Employment Stability via Annualized Hours Contracts?

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Abstract: The presented paper proves that working time arrangements, which include hours flexibility and enable hours deposits, are appealing under product market uncertainty. The model integrates efficiency wage arguments into an implicit insurance–contract environment, thus extending the existing literature. The solutions are renegotiation–proof and the long–run optimum is spot implementable. Moreover, well–defined complementarities with additional instruments exist: institutionalized systems of firm level communication and information, investments in information technology and further training as well as team work together with working time accounts imply positive system effects, thus constituting a complementary human resource management system.

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Contents

1 Introduction

Research on long–term employment relations is of major interest in labor economics (and economics of personnel). Usually employment duration is measured by tenure, thus defined as the spell of an unique and identical worker–firm match. Spells can either be completed or refer to ongoing contracts. In the latter case tenure measures the minimum length of continuous employment[1]. The presented paper analyzes the topic from an unusual perspective (at least in Western terms), since workers are explicitly guaranteed employment security, which in fact implies long–term employment relations. In implicit insurance contracts, employers commit not to lay off workers, whereas workers supply intertemporally flexible working hours. Such hours deposits represent firm specific adjustment of the production factor labor under market uncertainty. Agreements take place in well defined constructs, denoted "working time accounts", which include among other things the waiving of dismissals due to demand fluctuation.

One conclusion of initial work on wage smoothing via implicit insurance contracts is that recruitment and separation activities are likely to increase on average: Wage guarantees imply per capita fluctuation (Baily (1974), Azariadis (1975)). More recent contributions, however, favor alternative explanations (transaction costs, reciprocal implicit contracts, segmented labor markets). Here the simultaneous presence of wage rigidities, seniority rules, promotion contests and long–term employment relations is proven, where the results do not depend on the restrictive assumption of diverging risk attitudes (Mayers/ Thaler (1979), Holmstrom (1983)).

Quite similar results emerge in contributions, which basically doubt the pertinence of risk theoretic approaches in the set of explanations for existence of long–term employment. They consider alternative determinants to be most important, namely the existence of non–separabilities in incentive systems and employment relations (Bull (1983)). Under this assumption a compensation package is obtained in exchange for a vector of multi dimensional tasks. Since the single tasks cannot be traded on separate markets, the task vector is non–separable, and is therefore supplied as an entity. Analogically, multidimensional tasks are rewarded by integrated bundles of incentive instruments (including monetary and non–monetary, direct and deferred elements). Such reciprocal lack of single markets establishes long–term employment.

The considered model also relates to articles, which stress the role of tenure for enforcement of implicit contracts (see e.g. Carmichael (1989), Spagnolo (1999)). Often the discussion is in conjunction with supporting institutions as reputation or reciprocity (Akerlof (1982), Carmichael (1984), Bull (1987)). Recent laboratory experiments could verify on the one hand that repeated interaction enhances the effectiveness of reciprocity, but show on the other hand that wage rigidities and substantial unemployment persist, regardless of underbidding of current wage levels by unemployed labor suppliers (Fehr/ Falk (1999), Fehr/ Gächter/ Kirchsteiger (1997)).

The following contribution also treats rigidities, yet not from the wages point of view. Rather it concentrates on employment rigidities. The general set–up is established by an insurance model, which integrates major results from efficiency wage models (Shapiro/ Stiglitz (1984), also Weiss (1991)). The objective is to prove the existence of (obligatory) employment rigidities to be Pareto superior. A model of working time flexibility is developed that justifies the advantageousness of working time accounts, which explicitly state job security. Given that this job security is not enforcable by courts, long–term employment relationships represent self–enforcing implicit contracts.

[1] Mobility, discrimination, human capital or training are typical research areas (Jovanovic (1979a/ b), Bellmann/ Schasse (1990), Carmichael/ MacLeod (1993), Acemoglu (1997), Acemoglu/ Pischke (1999)). Moreover country specific hypotheses exist (Kanemoto/ MacLeod (1991), OECD (1993)).

Stochastic demand entails the need for flexibility and adaption, where the results are derived under the additional assumption that employers and employees differ with respect to their attitude towards risk.

Incentive arguments generate downward rigid wage levels. If the incentive compatible wage level is above the hypothetical wage level under insurance at fair odds, then traditional insurance models on wage smoothing[2] have to be modified in a way that allows for a priori smoothed wages.

In the sequel, such a modified model is presented and significant implications are discussed. For example, it is shown that working time accounts are efficient in the long run, if firm level institutions for information and communication exist, and both are integrated into a coherent over–all conception. Thus, working time accounts are part of a complementary system. Though the presentation concentrates on output market risks, additional risks as variations at the production level augment system effects. Further extensions are conceivable. The paper concludes with a brief summary and outlook, mainly on opportunities for empirical research.

2 An Insurance Model

Similar to the available work on implicit insurance contracts, this model is based on Pareto improving effects of an altered risk allocation between employer and employees. But unlike the majority of existing models it does not derive the smoothing of wages via insuring income risks. Instead, employers insure their employees against demand driven unemployment risks. Thus, the model proves the *existence* of long–term employment relations as a result of optimization behavior.

As a rule, insurance activity shifts an ex–ante lottery to an ex–post lottery, i.e. the insurer receives a fixed premium with certainty, whereas the parties face a repayment–lottery, whose outcome depends on the state of the world occurred (e.g. Hillier (1997)). The case discussed here differs: The solutions entail premiums which are not fixed, as they vary with alternative realizations of product demand. In addition, these premiums have to be interpreted as compulsory savings, if hours deposits are translated into monetary equivalents. Thus, premiums are not pecuniary in the literal sense, because they are determined by current differences of expected and realized states of the world (see Section 2.3). The payment itself is operationalized by flexible working time schedules, particularly by schemes which explicitly allow for working time deposits (annualized hours contracts are one example). Throughout the paper the term ”working time accounts” (resp. ”windows of working time”) is used.

The fact that working time deposits represent controlled savings, facilitates a reciprocal interpretation of our insurance model: Employees insure part of the employer’s output market risk, which results from stochastic demand. This interpretation is more in accordance with traditional insurance models: Introduction and maintenance of working time accounts cause just fixed costs, which in turn define part of the fixed premiums paid by the employer–insuree. The other part is linked to fixed wage income (per capita and period) at the ex–ante optimal number of employees.

[2]Early contributions integrate just the two variables wages and employment. Superiority of implicit contracts, in which a risk averse employee is covered from fluctuation in wage levels by a risk neutral employer, results from efficient risk allocation. Wage rigidities entail amplified adjustment of labor (hours and per capita, see Rosen (1985), Lowenstein (1983)). To cope with the problem of moral hazard under asymmetric information, insurees are covered only incompletely and compensation depends on the observation of prespecified indicators (often restricted to be verifiable), thus managing the trade–off between efficient risk allocation and adequate incentives (for an overview: Hart/ Holmstrom (1987)).

Altogether, this double–sided character is crucial in the stability discussion of the model solutions. No party has an incentive to deviate from the terms once agreed to. If demand is random, if the variance is not too high, and if a substantial level of unemployment exists for reasons of motivation, then working time accounts are likely to exist even on a long–term basis. For a further discussion of renegotiation–proof working time arrangements as a promising instrument in the economics of personnel see Section 2.3. The role of working time accounts in an integrated human–resource–management system is discussed in Section 2.4. Critical remarks can be found in Section 2.5. Section 2.6 contains suggestions for analytical extensions.

2.1 Working Time Accounts as a Means of Insuring the Risk of Job Loss

The model applies for existing firms, which dispose of substantial experience in their product markets. One major objective of the paper is to develop an explanation for the existence of employment rigidities (in contrast to wage rigidities) and to show the Pareto advantages of working time accounts, when announced as integral parts of so–called "employment pacts" and enabling hours deposits.

The time horizon of the model leads to a dynamic setting, which can easily be solved, because these particular working time arrangements allow for the formulation of the firm's decision making process as a sequence of spot solutions. Let's illustrate this in a recontraction game (which implements the long–term optimum, see Rey/ Salanie (1990)): One the first stage the parties agree on the ex–ante optimal (spot) contract that renews in every period. Wage income, optimal output decision and price setting are part of this contract. At stage 2 realized demand becomes known. On a third stage working time flexibility enables ex–post adjustment of production to demand levels.

The shape of the decision process as a spot sequence simplifies the discussion of Pareto characteristics of the solutions. On the one hand, working time accounts imply a firm specific credit market, which is constrained to within–firm credit and debt, i.e. transfer of working hours. On the other hand, working time accounts as an instrument of personnel policy are optimal in the long–run, at least when they are combined with sufficient information participation of employees or are part of an integrated and coherent human resource bundle, respectively. Such bundle should constitute a human–resource–management system (HRM–system) as in Topkis (1995, 1998) or in Milgrom/ Roberts (1995a). The argumentation on complementarities is deepened in Section 2.3.

Apart from the crucial assumptions on risk attitudes, demand uncertainty, price setting behavior, and product range *lack of inventories* (*prohibitive costs of inventories*, respectively) is postulated. This last assumption is critical, too, and it is compatible with grown interest in time management as a key success factor for firms, as well as with empirical evidence on just–in–time production. Altogether, the assumptions of the model are as follows:

A1 Decision making units are [i] the firm and [ii] employee(s). Wages w and employment L are chosen by the firm. Employees decide to accept or reject the employment contract (participation constraint). In case of participation each employee fills exactly one job slot.

A2 Attitudes toward risk diverge: the firm is risk neutral, employees are risk averse.

A3 Either Q is the single product produced by the firm or it denotes a product range of close substitutes. Inventories do not exist.

A4 Production of Q consumes two factors: labor L and capital K, with capital fixed in the short run. L is measured in efficiency units and consists of two components: a) working time $\mathbf{h}$, b) number of employees $\mathbf{N}$. The number of hours worked is the same for all employees within the firm.

A5 The firm fixes prices. It's downward sloping demand curve $P(Q)$ is well known, though the reservation price is random. Demand uncertainties offset over time, i.e. the firm's expectations are correct on average and the prediction of demand is unbiased. The chosen price p is constant over a period.

A6 Information on realized random variables become evident instantaneously.

A7 Incentive problems exist: Effort causes disutility. But the firm can cope with it adequately in an efficiency wage framework: Time wage w is chosen according to $e_w \cdot w \cdot e^{-1} = 1$ (Solow (1979)). The no–shirking condition in Shapiro/ Stiglitz (1984) applies[3]. The compensation system consists of no further pecuniary elements.

Assumptions **A3** to **A6** are in the style of Nickell (1978). In addition, from **A7** immediately follows that an insurance approach to wage rigidities (Rosen (1985)) is inappropriate: Potential variation in compensation is already smoothed, since the Shapiro/ Stiglitz (1984) model predicts c.p. time–invariant compensation levels above the market clearing level. Actual compensation exceeds actual value of marginal product in each period[4]. Hence employers cannot credibly commit to lower wages in periods of lack of demand.

This leads to the conclusion that efficiency wages provide sufficient evidence for downward rigid wages. Thus, traditional insurance approaches to implicit contract theory will no longer apply in this context, as corresponding insurance premiums for covering income risks would induce reasonable wage reductions, which contradicts the conclusion.

Nonetheless, the agents agree on risk transfer, although for a different reason, which will be discussed in detail. Altogether Pareto improvements result, enabled by working time flexibility that allows for intertemporal transfer of working hours. This is favorable for both parties, employer and employees, if consensus is accomplished with respect to the period of time in order to balance such transfers.

A2 implies the following: Since a risk neutral firm is indifferent between the certain realization of the expected value of any sales–lottery and the lottery itself, it fixes identical prices under demand fluctuations and under certainty (see also figure 1). Then it follows from **A5** in conjunction with **A3** that in any period either part of the output perishes, or expected demand is met, or part of market demand cannot be satisfied.

On the basis of their risk aversion workers are in principle willing to pay a premium to insure against the risk of being laid off, which results from demand uncertainty[5]. For any *high–effort*

[3]Notice the following: Incentive effects in Shapiro/ Stiglitz (1984) require a substantial and persistent level of unemployment, it is necessary as a means to discipline workers. It is assumed that both, employer and employees, know the relevant parameters of the no–shirking condition. They are aware of the fact, that any "caught" shirking employee would be laid off (in equilibrium this will not occur) and is likely to stay unemployed for a remarkable duration. This kind of unemployment results from firm's optimization behavior to reach second best and is not analyzed in the presented paper. Here, the focus is on an additional risk, which ensues merely on a second stage from circumstances, which translate into a shifting labor demand curve. Thus, the unemployment risk this paper deals with is completely product demand driven, as it results from a second stage (downstream) employment lottery that is unaffected by incentive motives. Just against the latter risk the workers are insured via working time accounts.

[4]The corresponding labor demand of profit maximizing firms is beneath the market clearing level. The size of the wage premium is determined by several parameters as a) firm specific need for control mechanisms or monitoring (complexity of technology), b) monitoring costs and monitoring intensity, c) (a priori) level of unemployment, d) unemployment benefits and e) discount rate or time preferences.

[5]For the risk neutral firm expected utility and utility from expected profits coincide, whereas for the risk

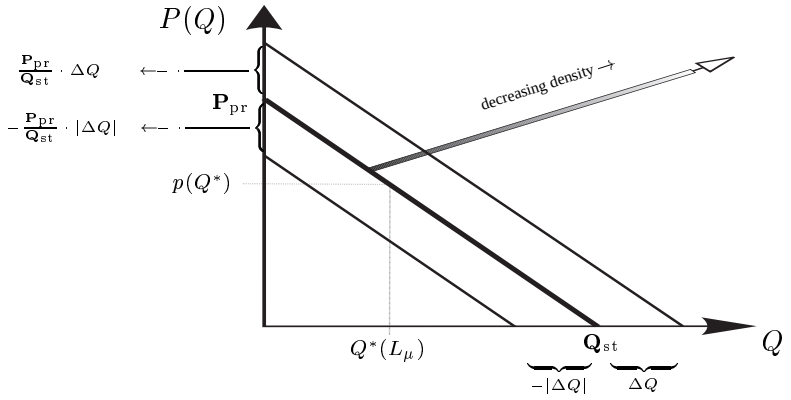

Figure 1: Stochastic market demand as defined in $\mathbf{A5}$ (linear demand curve, reservation price $\mathbf{P}_{\mathrm{pr}}$, saturation of demand $\mathbf{Q}_{\mathrm{st}}$)

individuum this risk can be quantified by the variance of demand fluctuations. The "downstream hazard" of unemployment is the higher the more the firm's output reaction to demand fluctuation results in per capita adjustments, for example in employment reduction.

The following description defines L_μ as a reference point. As already mentioned, price setting behavior in the model is unaffected by the fact that output demand is randomly distributed. Let $L_\mu = \{N_\mu, h_\mu\}$ denote the corresponding optimal employees–hours–combination under certainty. For simplicity, let h_μ equal standard working hours. Under uncertainty $\mathbf{h}$ (see $\mathbf{A4}$) comprises two elements: h_t and h_μ, where the first measures actual working hours in period t, which may or may not coincide with standard working hours. If one allows for working hours flexibility, $\mathbf{h}$ discloses information on optimal working time under certainty h_μ and on requested number of hours h_t. For example, expected demand is met in the case where $h_t = h_\mu$. The same applies to N, so $L_t = \{N_t, h_t\}$ measures the (if so) adjusted factor labor.

Our firm strives for a persistent market presence. Thus, the periodic specific adjustment or flexibility potential is measured by $\Delta L_\mu \equiv \{\max|N_t - N_\mu|, \max|h_t - h_\mu|\}$, with $\max|\,.\,|$ as the maximum feasible deviation between current and standard variables. The maximum adjustment range derives from alternative sources. First, legal regulation prescribes a supremum for working time flexibility and for per capita adjustment[6]. Second, this measure can be restricted further in collective or firm specific agreements, which may e.g. impede temporary layoffs or permit a scope of daily transfers of x hours. Basically, firms adjust the elements $h_t \lessgtr h_\mu$ or $N_t \lessgtr N_\mu$, respectively.

Let employee preferences for intertemporal smoothing of working hours be of minor importance. In addition, if workers have time preferences regarding the allocation of working time, let the discount factor be in the neighbourhood of one[7]. Acceptable transfer limits from the work-

averse employee the following applies: the utility from continuous employment exceeds the expected utility from the respective employment lottery, such that the first is preferred (see Akerlof/ Miyazaki (1980)).

[6]In Germany, for example, the *Arbeitszeitgesetz* stipulates appropriate limits (Anzinger (1994)).

[7]Alternatively, one could introduce interest rates on hours deposits on the one hand and insurance fees

force's point of view are conveniently defined by existing legal sources.

Solving the optimiziation problem subject to all the restrictions yields characteristic $\{N_t, h_t\}$–combinations, where the components vary with the firm's adjustment costs concerning hours variation and recruitment/ displacement decisions. With a time horizon of T periods the assumptions on the stochastic process imply that the periodwise sum over the adjusted factor labor equals T–times the reference point under certainty L_μ, provided that market experience is long enough. In the extreme case of rigid employment merely h_t differs between periods, while the number of job slots always amounts to N_μ. In the other extreme hours are held constant at the level of h_μ, thus labor is completely adjusted via hiring and dismissals. The different strategies are common knowledge.

Consequently, the expected value of hours $\mathrm{E}(\sum_{t=1}^{T} h_t|_{N_t=N_\mu})$ over the horizon T of the model equals $T \cdot \mathrm{E}(h_t) = T \cdot h_\mu$ and the expected number of employees $\mathrm{E}(\sum_{t=1}^{T} N_t|_{h_t=h_\mu})$ over the same number of periods is $T \cdot \mathrm{E}(N_t) = T \cdot N_\mu$.

The potential attractivity of the strategy *per capita variation* suffers from fixed and quasi–fixed costs of recruitment and separations, from essential investments in human capital as well as from legally and institutionally enforced regulation (Oi (1962), Hamermesh (1989), Bellmann et al. (1996)). In fact firms will take alternatives into consideration. In the upshot, choice will be affected by firm specific restrictions. The literature on optimal adjustment strategies to temporary shifts in labor demand discusses the utilization of "employment capacity" and often concentrates on the debate on overtime work and short–time work (e.g. Hart (1988), Hart/ Moutos (1995)). Thereby, labor is partitioned into the two *sub*factors (i) working hours and (ii) number of employees, who are assumed to be substitutive in the short run.

The presented model extends these contributions as it integrates expanding elements of adjustment as well as shrinking elements in just one unique instrument, namely an idiosyncratic form of working time flexilbility in an insurance environment[8]. I.e. desired variations in labor utilization are generated via *working time accounts* which comprise job security. During the validity of the instrument employees are more or less fully covered against product market induced dimissal risks and potential concequences, since employers commit themselves not to lay off. Respective insurance aspects and employees' motives will be discussed in detail later. At this point let us remark that the execution of working time accounts generates Pareto improvements that are achieved without recourse to overtime or short–time work. Thus, related costs' increases can be avoided, although exactly the same adjustment effects are resulting. Hence the accounts–approach is Pareto superior compared to well–known strategies of flexibilization.

Let output Q be produced according to the production function in equation (1). Since a risk neutral firm comes to the same profit maximizing output–decision as under certainty, equation (2) also applies:

$$Q = f\left(L(N,h),K\right) \tag{1}$$

$$Q_\mu = f\left(L(N_\mu,h_\mu),K\right) \equiv Q^* \quad . \tag{2}$$

As the common assumption was made that capital is fixed in the short run, investment in

concerning continuous employment on the other. As the employee's utility function is intertemporally separable, none of the results changes, if one further assumes that both just balance.

[8]See Lindecke/ Lehndorff (1997) for an overview of firmlevel agreements including arrangements on innovative working time schedules reflecting part of German industrial relations.

e.g. machinery equipment is not analyzed. Further, the cost function is assumed to be additively separable. Let us first concentrate on a cost function in a firm that abstains from adjustment activities. Production of Q then causes (a) personnel costs amounting to wN_μ, with w as the incentive compatible time wage (determined at standard working hours h_μ), and (b) fixed capital costs, which amount to $\overline{c_{\overline{K}}}$. The corresponding cost function equals the cost function in a world under certainty or when expected and realized demand coincide:

$$C_\mu \quad = \quad g(L_\mu, \overline{K}) = w \cdot N_\mu + \overline{c_{\overline{K}}} \quad . \tag{3}$$

Under stochastic demand, however, it seems not very reasonable that such behavior in fact occurs. Instead appropriate means of adjustment (flexibility strategies) are likely to be developed, at least under $\mathbf{A2}$, $\mathbf{A5}$ and the profit maximization hypothesis. Effects on the cost–side ensue immediately. Respective adjustment costs differ with the flexibility strategy chosen. A generalized version of the cost function in equation (3) is therefore:

$$\begin{aligned} C \quad &= \quad g(\mathbf{L}, \overline{K}) = g(L_\mu, \Delta L, \overline{K}) \\ &= \quad w \cdot N_\mu + c_t(\Delta L) + \overline{c_{\overline{K}}} \quad , \end{aligned} \tag{4}$$

where $\Delta L = \{N_t - N_\mu, h_t - h_\mu\}$ measures the ex–post difference between *adjusted* utilization of the factor labor on the one hand and it's expected value on the other hand. Adjustment costs are denoted by $c_t(\Delta L)$, with an expected value of $\mathrm{E}(c_t(\Delta L)) = 0$. They result from the objective to align current demand and output. The reference point L_μ comes along with lack of adjustment costs as well as a scenario, where no flexibility strategies are utilized: $c_t(\Delta L) = 0|_{\{0,0\}}$.

Fixed adjustment costs ($c_t(\Delta L) = \overline{c_\Delta}$) do not affect the firm's output decision, since marginal costs remain unchanged. *Working time flexibility,* where — within predetermined limits — intertemporal transfer of monthly (yearly) hours, and therefore the distribution of working time, is within the scope of the entrepreneur's duties, is one example for a strategy, which causes fixed adjustment costs. Here it is at the firm's discretion to temporarily cut hours of work in times of negative shocks of demand and to temporarily extend working hours in the reverse case, thereby avoiding premium payments pertaining to overtime hours.

If negative demand shocks in t are handled with *reduction in staff,* adjustment costs are for instance $c_t(\Delta L) = -w \cdot (N_\mu - N_t) + \sum_{i=1}^{I} S_i^t + c(\textsc{SoPl})$, with severance payment S_i^t to the i–th dismissed person, and overhead costs $c(\textsc{SoPl})$ due to the implementation of a social plan or similar institutions.

A conceivable strategy to cope with positive demand shocks is *overtime work.* Under identical magnitude of overtime for different workers well–known adjustment costs $c_t(\Delta L)$ result: $(1 + \tau)\frac{w}{h_\mu} \cdot (h_t - h_\mu)\, N_{it} =: (1 + \tau)\, \omega \cdot \Delta h_t\, N_{it}$, where the number of employees involved is N_{it}, while τ denotes overtime premiums, and Δh_t measures overtime hours per worker. The mark up τ is based on *standard hourly wages* ω, which can be constructed by dividing the time wage at standard working hours w by the number of standard working hours h_μ.

Under $\mathbf{A5}$ and supposing normally distributed disturbances, it follows that current demand Q_M is normally distributed with constant variance. ΔQ measures deviations between realized demand Q_M and the firm's ex–ante solution of the maximization problem Q^*. Consequently ΔQ is also normally distributed with identical variance:

$$Q_M \sim N\left(Q^*, \sigma_M^2\right) \quad , \tag{5}$$

$$\Delta Q \sim N_0\left(0, \sigma_M^2\right) \quad . \tag{6}$$

Though, in principle, the risk neutral firm does not care whether operating on the basis of the demand–lottery Q_M or being confronted with the certain realiziation of the respective expected value $\mathrm{E}(Q_M) = Q^*$, the discussion of appropriate adjustment strategies is not redundant, because **A 3**, namely the absence of inventories, requires a slightly altered argumentation. The point will now be elucidated.

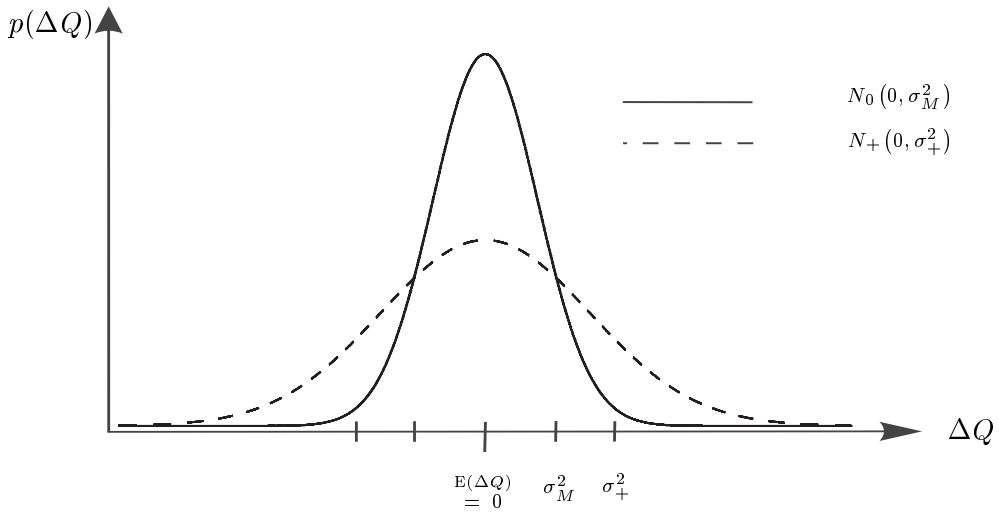

Figure 2: Identical expected demand, divergent dispersion

In figure 2 both random variables $N_0(0, \sigma_M^2)$ and $N_+\left(0, \sigma_+^2\right)$ render **A 5**. Furthermore, profit maximizing behavior restricts firms to opt for exactly the same price–output–combination $\{p, Q^*\}$, irrespective of whether N_0 or N_+ were the underlying error distribution. However, distribution N_+ has larger dispersion, is therefore characterized by increased demand risk, and consequently is less favorable.

Although risk neutral, the firm prefers the stochastic process $N_0(0, \sigma_M^2)$ to the latter. It is in the firm's interest to be confronted with a distribution that implies as little variance as possible, i.e. a mean preserving random variable with zero variance is strictly preferred to all the other random variables. Correspondingly, define the case under certainty ($\sigma = 0$) as a first–best benchmark, denoted by FBB. This benchmark plays a role in the following considerations, which treat the random variable $Q_M \sim N(Q^*, \sigma_M^2)$ as given. Remember that Q_M is already an outcome of the employer's optimization behavior.

The following results constitute the core of the paper. It will be proven by means of a comparison of typical scenarios that the introduction of working time accounts is appealing for both, firms *and* for workers: A situation under certainty (1) ist juxtaposed to (2) demand fluctuations with perfect adjustment, as well as to (3) product market uncertainty exclusive of engagement in

potential adaption strategies. Evidently working time accounts represent a flexibility strategy that comes close to (2).

Now the maximum of (ex–ante) expected profits $\mathrm{E}\,\Pi^*_{fb}$ is derived. This expresses exactly the hypothetical benchmark FBB, just defined:

$$\mathrm{E}\,\Pi^*_{fb} \quad = \quad p \cdot Q^*(L^*, \overline{K}) - C(Q^*|\overline{K}) \quad , \tag{7}$$

with $C(Q^*|\overline{K})$ as defined in (3), since $c(\Delta L) = 0$ applies. The first order condition becomes:

$$p + P_Q \cdot Q^* \quad \stackrel{!}{=} \quad C_Q \quad , \tag{8}$$

where p denotes the price where output meets the product demand curve $P(Q)$. I.e. the firm fixes p according to it's output decision Q^*, namely time invariant during a period by assumption. Apparently, no scenario under uncertainty is able to replicate the value of $\mathrm{E}\,\Pi^*_{fb}$, unless the contemplated profit–lottery permits of frictionless adaption (see equation (7)).

Under the given framework any ex–post achievable value of expected profits $\mathrm{E}\,\Pi_M$ falls short of FBB, since ex–post variables base on realizations of expected demand. The relevant relation is depicted in equation (9). A comparison with equation (7) indicates that ex–ante expectations of risk neutral firms overstate obtainable magnitudes:

$$\begin{aligned} \mathrm{E}\,\Pi_M \quad &= \quad \left[1 - \text{prob}(Q_M \leq Q - 1)\right] \cdot P(Q) \cdot Q \\ &+ \quad \text{prob}(Q_M \leq Q - 1) \cdot P(Q) \cdot Q_{M,\Delta<0} \\ &- \quad C(Q|\overline{K}) \quad . \end{aligned} \tag{9}$$

Q measures expected as well as planned output subject to $P(Q)$, Q_M measures the realization. As excess demand cannot be satisfied, in all states where $Q_M \leq Q^*$ materializes, the equation $Q_M = Q$ holds, i.e. planned and sold output are identical. Otherwise $Q_{M,\Delta<0}$ indicates states where excess supply occurs, i.e. effective sales fall short of the production program. The cumulative density of the latter states ($Q_M \leq Q^* - 1$) equals the value of the commensurate distribution function at $F(Q^* - 1)$. Moreover $z = \frac{Q_M - \mathrm{E}(Q_M)}{\sigma_M}$ applies as a result of the normal assumption.

Hence, the maximum of expected profits $\mathrm{E}\,\Pi^*_M$ is given by the following equations:

$$\begin{aligned} \mathrm{E}\,\Pi^*_M \quad &= \quad \left[1 - \Phi\left(-\frac{1}{\sigma_M}\right)\right] \cdot \Big(p \cdot Q^* - C(Q^*)\Big) \\ &+ \quad \Phi\left(-\frac{1}{\sigma_M}\right) \cdot \Big(p \cdot Q_{M,\Delta<0} - C(Q^*)\Big) \end{aligned} \tag{10}$$

$$= \quad \left[1 - \Phi\left(.\right)\right] \mathrm{E}\,\Pi^*_{fb} + \Phi(.)\,\mathrm{E}\,\Pi^*_{fb} + \underbrace{\Phi(.) p \cdot \Delta Q}_{<\,0} \quad , \tag{11}$$

whereas $\Phi(.)$ describes the standard normal distribution. Obviously, $\mathrm{E}\,\Pi^*_M < \mathrm{E}\,\Pi^*_{fb}$ is valid, since $\Delta Q < 0$. Here $\Delta Q = Q_M - Q^* < 0$ is a measure for *perished* output. Negative values of ΔQ

correspond to revenues of $p \cdot Q_M < p \cdot Q^*$, while for all $\Delta Q \geq 0$ exactly $p \cdot Q^*$ is earned.

Since adjustment costs and potential gains from flexibility have not materialized so far, production costs at this stage amount to $C(Q^*|\overline{K})$, independent of ΔQ. With a positive probability of states $\Delta Q < 0$ the (first best) benchmark in equation (7) is merely hypothetical, as $\mathrm{E}\,\Pi^*_M < \mathrm{E}\,\Pi^*_{fb}$ holds[9].

A first upshot is that product market uncertainty in combination with increased needs for time management entails considerable consequences for the firm's optimization behavior. Hence, the firm is after activities to decrease the difference between (7) and (11) at a reasonable level of adaption costs. Recent contributions emphasize the potential of strategies that facilitate flexibility. Here we concentrate on the instrument of working time accounts (their equivalent windows of working time) as a unique form of working time flexibility, as they allow to imitate demand fluctuations via intertemporal transfers of actual working hours. In contrast to traditional flexibility instruments they are not penalized with increased marginal costs or compensated idle capacity.

Several advantages emerge for the firm: First, working time accounts are appealing because of their capability to adapt almost perfectly to either direction of demand shifts. Second the costs argument is convincing, since the constant time wage for an employee over all periods implies constant wage costs per period (remember the number of employees is fixed, as they are guaranteed job security when participating in the time schedules for insurance motives). Thus, on the one hand no overtime premiums augment wage costs in periods of temporary positive demand shocks. On the other hand periods of negative demand shocks are not characterized by payments for *wasted time*, e.g. full compensation despite spare capacity. The offsetting profile of adjustment is carried into effect by deposits of working hours.

If firms opt for working time accounts for reasons of adjustment, respective marginal costs keep unchanged, are therefore unaffected by fluctuations in demand. Moreover, they yield the same optimum strategy as under certainty. Altogether, working time accounts are superior to alternative adjustment strategies under benefit-cost analysis (an outline of the main results is given in Section 2.2. For a detailled discussion see Carstensen (1999b), which also contains some remarks on the legal basis in Germany).

A definition of, respectively, *working time accounts* and the equivalent *windows of working time* is straightforward. By construction they integrate firm specific circumstances as well as employees' preferences, since the constituting elements entail idiosyncratic specifications.

Definition 1 ($\mathbf{wta}$) *A working time account* $\mathbf{wta} = \left\{h_\mu, \min\left[\,|h_t - h_\mu|, \Delta h_\mu\,\right], \Delta t, w, \textcircled{S}\right\}$ *is specified by the following five elements:*
(a) standard working hours h_μ*,*
(b) maximum of hours deviation $\Delta h_\mu = \max|h_t - h_\mu|$*,*
(c) account's time horizon Δt*, i.e. maximum period of time in order to balance,*
(d) constant time wage w *that participating employees receive, and*
(e) insurance Ⓢ*, i.e. participants are covered from dismissal risks caused by fluctuating demand.*

[9] An example may illustrate: Suppose a lottery with expected value Q^* and exactly three different realizations. State 1, the realization of the expected value, occurs with probability $(1-a)$. State 2 and state 3 materialize each with probability $a/2$, where state 2 depicts $(Q^* - \sigma_M)$ and state 3 depicts $(Q^* + \sigma_M)$. Thus expected revenue $\widetilde{\mathrm{E}\,\mathrm{R}}$ under uncertainty is exactly $(1-a)\cdot pQ^* + \frac{a}{2}\cdot pQ^* + \frac{a}{2}\cdot p(Q^* - \sigma_M)$. Then $\mathrm{E}\,\Pi^*_M$ is given as $\widetilde{\mathrm{E}\,\mathrm{R}} - K(Q^*) = \mathrm{E}\,\Pi^*_{fb} - \frac{a}{2}\cdot p\sigma_M < \mathrm{E}\,\Pi^*_{fb}$. In general the extent of profit–loss increases with the degree of uncertainty, measured by σ_M.

As already mentioned, standard hours in (a) coincide with expected hours h_μ. A measure can be stipulated legally, in collective agreements or in firmlevel agreements, depending on the specificity of product markets and on the information generating capacity of firms. With Δh_μ in (b) an idiosyncratic supremum for periodwise differences between current and expected number of hours is defined, i.e. the maximum amount that h_t may exceed (fall short of) h_μ is stated. So far the definition of (b) refers to symmetric differences around h_μ, although generalizations in the direction of diverging bounds for per period hours credits and per period hours debts can easily be integrated. Since none of the models' results will change, further discussion concentrates on cases where $\{\Delta h_\mu \in \mathbb{R} \quad | \quad \max_{h_t > h_\mu} |h_t - h_\mu| = \underset{\Delta > 0}{\Delta} h_\mu = \underset{\Delta < 0}{\Delta} h_\mu = \max_{h_t < h_\mu} |h_t - h_\mu|\}$.

Remark that it is not the firm's objective to contract the adjustment potential Δh_μ as large as possible, since the incentive constraint in $\mathbf{A7}$ in combination with payment of constant time wages constrains feasible variations in derived hourly wages ω_t and consequently Δh_μ. In practice either the numbers of hours is realized, which is sufficient to produce an output level that imitates the analogue on the shifted demand curve, or the bound Δh_μ becomes effective. If the latter occurs too often, despite the no–shirking condition is met and negative incentive effects can be prevented, it is more than likely that (a) will be renegotiated or per capita adjustments will be made.

The purpose of (c) quit similar. The choice of an adequate spell to obligatory settle the working time account is not a trivial problem. On the one hand, the period of time, in which working hours credits and debts are forced to have offset, should be long enough concerning a problem, which is usefully prescribed by the phrase 'small–sample problem with respect to the number of periods (e.g. weeks). On the other hand it is possible that, for whatever reasons, expectations may be biased or permanent demand shifts may occur. Thus, it is sensible to agree a priorily to renew $\mathbf{wta}$ in regular intervals, and if necessary modify, which means (c) defines a pro forma expiration date.

From the employees' point of view there is no reason to support the described credit market for working time except for job security motives. Thus, they will agree to $\mathbf{wta}$, if the employment insurance argument as provided in (e) is prevalent. In other words, if demand variation is significant or if cumulated market risks introduce an ex–post employment lottery with sufficient low expected values (representing the probability of continued tenure), it is fairly reasonable for employees to participate in contracts on working time accounts. Thus, efficent risk allocation can be achieved via $\mathbf{wta}$. The present situation on labor markets and growing incidence of working time accounts, too, underline the presumption, that employees in fact benefit from inherent insurance. The major benefit for firms stems from the variable risk premiums that insured employees pay, since these premiums generate — up to a certain extent — cost neutrality of $\mathbf{wta}$ with regard to variable costs, as (d) points out.

The preceding arguments make clear that industrial relations play a crucial role for the success of working time accounts, since a coordinated approach of management and employees (their representatives) in construction, implementation and execution enhances Pareto improving effects. The respective costs, i.e costs of installation and maintenance, are primarily fixed costs, as they can be assigned to the area of information and communication. Compared to alternative flexibility strategies working time accounts come along with a lot of cost advantages. E.g. contribution margins are usually lowered in periods of underutilization of production capacity due to continuous compensation of workforce or short–time. Otherwise typical increases in marginal costs due to longer working hours and overtime premiums are cut off in working time accounts. A similar argument applies to recruitment costs and costs of (temporary) separations or (re–) employment, as the case may be. Insofar working time accounts represent a worthwhile adjustment strategy, which in addition yields continuous employment for incumbents.

The following section treats working time accounts from the employer's point of view. It discusses their relative advantages with attention drawn to the objective of job security. Continuous–employment guarantees are given in implicit insurance contracts on the firm level. It is likely that both, employer and employees support this adjustment strategy, if such guarantees can be verified, at least by employees' representatives. If a firm reneges, i.e. unexpected dismissals occur, then employees withdraw agreement to all further **wta** schedules.

2.2 Alternative Adjustment Strategies

Working time accounts delineate one possible strategy to cope with short–run demand fluctuations. Though this instrument is appealing owing to its capability to adequately handle positive as well as negative shocks, alternative instruments exist, which cope for at least one the two directions of deviation. These alternative strategies differ mainly according to their intrinsic cost profiles and they diverge concerning the degree of reversibility.

The following pages provide a short discussion of the different cost profiles as an outcome of utilization and retraction of single instruments. The results base on Carstensen (1999b), which contains a more detailed assessment. The instruments included predominantly aim at temporary fluctuations, thus should be reactive and invertible (e.g. Bellmann et al. (1996)). Overtime work, extra shifts, postponement of holidays, placement of orders with external firms, temporary work, and (fixed–term) contracts are possible means of managing excess demand. If current demand falls short of expected demand, cutback of overtime working, short–time work, reduction of working hours, drop of shifts, retraction of orders with external firms, phasing out fixed–term contracts, non–replacement of personnel fluctuation, contracted separations, and lay offs can be taken into consideration.

Whilst the imitation of temporary fluctuations in product demand via working time accounts takes place without any additional compensation, one–time costs of negotiation and initiation as well as expenditures for documentation and maintenance of an account system emerge. System maintenance is necessary, since working time accounts regulate the intertemporal allocation of working time within the firm. Altogether **wta**s induce fixed costs.

Overtime hours that are always counterbalanced with leisure are equivalent to hours credits in working time accounts. But the bulk of *overtime hours* is compensated with overtime premiums. Moreover, timing and implementation of overtime work suffer from uncertainties, which are best depicted by institutional inertia. Thus — a priori — the adjustment potential of overtime work is restricted substantially. The legislation on *short–time* work is stringent. For instance, in Germany the following holds: On the whole, short–time working benefits are restricted to employees in firms, where capacity utilization — related to payroll including taxes — transiently falls under 60 %. Entitled firms are obliged to approach the regional employment office with a written application for short–time and under submission of a set of supplementing documents. Thus, short–time work under German legislation comes along with non neglectable transaction costs. If firm level institutions already exist, which can be interpreted as hours flexibility instruments, then short–time work cannot be implemented, unless the adjustment potential of such instruments is completely exhausted. This further limits short–time as an adjustment instrument.

The transaction costs argument also applies, if it comes to the assessment of the instrument *disentanglement of working hours and operation time*: Set–up and cutback of shifts cause per capita costs on the one hand. On the other hand expenses for maintenance and repair increase. At times it is argued that *part–time work* holds a remarkable capability for flexibility (e.g. Bellmann et al. (1996)). Contributions that properly provide theoretical or empirical evidence are hardly

available. Thus, hypotheses as "part–time contracts more often (i) agree on hours corridors or (ii) implicitly use working time flexibility than their full–time counterparts" still lack analytical verification. The strategy to absorb risks on product markets via 'smart' *combinations of external and internal labor markets* proves to be myopic, since recent experiences in industrial relations reveal large transaction and bargaining costs, when it comes to the decision of either to enforce the expiration date of a fixed–term contract or to convert it into a permanent contract.

The primary focus of agreements on *early retirement* is rather on permanent demand shifts than on short–termed deviations. The corresponding procedures are extremely time–consuming and evaluations should pay attention to the fact that social costs of early retirement will always exceed firm specific costs by considerable amounts, since prevailing schemes are characterized by take-up of subsidies and use of unemployment benefits through integration of long–term unemployment for former incumbents. Moreover, per capita adjustment is not attained, since legislation prescribes to fill in the vacant slot immediately with an outsider. Thus, early retirements primarily entail qualification flexibility, i.e. adjustment of human capital profils.

To conclude, working time accounts are superior to alternative adjustment instruments with respect to adjustment costs. In addition they imply ex–post congruence of demanded and realized output. Correspondingly $\mathbf{wta}$ can be interpreted as 'natural' occurrence of strategies, which obtain ex–post efficiency for spot–contract sequences in renegotiation games, thus generating renegotiation–proofness. Moreover, they guarantee implementability of the long–run optimum by spot contracts as defined in Chiappori et al. (1994) (see also 2.3). Correctly designed, working time accounts are capable to (almost) offset reduction in profits, which are induced by product market uncertainty[10].

Thus, a hierarchy of adaption seems plausible, which links single instruments to the expected duration of demand deviation. Fluctuations, which mainly represent white–noise errors are regulated completely via working time accounts. Non–transitory deviations or longer termed shifts of the demand curve to the northeast correspond e.g. with a well–designed (consistent) timing of, first, credits of working time, (ii) overtime hours, and (iii) recontracting of elements in $\mathbf{wta}$ as well as hiring. Reversed trends could be accompanied by cutback of overtime work, reductions in standard hours, non–replacement of exits, and separations. The relative weights of individual instruments in a period specific basket depend on the length of Δt, i.e. the account's time horizon, on the degree of product market uncertainty, and on the relative frequency of permanent shocks.

The model so far leads to the conclusion that employers are able to credibly commit to insure their (high effort) employees against the loss of jobs as stated in Definition 1, where the risk of unemployment is induced by demand fluctuations. Credibility is given, because employees hedge employers against demand fluctuations, if working time accounts are effective, thus generating mutual dependence. Similar properties could be reached via inventories, as they provide

[10]The following remark is important. As the shape of the firm's production function influences the marginal–costs—marginal–revenue—differential, alternating output levels cause inefficiencies. I.e. intertemporal transfer of production drives the firm to deviate from the short–run optima, which can be calculated with the usual microeconomic tools. For output Q_t in period t marginal revenue exceeds marginal costs under negative demand shifts, whereas the difference between marginal costs and marginal revenue is positive in cases, where the realization of demand is larger than expected demand. Generally, if the shape of demand fluctuation allows for fairly narrow windows around standard working hours (see (b) in Definition 1), the threat of deviations from optimal output decision diminishes. The latter argument demonstrates that complementary instruments, as for example marketing activities, can be sensible, since they serve to lower the variance of demand (see also 2.6).

capacities for intertemporal production buffers. For storable goods the same results are attained as under working time accounts, but with large investments. Thus, inventories raise considerable 'adjustment' costs and are inferior to working hours buffers as ruled in working time accounts. Altogether the latter are consistent with recent time management, whereas the former are not.

Several strategies are a priori not restricted to be just a substitute for working time accounts. Wage cuts, price policy and multiskilling may be practised complementarily to working hours transfers. Let's consider wage cuts first. Within the efficiency wage framework reductions in wages cannot be promising, since this violates the non–shirking condition in **A7**. Thus, wage cuts are not a suitable adjustment strategy, unless employees voluntarily offer. But such behavior does not seem very likely at all.

Price policy subsumes the following proceeding: The firm sets the profit maximizing price p under the optimal output decision Q^*. If product demand Q_M, revealed at p, deviates from Q^* then the firm deduces the current demand function $P(Q + \Delta Q)$ from the realization (see figure 1, $\Delta Q \neq 0$). This function advises how to adequately adjust price to $p^{pp}|_{Q_M} \gtrless p$, i.e. the market clearing price for hitherto excess demand or excess supply, respectively.

Admittedly, under the strategy of price policy the denoted price increase $p^{pp} - p$ at Q^* in case of excess demand depicts a suboptimal choice, since optimal output will no longer be at Q^*. Thus, the firm's output decision will be also adjusted. Price policy introduces a second optimization process, which refers to the ex–post demand curve and leads to altered output decisions, i.e. to production augmentation in the short run. Consequently, in all likelihood overtime hours (and/ or temporary work) are demanded. As a result the model predicts complementarity of price policy and overtime work, with the first instrument related to marketing policy and the second instrument related to personnel policy.

Expected values of revenue and costs of a price adjustment policy can be split up into partial expected values, each corresponding to one the three possible forms of realization (excess demand, excess supply, no deviation from expected demand). The potential success of price policy varies with the generic shape of demand according to **A5**, with the dispersion of this function, and with the shape of marginal costs.

The sign of the profit differential between the two adjustment strategies *price policy* and *working hours flexibility* is not unequivocally predictable, since it is determined by several, sometimes related factors. Working time accounts are c.p. the more favorable the higher the degree of uncertainty, the larger overtime premiums, and the higher per capita recruitment costs. Here further research, mainly empirically, promises interesting new insights. E.g. the pairwise consistent combinations (i) price policy/ overtime work and (ii) **wta**/ firm level communication system could be subsystems of a higher ordered conjoint supermodular system, or they could stem from diverging (sub) systems of entrepreneural activities. The latter would predict diverging equilibria. The former predicts multiple equilibria, which describe increasing sets. Translated into empirical framework of cross–section and panel data that property implies interactions between variables.

Whether price policy is suitable in rent sharing environments (Slichter (1950), Carruth/ Oswald (1989)), is ambiguous, since elaborated motivational aspects and industrial relations gain weight. It is not unreasonable to argue that alternative instruments, particularly marketing related activities are preferred, e.g. maintenance of customer relations, service strategies, quality management or time management. The desirability of price policy as an adjustment instrument depends on relative weight of equilibrium unemployment, demand driven unemployment risks, prediction over chances of re–employment, and on the underlying product market structure. Decisive is whether major contribution in the determination of unemployment comes from incentive arguments or from market uncertainty. Related work on the wage curve portrays important properties (Blanch-

flower/ Oswald (1994), Carstensen (1995)).

Multiskilling comprises efficient allocation of the different single skills, i.e. efficient assignment of several tasks in a multitasking environment. Thus, dependent on demand fluctuations, employees could redistribute the share of e.g. production activity j, production activity k, different maintenance activities, quality assurance, further training, etc. But adaption via flexibility in qualifications causes expenditures for further training on the one hand (Carstensen (1999a)) and may induce short–termed productivity leakages due to learning curves on the other (Pil/MacDuffie (1996)). From this point of view one should expect the presence of interdependencies (complementarities) between **wta** and multiskilling or skill upgrading.

To summarize, successfully practised working time accounts cover employees fully from labor market related consequences, as long as temporary fluctuations are considered. The presented model assumes intertemporal transferability of working time within firms in contrast to non–storable goods or prohibitive costs of inventories. The idiosyncratic supremum of hours transfers arises from efficiency wage arguments, which are integral part of the model. Consequently, employees base their effort decision on standard hours. Altogether the combination of incentive theoretic and insurance arguments results in a (at least) pairwise interlocking of periods via hours transfers and moreover in long–term employment relations.

Initiation and implementation of working time accounts are potentially surrounded by institutional restraints. Precise examinations of the predicted power of the insurance argument are reserved for future research. An interesting aspect will be credibility. The question is, whether firms can in fact credibly commit not to renege the implicit contract, or whether incentives to lower standard hourly wages via pseudo–balancing dominates, i.e. skimming of cost advantages from lacking overtime premiums occurs without respective hours cutback in opposite periods. The latter behavior might occur, if contracted standard hours are suboptimal (resp. too low) for firms.

Even if credibility is given and employees have agreed, the contribution of this model to research in labor economics is restricted to the environment of temporary shifts of the demand curve and depends on firm's predictive ability. In addition suitable institutions, which regulate negotiation and renegotiation of working time accounts or single elements in **wta**, should be installed as e.g. well designed routines for the bargaining process, in which the works council participates and that are effective prior to schedule's enactment.

2.3 Renegotiation–proofness of Working Time Accounts

As the model is designed as a sequence of spot contracts, the solutions form also a spot sequence. Thus, it is necessary to deal with ex–post efficiency of contracts under insufficient commitment possibilities (spot implementability) and to apply the results to the specific case of working time accounts. Renegotiation–proofness as a neccessary condition for optimal long–term contracts to be implementable via spot contracts is of interest, too[11]. The contemplation of renegotiations is

[11]The optimal long–term contract is renegotiation–proof (ex–post efficient). Spot contracts are ex–ante efficient, but usually lack ex–post efficiency, since in general they are not renegotiation–proof (as defined in the game–theoretic framework, see Dewatripont (1988), Fudenberg/ Holmstrom/ Milgrom (1990)). The contract's capability for memory is crucial: If the optimal long–term contract exhibits e.g. memory of wages, which means past wage levels affect current wages, the spot sequence is Pareto–dominated by the optimal long–term contract. This result can be altered, if well defined credit market conditions apply, which translate into specific constraints for credit access. Thus, spot implementability can be generated

crucial for various reasons, e.g. if integration of persistent shocks is needed (see also figure 3)[12].

First, it has to be verified, whether the T–period working time model in the just discussed manner can adequately catch the economic problem of demand uncertainty or whether alternative approaches are needed to meet the requirements of the multi–period economic environment. The second question deals with moral hazard, primarily on the employer's side. In the stability analysis it is of significant interest, in which circumstances incentives emerge to lie, when announcing the necessity of adjusted hours, and how these incentives depend on expectations of future developments, e.g. legal regulation.

The labor contract $\mathbf{wta} = \{h_\mu, \min[\,|h_t - h_\mu|, \Delta h_\mu\,], \Delta t, w, \textcircled{S}\}$ derived in Section 2.1 consists of hours elements, of remuneration elements, and of employment security elements. The latter two components embody planning reliability, whereas the first component carries the adjustment potential of working time accounts. It can be shown that parallelisms exist between the working hours flexibility approach and well–known contract– or game–theoretic approaches. Current working hours h_t do not always coincide with standard working hours h_μ, thereby introducing limited commitment into the presented model. In a slightly different economic context Chiappori et al. (1994), hereafter CH94, develop an integrated multi–period principal–agent–model, which deals with the same problem. The following argument uses their results on spot implementability to prove sequences of $\mathbf{wta}$ to be optimal in the long run.

Given limited commitment and lack of memory in spot contracts, the corresponding sequence of spot contracts (the periodwise chain) usually generates solutions, which are suboptimal in the long run, i.e. they diverge from the solution, which the optimal long–term contract possesses. Thus, with only a few exceptions, the long–run optimum is not renegotiation–proof, and that effect not spot implementable. Since long–term contracts inherently produce memory, they internalize negative externalities resp. enable efficient risk allocation by intertemporal smoothing, a task which iterated spot contracts cannot accomplish. However, important exceptions exist. Trivially, any spot sequence which imitates a memoryless long–term contract is ex–post efficient, where the sequence is the T–times repetition of the optimal static contract. More exciting, ex–post efficiency can likewise be achieved, if one successfully implants memory in a spot sequence.

Keeping the latter in mind the above authors prove that the following two cases produce renegotiation–proofness and imply spot implementability[13]: (a) Agent's savings are observable and can be controlled/ monitored by the principal, (b) randomized savings.

They model the firm's decision problem over wage contracts in a multi–period principal–agent–setting, which explicitly integrates credit market access. Thus the (employee–) agent's period income and period consumption no longer coincide by definition. The control of credit

via optimizing over the choice of savings, where the following definition applies: A "long–term contract is spot implementable if and only if there exists a perfect Bayesian equilibrium of the spot contract game" (Chiappori et al. (1994), see also Rey/ Salanie (1990)) that replicates the outcome of the long–term contract.

[12]Fudenberg/Tirole (1991) discuss the replacement of one (long–term) contract by another subject to parameter changes as a second alternative under the topic *renegotiation–proofness.*

[13]Renegotiation–proofness and spot implementability exist in a third case, too, in which the agent disposes of unrestricted access to a perfect credit market. Transferred to the $\mathbf{wta}$–scenario in the working hours model this would give complete control to the employer in every single period with respect to each element in the working time account. Thus, the realization of the random variable Q_M would remain his private information and compliance of employees is just as needless as their involvement in installation, maintenance and adaption of working time flexibility. Under the presented arguments on employment guarantees it follows immediately that working time account will not exist within such a scenario.

market access as mentioned in (a) allows the (employer–) principal to endow spot contracts with memory, although they originally were memoryless. In this regard, the agent is offered a well defined compensation package, which combines period consum and period savings subject to all the period specific participation constraints (employee's reservation utilities). In doing so, the long–run optimum can be attained in a sequence of spot contracts, which solves the optimal choice of incentives. CH94 do not miss to indicate lack of empirical relevance and transferability of their theoretically appealing results. This is not surprising at all, since usually the agent's consumption is not — as claimed in (a) — observable by the principal (resp. the credit market cannot be restricted to the two participants principal and agent).

Fortunately, this shortcoming does not apply to the presented **wta**–model. Therefore, working time accounts are a suitable example for a chain of iterated spot contracts being renegotiation–proof and for spot implementability of the long–run optimum à la CH94, as they, too, provide efficient consumption smoothing. In the sequel case (a) is transferred onto the working time account approach. Spot efficiency is proven under controlled savings, although the design of **wta** interestingly also includes case (b)[14].

If the expected value of the random variable *product demand* is time invariant as postulated in **A5**, then the implementation of **wta** is identical to controlled savings (for a more detailed description see Chiappori et al. (1994)), with the principal monitoring agent's credit market access, thus determining the agent's savings–path. The solution of the optimization problem shows the following typical properties: The generated sequence of single–period contracts is renegotiation–proof and, moreover, the so defined employment relation is spot implementable. The demand function provides enough (sufficient) memory as it has constant expected shape and mean demand, i.e. uncertainty pertains the parameter with an expected value of zero.

To elucidate and in order to provide evidence for the complementary approach (see Topkis (1998)), let us consider the scene from alternative perspectives: Scenario ① and scenario ② cover exactly the same economic situations but utilize different vocabulary, i.e. role reversal of principal and agent. Particularly scenario ②, which concentrates on the pure credit market horizon, then allows for interesting interpretations and new insights. The core is the intrafirm credit market for hours deposits, which trades hours credits and hours debts (savings and borrowing). But before going into detail, scenario ① is discussed as it it formulated analogously to CH94, with the employer as the principal and an employee in the agent's role.

This assignment of roles is feasible, though an intuitive approach would be of reversed direction: Since employees own the production factor labor, they also execute saving and borrowing of working hours, which puts them into the position of the lender and the firm into the position of the borrower. In the controlled savings model with perfect credit access, for the principal this would translate into a situation, where not the employer posesses perfect access, but the employee,

[14]The applicability of CH94 necessitates the validity of a few (weak) conditions, which are met by the presented model. Critical is the constraint that interfirm transfers of working hours do not occur. This becomes plausible when discussed in a manner similar to non–transferability of specific human capital. Were accumulated human capital unequivocally separable into general and specific components, the latter would depreciate completely in case of interfirm mobility. This result might change, however, if non–separabilities exist (for diverging predictions see e.g. Acemoglu/Pischke (1999), Hübler/ König (1999). Since hours worked in firm i in our model are not affected by non–separabilities, it is reasonable that time deposits are not interchangeable between different firms. Furthermore, under the assumption that employees value continuous employment, the model comprises a kind of non–transferability as mobility does not occur.

which would contradict scenario ①. The following result in CH94 illustrates that this is not the case: If we are confronted with a situation where at least one of the parties (for example exclusively the agent) has access to a perfect credit market and additionally the agents's borrowing and saving can be monitored by the principal, it does not matter who disposes of credit access. Since the employer–principal determines current hours h_t, he implicitly controls the employee–agent's savings via the difference $h_t - h_\mu$. Thus, the matter at hand is equivalent to the situation *credit market access for the principal, no access for the agent*, which fits scenario ①. The retention of principal and agent as in CH94 and the intuitive approach produce therefore identical results.

Then *scenario* ① is: the employer–principal controls the employee–agent's savings through the variation of 'artifical' components within the compensation package. This becomes obvious, if the constant time wage, i.e. the *constant period income* $w = \omega \cdot h_\mu$, is split up to reveal information on the two periodic specific (time–variant) summands *demand–adjusted earnings* and *compulsory savings*, where the level of current lending or borrowing $\tilde{s}_t h_\mu$ is enforced via the working time account:

$$w \quad = \quad w \cdot \frac{h_\mu}{h_t} + \tilde{s}_t h_\mu \quad , \tag{12}$$

$$\text{with} \quad \tilde{s}_t \sim N\left(0, \sigma^2_{\tilde{s}}(\sigma_M)\right) \quad . \tag{13}$$

The size of $\tilde{s}_t$ is determined by the employer and depends on the ratio of standard hours to realized hours. Period savings are zero, if h_μ and h_t coincide and decrease with the ratio $\frac{h_\mu}{h_t}$. Thus excess demand augments the fictitious share of savings in constant time wages, which is equivalent to borrowing working hours by employers.

Working time accounts are in fact characterized by variation in hourly earnings. This becomes evident, if equation (12) is converted to hourly levels:

$$\frac{w}{h_\mu} \quad = \quad \frac{w}{h_t} \quad + \quad \tilde{s}_t \qquad \text{bzw.}$$

$$\underbrace{\omega}_{\substack{\text{reference point: constant} \\ \text{standard hourly wages}}} \quad = \quad \underbrace{\tilde{\omega}_t}_{\substack{\text{time–variant,} \\ \text{hourly earnings}}} \quad + \quad \underbrace{\tilde{s}_t}_{\substack{\text{compulsory savings} \\ \text{(determined by the firm)}}} \quad , \tag{14}$$

where both, *hypothetical* hourly earnings $\tilde{\omega}_t$ and obligatory savings $\tilde{s}_t$, are random variables, with $\tilde{\omega}_t \sim N\left(\omega, \sigma^2_\omega(\sigma_M)\right)$. Since the constant expected value of $\tilde{\omega}_t$ is ω and the constant expected value of $\tilde{s}_t$ is 0, the following conclusion can be drawn: The sequence of spot contracts **wta** implies the long–run optimum and employment relations, which are enabled by working time accounts, are renegotiation–proof.

Scenario ② is logically equivalent, thus leads to the same conclusion, but reversely defines the roles of principal and agent. Based on an intuitive approach to the inner firm credit market for working time, the employee (resp. his representatives) is denoted as the principal who constraints credits, whereas the employer is stated to be the agent, whose hours savings are monitored by the principal. This definition leads to very interesting implications and facilitates conclusions on economies of scope between well defined instruments of personnel policy, particularly between *working time flexibility* and *elaborated information channels*.

In a world with working time accounts employees act as a banking house. Thus they should be able to verify the actual borrowing of the firm, which is $h_t - h_\mu$, at least when the firm is after

the stability of working time accounts as a favorable adjustment strategy.

Empirical implications are straightforward: Employees or their representatives in firms with **wta** schedules should be given substantial information, since they have to be sufficiently knowledgeable about the firm's situation. Otherwise long–term efficiency is hardly achievable for the inner firm credit market, since efficiency of the (spot–) **wta**–sequence depends on employees' ability to control the firm's credit access, represented by actual hours requirement. In this context the term *employee–principal monitored credit access of the employer–agent* measures the following: The buffer defined in **wta** (Δh_μ: permitted hours credits or hours debt per period, Δt: maximum period of time to settle the account) is controlled by employees. By definition they are aware of e.g. how an ordinary range for Δh_μ would look like. Thus, stability of working time accounts as a personnel instrument benefits from activities which inform employees on quantity of sales orders, on market appraisal and market forecast or alternative short–run indicators. Moreover, it seems sensible to raise firm level institutions, that regulate the flow of information as e.g. well defined channels or chains of communication (information system).

Consequently, employees should be able to estimate and evaluate h_μ (resp. the necessary level of s_t) in an arbitrary period. If unforeseen deviations out of the ordinary occur, thus necessitating changes in "contracted" elements in **wta**, then employees, too, should participate in decision making on modifications of **wta**. Furthermore, due to efficiency wage arguments, the intertemporal transfer of working hours is restricted a priori to levels that do not violate the *no–shirking condition* for incentive compatible compensation levels. Thus, a well defined supremum for Δh_μ exists, such that employees' contribution when determining the several elements of **wta** prior to the enactment of working time accounts is more than sensible. Remember h_t varies by period.

The just derived properties of spot implementability and renegotiation–proofness rely on the assumption of time invariant expected demand. As mentioned in case of durable demand shifts the respective elements in the firm's working time account have to be adjusted, i.e. contract renewal requires alteration, e.g. reduction in h_μ (see also $Q_M^{\ominus} \sim \left(Q^* - \delta,\ \sigma_M^2\right), \delta > 0$, figure 3). Persistent excess demand carries the risk of moral hazard, as firms have an incentive to execute concealed reductions in standard hourly earnings ($\tilde{\omega}_t$), at least at first sight. If the above discussed firm level institution *information system* exists, however, such behavior is myopic and is seems very unlikely that firms take this strategy seriously into consideration, because employees would try to enforce the alteration of single elements in **wta** or abolish the account system at all. Alternatively, they could try to enforce hiring.

Altogether, **wta**–models can be interpreted as a variant of two–sided principal–agent–models, in which roles are reversed more than once (see Bull (1983)). This leads to a few questions regarding the consequences for the framework of the model, primarily compatibility, with the assumptions made on the parties' attitudes towards risk (**A2**). Given that one defining feature of the model has been the employer's role as principal due to compensation matters, the fact that the same employer is agent with respect to the intrafirm credit market seems to be in conflict with **A2**. But, as shown in Rogerson (1985), correct definition and assignment of risk attitudes is crucial, since the stability, as proven for scenario ②, critically depends on the assumption of relatively higher risk aversion for agents. Thus it has to be verified that in the **wta**–world employers in fact show a higher degree of risk aversion than respective employees.

From equation (10), it can be seen that, if the firm refrains from adjustment activities expected profits are below expected profits under perfect adjustment, which translates into employer's risk aversion towards deviations between operated and demand–corrected working hours. Thus the employer–agent does in fact not contradict Rogerson (1985). Moreover, for employees' preference order we assumed intertemporal separability regarding working time with sufficiently low interest

rates (resp. no preferences for smoothing of hours). The interpretation of the employee–principal is straightforward and consistent with Rogerson (1985) as well.

Working time accounts are part of implicit contracts, in which the parties postulate distributions over future states. The moments of the underlying distribution may change, or outcomes may be observed, which are not in the event set. If unforeseen contingencies occur, incomplete contracts utilize mechanisms for adaption or rules that enable exactly one party to choose adequate instruments for adjustment, but usually recontraction and ex post hold–up are a problem (cf Maskin/ Tirole (1999)).

In our context, the recontraction game implies that neither party will insist on enforcement of (unchanged) **wta**s that lack efficiency nor will they omit adjustment strategies that entail job stability and promote profits. To conclude, from the employer's point of view working time flexibility is a suitable means to strengthen profits, whereas from the employee's point of view this adjustment stategy is worthwhile, if employment guarantees are sufficiently credible.

2.4 Working Time Accounts as Part of a Complementary System

The above discussion of control capacity for employees in order to generate renegotiation–proof solutions) points out that working time accounts (**wta**) show complementarities to intrafirm information and communication systems (**inco**). In the context so far, information means reporting the firm's situation on product markets on a regular basis and evaluation of additional variables, on which success depends, such as revenue, labor productivity or prediction of future markets.

Under Definition 1 and the constraint of regularity, it is reasonable to use modern IT–facilities (**it**) as well: Documentation, execution and maintenance of the accounts system simplify. Thus **it** forms another element of the complementary system, to which **wta** belongs. As the feasibility of modern IT–facilities depends on certain conditions on human capital, further training (**tra**), particularly firm provided training, is another candidate. In addition, it is well–known that modern modes of operation and production technologies (**mot**) together with team work (**team**) and job–related participation in decision making (**ei**) form a complementary sub–system with **tra** (Ichniowski et al. (1996), Pil/ MacDuffie (1996)).

Thus working time accounts, institutionalized information, and employee involvement in decision making, IT–facilities, modern production, teamwork, firm supported training, and efficiency wages constitute a system of complementary instruments. Consequently, an analysis of simultaneous variation of these instruments is needed to identify system effects. The theory of supermodular optimization (spmo) proves quite useful in this regard (Milgrom/ Roberts (1994), Topkis (1978, 1995, 1998)). The charme of spmo as an analytical tool results from several characteristics. First optimal allocation of single instruments to well–balanced packages in optimal solutions is derived, where changes of variables and parameters of contrary direction orientation can be integrated in a coherent framework (Holmstrom/ Milgrom (1994)). Second, and more importantly, the results do not depend on differentiability. Thus, the theory of supermodular optimization provides monotone comparative statics (complementarities). This property is quite important for research in contract theory and in personnel economics that are environments which a priori are restricted to discrete variations of single instruments, and typically lack differentiability of the objective function (Milgrom/ Shannon (1994), Milgrom/ Roberts (1995a)).

Under the derived hypothesis on complementarity comparative statics for working time flexibility, e.g., predict that profit mazimizing firms, which lack a suitable base for implementation of **it**, may fail when introducing just **wta** or **team**, though the latter instruments both promise positive effects. In other words, if success crucially depends on introduction and stability of working

time accounts (and/ or team work), firms should also invest in an intrafirm system of information and communication. The hypothesis that those working time accounts lack continuous presence, which are effective in firms, who refrain from systematic information dispersion, and moreover determine elements of **wta** without employee involvement in decision making, follows from a strict interpretation of scenario ②. In this context alternative patterns of **wta**–emergence may be observed, in which periods of a) existence, b) planning, and c) abolishment alternate repeatedly.

Analytically, a firm opts for an idiosyncratic equilibrium, when choosing its well–balanced combination of single instruments under firm specific restrictions. The different equilibria emerging on an aggregate level describe a partially ordered set, whose greatest element corresponds to the full complementary system, including **wta**, **inco**, **it**, **ei**, **tra**, **mot**, and **team**. This maximum element dominates all other (HRM–system) equilibria, which use just one single instrument or any subsystem, since marginal benefits from introduction of the complete system exceed the sum of marginal benefits due to isolated variation of each single instrument.

In the initiation phase, however, the coordinated approach is more time–consuming than strategies, which concentrate on specific personnel instruments. Coordination efforts and time lags prior to initiation increase, though (mid– and long–run) forecasts are much better. The role of time as a key success factor should not be underestimated, thus limiting facilities to introduce comprehensive coherent systems in one step, particularly when adaption to shocks is needed. Shocks may require instantaneous reactions, thereby increasing the probability for *instrumentwise* introduction of HRM–systems. At first, those instruments will be installed, which predict the largest isolated effects. Anyhow, under such behavior the firm faces a lock–in to specific versions of HRM–systems.

If introduction of working time accounts takes place as in scenario ②, then addition of strategies seems reasonable, which e.g. aim at the limitation of demand fluctuation. Imaginable is that measures as *concentration on specific customer groups* or *specialization to high quality production* accompany the complementary HRM–system. In the future the practical impact of complementarities integrating **wta** will be investigated on base of panel data for firms. If possibilities for complete systems lack, these data also give hints on sensible orders of introduction. Moreover, they can be exploited to identify suboptimal behavior and to draw appropriate recommendations for personnel policy.

2.5 Critical Remarks

Long–term employment was established by intertemporal transfers of working time. Pareto improving effects of working time accounts result from diverging risk attitudes of workers and firms. This section contains some remarks, which facilitate a judgement of the results and typical shortcomings of the model. Hints for analytical extensions and empirical research follow.

First, any integrated model on optimal adjustment decisions should discuss in more detail the choice of alternative flexibility schedules. That means that motives and restrictions for adoption of different strategies have to be examined. The task is to identify circumstances under which e.g. either working time accounts are preferred to price policy or combinations of both strategies come into use. In this context opportunities for monopolistic price discrimination and persistence of monopoly rents influence the relative attractiveness of price adjustment.

It is not beyond dispute, whether the maxim *providing job stability* should be pursued unconditionally, since efficient separations are prevented (resp. bad matches keep valid). Inefficient quits, however, do not occur (e.g. in economic downturns, see den Haan et al. (1999)). It is widely

recognized that long–term employment interacts with technological progress, promotion policy and human capital accumulation. The issue is, whether "obligatory" tenure generates similar effects. One hypothesis for future research states that firm level training and innovation activities are complementary elements that serve to decrease spread and variance of demand, thus underscoring the implications of the model so far.

The restriction to changes in net employment neglects the phenomenon of churning, thus leaving realized separations and recruitment aside. Part of the job turnover is not considered (e.g. Davis/ Haltiwanger (1992)). The model contains no predictions for the sign of changes in job turnover due to existence of working time accounts, although an intuitive hypothesis would c.p. suppose a decreased job turnover rate. This, too, offers attractive research perspectives.

Some important arguments, why firms do not change output via (temporary) per capita variation appear in 2.2. Here institutional inertia, fixed and quasi–fixed costs of employment and convex adjustment costs should be emphazised (see Carstensen(1999b)). Furthermore, under the given assumptions on risk attitudes and demand uncertainty, such strategies would be suboptimal in a world consisting of firms and employees.

The discussion so far has not disclosed information on an appropriate confidence interval for demand uncertainties. But since large levels of demand shocks may crucially threat the firm's existence, it has to be examined, whether a critical value for the probability density of expected demand Q^* exists. The following scenario with negative demand shocks may illustrate: Let the firm exit the market for reasons of insolvency, if realized demand is at least $\gamma-$percent below expected demand. With increasing variance the probability of falling below the critical demand level $(1-10^{-2}\cdot\gamma)\cdot Q^*$ increases, too. Thus, an upper bound for dispersion exists, which determines the critical value for credibility of employment guarantees, beyond which a firm is no longer able to credibly commit not to dismiss insiders due to augmented risk of insolvency.

In conjunction with the credibility argument it follows that contracting and enforcement of **wta**–arrangements depend on the employees' ability to estimate such bounds and to evaluate the character of large–valued shocks as temporary or permanent. Remark that the risk of bankruptcy is usuallly not ruled in working time accounts. In case of liquidation working time credits and debts expire. In case of a persistent shift of the demand curve alterations in expected values will eventually become apparent lately, since working time accounts allow for short–run window–dressing as do inventories. Both arguments elucidate that supplementary measures for profit stabilization are advantageous in principle. Working time accounts, which provide opportunities to convert *persistent* hours credits into stock market equivalents also integrate means that permit credibility at the tails of demand distribution.

In addition, for myopic employers moral hazard may be appealing. The strategy to conceal persistent demand increases is an example: saving of recruitment costs is combined with lowering of average hourly earnings. Sufficiently large fixed recruitment costs (Oi (1962), Hart (1988)) or suboptimal number of standard hours strengthen incentives for such behavior. However, job security and long–term employment relationships encourage reputation and similar firm level institutions, such that potential benefits are just short–termed, whereas employees' penalization lasts longer. Thus the insurance property of **wta**s erode attractiveness of moral hazard. Synergies, particularly with the intrafirm system of information and communication (**inco**), underscore.

Persistent demand shocks as analytical extensions are briefly discussed in the next section. Some characteristics of the two complementary systems *human resource management* and *sales policy* are pointed out.

2.6 Extensions: Permanent Demand Shifts and Production Risks

The consequences of permanent shifts of the demand curve are illustrated in Figure 3. A persistent reduction in product demand Q_M entails e.g. random variable $Q_M^{\ominus} \sim N\left(Q^* - \delta, \sigma_M^2\right)$, and thus $\Delta Q^{\ominus} \sim N_{\ominus}\left(-\delta, \sigma_M^2\right)$. For the reverse case let us assume demand function and deviation as $Q_M^{\oplus} \sim N\left(Q^* + \delta, \sigma_M^2\right)$ and $\Delta Q^{\oplus} \sim N_{\oplus}\left(\delta, \sigma_M^2\right)$, respectively, where $\delta > 0$.

Both cases require adjustment due to altered expected values, though the inherent hours buffer in working time accounts can postpone this need for a while. With **inco** effective, it is likely that employers as well as employees aspire to contract alterations. These concern the constituting elements of **wta**, particularly the length of standard hours and the account's time horizon. Limitation of the latter aims at an automatic evaluation of working time accounts as a flexibility instrument. If further adaption is needed, hiring or separations, reorganization or productivity enhancing technological progress are in the choice set.

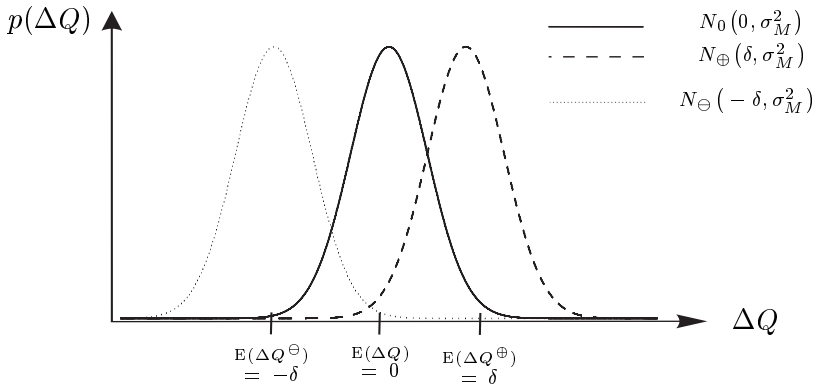

Figure 3: Permanent demand shift

The success of renegotiations depends on whether employment guarantees, given by firms, are credible or not, i.e. whether a firm's reputation is sufficient or opportunities for reciprocity exist. As demonstrated, there exist means to foster reputation. The discussion of complementary instruments of human resource policy also verified that it is almost necessary to raise an inner firm institution, namely an information– and communication–system, if discussing working time flexibility. Regular utilization of **wta** enhances the enforceability of altered needs for flexibilization, since it eases signalling demand shifts or changes in variances in a good time. Furthermore, structural changes and trends become more transparent to workers. Thus, incentives for firms diminish to keep cream skimming, which means, firms earn extra rents in periods of sustained excess demand via obligatory savings for employees (hours credits), whereas they try to dismiss, if trends are reversed into non–transitory (medium–termed) lack of demand. If specific human capital is a key success factor, then incentives for such behavior are lowered.

Let us consider another complementary strategy in the system *key success factors*, but now in the domain of *market evaluation & marketing policy*. This strategy affects the demand function at the a priori level and aims at the reduction of demand uncertainty (resp. variance of sales)

in a way that ensures a sufficient probabilty density[15] of the expected value of product demand, consequently lowering the likelihood that part of output perishes.

If in addition the production function is random, then strategies like *frontline worker–aided quality control* or *employee involvement in procurement scheduling* are analogues to the above strategies. Under the simplifying assumption, that production risks and sales risks are not correlated, the probability of profit curtailment is:

$$P(Q_M \leq Q^* - 1) = F(z) = \Phi\big(z\big) = \Phi\left(-\frac{1}{\sigma}\right) \quad , \tag{15}$$

$$\text{with} \quad z = \frac{Q_M - Q^*}{\sigma} \sim N\big(0,1\big) \qquad \text{and} \quad \sigma = \sum_{i=1}^{K} \sigma_i \quad ,$$

where the K different $\sigma_i,\ i = 1, \ldots, K$ are independently distributed. The firm defined so far is interested in decreasing the several risks via reduction of $F(z)$, particularly in case of large fixed costs of implementation and maintenance of **wta** or when weak reputation permits merely low values for Δt.

Last not least, consider a scenario, where the firm's existence is already threatened. In such circumstances an integrated approach may be necessary that simultaneously utilizes multiple instruments from complementary subsystems (working time accounts, team production, quality control, just in time production, market evaluation, etc.). Otherwise the cumulative effect (see Section 2.4) cannot be realized. Sometimes dismissals cannot be prevented, but it should be expected that they take place at lowered levels.

3 Concluding Remarks

The presented discussion has proved that existence of product market risks affects optimization behavior of risk neutral firms. In particular, adjustment strategies become necessary. Working time flexibility was considered in detail. If efficiency wage arguments are valid, then working hours schedules, which explicitly enable hours deposits (denoted as "working time accounts"), are superior to alternative adjustment strategies as e.g. overtime work and short–time work, internal labor markets vs. temporary worker or separations and re–employment.

Risk averse employees also prefer such working time accounts, since, in exchange for variable working hours, they are covered from unemployment risks due to sales risks. Thus, working time accounts are a solution of reciprocal insurance. But the favorability of these working hours contracts is not merely based on cost advantages and efficient risk allocation. The above discussion has proved the solutions to be renegotiation–proof and the long–run optimum to be implementable via the sequence of spot contracts, if firms introduce systems of information and communication. Working time accounts and inner firm information systems are part of the same complementary system. Plausibility arguments show that this system includes additional incentive instruments as further training and team work. Synergies with IT also exist.

[15] The assumption of normal errors is still effective, thus $f(Q^*) = \frac{1}{\sqrt{2\pi}\cdot\sigma_M}$.

Although the focus was on product market uncertainty, additional sources may cause deviations between expected and realized demand. As a first extension fluctuations at the production level were considered. Things simplify, if risks from different domains are uncorrelated, since then variances just add up. The critical limit, however is reached sooner, thus necessitating supplementary measures to shrink dispersions (marketing policy, quality control, purchase policy). But if interdependences exist e.g. between output market and input market, additional interaction terms have to be included. In principle, the need for flexibility increases with each additional source of uncertainty, unless risks are negatively correlated.

Empirically, it cannot be expected that flexibility strategies are restricted to the adjustment of the production factor labor, rather that well–defined bundles of reinforcing instruments are exploited, which aim at both levels, a priori minimization of uncertainty and ex–post adjustment in case of ocurrence (see Milgrom/ Roberts 1995b).

Here, empirical investigations on the base of enterprise panel data will give further insights into the question, whether the postulated instruments in fact constitute a complementary system, which additional instruments enhance a firm's success, and which instruments contradict the inner firm credit market for working hours. Interesting tasks for future theoretical and empirical research will be the integration of correlated risks as well as the analyses of firms with multiple output markets, which differ geographically and with respect to price setting behavior.

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