$)



Graph B: Changes in Uncertainty

($\mu = 0; \rho = .025; W = 1; F = 1$)



Graph C: Changes in Firing Costs

($\mu = 0; \rho = .025; \sqrt{\sigma} = .1; W = 1$)

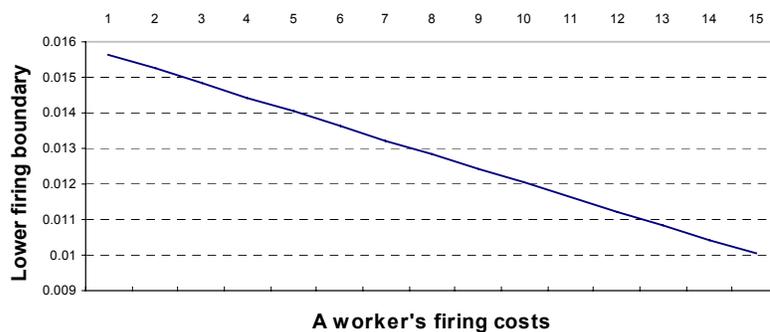
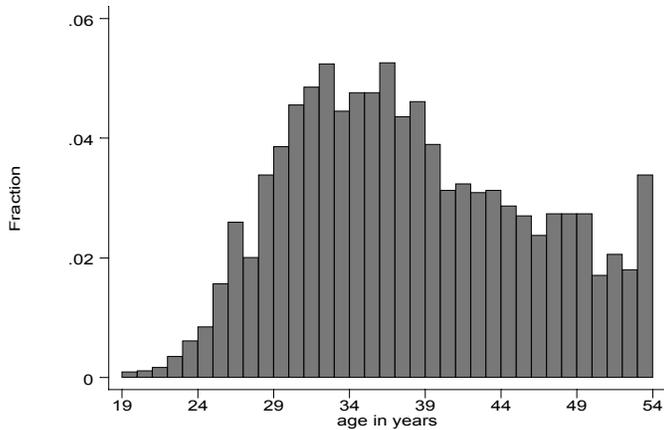
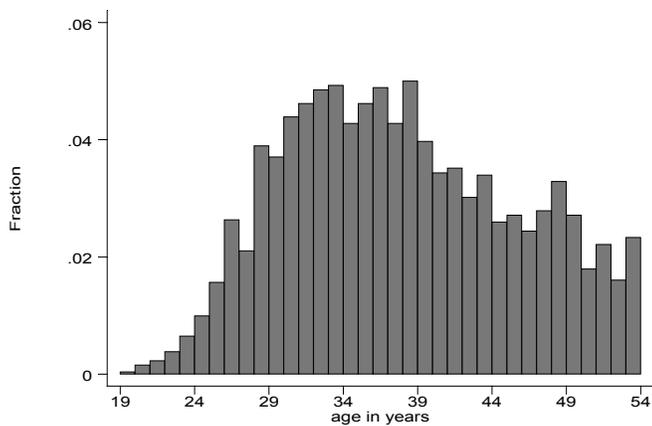


Figure 2
Age Distributions in Years

Graph A: All Workers



Graph B: Retained Workers



Graph C: Dismissals

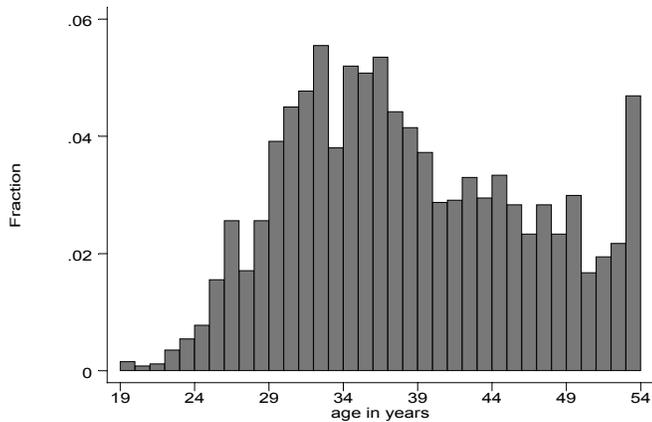
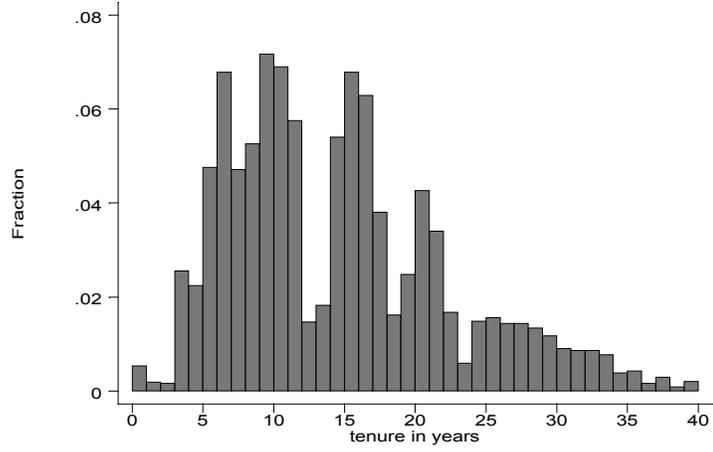


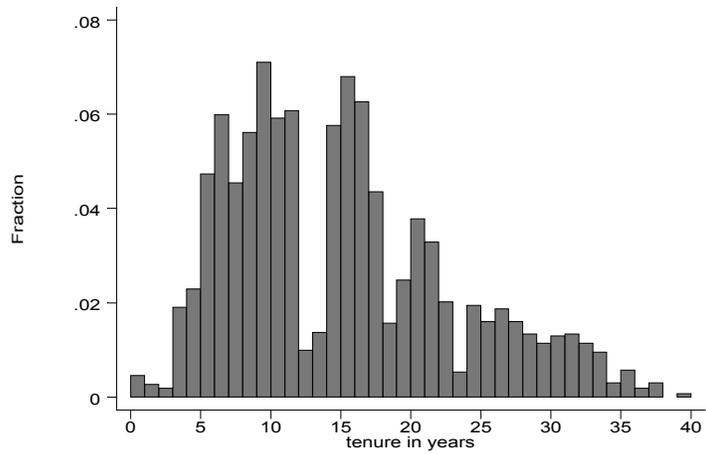
Figure 3

Tenure Distributions in Years

Graph A: All Workers



Graph B: Retained Workers



Graph C: Dismissals

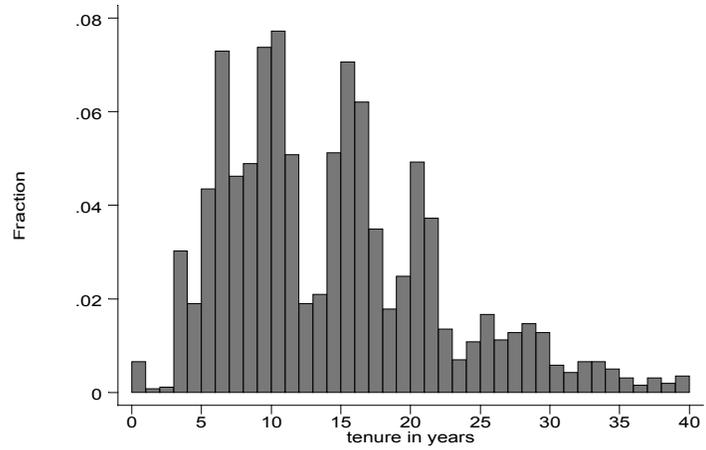
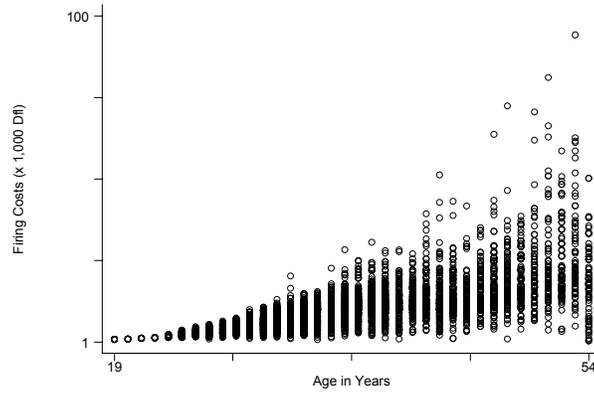


Figure 4
Idiosyncratic Firing Costs

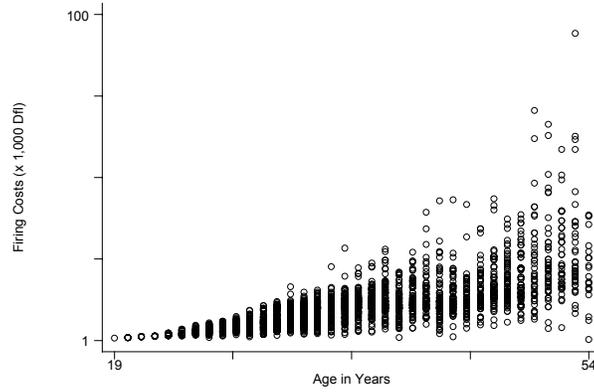
Graph A: All Workers

\bar{F}_i : 12,085 -- 95% C.I.: [11,873 ; 12,297]



Graph B: Retained Workers

\bar{F}_i : 11,944 -- 95% C.I.: [11,645 ; 12,243]



Graph C: Dismissals

\bar{F}_i : 12,228 -- 95% C.I.: [11,927 ; 12,529]

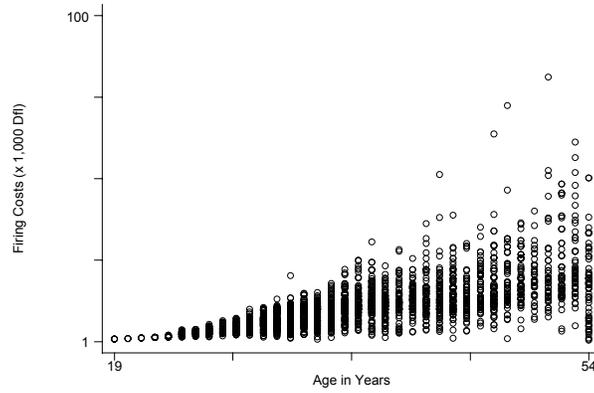


Figure 5
Profit Growth Uncertainty and Tenure

1993-1996

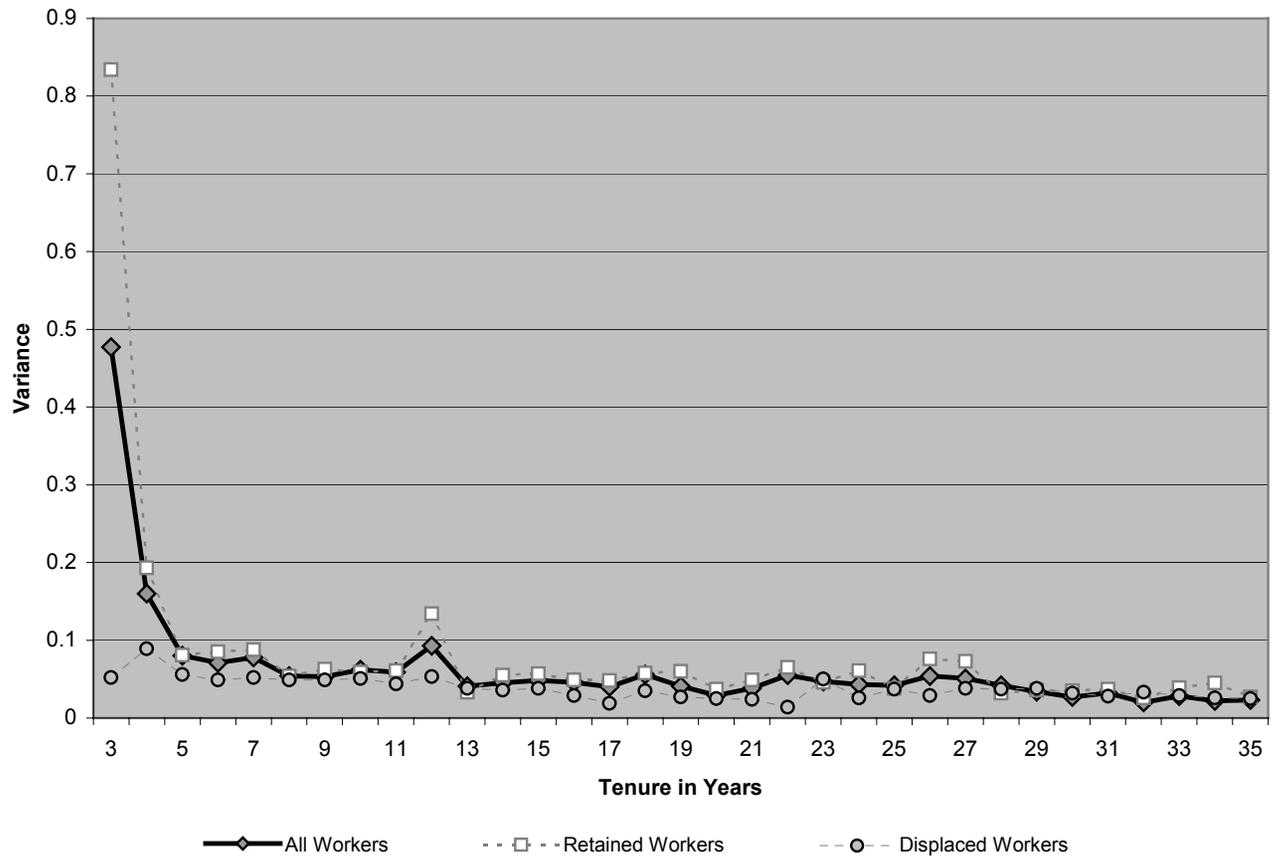
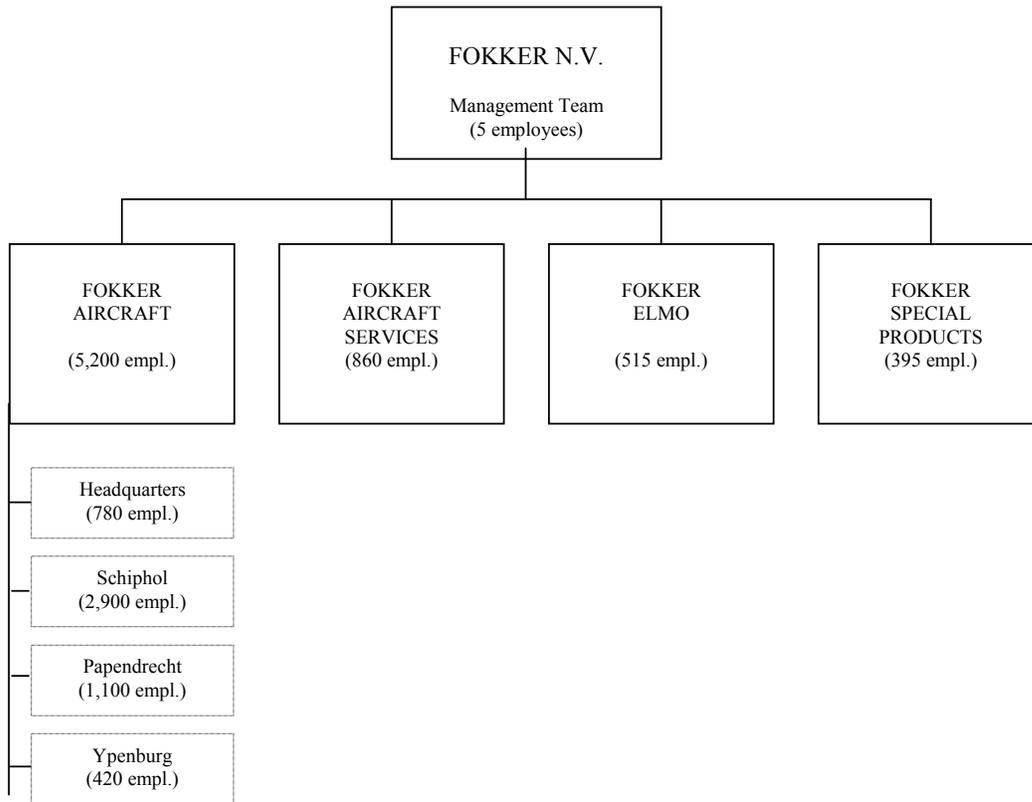


Chart 1

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)

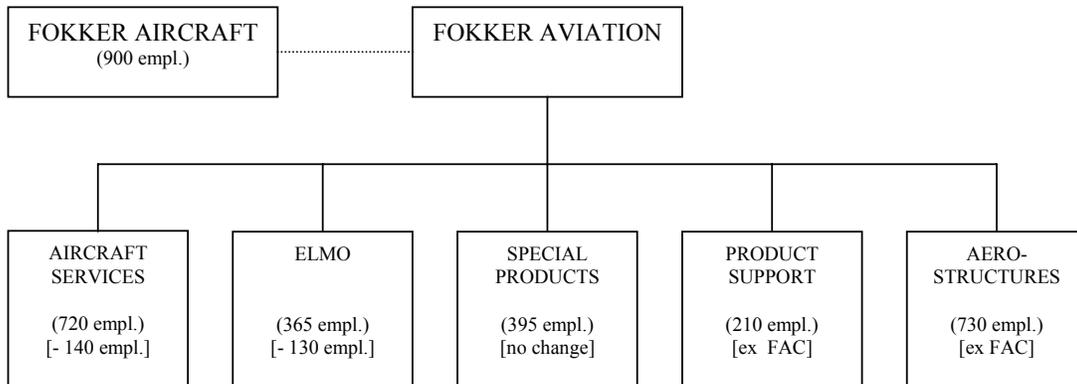


Table 1

Hourly Wage and Wage Changes of Retained and Displaced Workers

Period	All Workers		Retained Workers		Displaced Workers	
	Level (in 1995 <i>Dfl</i>)	% Change	Level (in 1995 <i>Dfl</i>)	% Change	Level (in 1995 <i>Dfl</i>)	% 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 2**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 (10.1) ¹	24.9 (7.5)	22.0 (7.7)	24.1 (7.7)	23.2 (5.8)	22.8 (5.6)	30.6 (11.4)
Wage change (in %) 1993-96	4.7 [4.6 ; 4.8] ²	4.1 [3.7 ; 4.5]	4.6 [4.2 ; 5.0]	5.2 [4.9 ; 6.0]	4.1 [3.7 ; 4.4]	3.9 [3.7 ; 4.1]	5.0 [4.9 ; 5.2]
<u>Retained workers</u>	2619	354	315	614	144	349	843
Hourly wage	26.4 (9.9)	24.9 (7.5)	22.1 (8.0)	24.4 (7.9)	24.0 (5.6)	23.8 (6.4)	31.2 (11.8)
Wage change (in %) 1993-96	4.9 [4.7 ; 5.0]	4.1 [3.7 ; 4.5]	4.6 [4.2 ; 5.0]]	5.2 [4.9 ; 5.5]	4.5 [3.9 ; 5.1]	4.2 [3.9 ; 4.4]	5.3 [5.1 ; 5.6]
<u>Displaced workers</u>	2578	3	42	86	223	608	1616
Hourly wage	27.3 (10.2)	23.8 (.27)	21.1 (4.9)	22.1 (6.0)	22.7 (5.9)	22.2 (5.0)	30.4 (11.2)
Wage change (in %) 1993-96	4.5 [4.4 ; 4.6]	1.4 [1.4 ; 1.5]	4.7 [3.6 ; 5.7]	5.1 [4.2 ; 6.0]	3.8 [3.4 ; 4.2]	3.8 [3.5 ; 4.0]	4.9 [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
<u>All workers</u>	116	681	1218	1182	814	708	478
Layoffs (in %)	44.8	46.5	50.4	49.6	48.6	48.4	56.5
<u>Retained workers</u>							
Hourly wage	15.6 (2.1) ¹	19.6 (3.1)	23.5 (4.7)	26.8 (6.9)	29.0 (10.5)	30.9 (11.6)	35.2 (17.5)
Wage change (in %) 1993-96	11.3 [10.4 ; 12.3] ²	7.7 [7.3 ; 8.0]	6.0 [5.7 ; 6.3]	4.3 [4.0 ; 4.6]	3.5 [3.2 ; 3.7]	3.0 [2.8 ; 3.3]	2.6 [2.3 ; 2.9]
<u>Displaced workers</u>							
Hourly wage	15.3 (2.0)	20.0 (3.7)	24.1 (5.6)	28.2 (8.0)	31.4 (11.6)	32.4 (12.9)	31.3 (13.3)
Wage change (in %) 1993-96	9.8 [8.5 ; 11.1]	7.3 [7.0 ; 7.6]	6.0 [5.7 ; 6.3]	4.4 [4.1 ; 4.7]	3.2 [3.0 ; 3.4]	2.3 [2.1 ; 2.5]	2.1 [1.9 ; 2.3]

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

Table 3.2
Wages, Wage Growth and Dispersion among Tenure Groups

TENURE:	≤ 7	8-11	12-17	18-22	23-29	≥ 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 (8.4) ¹	24.0 (8.1)	26.8 (9.6)	28.8 (10.1)	33.0 (13.8)	29.1 (7.5)
Wage change (in %) 1993-96	8.8 [8.3 ; 9.3] ²	5.6 [5.4 ; 5.9]	3.9 [3.6 ; 4.1]	3.0 [2.7 ; 3.3]	2.9 [2.6 ; 3.3]	2.7 [2.3 ; 3.0]
<u>Displaced workers</u>						
Hourly wage	24.3 (8.1)	25.6 (8.8)	28.6 (11.4)	29.7 (11.2)	32.0 (11.1)	28.1 (6.7)
Wage change (in %) 1993-96	7.8 [7.4 ; 8.2]	5.5 [5.3 ; 5.7]	3.5 [3.3 ; 3.7]	2.6 [2.4 ; 2.8]	2.2 [2.0 ; 2.4]	2.0 [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
<u>All workers</u>	3821	1376
Layoffs (in %)	50.4	47.3
<u>Retained workers</u>		
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]
<u>Displaced workers</u>		
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 parentheses² 95% confidence intervals in squared brackets.

Table 3.4
Wage, Wage Growth, Dispersion, and Type of Job

		Production Workers	Managers
<u>All workers</u>			
		3542	1655
Layoffs (in %)		46.9	55.3
<u>Retained workers</u>			
Hourly wage		21.8 (3.1) ¹	37.8 (12.0)
Wage change (in %)	1993-96	4.2 [4.0 ; 4.3] ²	6.6 [6.3 ; 7.0]
<u>Displaced workers</u>			
Hourly wage		21.8 (3.2)	37.3 (11.0)
Wage change (in %)	1993-96	3.7 [3.6 ; 3.8]	6.0 [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)
<u>All workers</u>	2853	2344	3911	1286
Layoffs (in %)	53.9	44.3	49.5	49.8
<u>Retained workers</u>				
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]
<u>Displaced workers</u>				
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)
<u>All workers</u>	2789	2407
Layoffs (in %)	.541	.444
<u>Retained workers</u>		
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]
<u>Displaced workers</u>		
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
<u>All workers</u>	568	4629
Layoffs (in %)	40.7	50.7
<u>Retained workers</u>		
Hourly wage	20.5 (5.3) ¹	27.2 (10.2)
Wage change (in %) 1993-96	5.0 [4.5 ; 5.6] ²	4.8 [4.7 ; 5.0]
<u>Displaced workers</u>		
Hourly wage	23.4 (6.7)	27.7 (10.4)
Wage change (in %) 1993-96	4.6 [4.0 ; 5.3]	4.5 [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
<u>All workers</u>	1906	3287
Layoffs (in %)	55.1	46.4
 <u>Retained workers</u>		
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]
 <u>Displaced workers</u>		
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

	1991-1996	1993-1996	1995-1996
<u>Retained workers</u>			
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]
<u>Displaced workers</u>			
Mean	24.2	5.45	.21
Std.Err.	.91	.64	.14
[95% Conf. Interval]	[22.5 ; 26.0]	[4.2 ; 6.7]	[.00 ; .48]
<u>Option Value Ratio</u>	1.07	1.41	4.67

Table 5
Heterogeneous Firing Costs, Profit Growth Uncertainty, and Layoff Probabilities

	<u>Mean</u> (Std.Dev.)	<u>Uncertainty</u> Performance Variation through Time	<u>Uncertainty</u> Earnings Growth Variation through Time	<u>Uncertainty</u> Asymmetric Earnings Growth Variation through Time
Firing Costs (x 1,000):				
\hat{F}_i	12.09 (7.80)	-.018 * (.006)	-.019 * (.006)	-.019 * (.005)
Expected Profit Growth:				
$\hat{\mu}_i^{1993-1996}$	-4.73 (2.61)	-.031 (.041)	-.027 (.041)	-.036 (.042)
Uncertainty:				
$\hat{\sigma}_i^{Perf}$.286 (.285)	-.036 (.071)		
Uncertainty:				
$\hat{\sigma}_i^{\mu: 1993-1996}$.065 (.407)		-.108 * (.053)	
Uncertainty:				
$\hat{\sigma}_i^{\mu: 1993-1996} \hat{\varepsilon}_i^{\mu} < 0$.022 (.056)			1.05 * (.374)
$\hat{\sigma}_i^{\mu: 1993-1996} \hat{\varepsilon}_i^{\mu} \geq 0$.043 (.405)			-.115 * (.055)
Matching Quality:				
\hat{w}_i	.00 (.545)	-.019 (.035)	-.013 (.035)	-.019 (.035)
Pseudo- R^2		.159	.160	.161
Log L		-2693.7	-2691.5	-2687.0
# Observations		4622	4622	4622

* Coefficients of Marginal Changes (Std.Err.) reported; p-value of z-score < .05

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)	-1.58 (.102)	-.471 (.016)	-15.4 [.000]
	FAS: Plant 3	.138 (.34)	-1.55 (.082)	-.492 (.016)	-18.9 [.000]
	FAC Ypenburg: Plant 4	.070 (.25)	.067 (.093)	.027 (.037)	.72 [.470]
	FAC Papendrecht: Plant 5	.201 (.40)	-.051 (.061)	-.021 (.024)	-.84 [.399]
Age (in years)					
	Reference Group: ≤ 24	22.7 (1.41)	-	-	-
	25-29	27.4 (1.39)	-.207 (.201)	-.082 (.079)	-1.03 [.304]
	30-34	32.0 (1.40)	-.153 (.241)	-.061 (.095)	-.63 [.526]
	35-39	36.9 (1.39)	-.039 (.292)	-.016 (.116)	-.13 [.894]
	40-44	42.0 (1.40)	.024 (.327)	.010 (.130)	.07 [.941]
	45-49	47.0 (1.42)	.137 (.351)	.054 (.139)	.39 [.696]
	50-54	52.0 (1.39)	.531 (.106)	.205 (.130)	1.47 [.141]
Tenure (in years)					
	Reference Group: ≤ 7	4.90 (1.19)	-	-	-
	8-11	9.12 (1.33)	.076 (.083)	.030 (.033)	.91 [.361]
	12-17	15.0 (1.36)	.154 (.120)	.062 (.048)	1.29 [.197]
	18-22	20.1 (1.19)	.202 (.136)	.080 (.054)	1.49 [.137]
	23-29	26.1 (1.82)	.032 (.143)	.013 (.057)	.23 [.821]
	≥ 30	32.9 (2.48)	.088 (.159)	.035 (.063)	.56 [.578]

Table 6 (continued)

	Mean (Std.Dev.)	Coefficient (Std.Err.)	Marginal Change ¹ (Std.Err.)	z-score [p-value]
Education²				
Reference group: vocational schooling basic level (39.8%)				
<u>General schooling:</u>				
Basic Level	.144 (.35)	-.218 (.073)	-.086 (.029)	-2.98 [.003]
Lower Level	.081 (.27)	-.083 (.088)	-.028 (.035)	-.81 [.417]
Medium Level	.024 (.15)	-.020 (.144)	-.002 (.058)	-.04 [.971]
Higher Level	.016 (.13)	-.339 (.171)	-.097 (.077)	-1.24 [.216]
<u>Vocational schooling:</u>				
Lower Level	.196 (.40)	-.024 (.059)	-.015 (.026)	-.57 [.572]
Medium Level	.105 (.31)	.065 (.090)	.026 (.036)	.72 [.471]
Higher Level	.036 (.46)	.436 (.132)	.136 (.048)	2.77 [.006]
Performance evaluation	3.57 (.72)	-.230 (.032)	-.092 (.013)	-7.11 [.000]
Training Courses				
Internal courses	7.05 (6.82)	-.019 (.003)	-.008 (.001)	-5.48 [.000]
External courses	1.04 (1.48)	.010 (.015)	.004 (.006)	.63 [.527]
Manager	.306 (.46)	-.262 (.150)	-.131 (.027)	-4.78 [.000]
Male	.888 (.31)	.014 (.083)	.006 (.033)	.18 [.860]
Married	.641 (.48)	-.130 (.045)	-.052 (.018)	-2.87 [.004]
Regression statistics	# Obs: 4622	Log L: -2687	Pseudo-R ² :	.161

¹ Unit change for dummy variables.

² The basic level of vocational schooling (the reference group) refers to secondary schooling only extended with an apprenticeship program (*leerlingwezen*) enforced by Dutch law for people of ages 16 or below. Lower level vocational schooling refers to *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 secondary 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.

Downsizing

ABSTRACT: This paper suggests that in order to optimally reorganize its workforce a firm sorts all incumbent workers according to each worker's expected future value. Once the size of the reorganization has been determined, the lowest value workers will be dismissed. A structural labor demand model with menu costs derived from heterogeneous irreversible firing costs is presented to determine a worker's idiosyncratic value to the firm. An econometric analysis using personnel records from a European aircraft building firm shows that a reorganizational design that accounts for idiosyncratic firing costs reduces the total downsizing costs by more than 25 percent.

Keywords: Firing costs; menu costs; value of the firm

JEL Codes: J61