Employment Effects of Work Sharing –
An econometric analysis for West Germany

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Abstract:

In this paper we estimate the employment effects of a reduction in weekly normal hours in West German manufacturing on the basis of an econometric models using industry panel data. We distinguish between unskilled, skilled and high-skilled workers and show that labor demand elasticities with respect to real wages differ significantly between these three skill groups. Given wages, the direct employment effect of a reduction in weekly normal hours is negligible for all three groups. However, taking the adjustment of wages into account, which compensates workers to some extent for lost income due to the reduction of working hours, the net employment effect becomes negative on average. Due to their relatively large wage elasticity, this negative effect is particularly strong for the unskilled. "Work sharing" by means of general hours-reductions can thus not be considered an adequate policy to reduce unemployment.

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I. Introduction

A general reduction of working hours – i.e. the number of hours mandated by law or collective bargaining agreements – as a means of reducing unemployment has a long tradition in the economic policy debate in Germany (see, e.g., Franz, 1984) and is also common in other European countries (OECD 1998, chapter 5). The latest example, passed in January 2000, is the French legal restriction of standard working hours to 35 hours as an attempt to reduce unemployment. In Germany, the dominant labor union, the metal workers union (IG Metall), has proposed a further reduction of standard working time from currently 35 to 32 or even 30 hours. In this paper, we analyze the likely employment effects of a further reduction in standard weekly hours in German[1] manufacturing.

For various reasons it remains very controversial whether a reduction in working hours is a suitable means to reduce unemployment (see, e.g., Dreze 1991, OECD 1994, Freeman 1998). As shown in section III below, such a policy will have both direct and indirect effects on the demand for labor. Given real hourly wages and labor costs stay constant, a reduction in standard hours changes the optimal mix between workers and hours (overtime). This direct effect is ambiguous, i.e. employment may increase or decline. If the reduction of working time leads to an increase in labor costs the demand for labor will be reduced due to both substitution and scale effects. An increase in labor costs is likely to occur because unions and workers will try to prevent weekly (or monthly) earnings to be reduced in proportion to the reduction in working time, which is known as "Lohnausgleich" in German collective bargaining. A general

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[1] Here and in the following, „Germany" always refers to West Germany. Standard working hours in East Germany are still considerably higher than in West Germany. Since the available time series data are too short and the labor market situation in East Germany differs in various ways from the one in West Germany, we do not include East Germany in our analysis here.

reduction in standard hours would also restrict firms flexibility to adjust actual working hours and may also lead to a "mismatch" of the firms' demand for and supply of labor by skill type.

For Germany, results from empirical studies (see König and Pohlmeier 1988, 1989, Lehment 1991 and Hunt 1998, 1999) suggest that the net effect of working-time reductions tends to be negative with respect to the overall level of employment. For example, Hunt (1999) concludes that the general reduction of standard hours in West German manufacturing has resulted in higher real hourly wages for those who remained employed but this has been achieved at the price of lower overall employment. However, these studies do not try to disentangle the various effects which make up the negative net effect. It is thus not clear from these studies to which extent the estimated net employment losses associated with a general reduction in working time are related to the wage adjustment rule, for example. Furthermore, these studies do not differentiate between skill groups and thus cannot account for the potential mismatch between the demand for labor and the unemployment pool which is mostly composed of unskilled labor.

In our econometric model of general working-time reductions, which is set out in section IV below, we take into account both the direct and indirect employment effects of a policy of general working-time reductions. In particular, we decompose the estimated net effect of a reduction in weekly working time (standard hours) into a direct effect, calculated for given wages, and an indirect effect which takes into account the reduction in the demand for labor due to an increase in real wages associated with working-time reductions ("*Lohnausgleich*"). The adjustment of wages to general working-time reductions may depend on institutional regulations which are briefly described in the next section. This section also contains a description of the development of working time, employment, and wages by skill type.

A novel feature of our econometric model is that firms' demand for labor is differentiated by skill level. As it turns out, estimated wage elasticities of labor demand differ distinctly by skill level. The indirect employment effects of working-time reductions therefore also differ markedly between the three skill groups considered here. This has important implications concerning the net employment effects of a general reduction in working-time, although the direct effects of such a policy hardly differ between the different skill levels. Since the wage elasticity of the demand for labor is relatively high for unskilled workers, a general reduction of standard hours has the strongest negative effect on the demand for unskilled workers for whom unemployment is already very high in Germany (see, e.g., Paqué 1999). A general reduction in working hours would therefore lead to a further deterioration of the employment prospects for this group. Hence, we conclude that a general working-time reduction is not an appropriate policy measure for reducing unemployment in Germany. Rather, by increasing labor costs only employed insiders would profit from such a policy. Thus, we conclude that a general working-time reduction is not an effective labor market policy instrument.

II. Institutional and Empirical Background

To set the scene for the following econometric analysis, in this section we briefly describe some institutional and empirical background relating to general working-time reductions in West German manufacturing in the period 1978 to 1998. In addition to changes in working-time regulations, we also describe changes in actual working hours as well as the development of employment and real wages by skill level.

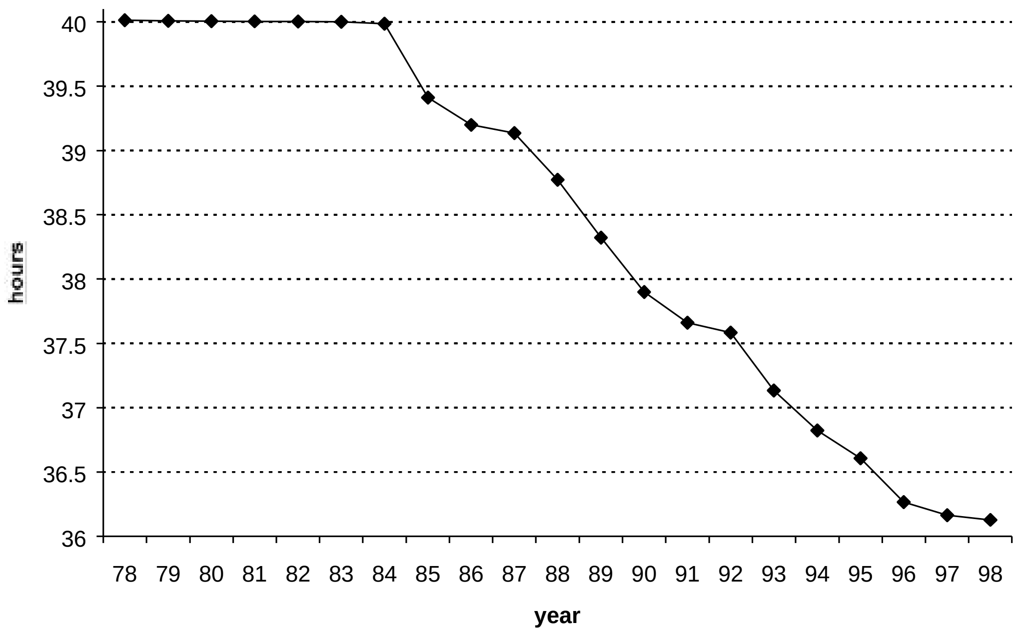
Working-time regulations in Germany are mainly determined by collective bargaining agreements. Although there are also legal regulations concerning standard working hours, these are typically dominated by regulations contained in collective bargaining agreements, especially in the manufacturing sector where the IG Metal – the union organizing employees in the metal manufacturing and electrical engineering industries (the metalworkers union for short) – plays a dominant role. The IG Metal is organizing about 2.7 million employees and its coverage of employment in this sector is even larger because collective bargaining agreements are also extended to non-union members. In 1978, the IG Metal initiated a campaign for a reduction in the work week to below 40 hours and, after a lengthy strike, succeeded in this campaign in 1984. The weekly working time in the metal manufacturing and electrical engineering industries was cut to 38.5 hours in 1985. Further working time reductions were negotiated to be introduced in various steps: standard working time was reduced to 37 hours in 1988, to 36 hours in 1993 and to 35 in 1995. Other industries, such as the printing industry and the chemical industry, also reduced standard working hours in various steps.

These agreements resulted in a stepwise reduction of the average standard working time in the whole manufacturing sector as shown in Figure 1.[2] On

[2] Although collective bargaining agreements concerning working time distinguish between blue-collar and white collar workers, working-time reductions have virtually been

average, standard working time decreased from 40.1 hours in 1978 to 36.4 hours at the end of the nineties. At the beginning of the observation period, standard hours varied little between industries in the manufacturing sector – the standard deviation was just 0.2 hours. In 1998, inter-industry differences in collectively bargained working time have markedly increased, as indicated by a standard deviation of 1.4 hours.

Figure 1: Development of average standard hours in West German manufacturing



Source: see data appendix.

Previous general working time reductions were accompanied by increases in hourly wages to prevent weekly or monthly wages to decline proportionally with the number of standard hours. This wage compensation policy, known as "*Lohnausgleich*", is typically considered an important component of collective bargaining agreements on the union side. In an empirical study for West Germany, Franz and Smolny (1994) show that in some industries (metal

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identical for the two groups. In Figure 1 only average standard hours are therefore shown.

manufacturing and electric engineering) the reduction in working hours *ceteris paribus* increased real hourly wages significantly, thus providing evidence for partial wage compensation. Hunt (1999) also finds some evidence for partial wage compensation in German manufacturing industries.

On the other hand, the stepwise reduction of working time in metal manufacturing was accompanied by the introduction of more flexible working-time arrangements in collective bargaining agreements. In particular, accompanying the working-time reduction to an average of 38.5 hours, in 1985 an agreement allowed actual hours for individual or groups of employees within a firm to vary between 37 and 40 hours as long as working hours within the firm reached 38.5 hours on average. Furthermore, the possibility that individual working time could be varied within limits by firms as long as an average of 38.5 weekly hours was reached within a two-months period was introduced. The collective bargaining agreement in the metal manufacturing industry which introduced the stepwise reduction of the standard working time to 37 hours per week by 1990 with full wage compensation was accompanied by a further step towards more flexible working-time arrangements. In particular, the period within which individual working time had to be balanced to reach average standard hours was extended from 2 to 6 months. Furthermore, individual working time could be differentiated between skill groups. These regulations were implemented at the firm level and specified in agreements between management and work councils. While more flexible working-time arrangements were widely adopted in large firms, they were hardly used by small firms.

The introduction of more flexible working-time arrangements in collective bargaining agreements affected average hours actually worked differently for various skill groups. Between 1974 and 1998, weekly paid working hours declined from 41.3 to 37.9 for unskilled and from 42.9 to 38.1 for skilled workers, respectively. In contrast, average paid hours worked by graduates increased from 41.8 to 42.1 per week in the period 1975 to 1996.[3] In the same period, weekly paid *overtime* hours in manufacturing declined from 2.1 to 1.1 hours for unskilled workers and from 3.3 to 1.6 hours for skilled workers. For graduates, overtime hours increased within the observation period.

How did the level of employment evolve over time? Total employment in West German manufacturing declined strongly from 8.3 to 6.3 million in the period 1978 to 1998. At the same time, the skill composition of employment changed markedly. To illustrate this, we have disaggregated employment into three skill groups according to an employee's highest educational or vocational degree. The three skill groups are

(i) *unskilled* workers: without a completed educational or vocational degree,

(ii) *medium skilled* workers: with a completed educational or vocational degree, typically apprenticeship training

(iii) *highly skilled* workers: graduates from a polytechnic ("*Fachhochschule*") or university.

The share of unskilled workers in West German manufacturing dropped from about 45% in 1978 to less than 30% in 1998, whereas in this period the share of skilled workers increased from about 52 to 65 percent and the share of highly skilled workers increased from about 3% to more than 7% (see Figure 2). The long-term decline of employment in the West German manufacturing sector is thus mainly related to the strong employment decline of unskilled labor.

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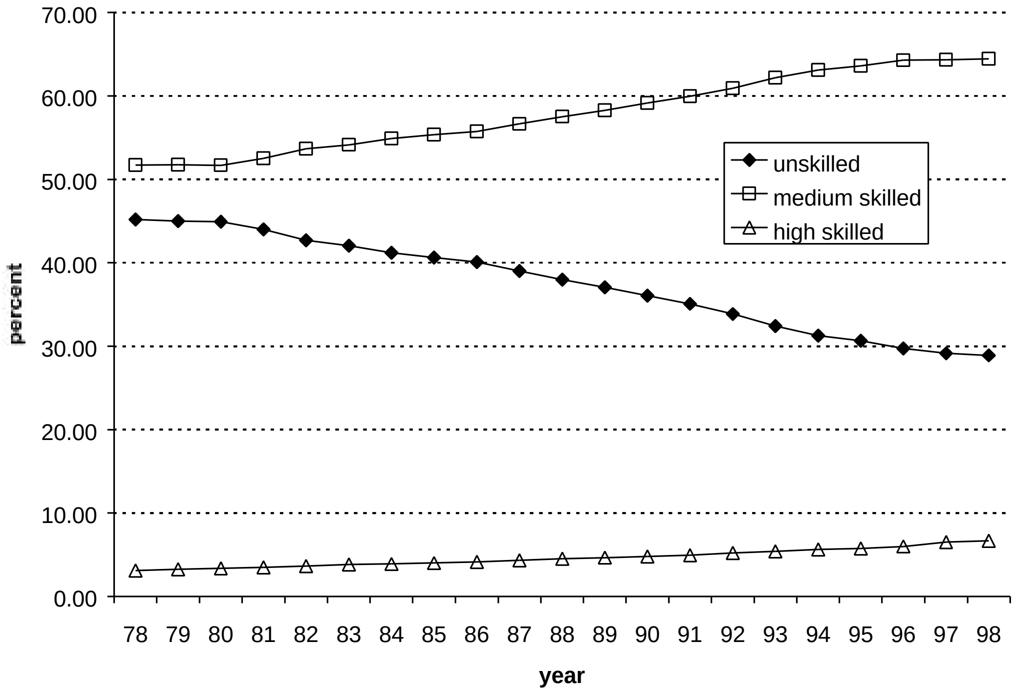
[3] Average weekly working hours for highly skilled workers are taken from the Labor Force Survey (Mikrozensus) and their definition is therefore not fully compatible with the one used for unskilled and skilled workers which are obtained from a different data source (see the appendix). However, changes in average working hours for unskilled and skilled workers as obtained from the Labor Force Survey are very similar to the corresponding changes as obtained from the statistics of the Federal Statistical Office.

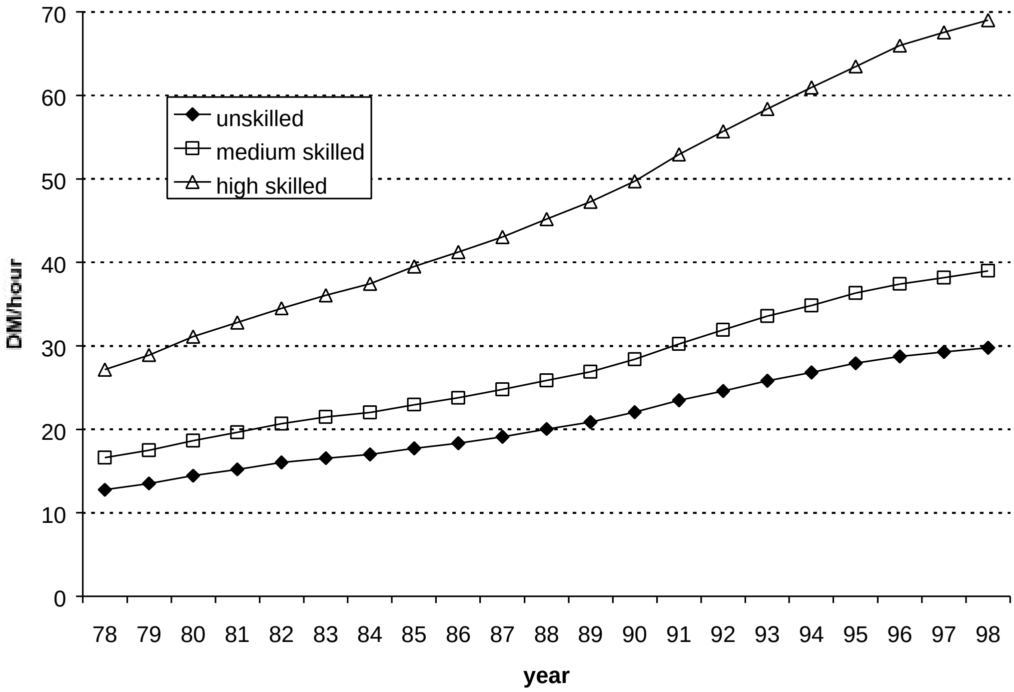
Figure 2: Development of the skill structure in West German manufacturing



Source: see data appendix.

How have wage costs for the three skill groups developed over time? To get a measure for the costs of employing labor by skill groups we use real labor costs including employers' social security contributions as described in the data appendix. As Figure 3 shows, real labor costs have increased most for highly skilled employees and least for unskilled workers. However, the difference in the increase of labor costs between unskilled and median skilled workers is relatively small and occurred mainly in the second half of the nineties.

Figure 3: Development of real labor costs by skill group in West German manufacturing



Source: see data appendix.

To sum up, the following picture emerges from the preceding discussion. Despite a relatively strong reduction of standard working hours since the late eighties, employment of unskilled workers in the manufacturing sector declined sharply. The reduction in standard working hours was accompanied by the introduction of more flexible working-time arrangements. This seems to have prevented paid weekly working hours to decline in proportion to the reduction of standard working hours. In particular, weekly paid working hours for highly skilled labor even increased in this period. Labor costs of highly skilled labor increased faster than for unskilled and medium skilled labor, but there was little change in relative wages between the latter two groups.

III. Direct and Indirect Employment Effects of Working-Time Reductions

There is a large theoretical and empirical literature on the employment effects of general working-time reductions focusing on various channels by which such reductions may be transmitted into employment changes.[4] Most of the theoretical models focus on the demand side of the labor market and implicitly assume that wages are given. Furthermore, it is typically assumed that labor is homogeneous. To start with, we will also make these assumptions and present a simple model due to Calmfors and Hoel (1988) which sheds some light on the substitution between workers and hours in firms' production decisions.

Assume that the firm's technology is given by the production function Y = F(L, K), where Y denotes output, L denotes labor and K is the capital stock. F(·) is a well-behaved concave production function. The amount of labor input is determined by the number of workers N and the amount of actual hours worked h according to the following assumed functional relationship: $L = G(h) \times N$. The function G(·), which is assumed increasing and concave in actual working hours over the relevant interval, transforms working hours into efficiency labor units, where workers' productivity depend upon the number of hours worked. This functional form assumption implies that output increases at a decreasing rate when employees work longer hours. Labor costs per worker are given by the following schedule:

$$\begin{aligned} W &= c + wh & & h \le h_s \\ & & \text{if} & \\ W &= c + wh + a\,w(h - h_s) & & h > h_s \end{aligned} \qquad (1)$$

where c denotes person-specific fixed costs, w is the regular hourly wage, a is the overtime premium, and h and h_s stand for actual and standard working hours,

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[4] For general surveys see, e.g., Hart (1987), Hamermesh (1993), Contensou and Vranceanu (2000).

respectively. Firms maximize profits at given wages, fixed costs, the fixed overtime premium and standard working hours by varying the level of employment, actual working hours and the level of output.

The employment effect of a reduction in standard hours depends on whether or not the firm has been working overtime hours before the policy change. First, assume the firm has initially been in an equilibrium where costs are minimized at given output and the firm's employees work overtime, i.e. $h^* > h_s$. In this case, marginal costs for, respectively, hiring an additional worker, MC_N, and for changing the number of actual hours of already employed workers, MC_{h^*}, are given by

$$\begin{aligned} &MC_N = c + wh + a\,w(h^* - h_s) \\ \text{and} \qquad &\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (2) \\ &MC_{h^*} = (1 + a)wN \end{aligned}$$

According to formula (2), marginal costs of working overtime do not depend on standard hours and are therefore not affected by the policy change, whereas a reduction of standard hours increases the marginal costs of hiring an additional worker. Because of the assumed properties of the production function mentioned above, this will also result in an employment decline and in an increase in the number of overtime hours. In other words, cost-minimizing firms working overtime in the initial equilibrium will substitute hours for workers to adjust to the reduction in standard hours. Furthermore, an increase in the costs of employing workers will induce firms to substitute labor by capital leading to a further decline in the demand for labor.

In case the firm worked standard hours in the initial situation, i.e. $h^* = h_s$, the effect of a reduction in standard hours on the level of employment depends on the nature of the new equilibrium. If it is still optimal for the firm to choose standard hours after the policy change, employment will increase. In case the firm chooses overtime after the reduction of standard hours, the employment effect is ambiguous. Finally, employment will not be affected by the reduction of standard hours if the firm's cost-minimizing choice of actual hours was less than the number of standard hours before the policy change and if it is still optimal to work less than standard hours after the policy change. In case the new optimum is shifted to the corner solution where $h^* = h_{s,}$, or if it even becomes optimal for the firm to choose overtime hours, employment may either rise or fall.

Depending on a firm's particular situation before and after a reduction of standard working hours, costs to the firm may increase or remain constant. If firms chose overtime hours in the initial equilibrium, a reduction in standard hours will increase labor costs. This implication of the model, however, depends on the assumption of the overtime premium remaining constant. If the premium is increasing in the number of overtime hours, marginal costs of working overtime are increasing as well and, according to equation (2), the employment effect of a reduction in working hours becomes ambiguous even if the other conditions mentioned above hold. Given leisure is a normal good, the overtime premium seems likely to be increasing in overtime hours.

So far, we have assumed that (hourly) wages for standard hours are not affected by a reduction in standard hours. The model therefore only shows the direct employment effect of a reduction in standard hours. However, given some bargaining power on the side of workers or their unions, hourly wages are likely to adjust at least partially to the reduction in standard hours in order to prevent earnings to decline proportionally. As mentioned in the previous section, wage compensation ("*Lohnausgleich*") has been an important factor in collective bargaining agreements concerning working-time reductions in Germany. Of course, unions can only bargain over *expected* real wages. Hence, to which extent wage compensation actually occurs will depend on the development of consumer prices and is thus an empirical question.

Assuming the real hourly wage depend on standard hours, i.e. $w = w(h_s)$, the change in the demand for labor of profit maximizing firms is given by

$$\frac{dN}{dh_S} = \frac{\partial N}{\partial h_S} + \frac{\partial N}{\partial w}\frac{dw}{dh_S} \tag{3}$$

where $\partial N / \partial h_s$ and $\partial N / \partial w$ denote the partial derivatives of the demand for labor with respect to standard hours and wages, respectively. That is, the first term on the right-hand side of equation (3) is derived for given wages. Multiplying both sides of equation (3) by h_s / N and expanding the last term of the resulting expression by w, we obtain the following elasticity formula:

$$e_{Nh_S} = e_{Nh_S|\bar{w}} + e_{Nw} e_{wh_S} \tag{4}$$

where e_{Nh_s} is the total elasticity of labor demand with respect to standard hours, $e_{Nh_s|\bar{w}}$ is the partial elasticity of labor demand with respect to standard hours, given the real hourly wage, e_{Nw} is the wage elasticity of labor demand and $e_{\mathrm{wh_s}}$ is the elasticity of the real hourly wage with respect to standard hours.

Whereas cost minimization implies that e_{Nw} is negative, the other two elasticities on the right-hand side of equation (4), cannot be signed unambiguously. According to the discussion above, the direct effect of a reduction in standard hours, given by the first term on the right-hand side of equation (4), may have either sign. The same holds true for the wage effects of a reduction in standard hours, i.e. the sign of $e_{\mathrm{wh_s}}$. In the framework of a wage bargaining model, Calmfors (1985) has shown that this elasticity can only be signed for very special cases and will also depend on the union members' preferences for leisure. Of course, to the extent that leisure is a normal good and the union acts in the interest of its members wages will have to adjust less than proportionally to the reduction of working hours. This will also depend on whether or not employers work their desired number of hours in the initial situation (see Freeman, 1998). In a different setting, Marimon and Zilibotti (2000) also find that the wage and hence employment effects of working-time reductions depend on individual preferences. In their model, small reductions in working-time increase equilibrium employment, whereas larger reductions in working time reduce employment.

The impact of a reduction in working hours on employment is thus theoretically ambiguous and remains an empirical question. As mentioned in the previous section, there is some evidence for partial wage compensation ("*Lohnausgleich*") in German manufacturing industries. Combined with the negative wage elasticity of the demand for labor, these results imply that the indirect employment effect of a reduction in standard hours is negative.

The analysis in this section refers to a very simplistic production structure, especially with respect to the assumption of homogeneous labor. If we consider different skill groups, the above analysis becomes much more complex and the likelihood of positive employment effects of general working-time reductions even more unlikely. Besides the possibility of substituting between the number of employees, overtime hours and capital, a reduction in working hours may lead to various demand-side effects concerning different skill groups. For example, firms may choose more capital intensive production as a response to reductions in standard hours. This is likely to affect skilled and unskilled workers differently because capital may be complementary with the former and a substitute for the latter. We take this into consideration in the following specification of our econometric model.

IV. Demand Model for Heterogeneous Labor

To estimate the demand-side effects of a reduction in standard hours we specify an econometric model of the demand for heterogeneous labor. As mentioned above, the employment effects of a policy of hours reductions are likely to differ by skill for two reasons. First, the direct effect (holding wages constant) may differ because of differences in the possibility to substitute hours for workers across skill groups. Second, the indirect effect of a general working time reduction related to wage compensation may also differ between skill groups because the wage elasticity of labor demand is likely to differ by skill groups as well. Both the direct effect of a general reduction in standard hours and the wage elasticity of labor demand by skill group can be estimated on the basis of the econometric model specified here. The estimation of the adjustment of wages to a reduction in standard hours, which together with the wage elasticity of labor demand, determines the indirect effect of a working-time reduction is discussed in section V below.

IV.1 Econometric Specification

Our econometric model of the demand for heterogeneous labor is based on the assumption of cost-minimizing firms and a flexible specification of the cost function. Given the specification of the technology of an industry, conditional labor demand functions can be derived by using some standard results on the duality between production and costs as follows (see, e.g., Varian 1992, chapter 4). Let $y^r = y^r(x^v, x^f, t)$ denote the industry production function which shows how real output y^r depends on a vector of variable inputs x^v, a factor of quasi-fixed inputs x^f , and a time index t representing the state of technology. For reasons of data availability, we have to ignore intermediate goods and use value added as the output variable in the production function. We have therefore to assume that intermediate goods are separable from the other inputs in the production function. Variable inputs are the three skill groups defined above, whereas the capital stock and standard hours are treated as quasi-fixed inputs. We will assume that variable inputs can be fully adjusted within a year whereas, due to costs of adjustment, quasi-fixed inputs are not always at their long-run optimal level. As regards standard working hours, although they are fixed for all firms covered by a collective bargaining agreement, they can be adjusted for the industry as a whole on the basis of a new collective bargaining agreement.

If the production function satisfies certain regularity conditions, and if firms minimize variable costs wx^v, where w denotes the vector of exogeneously given wages of the three skill groups, there exists a restricted cost function given by

$$C = C\left(w, y^r, x^f, t\right) \tag{5}$$

This restricted cost function is dual to the production function and contains all economically relevant information on the production technology prevailing in a particular firm or industry. To qualify as a proper restricted cost function, C must be homogeneous of degree one, non-decreasing as well as concave in w, non-decreasing in y^r, and non-increasing and convex in the quasi-fixed factors of production, x^f.

For a given output level and exogenously given factor prices the cost-minimizing demand for labor input i can be derived according to Shepards's Lemma by differentiating the restricted cost function with respect to this factor (see, e.g., Varian, 1992: 74):

$$x_i^v = \frac{\partial C(w, y^r, x^f, t)}{\partial w_i}, \text{ for all } i \in \{1, 2, 3\} \tag{6}$$

The derived factor demand equations are homogeneous of degree zero in all input prices and non-increasing in own input prices. The factor demand equations also imply certain symmetry restrictions which must be fulfilled for the cost function to provide an economically meaningful description of technology. These restrictions can be tested, and if not rejected by the data, imposed on the estimated system of factor demand equations.

To estimate the factor demand system given by equation (6), a functional form of the restricted cost function has to be specified. A popular specification of the production technology is based on the so-called generalized Leontief cost function (see, e.g., Berndt 1991, chapter 9). The great advantage of this cost function is that it puts only rather general regularity conditions on the functional form of the cost function and nevertheless implies a system of linear demand equations which is relatively easy to estimate.[5] However, we will also assume that the cost function is homothetic and homogeneous of order one in the level of output implying constant returns to scale in production.[6] This assumption has the advantage of considerably simplifying the estimation of the labor demand equations by reducing the number of parameters to be estimated because all interaction terms between output and all other variables of the cost function drop out.

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5 As the translog cost function, which is the most popular alternative econometric specification for the estimation of multi-factor demand equations, the Diewert cost function can be derived as a second-order linear approximization of an arbitrary function with continuous first and second order derivatives which is homogenous in prices, non-decreasing in input prices and non-decreasing in real output (see, e.g., Varian, 1992: 84f.).

6 A cost function is homothetic if it can be written as a positive monotonic transformation of a function that is homogeneous of degree one (see, e.g., Varian, 1992: 482). For example, the cost function $C(p,y) = y^{\alpha} \times g(p)$, where g is a function of the input prices, p, y is output and α is the elasticity parameter, is homothetic if g is homogeneous of degree one in prices and $\alpha > 0$.

Formally, the cost function used here is given by

$$C\left(w, x^{f}, y^{r}, s, t\right) = y^{r}_{s,t} \times \left[\sum_{i=1}^{n} \sum_{j=1}^{n} b_{ij} \left(w_i w_j \right)^{1/2}_{s,t} + \sum_{i=1}^{n} \sum_{j=1}^{m} g_{ij} \left(w_i x^{f}_{j} \right)_{s,t} + \sum_{i=1}^{n} d_{i1} \left(w_i \right)_{s,t} \times t + \sum_{i=1}^{n} d_{i2} \left(w_i \right)_{s,t} \times t^{2} \right] \tag{7}$$

where C = real total variable costs

y^r = real value-added

x^f_j = quasi-fixed factors (j = 1: standard weekly working hours
j = 2: real capital stock), m = 2

w_j = wage of skill group $j \in \{US, MS, HS\}$, n = 3

US = unskilled

MS = medium skilled

HS = high skilled

s = sector (s = 1, 2 ... 27)

t = time period t (t = 1978 ... 1995)

$\left.\begin{matrix} b_{ij} \\ g_{ij} \\ d_{ik} \end{matrix}\right\}$ = unknown parameters

The time trend, which is used as a proxy for technological change, enters the cost function with a linear and a quadratic term interacted with the wages of the three skill groups. Thus, the effects of (non-neutral) technological change on labor demand may differ by skill level. In the estimation of the model, the manufacturing sector is disaggregated into 27 sectors (industries) denoted by *s*. For data-related reasons (see the appendix), four of the 31 industries comprising the German manufacturing sector had to be excluded from the analysis. The available data for West Germany cover the period 1974 to 1998. However, for estimation purposes we can only use years 1978-1995 for which the number of employees and the net capital stock are available..

Applying Shephard's lemma to the above cost function, the following conditional (with respect to output and the quasi-fixed factors) demand equations for the variable labor inputs x^n_i, i=*US, MS, HS*, can be derived

$$\left(x_i^v\right)_{s,t} = \left(\frac{\partial C(\cdot)}{\partial w_i}\right)_{s,t} = y_{s,t}^r \times \left[\sum_{j=1}^{n} b_{ij}\left(w_j / w_i\right)_{s,t}^{1/2} + \sum_{j=1}^{m} g_{ij}\left(x_j^f\right)_{s,t} + d_{i1} \times t + d_{i2} \times t^2\right] \tag{8}$$

Dividing these factor demands by real value added yields a system of input-output coefficients of the following form:

$$\left(p_i\right)_{s,t} \equiv \left(\frac{x_i^v}{y^r}\right)_{s,t} = \sum_{j=1}^{n} b_{ij}\left(w_j / w_i\right)_{s,t}^{1/2} + \sum_{j=1}^{m} g_{ij}\left(x_j^f\right)_{s,t} + d_{i1} \times t + d_{i2} \times t^2 \tag{9}$$

The specification of the labor demand equations in terms of input coefficients avoids multicollinearity problems between value added and the capital stock, which typically plague the estimation of labor demand equations including both separately as explanatory variables.

There are 486 ($s \times T = 27 \times 18$) observations for each of these three equations. In principle, consistent parameter estimates could be obtained by estimating each equation separately. However, there are cross-equation restrictions implied by the homogeneity and symmetry restrictions mentioned above (see, e.g., Berndt 1991: 461ff.). For the following reasons, these restrictions should be imposed in the estimation. On the one hand, estimated parameters in the system of equations have to fulfill these restrictions if they are to be interpreted as structural parameters of the assumed cost function. On the other hand, the imposition of these restrictions may considerably increase the efficiency of estimation. These restrictions can be imposed by estimating the equations in (9) by a system estimator (see, e.g., Greene 1997, chapter 17).

On the basis of the estimated coefficients from this system of demand equations, own-price and cross-price elasticities for the various skill groups can be calculated according to the following formulas (where a hat „^“ above a parameter denotes an estimate):

own-price elasticities

$$\left(\frac{\partial x_i}{\partial w_i}\times\frac{w_i}{x_i}\right)_{s,t} \equiv \left(e_{ii}\right)_{s,t} = -\left(\frac{\sum_{j=1,\, j\neq i}^{3}\hat{b}_{ij}\left(w_i / w_j\right)^{-1/2}}{2\hat{p}_i}\right)_{s,t}, \qquad (10)$$

$$i, j = US, MS, HS$$

cross-price elasticities

$$\left(\frac{\partial x_j}{\partial w_i}\times\frac{w_i}{x_j}\right)_{s,t} \equiv \left(e_{ij}\right)_{s,t} = \left(\frac{\hat{b}_{ij}\left(w_i / w_j\right)^{-1/2}}{2\hat{p}_i}\right)_{s,t}, \ \forall j\neq i, \ \ i, j = US, MS, HS \quad (11)$$

As formulas (10) and (11) show, own-price and cross-wage elasticities depend on the structural parameters of the cost function, on relative wages and the estimated input-output coefficients for the various skill groups as well as on the industrial sector *s* and on the time index *t*. Hence, these elasticities vary both between and within industries.

IV.2 Estimation Results

In a first step, the system of labor demand equations in (9) was estimated in levels of the dependent and independent variables. To control for fixed unobserved industry effects in the estimation of the system of equations (9),we included 21 industry dummy variables.[7] The system of labor demand equations was estimated by the method of Seemingly Unrelated Regression (SUR) with all homogeneity and symmetry restrictions imposed. As shown by the very low value of the Durbin-Watson (DW) test statistic, this static specification of the labor demand system generated a very high degree of serial correlation in all equations. Assuming a first-order autoregressive process (*AR*(1)-process), we tried to correct for autocorrelation (see, e.g., Berndt 1991: 476ff). This procedure yielded *AR*(1)-coefficients close to one in each of the three equations. Given this extremely high autocorrelation in the levels equations, it seems more appropriate to estimate the equation system (9) in first differences. Thereby the industry dummies drop out and the system of estimating equations simplifies to:

$$\left(\Delta p_i\right)_{s,t} = d_{i1} + d_{i2} \times t + \sum_{j=1}^{n} b_{ij} \Delta\left(w_j / w_i\right)_{s,t}^{1/2} + \sum_{j=1}^{m} g_{ij}\left(\Delta x_j^f\right)_{s,t} + u_{i,s,t} \qquad (12)$$

where $u_{i.s,t}$ is an additive error term with the following assumed distribution:

(13)

$$E\left(u_{i,s,t}\right)=0,\ \ E\left(u_{i,s,t},\Delta(w_j / w_i)_{s,t}\right)=0,\ \ E\left(u_{i,s,t},\left(\Delta x_j^f\right)_{s,t}\right)=0,\ \ \forall i,j,s,t$$

$$E\left(u_{i',s,t},u_{i.s,t}\right)=0,\ \forall i \neq i',\ \ E\left(u_{i.s,t},u_{i.s',t}\right)=0,\ \ \forall s \neq s',\ \ E\left(u_{i.s,t},u_{i.s,t'}\right)=0, \forall t \neq t'$$

Estimation results for the system of equations in (12) with all homogeneity and symmetry restrictions imposed are reported in Table 1. In *specification* I, the estimated coefficients b_{13} and b_{23}, which refer to relative wages of unskilled to high skilled and of medium skilled to high skilled labor, respectively, turned out to be statistically insignificant. Estimation results for *specification* II with these insignificant coefficients restricted to zero show that estimated coefficients of the other variables differ little between the two specifications.

At least for the relationship between the unskilled and high skilled labor the result that these groups are not substitutes in production seems plausible. According to our estimates this also holds between medium skilled and high skilled labor. In the following, own-price and cross-price elasticities are therefore only reported for *specification* II.

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[7] For $i = j$, the first term on the right-hand side in each of the equations in (9) collapses to a constant. In the estimation we assume that these may differ between industries and may be treated as fixed industry effects.

Table 1: Estimation results for the labor demand system (12)– SUR-estimation

	specification I		*specification* II	
	coeff.	t-value	coeff.	t-value
d_{11}	–0.138	–3.89	–0.138	–3.89
d_{12}	–0.007	–1.76	–0.007	–1.76
b_{12}	1.877	1.67	1.838	1.72
b_{13}	0.025	0.09	–	–
g_{11}	0.026	0.48	0.026	0.49
g_{12}	0.033	2.31	0.033	2.31
d_{21}	0.054	1.12	0.053	1.10
d_{22}	–0.005	–1.03	–0.005	–1.01
b_{23}	–0.179	–0.67	–	–
g_{21}	0.090	1.22	0.092	1.24
g_{22}	0.046	2.38	0.046	2.38
d_{31}	0.007	2.12	0.008	2.46
d_{32}	0.000	1.12	0.000	1.08
g_{31}	0.006	1.06	0.005	1.04
g_{32}	0.005	3.50	0.005	3.70
Total number of observations	1.296		1.296	
US-equation				
Number of observations	432		432	
R^2	0.98		0.98	
DW	1.76		1.76	
MS-equation				
Number of observations	432		432	
R^2	0.92		0.91	
DW	2.26		2.26	
HS-equation				
Number of observations	432		432	
R^2	0.98		0.98	
DW	2.20		2.19	

Notes: estimation period 1980 – 1995, West German manufacturing sector except oil refining, tobacco, aircraft, computers and office machinery (see the data appendix); R^2 refer to the levels of the variables.

Estimated coefficients on standard hours (g_{11}, g_{21}, g_{31}) are positive but insignificant (at the 10% level) in all three equations. This implies that changes in standard hours have no significant effects on the demand for the various skill groups. A positive coefficient would imply that the demand for the respective skill group, given relative wages, output and the capital stock, is reduced by a reduction in standard hours. As discussed in section 2 above, such an effect is theoretically possible but empirically not very likely.

The indirect effect of a reduction in standard hours also depends on the wage elasticity of labor demand. In Table 2 estimated own-wage elasticities of unskilled and (medium) skilled workers are reported. As mentioned above, the own-wage elasticity of high skilled labor is restricted to zero This also implies that the cross-wage elasticities between unskilled and skilled labor are (in absolute value) identical to the respective own-wage elasticities, see equations (11) and (12).

The average own-wage elasticity of unskilled workers in the whole manufacturing sector is –0.23.[8] However, there is substantial variation in estimated elasticities between industries: for example, in the chemical industry this elasticity is –0.43, whereas it is only –0.10 in the ceramic industry. As shown by the standard deviation of estimated elasticities within the observation period, there is also substantial time variation of elasticities for unskilled workers within industries. For example, the standard deviation of this elasticity is 0.13, but only 0.01 in the ceramics industry. These differences are presumably related to differences in the response of labor demand to the business cycle at the industry level.

As expected, estimated own-wage elasticities for skilled workers are markedly lower. On average, the wage elasticity of the demand for skilled workers is just –0.12. Compared to the estimates for unskilled workers,

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[8] This is the simple mean calculated without weighing the elasticities by sector size.

estimated elasticities for skilled workers also vary little between industries and over time.

There are few other studies which estimate the demand for heterogeneous labor in West German manufacturing. On the basis of a different specification of the cost function but a similar data set, Falk and Koebel (1999) also obtain comparable estimates of own-price elasticities of unskilled and skilled labor. Furthermore, Falk and Koebel (1999) also estimated insignificant own-wage elasticities for highly skilled labor. Qualitatively, our elasticity estimates are compatible with a large international literature, surveyed in Hamermesh (1993), which shows that there is a clear hierarchy of own-wage elasticities of the demand for heterogenous labor with the wage elasticity for unskilled labor being the highest and for highly skilled labor the lowest.

Table 2: Estimated own-wage elasticities in West German manufacturing industries

Industry	Unskilled		Medium skilled	
	$\bar{e}$	σ	$\bar{e}$	σ
Chemical Products	–0.43	0.13	–0.13	0.01
Sythetic materials	–0.18	0.03	–0.12	0.01
Rubber products	–0.18	0.03	–0.14	0.01
Stone and clay	–0.32	0.06	–0.15	0.01
Ceramics	–0.10	0.01	–0.11	0.01
Glass	–0.19	0.05	–0.13	0.01
Iron	–0.20	0.06	–0.11	0.01
Nonferrous metals	–0.21	0.07	–0.12	0.02
Foundries	–0.17	0.01	–0.14	0.01
Fabricated metals	–0.21	0.04	–0.13	0.01
Steel, light metals	–0.37	0.06	–0.09	0.01
Machinery	–0.35	0.05	–0.09	0.01
Vehicles and repairs	–0.27	0.05	–0.11	0.01
Shipbuilding	–0.35	0.11	–0.07	0.01
Electrical appliances and repair	–0.25	0.07	–0.12	0.01
Precision and optical instruments	–0.24	0.05	–0.09	0.00
Metal products	–0.18	0.03	–0.11	0.00
Musical instruments, toys, jewelry	–0.26	0.05	–0.14	0.01
Woodwork	–0.16	0.05	–0.14	0.02
Woodprocessing	–0.20	0.02	–0.10	0.01
Fibres, paper production	–0.24	0.06	–0.15	0.01
Paper processing	–0.20	0.04	–0.14	0.01
Printing and publishing	–0.33	0.04	–0.09	0.00
Leather	–0.10	0.02	–0.10	0.01
Textiles	–0.12	0.02	–0.11	0.00
Clothing	–0.13	0.03	–0.08	0.01
Food, beverages	–0.27	0.02	–0.12	0.01
Average manufacturing	–0.23	0.09	–0.12	0.02

Notes: $\bar{e}$ = mean of estimated elasticity within a particular industry, σ = standard deviation of estimated elasticities within the observation period. The manufacturing sector does not include oil refining, the tabbaco industry and aircraft manufacturing here.

Source: Estimation results in Table 1.

V. Wage Adjustments to Reductions in Standard Hours

According to the elasticity formula (4) derived above, we require an estimate for the elasticity of wages with respect to a change in standard hours in order to decompose the total employment effect of a working-time reduction. In this section, we estimate this elasticity for the three skill groups on the basis of reduced-form wage equations. Estimation is based on the following system of equations:

(14)

$$\Delta \log(w_{i,s,t}) = \alpha_{0,i,s} + \beta_{i,1}\Delta h^{s}_{i,s,t} + \beta_{i,2}\Delta h^{s}_{i,s,t-1} + \gamma_{i,1}\Delta \log(q_{i,s,t}) + \gamma_{i,2}\log(U_t) + u_{i,s,t}$$

where $q_{i,s,t} \equiv y^{r}_{s,t} / x^{v}_{i,s,t}$ is the level of productivity of skill group i in industry s in period t, U is the average level of unemployment, $\alpha_{0,i,s}$ is an industry fixed effect and u is an iid error term assumed uncorrelated with both $\alpha_{0,i,s}$ and the explanatory variables in equations (14); the other symbols have already been defined above.

The lagged hours term in (14) accounts for the sluggish adjustment of real wages to changes in standard hours. Whereas the effect of a change in standard hours on the employment of a particular skill group within a year, i.e. the short-term effect, is given by the respective β_1-coefficient, the long-term effect is given by the sum of β_1 and β_2. Apart from the inclusion of the contemporaneous and the one-period lagged change in standard hours, the specification in (14) is equivalent to the standard specification of a long-term Phillips equation with the restriction that the coefficient on the price term equals one, i.e. the growth rate or real wages depends positively on the growth rate of labor productivity and negatively on the aggregate (log) unemployment rate.

SUR estimation results of the system of equations (14) are reported in Table 3. According to our estimates, a reduction of standard hours has a significant positive effect on the real wage for each of the three skill groups .

The sum of the estimated b_1 and the b_2 coefficients, i.e. the long-term elasticity of real wages with respect to standard hours, is –0.017 for unskilled and medium skilled workers and –0.022 for high skilled employees. The size of the latter coefficient, for example, implies that for high skilled workers a general working-time reduction by one hour would result in an increase of the real hourly wage by about 2%. In terms of elasticities our estimates yield values of –0.66 for unskilled and medium skilled workers, and –0.85 for high skilled employees.[9]

Table 3: Estimation results for the wage adjustment equation by skill group

	US		MS		HS	
Variable	coeff.	t-value	coeff.	t-value	coeff.	t-value
constant	0.050	3.03	0.042	2.59	0.042	2.63
Δh^s	–0.010	–1.90	–0.010	–1.87	–0.017	–3.37
Δh^s_{-1}	–0.007	–1.27	–0.007	–1.31	–0.005	–9.42
$\Delta \log(q)$	0.285	9.02	0.279	8.89	0.286	9.42
$\log(U)$	–0.019	–2.34	–0.015	–1.89	–0.013	–1.72
# observations	506		506		506	
DW	1.82		1.83		1.87	
R^2	0.96		0.96		0.96	
χ^2 (*p*-value)	6.16 (0.013)		6.18 (0.012)		11.16 (0.001)	

Notes: Estimation period is 1979-1995; estimation is by Seemingly Unrelated Regression (SUR); sector dummies and a constant term are included in each equation; the χ^2 test refers to a Wald test of the null hypothesis that the coefficients of Δh^s and Δh^s_{-1} are jointly zero, the values given in parentheses are the respective p-values for this hypothesis.

9 Given that the average number of standard hours in manufacturing was 38.8 in the observation period, a reduction of standard hours by one hour per week means a reduction in working-time by 2.58%. The coefficient of 0.022 estimated for the high skilled, for example, thus implies an elasticity of 0.85 (=2.2/2.58).

In a recent study, Hunt (1999) reports estimated average wage elasticities with respect to standard hours between 2 and 2.4%, depending on the particular sector analyzed but without distinguishing between skill groups. Franz and Smolny (1994) also report negative effects of a general reduction in working time on wages, also without distinguishing between skill groups. Their estimated effects vary across industry but, on average, are of similar size as the ones obtained here.

VI. Total Employment Effects of Working-Time Reductions

On the basis of the estimated elasticities obtained in the previous two sections, we can now calculate the total employment effect of a general working-time reduction according to formula (4) in section III. According to our estimates, for given real hourly wages the direct employment effect of a working-time reduction, $e_{Nh_s|\bar{w}}$, is insignificant for all three skill groups. However, there is an indirect effect for workers for whom both the wage elasticity of labor demand, e_{Nw}, and the elasticity of the wage with respect to standard hours, e_{wh_s}, are significantly different from zero. This indirect effect is zero for highly skilled workers, because for them the estimated wage elasticity of labor demand is insignificant. Since for the other two skill groups both elasticities are negative and significantly different from zero, the indirect effect is positive and significant. Thus, a reduction in standard hours reduces employment of unskilled and skilled workers. These effects are summarized in the following table.

Table 4: Employment effects of a working-time reduction by one hour in manufacturing

Skill group	Employees (in 1000)	Employment loss in %	in persons
US	1,707	0.43	7,336
MS	4,376	0.19	8,271
HS	443	0	0
Sum	6,526		15,606

Notes: There is no direct employment effect because the estimated elasticity of labor demand with respect to standard hours is insignificant for all skill groups. Indirect employment effects are calculated from wage estimated average elasticities of labor demand (e_{Nw}) for unskilled and skilled workers within each industry as given in Table 2. Data on the level of employment by skill group refer to the year 1998 and are from the Federal Labor Office.

According to our estimates, a reduction in standard working-time by one hour would result in an employment decline in West German manufacturing by about 15,600 jobs. This number corresponds to roughly 0.25% of all jobs in the manufacturing sector. Proportionally, the employment decline among unskilled workers is stronger than among skilled workers because of the higher wage elasticity of labor demand estimated for unskilled workers. Given that the demand for highly skilled workers is completely inelastic, employment for this group is not affected by a reduction in standard hours despite the relatively strong wage effect of a reduction in standard hours estimated for this group.

These calculations are based on elasticities estimated from data for the period 1978 to 1995 and on the assumption that both the underlying technological relationships and the wage bargaining system remains unchanged in the future, in particular following a working-time reduction. This assumption is the less likely to hold the more standard working time is reduced. The metal workers union (IG Metall) has been suggesting a reduction of standard working hours from currently 35 in this sector to 32 hours per week. Given that our estimated elasticities can also be applied to this relatively large change, we would expect that such a policy, if applied to the whole manufacturing sector, would reduce employment by about 50 thousand people. If only applied to the metal manufacturing and electrical engineering industry, which is covered by IG Metall, the expected employment loss would be about 30 thousand people, among them about 10 thousand unskilled and 20 thousand skilled workers.

VII. Summary and Conclusion

There has been a strong long-term decline in standard working hours in West German manufacturing, especially in the important metal manufacturing and electrical engineering industry where standard working time has been reduced to 35 hours. Nevertheless, a further working-time reduction to 32 hours has been proposed by the metalworkers union (IG Metall) as a means to reduce the persistently high level of unemployment prevailing in Germany.

However, the effects of general working-time reductions on unemployment and employment are theoretically ambiguous. We have shown that the net employment effect of a working-time reduction depends on the distribution of firms across the various working-time regimes before and after the policy change and that the net effect is ambiguous even in the case of constant real wages. Taking into account wage increases due to the so-called wage compensation rule ("*Lohnausgleich*"), which the unions typically try to include in collective bargaining agreements in order to prevent weekly or monthly earnings to decline in proportion to the reduction in standard working hours, render positive employment effects of general working-time reductions even more unlikely. It thus comes as no surprise that most previous empirical studies find no or even negative employment effects of general working-time reduction in Germany.

In this study, we have extended previous empirical research on the employment effects of working-time reductions in two important ways. First, we estimate both a structural labor demand model and a system of reduced-form wage adjustment equations. This provides a way to decompose the net employment effect of a reduction in standard hours into a direct effect, holding wages constant, and an indirect effect also allowing for adjustments of hourly wages to a reduction in standard hours. Second, in contrast to most previous research we distinguish between various skill groups, i.e. we estimate a labor demand model for heterogeneous labor and also allow the degree of wage compensation to differ by skill group. Given that both the direct employment effect of a reduction in standard hours and the wage elasticity of labor demand are likely to differ between unskilled, medium skilled and highly skilled workers, the employment effects of general working-time reductions by skill group will differ as well.

For none of the three skill groups we could find a significant *direct* employment effect of a reduction in standard hours. That is, the positive and negative direct employment effects of such a policy, discussed in the theoretical section of the paper, seem to cancel each other. However, there are significant negative *indirect* employment effects, at least for unskilled and medium skilled workers. These negative effects were obtained from the estimated wage elasticities of labor demand by skill group and the wage elasticity with respect to a change in standard hours estimated from the system of wage adjustment equations. The average elasticities for the manufacturing sector as a whole are estimated to be –0.25 and –0.11 for unskilled and skilled workers, respectively. For highly skilled employees the wage elasticity was estimated to be insignificant, implying that there is no significant indirect employment effect for this group. On the other hand, our estimation results show that the adjustment of real wages to a reduction in standard working hours is quite similar across the three groups: a reduction by one hour increases real wages of unskilled and skilled workers by 1.7%, compared to 2.2% for highly skilled labor.

Taken together, these elasticity estimates imply that a working-time reduction will have negative net employment effects for unskilled and medium skilled workers, and that this effect will be stronger for unskilled workers. A general reduction of standard working time by one hour will lead to a reduction of unskilled workers by about 0.4% and by 0.24% for skilled workers. In absolute numbers, this would imply an employment reduction in the West German manufacturing sector of about 15,000 jobs. Only highly skilled employees would unambiguously gain by such a policy because their wages would increase significantly without a significant reduction in the labor demand for this group. Among unskilled and medium skilled labor only those workers lucky enough to keep or get a job will profit from the wage increase related to the unions' wage compensation policy. This policy would thus strengthen the position of insiders at the costs of outsiders in the labor market. In view of these results and the high unemployment rate of unskilled workers we conclude that a general working-time reduction is not an effective tool of employment policy.

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Data Appendix

We combine data from various statistics of the Federal Statistical Office (Statistisches Bundesamt) and from the Federal Labor Office (Bundesanstalt für Arbeit) as summarized in Table 5 below. All data refer to the West German manufacturing which comprises 31 industries at the two-digit level. The oil refining, the tabbaco industry and aircraft manufacturing (Luftfahrzeugbau) had to be excluded because value-added is not an adequate output measure due to the very high level of commodity taxation and subsidies (for aircraft) in these industries. The computer and office machinery industry had to be excluded due to an obvious (but unexplainable) break in the data series[10] The data cover the period 1978 to 1998. Since data on the capital stock are only available until 1995, the estimation period is 1978 to 1995.

Table 5: Employment effects of a working-time reduction by one hour in manufacturing

Variable	Statistics
Standard hours contained in collective bargaining agreements	Amtliche Statistik der Tariflöhne und Gehälter (Series Number. 16 R 4.3), German Statistical Office
Average number of paid weekly hours/overtime hours	Verdiensterhebung für das Produzierende Gewerbe (Series Number. 16 2.1 – 2.3, German Statistical Office)
Average paid hours/overtime hours for white-collar workers	Mikrozensus (Labor Force Survey), German Statistical Office
Employment by skill group	Beschäftigtenstatitisik der Bundesanstalt für Arbeit (Federal Labor Office)
Real value-added, product price deflator, real capital stock	National Accounts (2-digit level); German Statistical Office

Employment by skill group

The number of dependently employed persons by skill level and industry is based on the employment statistics ("Beschäftigtenstatistik") of the Federal Labor Office. This data source provides data on all dependently employed people covered by the social security system. In the manufacturing sector this means almost complete coverage of workers. The skill groups

[10] According to data supplied by the Federal Labor Office employment of all three skill groups declined by about 33% between 1992 and 1993, whereas real value-added only decreased by 13%.

are as defined in section II in the text. The industry classification at the two-digit level in the IABS can be matched to the one in the disaggregated National Accounts (see below).

Hours

Standard hours contained in collective bargaining agreements are contained in the official statistics on contract wages of blue- and white-collar workers. The average number of paid weekly hours as well as overtime hours are taken from the official earnings statistics for blue- and white-collar workers in the manufacturing sector. Paid hours include effectively worked hours plus paid non-working time due to sickness or holidays. Overtime hours are defined as working hours exceeding average hours worked by the firm which are not compensated by time-off in some other period, irrespective of whether or not a premium is paid for overtime. Since these statistics do not refer to white-collar workers, data on the number of average paid weekly hours and overtime hours for highly skilled workers (graduates) were obtained for various years from the Labor Force Survey.[11]

Earnings and labor costs by skill group

The earnings statistics of the Federal Statistical Office used here distinguishes skill level by “performance groups” (*Leistungsgruppen*).[12] As workers we consider all persons in dependent employment who are subject to the insurance obligation in the workers' pension scheme . We do not include part-time workers and trainees. There are three skill groups for blue-collar workers and four such groups for white-collar workers. We use two of the former and one of the latter groups to represent the skill structure defined above. For blue-collar workers, group I refers to employees performing jobs which require a completed apprenticeship training of at least three years, whereas group III refers to workers performing unskilled jobs. White-collar group II represents highly skilled workers who have a certain responsibility concerning the management of other workers and/or administrative or technical tasks. In our opinion, these categories yield a satisfactory matching of performance groups as contained in the earnings statistics and skill groups as defined above.

For blue-collar workers the gross hourly wage is available form the earnings statistics of the Federal Statistical Office. It includes all payments on a regular basis. Usually, this

[11] Data from the Labor Force Survey were available to us for the years 1976, 1980, 1982, 1985, 1987, 1989, 1991, 1993, 1995 and 1996. We thank ZUMA Mannheim for providing us with the calculations for the years 1976 to 1989.

[12] We use this data base for earnings by skill group rather than the I_ABS because the median earnings are censored in the latter data base as mentioned above.

consists of the collectively bargained or individually agreed wage including regularly paid fringe benefits. These payments do not include employers' social security contributions and irregularly paid fringe benefits, in particular holiday and Christmas gratification. For white-collar workers, gross monthly earnings also include fringe benefits paid on a regular basis, but excludes irregular payments. Hourly gross wages were obtained by normalizing by average weekly hours.

Labor costs per hour were obtained by adding employers' social security contributions obtained from the National Accounts which contain both the sum of gross earnings (wages and salaries) which include employees' contributions to social security and gross income from dependent employment which also includes employers' social security contributions. The ratio of these two series, which are available for each industry, gives employers' social security contributions as a share of gross earnings. Labor costs per hour were obtained by adding this percentage to the hourly gross wage. To take into account the amount of fringe benefits typically paid on an irregular basis, labor costs per hour were multiplied by the factor 13/12. Real labor costs were obtained by normalizing nominal costs by an industry's product price deflator which was derived from the disaggregated National Accounts.

Real value-added, real capital stock

In addition to an industry's product price deflator; the disaggregated National Accounts provide data on real value-added and the real capital stock at the two-digit level. Gross value added is calculated by subtracting the value of intermediate inputs from gross product. The net capital stock includes the stock of machinery and buildings adjusted for depriciation. Gross value added and the net capital stock are measured at 1991 prices.