Reorganization of Firms and Productivity: A Treatment Effects Approach

Vivian Carstensen*

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Abstract

This paper addresses the question of organization of work and efficient reorganization. An emerging literature is basically concerned with the polar model of high–involvement *(holistic)* vs. traditional *(Tayloristic)* work organizations. This paper extends in two ways: First, the polar case is augmented by an intermediate layer, referred to as the *intertemporal–transfer* organization. It integrates output market shocks and stresses the adaptability of production, including over time transferability of working hours. Second, on the basis of a survey of manufacturing firms in Germany, the three layer model is investigated empirically. Hypotheses to be tested are: Do the different types indeed exist? Which productivity effects accrue from reorganization? In particular, the complementarity hypothesis of increasing marginal returns of multitasking is studied. A treatment effects approach is used to control for self selection of firms (Maddala (1983)). Empirical findings are that Tayloristic firms still have the greatest portion. Productivity is highest in holistic firms, Tayloristic firms are least productive. Marginal returns from reorganization describe the following ascendinging rank order: Tayloristic firms – intertemporal–transfer firms – holistic firms. In sum, empirical evidence supports the predictions from theory.

* *University of Hannover, Department of Economics, Institute for Quantitative Economic Research, Königsworther Platz 1, D–30 167 Hannover, Tel.: +49 511 762 5901, Fax.: +49 511 762 8297, email: carstensen@mbox.iqw.uni-hannover.de, carstensen@gmx.de.* *Financial support of Deutsche Forschungsgemeinschaft (Bonn) is gratefully acknowledged.*

1 Introduction and Summary

The ongoing discussion of workplace organization and efficient reorganization motivates this study. The main findings from theory are that technological and informal complementarities are responsible for far reaching and disruptive reorganization of workplaces in the manufacturing sector. Organizational change is associated with altered job design, the rising of flexibility yardsticks and vanishing importance of occupational specialization (Holmstrøm & Milgrom (1991), Lindbeck & Snower (1996, 2000), Baker, Gibbons & Murphy (2002)).

Growing empirical literature studies the impact of so called high–performance human resource management systems or high–involvement work practices on firm–level productivity, usually identifying productivity enhancing system effects (Osterman (1994), MacDuffie (1995), Ichniowski, Shaw & Prennushi (1997)). Since (IT–enabled) restructuring of firms seems to come along with skill–biased technological change, this issue is also addressed, and the consequences of skill–technology complementarities for the wage structure are investigated (Capelli & Rogovsky (1994), Adams (1999), Caroli & van Reenen (2001), Breshnahan, Brynolfsson & Hitt (2002)). Recent work is concerned with social networks and reorganization (Gant, Ichniowski & Shaw (2002)).

We present new evidence on the reorganization of work. The focus is on complementary systems of workplace practices, information sharing, human capital investment and remuneration packages, where we allow for heterogeneous behavior on incomplete output markets. The paper extends both, theoretical and empirical analysis.

First, a three layer model of reorganization is predicted out of the combination of two microeconomic models of work organization (Lindbeck & Snower (2000) and Carstensen (2000, 2002b). Lindbeck & Snower (2000) are concerned with the debate on multi–task learning and upskilling. Based on the impact of decreased costs of communication and increased disposability of flexible machinery equipment on learning and human capital accumulation, the polar model of *Tayloristic organization* vs. *holistic work organization* is predicted. Moreover, recent developments favor the holistic reorganization of work, thereby stressing versatility and mobility requirements. Stylized facts like growing incidence of demand shocks or shortened product cycles dominate the approach of Carstensen (2000). There, time flexibility of human capital is the key success factor. Extending the polar model, an intermediate layer, referred to as the *intertemporal–transfer organization of work* is derived, which includes the crucial element of inter period transferability of working hours contingents. Hence, instantaneous adaption of production is supported. Moreover, this organization of work operates even if necessary skill requirements for multitasking and holistic reorganization are missing.

Second, the three layer model of work organization is empirically investigated on the basis of a survey of manufacturing firms in Germany. This survey is similar to WIRS and AWIRS (Millward (1993)). Hypotheses to be tested are: Do the three different types exist? Which productivity effects accrue from reorganization? In particular, the complementarity hypothesis of increasing marginal returns of multitasking is examined. Since self selection of firms into multitasking cannot be ruled out, we apply a treatment

effects approach (Maddala (1983)) to prove increasing returns from reorganization.

Although a considerable amount of firms is holistically reorganized, the empirical evidence reveals that Tayloristic firms still constitute the largest group. Every fifth firm is structured according to the intertemporal–transfer mode. Productivity is highest in holistic firms, which account for 35 % of the sample firms. Marginal returns from reorganization are significantly increasing from Tayloristic firms via the intertemporal–transfer firms to holistic firms. Indeed, the estimated multitasking effect is negative in Tayloristic and intertemporal–transfer type firms. In contrast, productivity gains accrue to multitasking in holistic firms.

The paper is organized as follows: Section 2 revisits the theoretical argumentation and specifies the hypotheses, which are provided by the combined theoretical framework. Section 3 describes the data. The empirical analysis appears in section 4. First, the properties of existing firm types are identified. Second, productivity enhancing effects, which potentially differ by firm type, are studied. Section 5 concludes.

2 Integrated Model of Work Organization: Equilibrium Types, Reorganization and Hypotheses

2.1 The Polar Model of Reorganization

Henceforth, we will denote the approach developed in Lindbeck & Snower (2000) as the polar model of reorganization, since it identifies two polar types of work organization as

the potential outcome of the optimization process: the Tayloristic organization of work vs. the holistic organization of work. The Tayloristic organization of work is characterized by a) single tasking, b) narrow specialization of employees and sharp occupational demarcations, c) scale economies and mass production. Contrarily, holistically organized firms rely on a) broader task definitions, multitasking and cross–training, b) close customer relations and feedback systems, c) economies of scope.[1]

Technically spoken, the two types are derived as alternative solutions to the constraint profit maximization problem of the firm, where the Tayloristic organization represents a corner solution and the holistic organization corresponds to an interior solution. Whether an interior solution exists and depicts a profit maximum, hence, which polar type is chosen, depends on the current environment, including, for example, informal and technological task complementarities as well as worker or consumer preferences and general properties of the human capital accumulation process. Correspondingly, comparative statics for efficient reorganization are analyzed (the debate on appropriate methods is

1 While the model discussed below will be the primary focus of the paper, another two contributions of the same authors should be noticed. Lindbeck & Snower (1996) discuss the employment opportunities within reorganized industries. In principle, workers can be assigned either to the pool with narrowly and occupationally specialized skills or to the pool with multiple skills and ongoing cross–task learning. With a perpetual restructuring process, employment opportunities for members of the first pool decline, with increasing expected duration of unemployment. On the other hand, employment opportunities rise for the second pool. Moreover, a steepened wage structure is predicted.
Efficient wage setting and bargaining with regard to information gathering and processing capacity and to incentives for well–advised multitasking and efficient cross–task learning are studied in Lindbeck & Snower (2001). In sum, two results are derived: First, since cross–task learning is a dynamic and firm specific process, centralized wage bargaining is costly and inefficient for holistically reorganized firms. Second, respective remuneration systems are intended not only to motivate workers to exert usual effort, but to acquire multiple skills and to use insights from cross–task learning in alternative tasks. Analogically to Shapiro & Stiglitz (1984) a no shirking condition for intertask effort applies, which can be satisfied with respective bonus payments. We will resume this argument in the empirical analysis, when we inspect remuneration packages of the different firm types.

outlined in Samuelson (1974), Milgrom & Shannon (1994), Gans (1996)). If, for example, cross–task learning or knowledge spillovers are prevalent, the fraction of holistically organized workplaces is expected to increase substantially.

The polar model relies on the following four basic conditions, which are assumed to affect major parts of the manufacturing sector, thus acting as driving forces behind a broader restructuring process: (1) The development of flexible production systems, implying advances in physical capital versatility. (2) The ongoing degression in the cost of information processing and communication does not only increase availability of IT systems, but consequently creates more favorable conditions for cross–task learning. (3) A global rise in skill standards facilitates human capital accumulation, for example, beyond occupational barriers (multi skilling), hence, strengthening human capital versatility. (4) One observes that workers more and more favor versatile work and task variety compared to narrowly defined tasks. Technically spoken, preferences for multi tasking are evolving.

The Ricardo–style model is formulated as a two–tasks$\times$two–worker$\times$single–product model. Simplifying, it is assumed that the comparative advantages of workers are reversely distributed between the two worker types. With physical capital held fixed in the short run, the two tasks are the only variable inputs. They are assumed as Edgeworth complements. Each task unit is composed of returns to specialization and of returns to informal task complementarities. The latter accrue from cross–task learning or inter-task effort, respectively. The objective of the firm is to determine the profit maximizing

degree of worker specialization τ, thus choosing either the corner solution of complete worker specialization ($\tau = 1$, Tayloristic organization) or the interior solution of incomplete worker specialization ($0 < \tau < 1$, holistic organization). Once determined, the specification pattern is time invariant, unless changes in the firm's environment occur as, for example, changes in common factor (2).

If the interior solution exists, is has to be evaluated, whether indeed a profit maximum is attained. Consequently, inspection of the second order condition and it's elements reveal interesting insights into the reorganization process.[2] As is argued by Lindbeck & Snower (2000), the adoption of the holistic polar case is ceteris paribus more likely, if:

- tasks are Edgeworth complements (technological task complementarities exist),
- forgone returns from cross–task learning and knowledge spillovers increase faster than the returns to specialization do, if a worker devotes more and more of his hours budget to the task, where he possesses the comparative advantage.
- the workforce is multiskilled (multifaceted skill endowment),
- workers dislike narrow tasks definitions and specialization.

Although the authors state all four factors as determinants, the following simplification can be derived from the alternative notation of the second order condition in

2 We will not restate the formal conditions here. They can be found in the original model (Lindbeck & Snower (2000, 364–372)). An alternative, but equivalent, notation is in Carstensen (2002a), who also refines the discussion of the determinants of reorganization.

Carstensen (2002a): Whenever technological task complementarities exist, the holistic reorganization is merely driven by the shape of worker preferences. With preferences for multitasking, the holistic organization of work will be doubtlessly chosen. Moreover, even with worker preferences for specialization, a holistic firm type may be optimal, if technological complementarities are sufficiently strong, if the impact of ongoing specialization on task endowment diminishes fast enough, and if the marginal product of task inputs is decreasing.

Unless parameter changes occur, the task proportions within the task bundle are time invariant, with $\tau = 1$ included as a special case. Parameter changes are caused, for example, by shifts in returns to ongoing specialization in comparison to knowledge spillovers and cross–task learning. Task–biased technological progress, hence, a shift in production elasticities, is another example. The polar model concentrates on the reorganization from the Tayloristic polar type of work organization to the holistic polar type, but does not deal with functional flexibility of workers within holistic firms. In other words, the question of over time variability of task assignment or dynamic (re)allocation of activities within task bundles is not addressed. For example, the rearranging of output quantity, product quality assurance, maintenance of machinery equipment and skill acquirement efforts is not discussed. Correspondingly, appropriate adjustment strategies for flexible production are not part of the polar approach.

Strictly speaking, the polar model of organization answers the question, whether *either* complete worker specialization *or* incomplete worker specialization reflects profit

maximization, subject to worker preferences, to technological properties of the production function, to inter– vs. intra–task learning and to the shape of the reservation wage function. If incomplete task specialization of workers solves the maximization problem, then each worker type performs multiple tasks, where the relative weight of the different tasks within the time budget is univocal determined for either type. Theoretically, this exactly constitutes the holistic organization of work.

Next, we will widen the scope of the polar model. The model to be recapitulated addresses flexibility needs. We will illustrate the link between the adaption device and work organization. Consequently, an intermediate type of work organization is derived, which stresses the role of intertemporal flexibility and information sharing. Within our organizational setting, it can be interpreted as an initial system change in a reorganization hierarchy (see also Gant et al. (2002)). In decreasing order, the hierarchy is given by 1. holistic, 2. intertemporal–transfer and 3. Tayloristic organization of work, respectively.

2.2 Extending the polar case

Grown availability of flexible production systems and usage of versatile machinery equipment are regarded as much as stylized facts as are augmented requirements for customer relations and the need of sophisticated feedback systems. Hence, flexibility and adaptability have become key success factors. Increased demand fluctuations and shortened product cycles as well as consumer preferences for product variety and high quality standards are considered as driving forces for the need of firm level adaptability and appropriate time management strategies. To some extend time is interpreted as an additional

input factor in the production function (cf. Bruns (1992)).

The polar classification model of efficient work organization inherently presumes instantaneous adaption to flexibility requirements. In contrast, we model flexibility and adaption endogenously by introducing product demand as a random variable. Under the additional assumption of costly inventories (*storage constraint*) the profit maximizing organization of work is determined. To start with the result, an intermediate type of work organization is derived, which will be denoted as the *intertemporal–transfer* organization.

The intermediate type deviates from the Tayloristic organization in two aspects: First, modern working time schedules are introduced, which enable the *(back and forth) transfer of working hours contingents* between different periods without being exposed to overtime premiums or suchlike.[3] Second, substantial information sharing for participating employees is implemented. Schematically spoken, operating output market figures of the firm and financial key data are revealed to workers under such working time schedules.[4] The information is transmitted within the framework of an institutionalized information and communication system. This second element of the intertemporal–transfer organization is termed as *employee involvement in market information*. Involvement in market information guarantees the stability of the intertemporal–transfer solution. In

3 Annualized hours contracts describe a typical institutional arrangement within the firm.

4 A typical institutional arrangement for the transmission of these data is a multistage internal information and communication system. For example, pre–determined routines between works council and management with follow up schemes between works council and employees could have been be specified.

sum, this type of work organization constitutes a reciprocal insurance solution between employees and employer. The reciprocal insurance arrangement is *the* striking property of the model. The formal analysis can be found in Carstensen (2002b) and Carstensen (2000). As before, we concentrate on a verbal presentation.

In general, three options exist to cope with varying product demand, when prices are held fixed. The firm could either change the number of employees and/or vary the number of working hours and/or shift weights within more complex task bundles. Each option has its assets and drawbacks. Apart from institutional inertia, output market driven hire and fire policies (option 1) implicate the loss of specific human capital. Thus, option 1 appears not very appealing. If the number of working hours is (reversely) aligned with current demand shocks, option 2 is drawn. Firms will normally have to pay for the usage of this option, for example, overtime premiums could have been negotiated. With negative demand shocks, firms may take short–time work into consideration. But in many countries, application to short–time working allowance is regulated. Thus, firms face more or less extensive transaction costs.[5] Hence, instead of short–time work, payment for idle capacity may be chosen.

Option 3 corresponds to shifted weights within (multi–)task bundles and is equivalent to functional flexibility or, equivalently, functional mobility. Functional mobility implies that temporarily, for example, a higher portion of the individual's or the team's

5 Even if firms apply successfully for short-time work, thus being temporarily exempted from base wage costs, usually additional payments have been negotiated. Such payments are intended to partly compensate for foregone shift premiums, boni etc..

working hours budget is spent for maintenance activities, whereas the fraction devoted to production activities is reduced and vice versa. For this option to be executable, workers strictly have to be multiskilled. Furthermore, perfect coincidence of outside shocks, internal firm requirements and internal firm disposability is essential. Functional flexibility is also an option if timing of quality assurance and maintenance are rather arbitrary, hence, can be aligned with output market restrictions.

The intertemporal–transfer model is linked to option 2. However, adjustment costs patterns are much more favorable than patterns of traditional adaption instruments. The underlying assumptions of the transfer model are as: 1. Product demand is normally distributed, with time invariant mean μ and variance σ^2. 2. The profit maximizing firm produces output Q with input factors labor L and capital K. Capital is assumed to be fixed in the short run and labor is composed of the number of workers N and the number of hours h. Non-storability of Q applies. 3. Worker behavior satisfies the expected utility concept. In particular, a VNM utility function is assumed (Neumann & Morgenstern (1944)). Comparably, firms follow the $\mu - \sigma^2$–criterion, which is well known from portfolio theory (Markowitz (1952)). 4. The shape of the expected output demand function, μ and σ^2 are known. Prices are set heterogeneously in an incomplete product market. Once determined, the product price p is fixed for the period under consideration. 5. Employment and remuneration are chosen by the firm, given the workers incentive constraint. Particularly, a no shirking condition in the sense of Shapiro & Stiglitz (1984)

is valid. The respective monthly salary is measured by w.[6]

The model results are easily summarized: The random distribution of product demand in combination with the non–storability constraint is responsible for the fact that firms are indeed risk averse. They are risk averse, since (i) output distributions with lower variances second order dominate output distributions with higher variances and (ii) the normal distribution implies equivalence of $\mu - \sigma^2$–criterion and expected utility concept (Lajeri & Nielson (2000)). In other words, the firm likes to insure against demand fluctuation: As an extreme, the situation under certainty, i.e. $\sigma = 0$, is preferred to any other situation. The corresponding willingness to pay (π_{fi}) is reflected by the Markowitz-risk premium.

Very similar, the risk averse worker likes to be covered from (lifetime) remuneration or dismissal risks, which accrue from negative demand shocks. The worker's willingness to pay (π_{wo}) is measured by the Arrow–Pratt risk premium. Both risk premiums are calculated in quadratic approximation of the variance and the value of the absolute risk aversion. As we are merely interested in a general proof of intertemporal hours transfers as dominating other instruments within option 2, we do not need to know the particular shape of the respective utility functions. Instead, we assume for simplicity that π_{fi} and π_{wo} are equal. Consequently, potential transfers, hence, hours credits and hours debts are not eligible to interest rates.

6 As we abstract from incentives for multi tasking, we do not deepen the discussion of (bonus) payments for cross–task learning (see Lindbeck & Snower (2001), which introduce another no shirking condition for intertask effort). We will leave this question to the empirical analysis, where remuneration system composition is inspected.

How does the reciprocal insurance work in practice? First, notice that respective arrangements are only valid within the particular firm under consideration. The mechanism of action is as follows: Workers are payed the salary w, irrespective of the number of hours currently worked. Thus, they are covered from variations in income. At the same time, firms are granted the transfer option. This option will be used in the following way: Periods of negative demand shocks are associated with a transfer of working time into future periods, whereas positive demand shocks are balanced by longer working time in the current period. The former can be interpreted as hours savings by firms and the latter can be interpreted as hours borrowing by firms, if we take expected or standard working hours as a reference mark. Since the distribution of demand is assumed symmetric, hours credits and debts will balance on average.

The fact that both parties, the firm and the employee prefer insurance establishes the reciprocity of the insurance solution. However, the intertemporal–tranfer option is not enforceable without further accompanying instruments. In sum, reciprocal insurance will only survive, if the actual use of the transfer option, i.e. the ”hours amount” imposed by output market conditions, can be verified by participating workers. Otherwise, the insurance solution will not be stable, since incentives for cheating of firms exist. Hence, firms could try to lower hourly wages by implicitly raising working hours on average. Nevertheless, the stability requirement can be satisfied relatively easy, if workers are provided with sufficient information pertaining to product market conditions and their development. Then, workers are aware of the difference between expected and

realized demand, hence, are able to evaluate the usage of the transfer option. This mechanism exactly describes the ”employee involvement in market information” element of the intertemporal–transfer organization.

The two–instruments–combination (i) hours transfer and (ii) information sharing defines a complementary system of work organization, which constitutes an intermediate layer in the polar hierarchy. The characteristic institutional arrangement of the transfer is represented by so called *working time accounts*. Those accounts document the transfer volume over the periods and allow to evaluate the difference between expected and realized demand over longer time horizons. In sum, hours credits and hours debts of each employee are registered in an individual account. In the stylized setting of the model with homogeneous labor, all accounts are identical. Provided, employee involvement in market information is installed and satisfies the stability (renegotiation proofness) constraint, working time accounts encompass the following elements (see Carstensen (2000)): 1. number of standard hours, 2. transfer limit per period, 3. actually requested transfer volume, 4. number of periods until compulsory settlement of accounts, 5. non–dismissal guarantee granted to workers.

Since hours credits and debts are balanced on average, working time accounts are also settled on average. Indeed, both parties gain from reciprocal insurance. The adoption of the reciprocal insurance model is ceteris paribus more likely in firms, where:

- output demand is exposed to (transitory) shocks and storage restrictions apply,
- (quasi–)fixed costs of recruitment and separation exist (cf. Oi (1962)),

- overtime premiums and/or negotiation costs apply,
- transaction costs for short–time work are substantial,
- the workforce lacks multiple skills (investments in human capital versatility and cross–task training are necessary),
- the workforce is relatively risk averse,
- workers favor relatively narrow tasks definitions and specialization.

To conclude, both models, the polar model of work organization and the intertemporal–transfer model, form the basis for the hypotheses that are presented in the next subsection. They will be empirically investigated in section 4. On the one hand, the theoretical analysis justifies multiple equilibria of well–defined work organizations, hence, co-existence of alternative types of work organization is predicted. On the other hand and based on complementary system arguments, a combined introduction of certain instruments is predicted, which translates in a ranking of work organizations according to their usage of sophisticated catalogues of instruments out of the labor economists toolbox. This rank order is preserved concerning productivity figures. Moreover, productivity enhancing effects from reorganization increase with higher ranks.

2.3 Hypotheses

The theoretical discussion has pointed out that well known facts like the variability of product demand, the cost structure of IT systems, the existence of cross–task learning

and knowledge spillovers or synergy effects in training, increasing flexibility of machinery equipment initiate shifts in the firms' value function. We can interpret the above three layer model as representing three distinct equilibrium types of organization of work.

In practice, we should observe three different firm types that can be categorized according to their work organization along the three layer model. These types are the outcome of a far–reaching reorganization process that took place in the last decade. Theoretically, all firms under consideration can be assigned to one equilibrium in the following ascending ranking of organizational equilibria: a) Tayloristic, b) intertemporal–transfer, c) holistic organization of work. Each of the three types is characterized by a coherent catalogue of organizational instruments. The idiosyncratic composition of instruments is coherent given the prevailing constraints set.

This leads to hypothesis **H1** on the existence of different organization of work types:

H1: In practice, three distinct types of work organization coexist: (i) Tayloristic organization, (ii) intertemporal–transfer organization, (iii) holistic organization.

The *Tayloristic organization of work* of single tasking hardly ever uses internal flexibility strategies like job rotation, flexible task bundles or intertemporal hours transfers. It also lacks elaborated schedules and strategies of upskilling or further training. Moreover, Tayloristic organizations are characterized by mass production and low price strategies, by high division of labor and narrowly defined tasks, highly and occupationallly specialized workers and by time invariant worker–task–assignments. The traditional conflict of interests between labor and management and the preclusion of employee involvement

in decision–making are also typical for the Tayloristic organization. Finally, appropriate monetary incentives are based on objective performance measures, which are predominantly linked to the individual worker. The Tayloristic image is changed in a few, but distinct elements, if we consider the intermediate layer type.

The *intertemporal–transfer organization* represents a reciprocal insurance solution and is characterized by an internal institution that regulates the relocation of hours contingents between periods. Not surprisingly, appropriate time management strategies are expected to dominate the market behavior of these firms. Institutionally, hours transfers are governed by working time accounts. The basis for thorough evaluation of the usage of the transfer option is ensured by the second characteristic element of the intertemporal–transfer organization: the participation of employees in operating figures at the output market. Technically spoken, workers control the firm's access to hours transfers at the internal credit market for working hours. Normally, the information sharing element is governed by joint labor–management consultations, typically involving the works council or comparable institutions. The latter illustrates the interlocking interests of firms and workers in the reciprocal insurance setting. Remuneration systems are expected to predominantly rely on time wages with reasonable efficiency wage premiums. If the stylized model is extended, and quality aspects of production gain importance, well balanced combinations of objective and subjective performance measure may be used as supplementary incentive packages. In addition, we expect these firms to invest in training to develop the versatility of human capital.

Finally, the *holistic organization* shows extended task scopes, employee involvement in decision making and explicit encouragement for acquiring multiple skills. This includes, for example, job enrichment, job enlargement, over time variability in task assignments, training of co–workers, worker initiated interventions at the process control level and discretionary control for adjustments in product quality/quantity as well as maintenance of productive equipment. Ideally, teams optimize over a vector of product (and task) characteristics. Correspondingly, we expect that product quality aspects and supplementing characteristics like environmentally friendly production dominate the market strategy combination. Holistic organizations make substantial use of modern communication technologies as well as of interrelated learning methods, supporting both, specialization and cross–task training. Basically, teams are expected to act as major communication platforms. Finally, more pleasant working conditions, group based monetary incentive systems and profit sharing, are associated with holistic firms.

This brief description illustrates the underlying type hierarchy, which exists with regard to elaborated personnel instruments. This is the contend of hypothesis **H2**:

H2: The three organization of work types describe a rank order according to the range of modern and participatory elements they make use of: lowest ranked Tayloristic organization, intermediate ranked intertemporal–transfer organization and highest ranked holistic organization. The most comprehensive catalogue of high–performance/–involvement instruments is found in holistically organized firms.

Hence, a reorganization from (i) a Tayloristic type to an intermediate type or (ii) from

an intermediate type to a holistic type is to be interpreted as a system upgrade, thereby exploiting increasing marginal effects, which result from complementarities between instruments (Milgrom & Roberts (1995b)). Correspondingly, we expect the productivity gains from reorganization activity (ii) to be greater than from reorganization activtiy (i). Technically spoken, complementarity is preserved under the maximization operation (Topkis (1998), Carstensen (2002b)). Equivalently, the value function shows increasing differences, which in turn imply that potential productivity effects of coherent subsystems are lowest in the Tayloristic organization, take intermediate values in the intertemporal transfer organization and are highest in holistic organizations.

Applied to the characteristic subsystem of multitasking, hypothesis **H3** postulates:

H3: The productivity enhancing effect of multitasking describes an ascending sequence that parallels the type order, hence, being largest in holistic firms and smallest in Tayloristic firms. Intertemporal–transfer firms corresponds to medium values.

With regard to the empirical analysis, we directly use the definition of multitasking from Lindbeck & Snower (2000, 355). Technically spoken, multitasking equals the *and*–inclusion of the two instruments (a) team work and (b) participation of shop floor workers in decision–making at the production level (involvement in contemporaneous quality adjustments, in innovations, engagement in customer relations/feedback).

Theoretically, we analyze whether multitasking is linked to a system effect of the work organization. If such a system effect exists, multitasking becomes more reasonable, when incorporated in more comprehensive changes in the organization of work. As an

extreme, negative productivity effects may occur, if the introduction of multitasking is not accompanied by complementary instruments within the reorganization process.

The above hypotheses will be empirically investigated on the basis of establishment–level data. The data are described in the next section.

3 The Data

The empirical analysis uses the Hannover Panel, a representative cross–section time–series data set for the manufacturing sector (Lower Saxony, Germany). The sample consists of 1025 privately–owned enterprises and encompasses annual information over the period from 1993 to 1997, for a total of 2686 observations.[7] Participation of firms has been voluntarily. The economic content of the yearly questionnaires is similar to British and Australian WIRS (workplace and industrial relations survey, Millward (1993)).

Part of the information used in the empirical analysis has been conducted for several periods (for example: value added, number of employees, capacity utilization). Other variables such as worker controlled quality assurance or the characteristics of inner firm communication channels and institutionalized information systems are available once. Consequently, the complete set of variables needed to derive the comprehensive system of work organization is also available once per firm. Methodologically spoken, we cannot apply estimates, which control for unobserved heterogeneity in the work organization decision. Henceforth, and with respect to the rather short observation period, we

7 Available number of cases drops and, in addition, varies between the different empirical specifications, mainly due to item non–response.

treat this comprehensive decision as time invariant.

In order to attain sufficient response rates, the questionnaire lacks physical capital and investment in productive capital. Therefore, capital had to be imputed from the records of the German central bank, where we use (ISIC Rev. 3–classification)×(sales–classes) cells (Bundesbank (1999)). This external data source measures capital shares. To construct physical capital for each sample unit, the capital share within the associated industry–sales–class cell is multiplied by firm level sales, where the latter reflect industry price level deflated figures.

Since we use deflated value added as a measure for firm level output per capita and, moreover, homogeneous price setting behavior at the industry level cannot be assumed, we use the level of industry production and the market share of the firm as additional variables. The integration of these variables removes the resulting (omitted variable) price bias (the procedure is derived in Carstensen (2001), for alternative approaches assuming heterogeneous price setting between industries, but homogeneous price setting within industries see Crepon, Desplatz & Mairesse (1999), Klette & Griliches (1996)).

4 Empirical Analysis and Results

This section is structured as follows: We begin with the presentation of the incidence of different firm types (section 4.1). The aim is to identify the three organizational equilibria stated in **H1**. Methodically, the results of a cluster analysis (cf. Jobson (1992)) are discussed. Tables 1 and 2 show the type specific characteristics of the organization

of work. The rank order hypothesis (**H2**) can also be inspected using tables 1 and 2. Interesting results are revealed with respect to remuneration packages and regarding participatory instruments like teamwork or employee involvement in decision making. Also, the divergent use of the reciprocal insurance arrangement is evident.

Subsequently, **H3** is investigated (subsection 4.2). The increasing productivity effect of multitasking as defined above, is checked. This examines the coherent system effect (tables 3 to 6). We follow a treatment effects approach to control for selectivity effects.

4.1 Types of Firms

This subsection is concerned with the characteristics of the identified types of work organization. We present the results of a k-means cluster analysis, with $k = 3$ in line with the theory. Basically, we like to know, whether the generated clusters differ systematically and whether they can be interpreted according to hypotheses **H1** and **H2**. Cluster calculation is carried out by minimizing the squared Euclidean distance between each member firm and the corresponding cluster mean until cluster means are stable. On the other hand, the distance between the three cluster means is maximized.

Table 1 (page 25) and table 2 (page 30) provide information about the group characteristics. They follow the same construction pattern: The first column contains the elements of the firm's constraint set to be considered or the instrument within the organization of work scheme. The group specific values of those variables, e. g. the level of *efficiency wages*, are reported in the second to fourth column. Holistic firms are represented by the group in column 2, intertemporal–transfer firms appear in column 3 and

Tayloristic firms are represented by the group in column 4. The last column informs about the level of significance, at which the hypothesis that alls group means are identical is rejected.

Table 1 contains two blocks of variables: Product market related variables and elements of the remuneration package. Table 2 gives an insight into four subsystems within the work practices and flexibility policy of the firm: a) the reciprocal insurance subsystem, b) the task assignment and employee involvement in decision making subsystem, c) the training and human capital accumulation subsystem as well as d) the subsystem of internal quality control and involvement of shop floor employees in quality assurance procedures. Altogether, the results can be interpreted as a noticeable hint for the existence of three distinct types of work organization, thus being supportive of **H1**.

We begin with the description of table 1. The output market related factors in fact seem to constitute three different regimes. Similar results are revealed by the remuneration package: Except the relative efficiency wage premium for white collar workers, all differences between the group means are significant at the 1%–level. Additionally to the simple comparisons, which test the hypothesis of identical groups, we performed multiple comparisons between the three groups to identify, which types differ significantly. Contrary to overall findings, the difference between the holistic and the transfer type does not remain statistically significant for the quality strategy on output markets, for firm size, usage of overtime, the level of efficiency wage premiums for blue collar workers. On the other hand, the difference between the intertemporal–transfer organization

and the Tayloristic organization cannot be statistically proven for an environmentally protective product strategy. Finally, with respect to short–time work incidence and its simultaneous occurrence with overtime work, as well as with respect to group based piece rates and bonuses, holistic and Tayloristic firms do not differ (basis: 5 %-level).

To summarize market strategy and flexibility results, holistic firms aim at success with a strategy combination of high product quality, appropriate time management and environmentally friendly production. 96 % of the firms assigned to the holistic group maintain high quality standards, 47 % deal with time as an input factor and 32 % use environmental protection to delimit from competitors and to attract consumers.

Although the intertemporal–transfer regime also focusses on product quality, comparatively clear emphasis is on the time management strategy: Two-thirds of these firms rely on flexibility and adaptability as a key success factor. Moreover, low price policies constitute a substantial part of the market strategy, since 46 % of the intertemporal–transfer firms maintain this policy to acquire consumers.

The expectation that Tayloristic firms pursue the mono–strategy low prices is not approved. As the intermediate layer firms, Tayloristic firms follow the strategy combination quality–flexibility–low prices, although with less intensity. Notice that we interpret the respective portions within the three strategy bundle as indicators for strategy intensity. The finding of less intensive market behavior corresponds to the literature on complementarity, which discusses system upgrades with stable inner system weights (cf. Holmstrøm & Milgrom (1994)). We observe a similar phenomenon if we pass over

Table 1: Work organization as a well defined catalogue of hr instruments

General frame/ set of human resource instruments	firm types			type difference
	Holistic	Transfer	Taylor	level of significance ⋆
Product market strategies				
– high product quality [a]	95.8	94.1	82.3	**
– proper time management [a]	47.3	66.2	47.8	**
– close customer relations [a]	26.8	17.4	33.4	*
– low price policy [a]	26.3	45.7	39.9	**
– environmental protection [a]	31.6	13.9	10.3	**
Firm size and order situation				
– number of employees	330	309	87	**
– capacity utilization [b]	89.6	87.2	86.9	**
– overtime work (Ov) [a]	79.7	80.4	64.9	**
– short–time work (Sh) [a]	11.5	27.0	14.9	**
– both (Ov & Sh) [a]	6.4	14.2	6.1	**
– working hours transfer buffer [c]	11.8	18.2	6.1	**
Remuneration packages				
– efficiency wage premium (blue collor workers) [d]	7.2	7.8	6.9	*
– efficiency wage premium (white collor workers) [d]	7.2	6.8	6.7	(0.46)
– piece rates (individually based) [a]	11.2	54.5	15.3	**
– bonus payments (individually based) [a]	17.1	49.8	7.1	**
– piece rates (group based) [a]	1.7	23.3	2.1	**
– bonus payments (group based) [a]	1.6	23.1	0.7	**
– profit sharing scheme (workers) [a]	32.5	19.8	5.4	**
– profit sharing scheme (management) [a]	61.8	67.5	28.2	**
Fraction of firm type [in %]	35.2	22.3	42.5	

⋆ Significance: ** (1%–level), * (5%–level), † (10%–level). Documented levels are Scheffe corrected (Scheffé (1959)).

[a] Percentage of firms utilizing the specific instrument.

[b] Percentage utilization of machinery equipment.

[c] Calculated time buffer in percent (relative to standard working hours) contracted in working time accounts or annualized hours contracts, respectively.

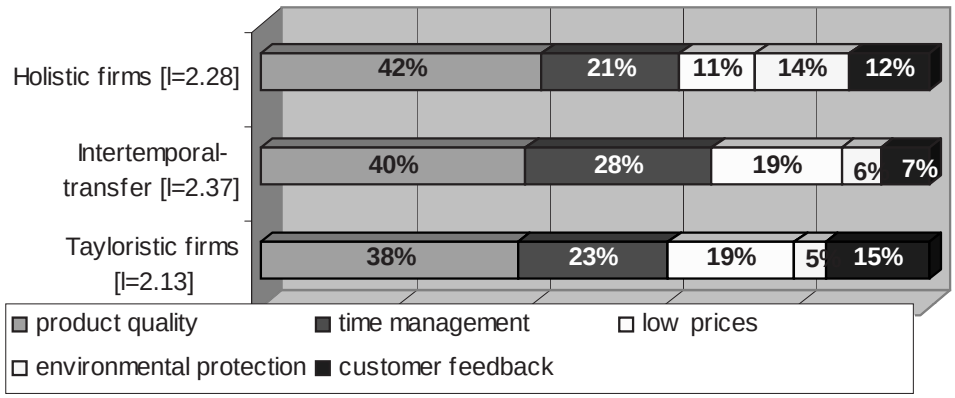
[d] Percentage difference between firm specific remuneration level and collective agreement counterpart.

Data: The Hannover Panel, period covered: 1993–1997. K–means cluster analysis has been performed by SPSS 10.0.

from Tayloristic to intertemporal–transfer organization of work, although a slight shift from price to time management strategies is recognized. For holistic firms we notice a relocation towards quality. Altogether, the market results are fairly in line with **H1**.

For sake of completeness, we consider the five–strategy bundles for product market behavior. The three beams in figure 1 depict the internal weight within the strategy combination for the three organization of work types, where the label at the vertical axis, for example, $[l = 2.28]$ indicates that the representative holistic firm simultaneously utilizes 2.3 strategies. Tayloristic and intermediate types distinguish by the following facts: Whereas Tayloristic firms pay more attention to close customer relations and customer feedback, intertemporal–transfer firms place, not surprisingly, more weight on time management.

Figure 1: Bundle of product market strategies: type specific internal weights



Contrary to both lower ranked types, holistic firms set less value on low prices and more value on environmental aspects during production. A similar picture appears for the quality strategy: The internal weight moderately rises from 38 % in the Tayloristic segment via 40 % in the intertemporal–transfer segment to 42 % in the holistic segment.

To conclude, holistic firms can be assigned to a quality dominated and otherwise bal-

anced strategy bundle with substantial impact of environmental aspects. Intertemporal–transfer firms are situated in a quality–time-management regime that often operates in low markup environments. The latter may explain, why intertemporal–transfer firms do not use price adjustments as an alternative to hours transfer. Finally, Tayloristic firms can be connected to a quality–price–time management–customer oriented strategy combination. The relative importance of the last element within the Tayloristic strategy bundle is a bit surprising, if we take Lindbeck & Snower (2000) into consideration. They argue not only that close customer relations are prevalent in holistic firms, but serve as a distinguishing criterion between the polar types.

On average, Tayloristic firms are smaller than the other types and their capacity utilization is slightly lower, with highest values in holistic firms. This clearly contradicts the mass production conjecture. Moreover, overtime is less often observed in Tayloristic firms. As expected, the relative hours transfer budget is highest in intertemporal–transfer firms. The incidence of short–time work as well as the the simultaneous occurrence of short–time and overtime is at each case highest in the transfer type. This result is quite interesting, since it indicates that respective firms are affected by rather considerable fluctuation, which cannot be completely handled by working time accounts. Indeed, in this segment more comprehensive adaption strategies have become a key success factor.

The lower part of table 1 reports the type specific usage of typical monetary incentive instruments. The composition of the remuneration system differs by firm type. In holistic firms, efficiency wage premiums and profit sharing schemes for both, employees and

management, play the key rule. This result parallels the Lindbeck & Snower (2001) argumentation on incentives for multitasking.

Within intertemporal–transfer organizations a comprehensive remuneration package is used. Hence, if we repeat the intensity interpretation for incentive systems, intertemporal–transfer organizations engage in high powered and high intensity pecuniary incentive systems. For an interpretation one could refer to Baker, Gibbons & Murphy (1994), who argue that, given multidimensional product characteristics and incomplete information, high intensity incentive systems that include objective and subjective measures may be Pareto improving. In our case, first, efficiency wages for blue collar workers are considerable, a result, which is in line with the reciprocal insurance model we discussed previously. Second, these firms rely on extensive incentive systems for individual workers. Hence, over 50 % pay piece rates and almost every second firms relies on individual bonus payments. For the group based counterparts the figures amount to 23 %, compared to 2 % or less in the Tayloristic and holistic control groups.

The portion of intertemporal–transfer firms that engage in profit sharing schemes for employees is one fifth, compared to nearly one third in holistic firms and less than 1 % in Tayloristic firms. The corresponding figures for the management level are 62 % in holistic firms, 67 % in the intermediate type and 28 % in Tayloristic firms, respectively. Tayloristic firms obviously base their individual monetary incentives on efficiency wages and piece rates. On the other hand, remuneration systems in holistic firms emphasize group related elements and elements that draw on subjective performance assessment,

thus encouraging mutual pressure among workers and establishing reciprocity (see also the discussion of guilt in Kandel & Lazear (1992)). In contrast, Tayloristic firms rate objective performance measures higher, hence, inherently facing the danger of dysfunctional incentives, if sufficient product quality is essential (Baker et al. (1994)).

Table 2 focusses on other typical subsystems of the comprehensive complementary system of work organization. The variables subsumed under the *reciprocal insurance subsystem* reflect the information and communication environment that prepares, supports, evaluates and maintains the insurance solution of working time accounts. As predicted by theory, employee involvement in information sharing on an institutionalized basis is highest in the intertemporal–transfer regime and lowest in the Tayloristic regime. We assess this as evidence for the renegotiation argument within the reciprocal insurance framework. If we consider information sharing, which is linked to specific topics, the supposed rank order of regimes is pointed out (see **H2**). The ratio of firms that regularly use project and topic–related communication channels amounts to 63 % in the holistic segment, to 56 % in the intertemporal–transfer segment and to 38 % in the Tayloristic segment.

If we pass over from employee involvement in information to employee involvement in decision making, the predicted ranking of work organizations is again broadly confirmed, where the difference between Tayloristic and intertemporal–transfer organizations seems to tag the crucial change. According to multiple comparisons, participation in decision making does not differ between holistic and intermediate firms. About 70 %

Table 2: Work organization as a well defined catalogue of hr instruments

General frame/ set of human resource instruments	firm types			type difference
	Holistic	Transfer	Taylor	level of significance ⋆
Reciprocal insurance subsystem				
– intertemporal hours transfer [a]	51.8	72.8	30.4	**
– works council [a]	73.6	89.5	52.0	**
– institutionalized regular IaC system/channels [a]	70.7	84.7	41.4	**
– regular IaC linked to specific topics/projects [a]	63.4	56.1	37.8	**
– degree of unionization [b]	39.8	51.3	30.9	**
– renegotiation proof working time accounts [a]	26.0	43.3	4.9	**
Task variety/worker responsibility subsystem				
– worker partizipation in decision making (P) [a]	71.7	69.2	16.4	**
– team work (incomplete specialization, T) [a]	69.0	62.9	51.3	**
– team coverage [c]	30.9	16.4	13.9	**
– holistic multi tasking (P& T) [a]	52.4	46.1	6.5	**
Training subsystem				
– financial support of further training by firms [a]	77.4	80.0	45.9	**
– annual per capita expenditures (further training) [d]	245.7	222.6	93.9	**
– strategy: continuous learning [a]	28.1	17.6	11.3	**
– strategy intensity: ongoing specialization [e]	3.7	2.9	2.1	**
– strategy intensity: diminution of comparative disadvantages /utilization of knowledge spillovers [e]	1.8	1.7	0.9	**
– strategie intensity: investment in multiskilling [e]	1.3	1.4	0.3	**
Quality assurance subsystem				
– at discretion of individual workers during the production process [a]	58.9	61.3	60.0	(0.27)
– at discretion of teams [a]	44.2	32.6	18.0	**
– own department for quality control [a]	70.5	79.2	54.8	**
Fraction of firm type [in %]	35.2	22.3	42.5	

⋆ Significance: ** (1 %–level), * (5 %–level), † (10%–level). Documented levels are Scheffe corrected (Scheffé (1959)).

[a] Percentage of firms utilizing the specific instrument.

[b] Percentage of workforce organized in a union.

[c] Percentage of blue collar workers working in teams.

[d] Industry level deflated values (in DM).

[e] Measure for the intensity by which the training strategy is followed: 0=not an issue, ..., 4=intensive use.

Data: The Hannover Panel, period covered: 1993–1997. K–means cluster analysis has been performed by SPSS 10.0.

of both grant their employee substantial workplace and production process related decision rights. Furthermore, the incidence of team production is 69 % in holistic firms,

with proportion of blue collar workers engaged in teams of 31 %. Respective values drop to 63 % (51 %) in intertemporal–transfer (Tayloristic) firms, with respective team coverage of 16 % (14 %). Only in the holistic segment more than half of the firms practice the characteristic subsystem of multi tasking (following the definition of Lindbeck & Snower (2000, 355)). Although the presented results on institutionalized information sharing, on short–time work and on hours buffers so far suggested a substitutional relationship between functional and time flexibility, the *task variety/worker responsibility subsystem* favors more the complementarity hypotheses between both flexibility instruments.

The next subsystem to be discussed, is compounded by human capital accumulation strategies. The corresponding *training subsystem* can be interpreted in conjunction with multiskilling and upskilling, which are regarded as necessary conditions for multi tasking and over time variability of task assignment. The familiar pattern appears: Holistic and intertemporal–transfer firms do more often report financial support of further training than their Tayloristic counterparts (77 % and 80 % vs. 46 %). Moreover, the amount spent per capita is much higher. If different dimensions of training are considered, we see that continuous and intra task learning are more often addressed in holistic firms than in intertemporal–transfer firms. If at all, Tayloristic firms show very weak cross–training and multiskilling engagement.

The last block of variables includes the *quality assurance subsystem*. First, we see that the three groups do not differ much regarding the usage of worker initiated quality

control and respective interventions during the production process. Rather 60% of the firms in all segments utilize this instrument to maintain high quality standards. This observation aligns with the previously illustrated facts on product market strategies, which all incorporated quality aspects. As predicted, the sphere of team competence is weakest in Tayloristic firms as is the existence of an own specialized department that performs quality controls on an independent and evaluating basis.

The overall impression from tables 1 and 2 is as follows: We find supporting evidence for hypothesis **H1**: The sample of firms splits into three distinct groups, which separate by their work organization. The corresponding types of firms differ systematically. Depending on the variable group under consideration either the difference between holistic and intertemporal–transfer types or the difference between intertemporal–transfer and Tayloristic types seems to be more pronounced. Nevertheless, with the few exceptions mentioned above, multiple comparisons between groups were significant at usual levels (1 %, 5 %). Compared to their Tayloristic counterparts, intermediate layer type firms more often use strategies for flexible production, engage in multidimensional and high powered monetary incentive packages and in profit sharing systems for the management. Furthermore, they more frequent use elaborated information and communication systems, team work and worker participation. Finally, they massively invest in sophisticated training strategies. On the other hand, capacity utilization is highest in holistic firms, although they least rely on price strategies. Holistic firms emphasize functional flexibility like explicit multiskilling, over time variability in task assignment as well as

topic–centered involvement of employees and teams.

To conclude, the composition of the organization of work type specific catalogue of instruments fits the description surrounding **H1**, although Tayloristic firms show unexpected close customer relations and intertemporal–transfer firms show unexpected high incidence of short–time work. With respect to the rank order hypothesis (**H2**), we can conclude, at least on a descriptive basis, from tables 1 and 2 that the predicted ranking concerning sophisticated work organization elements is pointed out, thus stressing **H2**. The next subsection examines the rank order in more detail. Particularly, hypothesis **H3** of increasing effects of reorganization, hence, the complementarity system hypothesis of multitasking, is investigated.

4.2 Complementary System Ordering

The research on the organization of work and on high–performance human resource management (HRM) systems argues that complementary instruments that aim to motivate employees are introduced as well defined combinations or catalogues (Milgrom & Roberts (1995a)). Correspondingly, productivity enhancing effects of such instruments mutually reinforce. Formally, we use the term monotone comparative statics. Hence, increasing marginal returns exist, that is returns to reorganization are growing with system comprehensiveness. We will investigate this presumption by analyzing the effect on productivity that is induced by a characteristic subsystem of modern work practices.

In the analysis, we take multitasking as such a subsystem. Especially, we examine, whether the multitasking effect varies systematically with the position of the firm in

the type hierarchy. The estimated multitasking effect is interpreted as a reorganization effect. Under the complementarity hypothesis, the magnitude of this effect is expected to depend on the current position of the firm in the organizational hierarchy, hence, on the realization of the firm type. Transferred to the three layer model, the effect on productivity of (the complementary subsystem) *multitasking* rises with the rank order of the organization of work type in which it is incorporated. We denote this phenomenon as an increasing effect from reorganization.

This, exactly, is stated by hypothesis **H3**, given the profit maximization assumption is valid: First, the adoption of multitasking affects productivity. Second, the productivity encouraging effect is weakest in the Tayloristic organization of work. It takes intermediate values in the intertemporal–transfer layer. Finally, the highest effect from reorganization towards multitasking is predicted for holistic firms. As we cannot rule out derogating effects a priori, a similar formulation states that potential alleviating effects are highest in Tayloristic firm. But once turned into positive effects, productivity never falls again.[8] Notice that the proof of monotone comparative statics depends crucially on the assumption that firms have already solved the optimization problem. Throughout the empirical analysis we maintain the assumption of optimal behavior.

The productivity effect is studied within a production function framework of the augmented Cobb–Douglas type. We are controlling for the fact, whether a firm operates under multitasking or not. Hence, the estimated effects indicate (overall) shifts in the

8 This property corresponds to the single crossing property (cf. Mirrlees (1971), Edlin & Shannon (1998)).

efficiency that are not embodied in other input factors.

But merely including the according dummy variable for multitasking and estimating the associated coefficient is rather inappropriate, since there is no argument for the presumption that firms are randomly assigned to the alternatives a) multitasking vs. b) non–multitasking. Quite the opposite: Our theoretical considerations predict that firms voluntarily opt for multitasking. Hence, the reorganization decision for multitasking specifies the outcome of a constrained optimization process. In sum, a compound effect that mixes selectivity and productivity effects, would be estimated if we not control for the selection into multitasking.

In the sequel, we apply a treatment effects approach to correct for the corresponding selectivity bias. This approach is appropriate, if the residuals follow a normal distribution. Estimation proceeds in two steps. The aim is to separate out the selection effect. In this sense, we first estimate the probability that a firm opts for multitasking. As determinants for the adoption, we include variables, which, for example, affect introduction costs of multitasking, but not productivity itself. This first stage estimation result is included as an additional regressor in the productivity equation that is estimated at the second stage. Technically, we follow the two step procedure suggested by Maddala (Maddala (1983, 117–122, 257–267)).

The associated econometric model is as follows. The main concern is with the productivity equation for firm i:

$$y_i = \mathbf{X}_i\boldsymbol{\beta} \; + \; \delta \, multitask_i \; + \; u_i \quad , \tag{1}$$

where $multitask_i$ denotes the dummy variable for the simultaneous existence of team production and shop floor worker participation in production process related decisions (our empirical measure for the multitasking subsystem). The row vector $\mathbf{X}_i$ of regressors depicts other variables that influence productivity y_i. The vector of coefficients $\boldsymbol{\beta}$ and the effect from reorganization δ are to be estimated.

Due to selection effects, the error term u_i is jointly distributed with ε_i, which appears in the adoption equation for multitasking. Selection into multitasking follows the following latent, but unobserved, decision rule:

$$multitask_i^* = \mathbf{W}_i\boldsymbol{\gamma} + \varepsilon_i \quad , \tag{2}$$

with the determinants row vector $\mathbf{W}_i$. The vector of coefficients $\boldsymbol{\gamma}$ will be estimated. The error term is measured by ε_i. Observed selection into multitasking is:

$$multitask_i = \begin{cases} 1, & \text{if } multitask_i^* > 0; \\ 0, & \text{otherwise} \end{cases} \quad . \tag{3}$$

The error terms u_i and ε_i are assumed to be bivariate normal, with the additional variance restriction $Var(\varepsilon_i) = 1$. This restriction is imposed, since we merely observe the sign of $multitask_i^*$:

$$\begin{bmatrix} u_i \\ \varepsilon_i \end{bmatrix} \sim N\left(\mathbf{0}, \begin{bmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix}\right) \quad , \tag{4}$$

with ρ as the correlation of u_i and ε_i. The standard deviation of u_i is measured by σ.

As mentioned, the value of δ is estimated in a two step procedure. The first step estimates the probability to opt for multitasking:

$$\text{Prob}(multitask_i = 1 \mid \mathbf{W}_i) = \Phi(\mathbf{W}_i\boldsymbol{\gamma}) \quad . \tag{5}$$

Φ depicts the cdf of the standard normal. Notice that the normal assumption is crucial. The row vector $\mathbf{W}_i$ includes the determinants of the preceding decision on multitasking. In tables 3 to 6 $\mathbf{W}_i$ corresponds to the right hand side variables in the selection equation.

On the basis of the probit model, i. e. using $\widehat{\boldsymbol{\gamma}}$, the selection term λ_i is estimated:

$$\lambda_i = \begin{cases} \frac{\phi(\mathbf{W}_i\widehat{\boldsymbol{\gamma}})}{\Phi(\mathbf{W}_i\widehat{\boldsymbol{\gamma}})}, & multitask_i = 1 \\ -\frac{\phi(\mathbf{W}_i\widehat{\boldsymbol{\gamma}})}{1-\Phi(\mathbf{W}_i\widehat{\boldsymbol{\gamma}})}, & multitask_i = 0 \end{cases} \quad . \tag{6}$$

The selection term is included as an additional regressor in the productivity equation in the second step of the estimation procedure:

$$\text{E}(y_i \mid multitask_i) = \mathbf{X}_i\boldsymbol{\beta} + \delta multitask_i + \underbrace{\rho\sigma}_{\equiv \widehat{\beta}_{\widehat{\lambda}}} \cdot \lambda_i \quad , \tag{7}$$

$$\text{Var}(y_i \mid multitask_i) = \sigma^2(1-\rho^2 d_i) \quad , \tag{8}$$

with d_i defined as $d_i = \lambda_i(\lambda_i + \widehat{\boldsymbol{\gamma}}\mathbf{W}_i)$.[9]

The results of the treatment effects estimates are displayed in tables 3 to 6. Before discussing these tables, let us consider a subset of the variables in the selection equation. This subset consists of artificial variables, which are the outcome of a factor analysis.

9 Because the normal assumption is crucial for the consistence of the two step estimator (Davidson & MacKinnon (1993)), kernel estimates of the residuals have been plotted against the normal distribution. The optical impression of these plots is satisfying.

The corresponding factor model has been estimated by principle components method.[10] Basically, information on job slot characteristics and their dynamics, on the firm's attitude towards innovation and customers, on R&D channels, on human capital investment regimes and on upskilling policies are included. Additionally, indicators for production flexibility needs and for assessment of restructuring activities are integrated. According to the scree–test and the eigenvalue–criterion, three factors are retained: (i) upskilling, (ii) rigidity, (iii) I-E efficiency. Their estimated factors scores (variable prefix FScore) are integrated as explanatory variables in the first stage of the treatment model.

The first factor upskilling captures a balanced strategy of human capital investment. By balanced strategy we mean that a bundle of training measures and incentives for helping colleagues is designed to generate a well–balanced mixture of returns from specialization (intra task learning) and returns from knowledge spillovers (cross–task learning). In detail, upskilling is strongly influenced by three variables: First, *intertask* denotes the average number of training measures the representative blue collar worker attends per year. In this context, we assume that a longer average duration indicates more pronounced investment in diversity of tasks, thus promoting the versatility of human capital and cross–task skills. Second, *intratask* quantifies the average duration of a typical training arrangement. Here, it can be argued that ongoing specialization and

10 Technically spoken, factor analysis aims at saving as much of the information generated by a set of correlated variables with preferably few artificial variables, called factors (see Jolliffe (1986)). In the factor model included in the selection equation, the uniqueness of the original variables is typically about 0.35 with a maximum value of 0.59 (average duration of further training) and a minimum value of 0.17 (number of training measures per year and capita). The detailed results are available from the author on request.

refinement of skills within the area of comparative advantage are associated to a longer duration. Third, *deepwide* is a dummy variable that indicates the simultaneous existence of the following: a) the documented length of on the job training required to develop full productivity related to the job slot exceeds one month but is less than one year, b) ongoing further training for permanent workforce is provided with a minimum of two measures per worker and year.

The second factor rigidity measures firm level characteristics and procedures, which contradict flexibility and prompt reallocation opportunities. Technically, rigidity negatively loads on the following three variables, which can be interpreted as several facets of internal flexibility: The dummy variable *flex_uptime* indicates shift work and/or continuous production. In addition, *flex_process* indicates that, in the observation year, the firm had introduced process innovations that aim at an improvement of flexibility and contemporaneous adjustability of manufacturing. Finally, *flex_RDcoop* captures the intensity of the firm's involvement in R&D cooperation. Strictly speaking, the sum over the partners and used information channels is taken: suppliers, customers, universities, other subsidiaries of the mother company. This last variable signalizes to which extend the firm exploits affiliations to external institutions or groups in a manner that their ability to evaluate products and inputs as well as to suggest improvements on a short–term basis is utilized. In sum, *flex_RDcoop* represents a form of knowledge capital, which can be referred to as affiliated or relocated versatility.

The third factor I-E efficiency depicts to which extend the firm values internal reor-

ganization and the restructuring of customer relations as a key success factor in mid– and long–run perspective. It is dominated by two variables: First, the dummy variable *restr_ext* indicates that the firm aims at the improvement of customer services and at the reconstruction of the delivery system to maintain future success. Second, *restr_int* is associated with the explicit purpose of redesigning the internal remuneration systems and of reformulating working time schedules. That is, the firm considers the need for adjustments in monetary incentive packages, in fringe benefits and in working time arrangements to assure high performance and long–term success.

The factor scores of upskilling, rigidity and I-E efficiency are included as determinants in the empirical specification of the decision for multitasking. For upskilling we expect a positive sign. In contrast the predicted sign of rigidity is negative, since a higher endowment with this flexibility inhibiting factor increases the introduction costs of multitasking. Finally, it is expected that I-E efficiency c. p. rises the probability to opt for multitasking.

In the data section, we argued that the level of industry production and the firm's market share should be included in the empirical model to control for heterogeneous price setting, hence, to correct for the associated omitted variable bias. Correspondingly, these variables appear in the productivity equation. A description of all variables in the treatment regressions can be found in table 8, which also provides summary statistics.

The basic treatment effects model is presented in table 3. It is re–estimated for three different subsamples (tables 4 to 6), where the subsamples are identical to the groups

that have been identified in the cluster analysis (see tables 1 and 2). All four tables 3 to 6 are based on the following construction pattern: The upper part displays the productivity equation, including the estimated reorganization effect resulting from *multitasking* and the selection effect into multitasking. The usual significance levels of 1%, 5% and 10% are indicated by **, * and †. The middle part of the tables contains the estimation results from the probit specification for adoption of multitasking. Basically, the determinants in the selection are associated with four areas, which we classify as influencing the multitasking decision by their corresponding cost attributes: 1. Human capital — preferences, characteristics and investment behavior. 2. Production systems — flexibility and feedback characteristics, innovation behavior. 3. Consumer preferences and market behavior regime. 4. Firm size and growth pattern.

The first three areas reappear as well defined variable combinations in the lower part of each table. Here, among other things, Wald tests of their joint significance are presented. The respective test statistic is interpreted as indicating the impact of the depicted area. In addition it is examined, whether the price bias variables improve the productivity specification. The associated level of significance at which the null hypothesis of lacking influence is rejected is documented in parentheses. Generally speaking, joint significance for area 3 (output market pattern). is not convincing for the whole sample and for the subsample of intertemporal–transfer firms. On the other hand, results for area 2. (physical capital characteristics) do not convince for Tayloristic and holistic firms. The Pseudo R^2 in the last row is related to the selection equation.

In the following, we consider the estimates for the different subsamples separately. We begin with table 3, where the whole sample is analyzed, thereby neglecting the complementary system effect. Thus, it is presumed that productivity shifts due to multitasking do not vary between the different layers within the work organization ranking. Correspondingly, the multitasking effect is supposed to be identical for Tayloristic, intertemporal–transfer and holistic firms. The same equality restriction is imposed for the coefficients in the selection equation.

The results of table 3 are easily summarized: 40 % of the variables in the selection equation exhibit a significant influence on the multitasking decision. Joint significance is proven for the human capital (investment) related variable combination and for the variables, which depict crucial characteristics of (integrated) physical capital. In sum and rakishly worded, a firm is more likely to opt for multitasking if it possesses, ceteris paribus, the following properties: It a) employs a high potential of knowledge capital[11] (positive sign for Lag(1) ln(knowledge capital)). It b) disposes of flexible production systems and affiliated diversity (negative sign for FScore rigidity). It c) launches product and process innovations on a frequent basis (innovation intensity). It d) is not dependent on strict time management and just in time production (proper time management, 10 %-level). Workers e) show preferences for versatile work (preferences for task variety, which is a proxy variable). No significant effects can be found for a well–designed training strategy that fosters multiple skills, continuous learning and upskilling (FScore

11 Knowledge capital is calculated on the basis of the perpetual inventory method with annual investment approximated by training expenditures plus R&D investments (see appendix for starting value details).

Table 3: Increasing Effects of Multitasking: Basic equation with no distinction between organizational types

Variable	Coefficient	(Std. Err.)
Productivity Equation: ln(labor productivity)		
capacity utilization	0.189	(0.186)
ln(capital)	0.656**	(0.026)
ln(labor)	0.027*	(0.014)
ln(industry output)	0.201*	(0.086)
ln(market share)	0.011	(0.011)
multitask	0.109†	(0.063)
selection term	-0.068†	(0.041)
Intercept	3.577**	(0.441)
Selection equation: *multitask*		
ln(labor)	-0.031	(0.072)
employment growth	0.533	(0.652)
Lag(1) ln(knowledge capital)	0.164**	(0.026)
FScore upskilling	0.061	(0.071)
FScore rigidity	-0.175*	(0.079)
FScore I-E efficiency	0.015	(0.068)
preferences for task variety	0.489**	(0.133)
ln(firm age)	0.142	(0.119)
innovation intensity	0.132**	(0.050)
low price policy	0.019	(0.140)
proper time management	-0.222†	(0.132)
high product quality	-0.025	(0.238)
environmental protection	0.137	(0.153)
overtime work	0.122	(0.156)
Intercept	-2.739**	(0.552)
joint significance of variables for ... (levels in parentheses):		
– heterogeneous price setting		(0.06)
– consumer preferences, output market patterns		(0.47)
– human capital: preferences, characteristics, investment		(0.00)
– production systems: feedback, flexibility, innovation		(0.00)
N	729	
σ_{u_i}	0.28	
$\chi^2_{(34)}$	1763.77	
Prob $> \chi^2$, Pseudo R^2	0.00 , 0.23	

Level of significance : †: 10% *: 5% **: 1% ; sector and year control included.

Estimation results calculated with Stata 7 (StataCorp (2001)), standard deviation in parentheses.

upskilling).

The estimated effect of multitasking on productivity shows the expected positive sign and is borderline significant. Given the empirical specification of the productivity equation, the adoption of multitasking is related to a 21 % upward shift in labor productivity, which is statistically proven at the 10 %–level. Coefficient and standard error of the selection term in table 3 show that the hypothesis of random assignment to the sub–groups (a) multitasking, (b) not multitasking cannot be rejected at the usual 5% level.

For the sample that does not distinguish between different organization of work types, the hypothesis of homogeneous price setting is rejected at the 6 %–level (joint significance of industry output and market share). Moreover, estimation results speak in favor for increasing returns to scale. From additional estimates of the structural coefficients markup pricing can be calculated. The average markup amounts to 17 %.

In contrast to the model estimated in table 3, the estimates presented in tables 4 to 6 do not impose the restriction that productivity effects from reorganization are the same, indepenent of the realized organization of work. A type specific impact of multitasking on labor productivity is now allowed. Correspondingly, we split the sample into the three subgroups, which have been identified in the cluster analysis. Table 4 depicts the Tayloristic group. Table 5 represents the intermediate layer and table 6 corresponds to the holistic group. Hence, we expect the separately estimated multitasking effects to differ systematically between the groups in a way that the effect documented in table 6 should exceed the comparative value in table 5, which, in turn, should exceed the value

denoted in table 4.[12]

The *Tayloristic* firms are discussed first (table 4). Although the hypothesis of random assignment to multitasking cannot be rejected, we interpret the variables in the selection equation: In contrast to all other specifications, the variable that indicates a low price strategy plays a significant role in the multitasking decision. Within the Tayloristic segment, the need for maintaining a low price level to attract consumers seems to drive reorganization towards functional flexibility. This impression is underscored, if the associated marginal effects are calculated. The human capital variables again exert influence: previous year value of knowledge capital increases the probability of multitasking (1 %–level significance). In contrast, substantial efforts for multiskilling and continuous learning patterns decrease the probability of multitasking ((FScore upskilling), 10 %–level). The latter result could again be interpreted within the scope of knowledge capital and multiple skill requirements as a necessary precondition for incomplete worker specialization. In this context, the upskilling variable represents preceding investment efforts of Tayloristic firms in order to meet the human capital versatility requirements, which are up to now lacking. The negative sign of FScore upskilling may indicate the chronological order *accumulation of multiple skills* $\rightarrow$ *trespassing the versatility threshold* $\rightarrow$ *adoption of multitasking*.

The multitasking effect on productivity in the Tayloristic group of organization of work is significantly negative at the 5 %–level. The calculated productivity loss amounts

12 It is further expected that selection matters and that firms positively select into multitasking, hence, possess comparative advantages in a multitasking environment.

Table 4: Increasing effects of multitasking: Regression for Tayloristic organizations only

Variable	Coefficient	(Std. Err.)
Productivity Equation: ln(labor productivity)		
capacity utilization	-0.007	(0.253)
ln(capital)	0.634**	(0.034)
ln(labor)	0.029	(0.019)
ln(industry output)	0.206†	(0.119)
ln(market share)	0.015	(0.015)
multitask	-0.309*	(0.142)
selection term	0.098	(0.088)
Intercept	4.154**	(0.502)
Selection equation: *multitask*		
ln(labor)	-0.006	(0.258)
employment growth	1.296	(1.659)
Lag(1) ln(knowledge capital)	0.319**	(0.099)
FScore upskilling	-1.181†	(0.647)
FScore rigidity	-0.134	(0.257)
FScore I-E efficiency	0.187	(0.198)
preferences for task variety	-0.123	(0.591)
ln(firm age)	0.212	(0.408)
innovation intensity	0.042	(0.174)
low price policy	1.063*	(0.479)
proper time management	-0.523	(0.455)
high product quality	-0.442	(0.519)
environmental protection	-0.438	(0.702)
overtime work	-0.315	(0.399)
Intercept	-5.478*	(2.439)
joint significance of variables for ... (levels in parentheses):		
– heterogeneous price setting		(0.16)
– consumer preferences, output market patterns		(0.10)
– human capital: preferences, characteristics, investment		(0.02)
– production systems: feedback, flexibility, innovation		(0.88)
N	208	
σ_{u_i}	0.32	
$\chi^2_{(30)}$	696.12	
Prob $> \chi^2$, Pseudo R^2	0.00 , 0.30	

Level of significance : †: 10% *: 5% **: 1% ; sector and year control included.

Estimation results calculated with Stata 7 (StataCorp (2001)), standard deviation in parentheses.

to 27 %. The hypothesis of homogeneous price setting cannot be rejected, but the joint influence of output market predispositions is proven.

The separate treatment model for the *intertemporal–transfer* organization is documented in table 5. Regarding the direction of potential influence on the multitasking decision, a selection pattern emerges that is very similar to the pattern represented in table 3. Interpretations, however, should be cautious, since the number of cases in the intermediate layer estimates is quite small (89). At least on a 10 %–level basis and taking the usual ceteris paribus perspective, the typical intertemporal–transfer organization is more likely to opt for multitasking, if it a) utilizes more flexible production systems, if it b) exists for a number of years, if it c) belongs to expanding market segments. Interestingly, the incidence of appropriate time management schedules neither increases nor decreases the probability of multitasking, hence, no conclusion on the relationship between functional flexibility and time flexibility can be drawn from this result. However, well–designed and multidimensional human capital investment schedules seem to be prolonged when opting for functional flexibility. That is higher scores for FScore upskilling result in higher probabilities for multitasking (10 %–level), hence, indirectly supporting the complementarity or rank order hypothesis of organization of work. The fact that a firm is not reluctant to considerable adjustments in incentive and delivery systems also increases the probability of reorganization (10 %–level).

As for Tayloristic organizations, the estimated reorganization effect on productivity is negative at the intermediate layer. The calculated productivity loss in the sub-

Table 5: Increasing effects of multitasking: Regression for the intertemporal–transfer type organizations only

Variable	Coefficient	(Std. Err.)
Productivity Equation: ln(labor productivity)		
capacity utilization	0.822*	(0.327)
ln(capital)	0.792**	(0.068)
ln(labor)	-0.043	(0.035)
ln(industry output)	0.186	(0.163)
ln(market share)	-0.019	(0.024)
multitask	-0.211**	(0.079)
selection term	0.118	(0.059)
Intercept	2.138**	(0.820)
Selection equation: *multitask*		
ln(labor)	0.049	(0.295)
employment growth	0.681*	(0.316)
Lag(1) ln(knowledge capital)	0.219*	(0.091)
FScore upskilling	0.347†	(0.199)
FScore rigidity	-0.364†	(0.220)
FScore I-E efficiency	0.368†	(0.198)
preferences for task variety	0.973*	(0.404)
ln(firm age)	0.705†	(0.405)
innovation intensity	0.006	(0.163)
low price policy	0.374	(0.391)
proper time management	-0.596	(0.429)
high product quality	0.229	(0.681)
environmental protection	0.521	(0.436)
overtime work	0.133	(0.479)
Intercept	-5.386**	(2.376)
joint significance of variables for ... (levels in parentheses):		
– heterogeneous price setting		(0.44)
– consumer preferences, output market patterns		(0.44)
– human capital: preferences, characteristics, investment		(0.01)
– production systems: feedback, flexibility, innovation		(0.14)
N	89	
σ_{u_i}	0.21	
$\chi^2_{(19)}$	221.51	
Prob $> \chi^2$, Pseudo R^2	0.00 , 0.26	

Level of significance : †: 10% *: 5% **: 1% ; sector and year control included.

Estimation results calculated with Stata 7 (StataCorp (2001)), standard deviation in parentheses.

sample of intertemporal–transfer organizations is 19 %. So far, the postulated increasing marginal returns from reorganization are not contradicted by the empirical analysis. Since marginal returns are negative on the lower layers of the organizational hierarchy, we speak of decreasing marginal loss so far.

Finally, the *holistic* subsample is considered. Table 6 contains the estimation results. Apart from two exceptions, the selection equation shows exactly the same coefficient signs as the estimates for the Tayloristic subsample. The first difference concerns worker preferences for versatile work. Remember, no influence of worker preferences could be proven for Tayloristic firms and, additionally, the sign had been negative. As theoretically expected, holistic firms are c. p. more likely to introduce multitasking, when workers prefer task variety (5 %–level). Moreover, as stated in Carstensen (2002a), whenever technological task complementarities exist, holistic reorganization is merely driven by the shape of worker preferences. Recalling that holistic firms are larger on average (table 1), the positive coefficient of innovation intensity in the selection equation could be interpreted as supporting evidence for technological complementarities in holistic firms. Hence, future research on the matching of firms and workers according to suitable type–preference combinations could reveal further evidence.

The second difference depicts a real contradiction of the polar type selection regimes: The significantly negative influence of low price strategies in holistic firms is in contrast to the significantly positive influence in Tayloristic firms. Hence, the multitasking inhibiting (fostering) influence of low price standards in holistic firms (Tayloristic firms)

Table 6: Increasing effects of multitasking: Regression for holistic organizations only

Variable	Coefficient	(Std. Err.)
Productivity Equation: ln(labor productivity)		
capacity utilization	-0.247	(0.335)
ln(capital)	0.658**	(0.045)
ln(labor)	0.066*	(0.028)
ln(industry output)	0.207	(0.139)
ln(market share)	0.013	(0.020)
multitask	0.287*	(0.141)
selection term	-0.159†	(0.090)
Intercept	3.747**	(0.612)
Selection equation: *multitask*		
ln(labor)	-0.216*	(0.107)
employment growth	0.781	(1.079)
Lag(1) ln(knowledge capital)	0.091*	(0.040)
FScore upskilling	-0.168†	(0.101)
FScore rigidity	0.075	(0.122)
FScore I-E efficiency	-0.112	(0.102)
preferences for task variety	0.474*	(0.020)
ln(firm age)	0.060	(0.178)
innovation intensity	0.122†	(0.073)
low price policy	-0.427*	(0.221)
proper time management	-0.133	(0.194)
high product quality	-0.358	(0.509)
environmental protection	-0.303	(0.214)
overtime work	-0.185	(0.258)
Intercept	0.369	(0.902)
joint significance of variables for ... (levels in parentheses):		
– heterogeneous price setting		(0.27)
– consumer preferences, output market patterns		(0.19)
– human capital: preferences, characteristics, investment		(0.01)
– production systems: feedback, flexibility, innovation		(0.37)
N	207	
σ_{u_i}	0.23	
$\chi^2_{(31)}$	451.33	
Prob $> \chi^2$, Pseudo R^2	0.00 , 0.09	

Level of significance : †: 10% *: 5% **: 1% ; sector and year control included.

Estimation results calculated with Stata 7 (StataCorp (2001)), standard deviation in parentheses.

indicates that firms that ceteris paribus to not use prices to attract consumers are more likely (less likely) to introduce functional flexibility. One explanation is that holistic firms offer products with multiple characteristics (cf. Lancaster (1966)) and prices play a minor role for product demand compared to durability or service, whereas Tayloristic firms stuck to homogenous products lacking other attributes than prices. Correspondingly, Lindbeck & Snower (2000) argue that consumer preferences and information technologies are alternative factors, which foster reorganization towards multitasking.

In the upper part of table 6 the productivity enhancing properties of multitasking within holistic organizations are examined. Here, we notice the significant positive coefficient of multitasking. The calculated productivity shift is 33 %. Together with the 27 % loss in Tayloristic firms and to the 19 % loss in intertemporal–transfer firms, this result is interpreted as an indication for the existence of the postulated increasing effect from reorganization.

Concerning the relevance of these differences, we asserted a common selection process and then tested for type specific multitasking effects. Tayloristic firms are taken as the reference group. Estimated productivity effects for the reference group are negative. A positive difference compared to this group is estimated for both, the intertemporal–transfer group and the holistic group. As expected, relative increase is larger for the latter type of organization. Based on F–tests, the following is concluded: The hypothesis of identical effects on productivity is strongly rejected (1 %-level). Effects differ significantly at the 8 %-level (1 %-level) between Tayloristic and intermediate firms (holistic

firms). Between intermediate and holistic firms the difference is also proven at the 1 %-level. Altogether, we find supporting evidence for the complementarity hypothesis **H3**, which we examined on the basis of marginal effects from multitasking.

The negative selection term in the holistic segment (10 %–level) signalizes that the adoption decision is undertaken in expectation of productivity gains. Hence, the usual interpretation that holistic firms with respective comparative advantages or preferences for multitasking select into multitasking is not confirmed. Nevertheless, if we had not controlled for selectivity, the productivity effect would have been underestimated.

5 Conclusions

Theoretical and empirical work on complementary systems of work organization and organizational change has motivated this paper. The main predictions from theoretical literature are that — regarding the aggregate of firms —, first, diverging equilibria of work organization co–exist. Second, it is expected that reorganization occurs on a disruptive basis. Third, it is postulated that the adoption of a high–involvement work systems improves firm performance. Correspondingly, increasing marginal returns from reorganization are derived. On the other hand, an emerging empirical literature normally finds that high–involvement work organizations outperform organizations with traditional (Tayloristic) workplace practices.

This paper has extended findings from theoretical literature to a three layer model of work organization. Existing work is to a large extend concerned with the polar model

of traditional vs. high–involvement work organization. Alternatively, the denotation Tayloristic vs. holistic is used. Although the above literature explicitly argues on the basis of varying output demand, it is usually not formalized. We integrated a model that formalizes randomly distributed output demand. Hence, an intermediate layer had been derived, which we termed the intertemporal–transfer model. The crucial property of this type of work organization is that it constitutes a reciprocal insurance solution between the firm and it's employees.

The three layer model represents the following ascending ranking: (i) Tayloristic organization of work, (ii) intertemporal–transfer organization of work, (iii) holistic organization of work. Each organization type represents a complementary system, with system (ii) marking the initial system of reorganization. Since maximization is an order preserving operation (Topkis (1998)), the rank order is maintained concerning profits. Thus, the impact on profit and productivity, which results from the adoption of a subset of instruments, differs by firm type. The value in holistic firms exceeds the comparison value in intermediate layer firms, which again exceeds the reference value in Tayloristic firms. We concentrated on multitasking as the respective subset.

We then investigated these theoretical predictions empirically on the basis of a representative survey in the manufacturing sector. In contrast to existing literature that usually studies complementarities on the basis of interaction effects or type dummies, we studied increasing effects from reorganization directly. Thus, the paper also extended empirical work. We first identified the different layers in the three layer model. We then controlled

for selection into multitasking, since adoption of multitasking itself is the outcome of an optimization process, not of random assignment. Finally, we estimated reorganization effects separately for each type of the three types of organization.

Altogether, we found empirical evidence for the complementary system hypothesis: The multitasking effect on productivity indeed differs between the organization of work types and parallels the postulated ranking. Interestingly, it is negative in both, Tayloristic and intertemporal–transfer firms, which further supports the above hypothesis. In this context, existing literature argues that typical high–involvement instruments need broader high–involvement environments to be able to initiate the desired effect.

Although the survey we used in the empirical investigation originally includes panel data, we had to rely on specifications, which do not control for unobserved heterogeneity, since the assignment of observation units to organization types is only available once. Hence, we could not study broader system changes and the switch between organizational types. This shortcoming is caused by the fact that a number of variables, which were included in the type generating model, have only be asked for once. Here, an extension of the data basis is needed for further research on organizational change in order to apply panel data estimation methods.

A Variable Description and Summary Statistics

Table 7: Labor Productivity and Firm Type: Multiple comparisons

productivity[a]	Holistic	Transfer	Taylor	all firms
	63,728	60,150	54,112	58,622
	(25,617)	(22,368)	(21,297)	(23,485)
no. of cases	669	368	882	1919
multiple comparisons				
Transfer[b]	(0.06)		(0.00)	
Taylor[b]	(0.00)	(0.00)		

[a] Labor productivity: industry price deflated values in EUR. Standard deviation in parantheses.

[b] Level of significance for difference between column type and row type productivity in parantheses. Figures are Scheffe corrected (Scheffé (1959)).,

Table 8: Summary statistics for treatment approach variables

Variable	**Mean**	**Std. Dev.**	**N**	**Description** [a]
capacity utilization	0.879	0.073	2670	utilization of machinery equipment, reference value of sufficient capacity set to 1.
environmental protection	0.180	0.385	2505	dummy variable=1, if output market strategy relies on a(n image) policy of environmentally friendly production,
high product quality	0.892	0.31	2505	dummy variable =1, if output market strategy relies on quality competition,
ln(industry output)	2.374	0.209	1856	industry output, calculated on the basis of sales data and industry price level (German Statistical Office, basis: $1991 \equiv 1$).
innovation intensity	2.087	1.475	2266	number of years with innovations over the observation period,
ln(firm age)	3.376	0.545	2680	log of number of years, since the firm exists,
ln(capital)	10.489	0.630	2310	log of fixed assets per capita,
ln(knowledge capital)	8.683	2.891	1816	log of per capita assets in knowledge, calculated via the perpetual inventory method, annual accumulation: sum of R&D expenditures and investment in human capital. Assumptions: pre observation growth rate = 0.05, human capital depreciation rate= 0.15;
ln(labor)	4.471	1.176	2588	log of number of employees (average within year of observation),
ln(labor productivity)	11.575	0.382	1919	log of value added per capita,
ln(market share)	2.381	1.268	1928	log of market share (major product),
low price policy	0.363	0.481	2505	dummy variable =1, if output market strategy relies on price competition,

[a] monetary figures: industry price deflated values (basis: DM)

to be continued...

... table 8 continued

Variable	Mean	Std. Dev.	N	Description [a]
multitasking	0.286	0.452	2402	dummy variable = 1, if firm practices team production,
overtime work	0.725	0.447	1772	dummy variable =1, if employees currently work overtime,
sector control			2682	29 dummy variables for sector affiliation,
time management	0.510	0.510	2682	dummy variable =1, if output market strategy relies on appropriate time management patterns,
year control			2686	dummy variables for year of observation (1993, 1994, 1995, 1996, 1997).

[a] monetary figures: industry price deflated values (basis: DM).

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