Technical Change, Labor Market Institutions and Wage Inequality: A Comparison of the U.S. and Europe*

by

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— Preliminary Version —

Abstract

This paper extends existing studies on the relationship between technological progress and educational wage inequality. In particular, the introduction of different measures of labor market institutions into the regression equation relativises the assumption of a unicausal explanation of wage inequality by skill-biased technological change.
Based on a Romer - type endogenous growth model, we examine the assumption of skill - biased technological change. Nevertheless, beside supply and demand effects, the positive time trend of educational wage inequality is not explained completely. By introducing labor market institutions we are able to give further insights in the factors determining the short and long-run influences of educational wage inequality for male and female workers as well as on an aggregate level.
Furthermore, the empirical part of the present paper compares the forces of wage inequality with time series data for the U.S. and Europe.

JEL - Classification: J24, J31, O30

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1 Introduction

During the last two decades, the wage differential between different educational groups has increased in many OECD countries. In particular, the U.S. and the U.K. experienced the highest growth in educational wage inequality. Whereas in Germany, Italy and France even slight increasing but also decreasing patterns of the wage differential were observable (See, for instance, Gottschalk and Smeeding (1997) or Katz and Autor (1999)). In order to get further insights why wage inequality behaves differently across industrialized countries, we examine, amongst others, an argument of Acemoglu (2002b) which states that lower inequality in Europe is explained by a stronger increase of higher educated people ('supply and demand effects') and also because of rigid labor market institutions which drive firms to invest in low skill complementary technologies.

Recently, two main branches of literature which study the sources of wage inequality exist. The first branch concentrates on supply and demand factors, in particular, on so called skill-biased technical change. It is generally accepted, that the growing demand for skilled workers, in particular, since the middle of the 1980's, has increased the wage differential.[1] The second branch of literature concentrates on the influence of labor market institutions as another source of wage inequality. There, the impact of trade unions, collective bargaining systems and minimum wages are identified as important institutions influencing the distribution of wages. Empirically this approach is examined by DiNardo et al. (1996), Fortin and Lemieux (1997) or Blau and Kahn (1999). Whereas the interplay between technological change and labor market institutions is studied theoretically by Acemoglu et al. (2001).[2]

However, the studies cited above either concentrate on supply and demand effects or on institutional aspects in order to explain the evolution of wage inequality. Complementary, we try to study both, the influence of skill-biased technical change and changes in labor market institutions in order to get further insights in cross country differences of wage inequality. In particular, we examine how changes and differences in labor market institutions account for the diverse pattern of inequality.

This study is based on a paper by Greiner et al. (2003), where the role of skill biased technological change is discussed in the context of a Romer type endoge-

[1]See, for example, Bound and Johnson (1992) or Aghion et al. (1999) for detailed surveys of skill-biased technical change as a source of wage inequality.

[2]The importance of institutional factors is also pointed out by, for example, Blau and Kahn (1996), Gottschalk and Smeeding (1997), Acemoglu (2002a,b) or Aghion (2002).

nous growth model, and, furthermore, where the basic equation which describes the evolution of the wage premium is estimated with time series data for the U.S. and Germany. Here, we apply the results of Greiner et al. (2003) to control for supply and demand effects. As in our previous paper, we want to apply time series data rather than panel or cross sectional data.[3] In the present study, we apply the Kalman Filter to estimate the constant term of the regression equation as a time varying parameter. This approach enables us to examine the influence of changes of labor market institutions on the evolution of wage inequality. In particular, we want to point out the attempt of this study is not to show that labor market institutions have influences on the wage setting (it is obvious that they do), but the question is how might changes in these institutions have influenced wages and wage inequality. The institutional changes are quantified by the 'time series' of labor market institutions published by Nickell et al. (2003).

Complementary to our previous study on wage inequality, we extend the empirical analysis by distinguishing between male and female wages. This is due to the evidences, for example reported by Gosling and Lemieux (2001), that changes in labor market institutions have different effects on male and female wages and also affect the pattern of wage inequality differently.[4]

The remainder of this paper is organized as follows. In section two we present a collection of stylized facts on wage inequality and labor market institutions. The third section outlines the basic structure of the underlying endogenous growth model by Greiner et al. (2003). In section four we analyze basic determinants of wage inequality. In the fifth section we examine the influences of labor market institutions on the trend of wage inequality. Section six concludes.

2 Basic Facts on Wage Inequality and Labor Market Institutions

Empirical Facts on Labor Market institutions

Labor Markets are characterized by various kinds of institutions. In general, these institutions determine the behavior of key outcomes of this particular market, for

[3]See, for instance, Card (1996), DiNardo et al. (1996) or Lee (1999) for approaches who apply panel regressions to investigate the impact of labor market institutions on the distribution of wages.

[4]See, for example, Blau and Kahn (2001) or Gosling and Lemieux (2001) who study the international differences in the gender pay gap and the impact of changes in labor market institutions on U.S. and U.K. earnings inequality.

example the transition rates in and out of employment, the evolution of long term unemployment, and, in particular, the wage setting procedures.[5]

According to Nickell et al. (2003) labor market institutions are treated in general as: unemployment benefits, trade unions (union density), employment protection, labor taxes and all kinds of wage inflexibility. As, amongst others, shown by Blau and Kahn (2001) an important factor determining the wage distribution is the existence of minimum wages, too.[6] Although the existence of minimum wages is very important, there is a lack of time series data of this variable.

In this study, we concentrate particularly on two main indicators: union density and benefit replacement rates.[7] The impact of trade union power is examined at a higher extend, because trade unions have an enormous impact on the U.S. and German wage setting, and, in both countries they are structured completely different.

Before studying the impact of labor market institutions on the German and U.S. wage spread in detail, we examine the evolution of these indicators for four main OECD countries. Figures 1 and 2 show the evolution of union density and benefit replacement rates for France, Germany, U.K. and U.S..

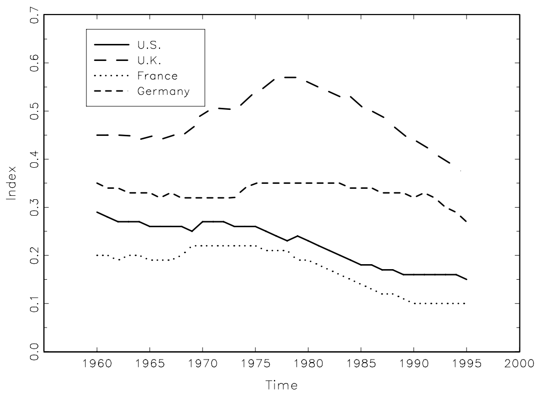

Figure 1: Trade Union density
Source: Nickell et al. (2003)

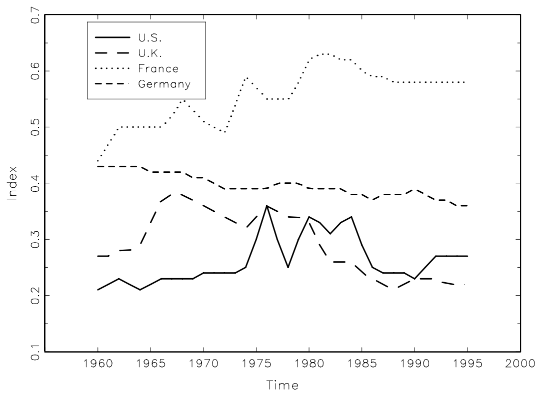

Figure 2: Benefit Replacement Rates
Source: Nickell et al. (2003)

[5]See, for instance, Blanchard and Wolfers (2000) for a study on the role of institutions as an explanation of the rise in European Unemployment.

[6]See Dolado et al. (1996), Fortin and Lemieux (1997), Blau and Kahn (1999) and Lee (1999) or Gosling and Lemieux (2001) for detailed discussions of the impact of minimum wages in explaining the wage distribution.

[7]According to Nickell et al. (2003) trade union density represents the ratio of total reported union members to employees and benefit replacement rates are constructed as benefit entitlements before tax as a percentage of previous earnings before tax. Cf. Nickell et al. (2003): 427.

Figure 1 shows that in the same time interval, union density has decreased over time. This holds, in particular, for the U.S. and the U.K.. In France it has decreased since the middle of the 1970's whereas in Germany, it remained relatively constant over time.

An additional indicator which is strongly related to trade union density is given by the rate of employees covered by collective bargaining systems.

Table 1: Collective Bargaining Coverage and Minimum Wages

	Bargaining Coverage			
Year	U.S.	U.K.	Germany	France
1980	26 %	70 %	91 %	85 %
1995	18 %	47 %	92 %	95 %
	Minimum Wages[a]			
	0.39 (1993)	0.40 (1993)	0.55 (1991)	0.50 (1993)

Source: Bierhanzl and Gwartney (1998), Dolado et al. (1996)

[a]Minimum wages as a fraction of average earnings (Dolado et al. (1996): 321).

Although the union density has decreased over time for each country (see figure 1) the number of employees covered by collective wage bargaining behaves differently. In particular, for Germany and France we observe the highest level of bargaining coverage and also an increase in this measure. On the other hand, for the U.S. and U.K. this rate has decreased. Concerning the differences how minimum wages are determined, e.g. by law or in collective agreements, table 1 shows that the highest minimum wages are set in Germany and France, too.

A slightly different pattern is shown for benefit replacement rates (figure 2). This index decreased significantly in the U.K. and slightly in Germany. For the U.S. the benefit replacement rates have been increased during the recessions at the end of the 1970's and the early 1980's. After a decrease at middle of the 1980's they increased slightly during the beginning 1990's. In the French case, benefit replacement rates increased steadily until the middle of the 1980's and remained at a constant high level.

As already shown in figure 2 benefit replacement rates and, furthermore, payments of the social security system are important factors of the wage setting, too.

In particular, such payments determine reservation wages. Table 2 compares the unemployment insurance payments of the above mentioned OECD countries.

Table 2: Unemployment Benefits

	Unemployment Insurance			*Unemployment Assistance*	
	Payment	max. Benefit[a] in USD (yearly)	Duration (months)	max. Benefit in USD. (yearly)	Duration (months)
Germany	60 %	30.890	12	27.286	no limit
France	75 %	60.184	60	4.479	no limit
U.K.	Flat Rate	4.084	6	4.084	no limit
U.S.	50 %	15.600	6	–	–

Source: OECD (2002)

[a]Payments in per cent of gross earnings, except Germany (net earnings). 1999 purchasing power parity unites are used by the OECD to calculate the USD values.

Consistent with figure 2, table 2 shows that the most generous social security payments are paid in European OECD countries. In particular, France grants the highest payments during the first 60 month after becoming unemployed. After the termination of unemployment insurance payments all countries, except Germany, pay significant lower unemployment assistance payments. Without loss of generality we can state that, compared to the U.S. and U.K., France and Germany show the highest degree of labor market institutions and, furthermore, the strongest relation between institutions and the wage setting.

In order to examine this relationship in a single variable, we calculate a combined indicator of union density and benefit replacement rates in order to analyze the effects of LMI's from a more comprehensive point of view. This indicator is calculated by the following formulae:

$$CI_t = UD_t^{(1-\alpha)} \times BRR_t^{\alpha} \qquad \text{with } \alpha = 0.5. \tag{1}$$

We interpret this measure as an indicator of the overall social welfare system.Of course, one should control for many different aspects of a welfare system in order to construct a measure as given in eqn. (1). For example one should control for factors like, social benefits, public health systems, dismissal protection, etc.. We want to point out that we do not neglect the importance of such factors but it is a general problem to collect the appropriate time series data. On the other hand, our measure includes two main factors, on the one hand we include union power and on the other social benefits given by benefit replacement rates. Union density gives us a measure of labor market regulation, as an indicator for employment protection, minimum wage systems, etc. whereas benefit replacement rates indicates the generosity of the social security system.

As Figure 3 shows, except Germany in all countries the values of this indicator decreased since the middle of the 1980's. The result for France seem a bit curious, but this pattern is explained by the low union density (see figure 1) and the relatively high weight of this indicator in the calculation. Beside the result for the French economy, the findings for the remaining countries seem reasonable.

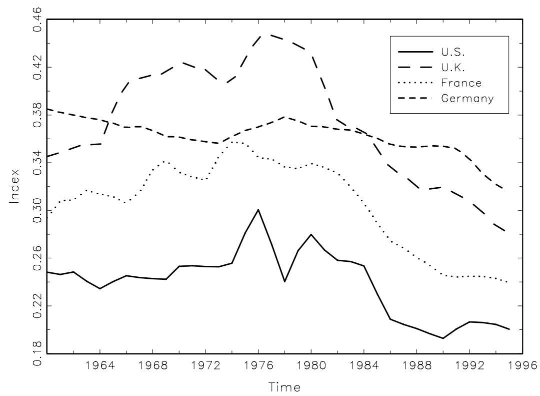

Figure 3: Combined Indicator

Source: own calculation

Empirical facts on wage inequality

Beside the significant change and obvious country differences in labor market institutions, the evolution of wage inequality behave similarly for the U.S. and Germany.

For the U.S. we observe the following pattern of overall wage inequality (see figure 4): An increasing wage spread between higher educated workers (workers earned some college degree) and lower educated workers which earned no college degrees (figure 4 solid line). A similar increase is observed for the so called 'college premium'. This means the wage spread between college educated workers and workers which earned a high school degree (dashed line). For lower educated workers a nearly constant relation is observed (dotted line). Figure 5 reports an increasing pattern of wage inequality for the German manufacturing sector. Although, the results presented by the OECD or Katz and Autor (1999) reports a decreasing pattern of wage inequality, we have to conclude that this does not hold for the German manufacturing sector.[8] In particular, the results given by figure 5 are supported by Fitzenberger (1999) who finds increasing patterns in wage inequality for male workers and a slightly constant wage premium for female workers for West Germany between 1975 - 1990.[9]

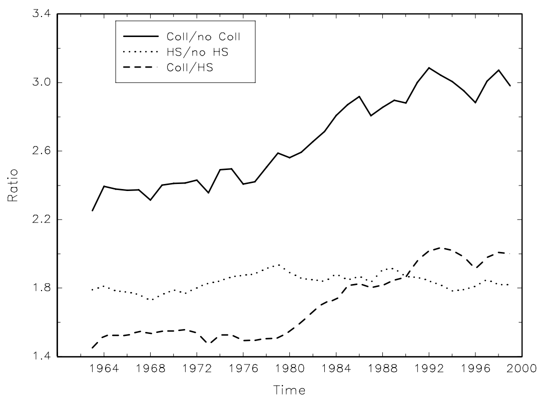

Figure 4: U.S. 1963-1999

Source: U.S. Bureau of the Census (2000) and own calculations

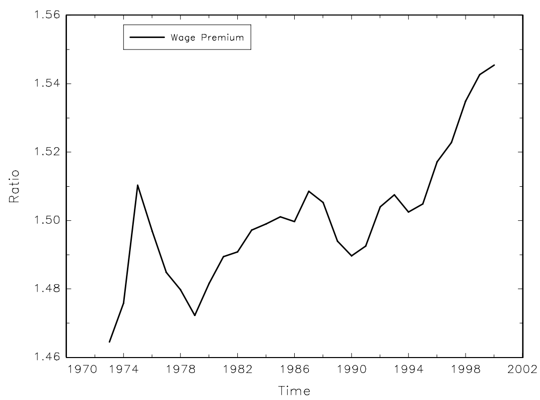

Figure 5: West-Germany, 1973-1999

Source: Federal Office of Statistics and own calculations

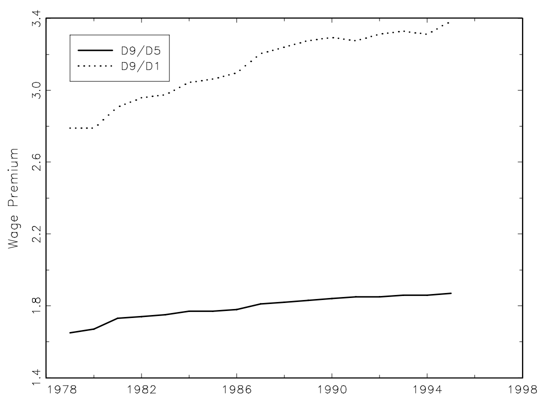

Figure 6: U.K. 1979-1994

Source: OCED (1993,1996)

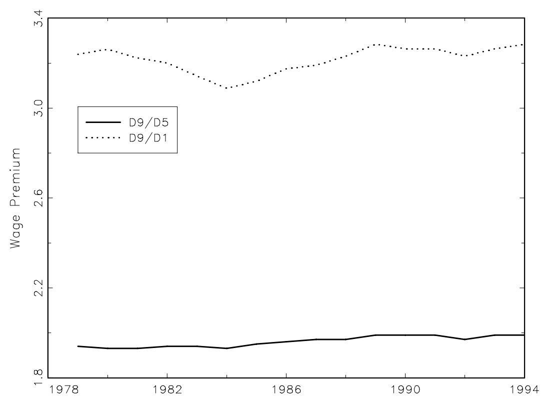

Figure 7: France, 1979-1994

Source: OCED (1993,1996)

[8]Calculating a time series for Germany with data taken from the 'Establishment Panel', published by the Bundesanstalt für Arbeit, one obtains an increasing pattern of wage inequality for the whole German economy, too. A detailed analysis based on the establishment Panel is given by Fitzenberger (1999). On the other hand, if we apply SOEP-data, as also done by the OECD, we would observe a decreasing patten of wage inequality.

[9]Cf. Fitzenberger (1999), Ch. 2.

For completeness figures 6 and 7 show the pattern of wage inequality for the U.K. and France. Similar to the U.S. and the German manufacturing sector the U.K. wage inequality is increasing over time. For France the wage ratio remains relatively constant over time.

In a further step we differentiate between male and female wage inequality. As shown by figure 8 in the U.S. the educational wage premium for females is significantly higher than for males. Whereas both series display similar time trends since the end of the 1970s. Before, female wage inequality displayed slightly a decreasing pattern, whereas one observes a marginal increase in male wage inequality. It is also shown that the differences between both time series is lower in the 1990's than in the 1960s.[10]

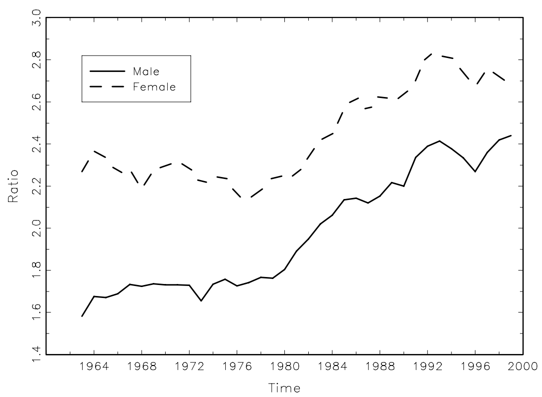

Figure 8: Male - Female Wage Inequality, U.S. 1963-1999

Source: U.S. Bureau of the Census (2000) and own calculations

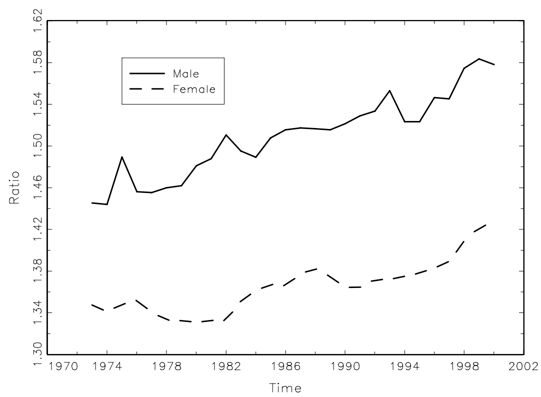

Figure 9: Male - Female Wage Inequality, Germany, 1973-2000

Source: Federal Office of Statistics and own calculations

For Germany we observe a different pattern. Figure 11 shows that the male wage spread is at a significant higher level than the female wage differential until. Comparing the evolution of both series it is obvious that the male wage spread increases steadily whereas the second series starts to rise in the middle of the 1980s.

Calculating the change in the wage spread relative to 1973 for both countries,

[10]Because of a lack of time series data for the U.K. and France we concentrate on the U.S. and Germany.

we observe (as expected) a higher increase in male wage inequality compared to the female wage spread (see figures 10 and 11 below).

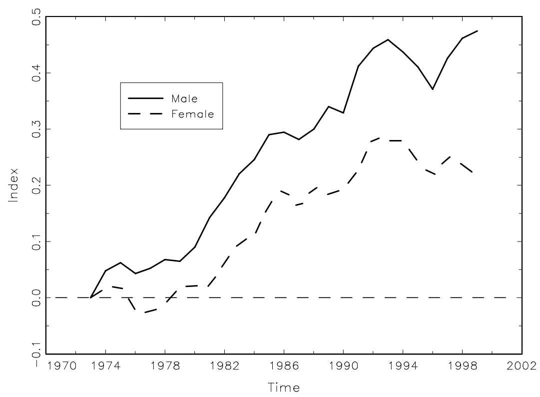

Figure 10: Evolution of Inequality, U.S. 1973-1999

Source: Own calculations

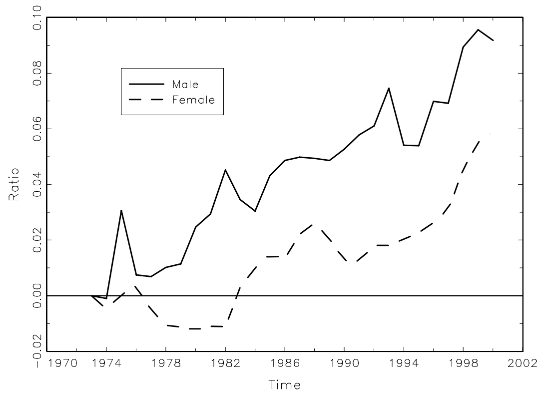

Figure 11: Evolution of Inequality, Germany, 1973-1999

Source: Own calculations

For both countries we observe a higher increase in male wage inequality. However, the rise in U.S. male wage inequality is about five times larger than in Germany. For the evolution of female wage inequality we observe that the wage spread has increased in the U.S. whereas it decreased in Germany.

In a further step, we examine the impact of the labor market indicators (LMI) on the wages paid for different educational groups. At first, we calculate correlation coefficients between labor market Institutions and wages. We apply time series data for the U.S.[11] from 1963 to 1995 and for Germany from 1973 to 1995. A comparison of the results for both countries are shown in table 3:

Table 3: Correlation between Wage Setting and Institutions , U.S.

	1963-95/99			**1963-79**			**1979-95/99**		
	UD	BRR	CI	UD	BRR	CI	UD	BRR	CI
no High School	-0.17	-0.22*	-0.20*	-0.12	-0.09	-0.06	-0.45***	-0.46***	-0.51***
High School	-0.08	-0.20*	-0.19	-0.14	-0.16	-0.12	-0.27*	-0.31	-0.41**
College	-0.08	-0.32***	-0.33	0.06	-0.28	-0.24	-0.40**	-0.40**	-0.55***

*Significance: ***=95 % ; **=90 % ; *=85 %*
UD = Union Density; BRR = Benefit Replacement Rates; CI = Combined Indicator

[11]Note that, the correlation coefficient of U.S. union density is calculated for the time interval from 1963 to 1999. There the data taken from Nickell et al. (2003) are extended by own calculations with data taken from the U.S. Bureau of the Census (2003).

We observe a negative correlation between U.S. labor market institutions and the wage growth. This effect might belong to the time trend of the decreasing union density (see figure 1) whereas the wages of all educational groups shows increasing patterns. Although the impact of labor market institutions on wages is quite similar for all educational groups, this result is consistent with the fact, mens wages account for a higher proportion of the overall wage inequality, and, secondly because of the fact that the unionization rates of men is concentrated near the middle of the wage distribution, i.e. near a lower educational degree.[12] A second result is, that the impact of institutions on wages turn to become significant in the second half of the observation period. This might be, on the one hand, due to the fact that U.S. institutions decreased enormously during that period and, at second, other factors like technological change became more important.

Table 4: Correlation between Wage Setting and Institutions , Germany

	Germany (1973-95)		
	UD	BRR	CI
-/-	n.a.	n.a.	n.a.
Lower job positions	0.6166***	0.0977	0.5250***
Higher Positions	0.6235***	0.0380	0.5352***

*Significance: ***=95 % ; **=90 % ; *=85 %*
UD = Union Density; BRR = Benefit Replacement Rates; CI = Combined Indicator

For Germany (table 4), we observe a highly significant positive correlation between wages and labor market institutions. This is explained by the role unions play in the centralized wage bargaining. This result is consistent with the facts outlined in tables 1 and 2 which show the high rates of union density, minimum wages and unemployment benefits which have increasing effects on the German reservation wages which explain to the positive correlations reported in table 4. Contrary to the U.S. benefit replacement rates have a lower impact on wages in Germany. Because of the decentralized wage setting in the U.S. benefit replacement rates might be a more important factor explaining U.S. reservation wages.

[12] See Card et al. (2003): 15.

3 The Model

The model, which is assumed in this paper, is based on Greiner et al (2003) who presented a complete derivation of the wage premium in an endogenous growth model. The framework is based on the seminal paper of Romer (1990) and, furthermore, on Murphy et al. (1998).

The economy is assumed to consist of three productive sectors, an R&D sector which develops new designs, an intermediate goods sector and a final goods sector which takes the intermediate goods, skilled and unskilled labor as inputs to produce a consumption good which either can be consumed or invested in physical capital, and a household sector.[13]

To derive the wage differential between skilled and unskilled workers, it is sufficient to concentrate on the production function of the final goods sector. In particular, we assume the following modified Cobb-Douglas production function:

$$Y = K^{1-\alpha} A^{\alpha} \eta^{\alpha-1} \left\{ \gamma_1 \left[A^{\xi} L_h\right]^{\frac{\sigma_p - 1}{\sigma_p}} + (1-\gamma_1)\left[A^{\epsilon} L_u\right]^{\frac{\sigma_p-1}{\sigma_p}} \right\}^{\frac{\alpha\,\sigma_p}{\sigma_p - 1}}, \qquad (2)$$

where K denotes physical capital, L_h and L_u denote high and low skilled workers. The stock of technology is denoted by A. $(1-\alpha) \in (0,1)$ gives the capital share and α is the labor share. $\sigma_p > 0$, finally, gives the elasticity of substitution between L_h and L_u.[14] As in Acemoglu (2002a) we say that skilled and unskilled workers are gross substitutes for $\sigma_p > 1$ and gross complements when $\sigma_p < 1$. ξ and ϵ measure the impact of the external effect, i.e. the impact of technical progress, on L_h and L_u. One important difference of eqn. (2) to existing studies, for example of Acemoglu (2002a), lies in the fact that we introduced external effects of knowledge. Generally it is assumed that two kinds of technology exists which are either complementary to high skilled workers or low skilled workers, respectively. Furthermore, η gives the units of foregone output which are needed to produce one unit of an intermediate good.

Defining $X = \gamma_1 \left[A^{\xi}(H - H_A)\right]^{\frac{\sigma_p-1}{\sigma_p}} + (1-\gamma_1)\left[A^{\epsilon} L\right]^{\frac{\sigma_p-1}{\sigma_p}}$ assuming further competitive labor markets, the wages of high and low qualified employees are equal to the marginal products of high and low qualified workers in the production sector.

[13]See Greiner et al. (2003) for the complete derivation of the model.

[14]As in Romer (1990), it is assumed that high skilled workers work either in the final goods sector or in the R&D sector. The economy wide number of skilled workers follows as: $H = L_h + L_{h,\mathrm{R\&D}}$.

This gives

$$\begin{aligned} w_H &= \alpha\gamma_1\eta^{\alpha-1}K^{1-\alpha}A^{\alpha}X^{\frac{\alpha\,\sigma_p}{\sigma_p-1}-1}A^{\frac{\xi(\sigma_p-1)}{\sigma_p}}L_h^{-\frac{1}{\sigma_p}}, & (3)\\ w_L &= \eta^{\alpha-1}\alpha(1-\gamma_1)K^{1-\alpha}A^{\alpha}X^{\frac{\alpha\sigma_p}{\sigma_p-1}-1}A^{\frac{\epsilon(\sigma_p-1)}{\sigma_p}}L_u^{-\frac{1}{\sigma_p}}. & (4)\end{aligned}$$

The wage premium, w_p, is given by the fraction of the marginal products:

$$w_p \equiv \frac{w_H}{w_L} = \frac{\gamma_1}{1-\gamma_1}\left[\frac{A^{\xi}}{A^{\epsilon}}\right]^{\frac{\sigma_p-1}{\sigma_p}}\left[\frac{H_Y}{L}\right]^{-\frac{1}{\sigma_p}} \tag{5}$$

Considering the wage premium, equation (5), we see that four main factors determine this variable.

First, the quotient of the productivity parameters $\gamma_1/(1-\gamma_1)$. If γ_1 is very small and close to zero the wage premium will have a small value, too. A small value for γ_1 means that the productivity of the high-skilled workers relative to the low-skilled workers is small, i.e. low-skilled workers contribute more to the output than high-skilled workers. Consequently, the wage of the low-skilled workers is relatively high and the wage premium is relatively low. If γ_1 is large, say near to one, the reverse holds. That is the productivity of the high-skilled workers is relatively high and, as a consequence, their wage rate and the wage premium are high, too.

Second, the ratio A^{ξ}/A^{ϵ} affects the wage premium. A high (low) value for ξ relative to ϵ means that the positive external effect of technical change affects high-skilled workers to a greater (lower) degree compared to low-skilled workers. That is, technical change, an increase in A, leads to a stronger (smaller) increase in the productivity of high-skilled workers compared to low-skilled workers. As a consequence, the larger the positive difference $\xi-\epsilon$ the higher the wage premium, provided skilled and unskilled labor are gross substitutes, i.e. for $\sigma_p > 1$.[15] Further, in this case technical change, i.e. an increase in A, raises the wage premium. If skilled and unskilled labor are gross complements ($\sigma_p < 1$) technical change, i.e. an increase in A, leads to a decline in the wage premium. This holds because in this case skilled and unskilled labor are gross complements and, therefore, the relative increase in the labor productivity of skilled labor also raises the demand for unskilled labor, where the latter increase exceeds the increase in demand for skilled labor.

Third, the number of high-skilled workers relative to the number of low-skilled workers determines the wage premium. If this ratio is high the supply of high-skilled

[15]Note that in this model, in contrast to Acemoglu (2002a), the value of σ_p is not the only factor determining the technology - skill complementarity, i.e. the difference of ξ and ϵ increases or dampens the influence of σ_p.

workers is relatively large. As a consequence, the wage premium will take on a low value.

The fourth factor which affects the wage premium is the elasticity of substitution between high-skilled and low-skilled workers, σ_p. To find the effect of σ_p on the wage differential we rewrite (5) and get

$$w_p = \frac{w_H}{w_L} = \frac{\gamma_1}{1-\gamma_1} A^{\xi-\epsilon} \left[A^{\epsilon-\xi} \left(\frac{L}{H_Y} \right) \right]^{\frac{1}{\sigma_p}} . \tag{6}$$

Differentiating (6) with respect to σ_p gives

$$\frac{\partial (w_H/w_L)}{\partial \sigma_p} = -\frac{\gamma_1}{1-\gamma_1} A^{\xi-\epsilon} \left[A^{\epsilon-\xi} \frac{L}{H_Y} \right]^{\frac{1}{\sigma_p}} \sigma_p^{-2} \, \ln \left[A^{\epsilon-\xi} \left(\frac{L}{H_Y} \right) \right] . \tag{7}$$

This expression is positive (negative) for $A^{\epsilon-\xi}(L/H_Y) < \; (>) \; 1$. This implies that a higher elasticity of substitution raises (reduces) the wage differential if the ratio (L/H_Y) is relatively large (small), i.e. if it is larger (smaller) than the threshold level $A^{\xi-\epsilon}$. That means if the supply of unskilled workers is relatively high an increase in the elasticity of substitution between high-skilled and low-skilled workers raises the wage differential. If the supply of unskilled workers is low a higher elasticity of substitution between high-skilled and low-skilled workers reduces the wage differential.

Defining

$$A_{w_p} \equiv \frac{A^\xi}{A^\epsilon}, \; L_{w_p} \equiv \frac{H_Y}{L}, \tag{8}$$

we can derive a differential equation describing the evolution of the ratio w_p which is

$$\frac{\dot{w}_p}{w_p} = \left(\frac{\sigma_p - 1}{\sigma_p} \right) \frac{\dot{A}_{w_p}}{A_{w_p}} - \left(\frac{1}{\sigma_p} \right) \frac{\dot{L}_{w_p}}{L_{w_p}}. \tag{9}$$

From the definitions of A_{w_p} and L_{w_p} we get

$$\frac{\dot{A}_{w_p}}{A_{w_p}} = (\xi - \epsilon) \frac{\dot{A}}{A} \quad \text{and} \quad \frac{\dot{L}_{w_p}}{L_{w_p}} = \frac{\dot{H}_Y}{H_Y} - \frac{\dot{L}}{L}. \tag{10}$$

The growth rate of the wage differential is given by equation (5) together with (9) and (10). It crucially depends on the elasticity of substitution between high-skilled and low-skilled workers, i.e. on σ_p. The effect of σ_p on the growth rate of the wage differential is obtained by differentiating (9) with respect to σ_p. This gives

$$\frac{\partial \dot{w}_p / w_p}{\partial \sigma_p} = \frac{1}{\sigma_p^2} \left[\frac{\dot{A}_{w_p}}{A_{w_p}} + \frac{\dot{L}_{w_p}}{L_{w_p}} \right] \tag{11}$$

If the sum in brackets is positive an increase in the elasticity of substitution raises the growth rate of the wage differential. This means the difference between high-skilled and low-skilled wages rises with a higher elasticity of substitution provided the term in brackets is positive.

Referring to equations (5) and (9) the main parameters of interest are the elasticity of substitution and the technology effect. Knowledge about the sign and values of these parameters allows for a better understanding of the forces driving the different patterns of wage inequality. Taking logs of equation (5) and differentiating with respect to time we obtain the growth rate of the wage premium:

$$\hat{w}_p = \frac{\dot{w}_p}{w_p} = \Big(\frac{\sigma_p - 1}{\sigma_p}\Big)(\xi - \epsilon)g_A - \frac{1}{\sigma_p}\Big(g_H - g_L\Big), \tag{12}$$

where $g_A = \frac{\dot{A}}{A}$, $g_H = \frac{\dot{H}_Y}{H_Y}$ and $g_L = \frac{\dot{L}}{L}$. Now, equation (12) allows for a closer examination of the technology effect and of the value of the elasticity of substitution. Rewriting equation (12) to:

$$\hat{w}_p = \beta_0 + \beta_1 g_A + \beta_2 g_{HL} + \varepsilon \tag{13}$$

Note that β_1 and β_2 describe the influence of technological change and the elasticity of substitution. Furthermore, β_0 accounts for an arbitrary (constant) factor determining the evolution of the wage differential over time, e.g. it might determine the trend of the wage premium.

4 Determinants of Wage Inequality

A detailed study of the relation between indicators of technological change, the relative supply of skilled workers and the evolution of wage inequality, as described by equation (13) is already presented by Greiner et al. (2003). In this section, we extend the study of Greiner et al. (2003) in the way that we distinguish between male and female wage inequality. This ensures further that this study is in line with, for instance, Card et al. (2003) or Gosling and Lemieux (2001) , which have, for example, shown that the rate of unionization differs across genders which results in different patterns of wage inequality. In particular, we combine the two sources of wage inequality: technological change and the different effects of labor market institutions. Complementary to our previous study we analyze a generalized version of the above equation, where we control for labor market institutions directly, in this section. In particular, we extend eqn. (13) to:

$$\hat{w}_p = \beta_0 + \beta_1 LMI + \beta_2 g_A + \beta_3 g_{HL} + \epsilon_t \tag{14}$$

Our approach is structured as follows, in a first step apply OLS estimates of eq. (14) to aggregate U.S. and Germany data. In a second step we differentiate between male and female wage inequality.

For the U.S. we obtained the following results:

Table 5: Determinants of overall Wage Inequality, U.S.

		Union Density											
		1964-1999				1964-1981				1982-1999			
		β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3
$\frac{\text{Bachelor}}{\text{No Bachelor}}$	R&D	+++		+	−−	+++			−−	−−−	−−	+++	+++
	R&D + Pat.	+++			−−−	+++			−−−	−	−−		++
	g_A				−−−				−−−	−	−		++
$\frac{\text{Bachelor}}{\text{High School}}$	R&D	+++		+++		+++		+++					
	R&D + Pat	+		+		++			−				+
	g_A			+					−				++
$\frac{\text{High School}}{\text{No High School}}$	R&D										−		−−
	R&D + Pat								−		−		−−
	g_A					++	++	−			−		−−

		Benefit Replacement Rates											
		1965-1995				1965-1980				1980-1995			
		β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3
$\frac{\text{Bachelor}}{\text{No Bachelor}}$	R&D	+++		++	−−−	+++	−−	+	−−−				
	R&D + Pat.	+++			−−−							−−	
	g_A				−−−	+	−−		−−−			+	+
$\frac{\text{Bachelor}}{\text{High School}}$	R&D	+++		+++		+++		+++		++		+++	
	R&D + Pat	+++								+++		−	
	g_A												
$\frac{\text{High School}}{\text{No High School}}$	R&D												
	R&D + Pat												
	g_A					+++		−−−					

		Combined Indicator											
		1965-1995				1965-1980				1980-1995			
		β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3
$\frac{\text{Bachelor}}{\text{No Bachelor}}$	R&D	+++		++	−−−	+++		+	−−		++	+	
	R&D + Pat.	+++			−−−	+++			−−−				
	g_A				−−−				−−−	−	+++	++	++
$\frac{\text{Bachelor}}{\text{High School}}$	R&D	+++		+++		+++		+++		+++	++	+++	++
	R&D + Pat	+++							−	+++		−	
	g_A		+	++							++	+	
$\frac{\text{High School}}{\text{No High School}}$	R&D					+							
	R&D + Pat								−				
	g_A					+++		−−					

Significance: +++ / −−− : 95 %, ++ / −− : 90 % , + /− : 85 %

The detailed results are reported in tables 18 to 20 in Appendix A.

Table 5 reports the obtained results of the factors determining the growth of overall (male and female) U.S. wage inequality. Concentrating on the wage differential between high and low skilled workers we observe a significant β_0 for the entire time period. Dividing the whole period into two subperiods this result holds for the period from 1964 to 1981. In the latter period β_0 becomes negative or even insignificant. This result is in line with Card and DiNardo (2002) who reports nearly constant wage inequality between in the 1990's. Furthermore, we observe positive influences of the various measures of technological change.[16] For the group of high skilled people, e.g. $\frac{\text{Bachelor}}{\text{no bachelor}}$, we observe negative signs of the variable of denoting the relative supply of each skill group except the latter time period between 1982 and 1995/99. It seems obvious that in this time period one could interpret this result as a skill bias. Concerning the influence of labor market institutions we have to state that they have no significant influence in the entire time period, but this result changes if one concentrates on the period between 1982 and 1995/99. There we observe negative correlation between union density and inequality and, furthermore, positive signs of the combined indicator.

More diffuse results are obtained if one examines female wage inequality.[17] There we observe also a positive β_0 for the fraction of higher skilled women to lower skill groups. Furthermore, for this class of inequality we obtained negative correlation for β_1. The sign of this parameter changes if one considers the wage spread between female workers with and without a high school degree. In general, we can state that the we observe a positive time trend, positive influences of technological change and, if significant, almost negative signs for the parameters capturing the effects of labor market institutions.

Examining male wage inequality[18] we found strond evidences for skill biased technical change and wage inequality. In particular we obtained positive signs for β_3, for all skill groups for the time period 1982-1995/99 and, furthermore,a positive impact of the technology - indicator (β_2). The influence of labor market indicators turned out to be insignificant.

For Germany, the obtained results are reported in table 6.

[16]As in Greiner et al. (2003), technological is measured as follows: (a) growth rate of R&D Expenditures per GDP, (b) mean growth rate of R&D per GDP and Patents, (c) a measure of the stock of knowledge as accumulated real R&D Expenditures

[17]See tables 21 to 23 in appendix A.

[18]See tables 24 to 26 in appendix A.

Table 6: Wage Inequality, Germany 1974-1995

	Overall Wage Inequality											
	Union Density				Benefit Rep. Rates				Combined Indicator			
	β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3
R&D										−−		
R&D + Pat.										−		
g_A									−	−−	+	
	Male Wage Inequality											
	Union Density				Benefit Rep. Rates				Combined Indicator			
	β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3
R&D	+		+++				+++				+++	
R&D + Pat.			+				+				+	
g_A							+		−−	−	+++	
	Female Wage Inequality											
	Union Density				Benefit Rep. Rates				Combined Indicator			
	β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3	β_0	β_1	β_2	β_3
R&D						−		+				
R&D + Pat.			+++	+		−	+++	++			+++	+
g_A												

Significance: +++ / − − − : 95 %, ++ / − − : 90 % , + /− : 85 %
The detailed results are reported in tables 35 to 37 in Appendix A.

Compared to the U.S. (see e.g. table 5) we found no significant time trend of wage inequality for Germany. Furthermore, β_1 reports even a slightly negative, but almos no significant correlation between labor market institutions and wage inequality. Beside this surprising result, we found positive influence of technological change on wage inequality when we differentiate between males and females.

5 Evaluation of $\beta_{0,t}$

As shown by the results of the previous section, a direct estimation of the relationship between wage inequality and labor market institutions does not lead to reasonable results. Therefore, in this section we follow another approach.

The structure of our empirical examination is as follows. In a first step, we refer to equation (13) which defines the wage premium as:

$$wp = \beta_0 + \beta_1 g_A + \beta_2 g_{HL} + \epsilon_t. \qquad (15)$$

Because of the fact that we consider growth rates which determine the evolution of wage inequality over time. Therefore, and beside the effects of β_1 and β_2, β_0 also influences the evolution of the premium over time. In particular, β_0 determines the trend of the evolution of the wage premium. In order to examine changing influences of other variables like labor market institutions on the wage premium we assume β_0 as a time varying parameter rather than a constant.

Assuming β_1 and β_2 as constant over time, we calculate

$$\Delta_t = wp - \hat{\beta}_1 g_A - \hat{\beta}_2 g_{HL}. \tag{16}$$

Note that Δ_t consists of the disturbance, ϵ_t, and, furthermore, of the 'constant' effect of β_0. Assuming β_0 as a time varying variable we can apply the Kalman Filter for estimation. Setting up the State Space Form (SSF), we rewrite equation (16) into:[19]

$$\Delta_t = x\beta_{0,t} + \xi_t \tag{17}$$

$$\beta_{0,t} = \beta_{0,t-1} + \nu_t \tag{18}$$

Correlate the time varying coefficient $\beta_{0,t}$ with various indicators of labor market institutions. The strategy of the application of the Kalman Filter in this section is as follows:

1. calculate Δ_t, where the values of $\hat{\beta}_1$ and $\hat{\beta}_2$ are taken from Greiner et al. (2003) and, furthermore, from OLS estimations of eq. 13 (see table 14, 15 and 16 in Appendix A) for the different ratios of skill groups.

2. Correlate the various Δ_t's with labor market institutions (Tables 7 to 11).

3. Application of OLS - Estimations where we also control for business cycle influences (Tables 12 to 13)

[19]Further details about the Kalman Filter can be found in Harvey (1989) or Hamilton (1994).

Table 7: Correlation $\beta_{0,t}$ and Labor Market Institutions, U.S.

	U.S.								
	High School / no High School			College / no College			College / High School		
	UD	BRR	CI	UD	BRR	CI	UD	BRR	CI
R&D Intens	-0.4463***	-0.4630***	-0.5114***	-0.0883	-0.1121	-0.1803	0.0603	0.1816	0.1638
R&D + Pat.	-0.2662	-0.3094*	-0.4053***	-0.0902	-0.1116	-0.0913	0.0191	0.1784	0.1463
g_A	-0.4004**	-0.4002**	-0.5547***	-0.0965	-0.1118	-0.1199	-0.0097	0.1747	0.1392

*Significance: ***=95 % ; **=90 % ; *=85 %*
UD = Union Density; BRR = Benefit Replacement Rates; CI = Combined Indicator

As expected from the previous results, we found negative correlations between labor market institutions and the trend of U.S. wage inequality, in particular, if one considers the lower skill group.

Table 8: Correlation $\beta_{0,t}$ and Labor Market Institutions, Germany

	high position / low position					
	1974-1995			1980-1995		
	UD	BRR	CI	UD	BRR	CI
R&D	0.5999***	0.0678	0.4665***	-0.1153	0.1152	-0.5137***
R&D + Pat.	-0.7909***	-0.0896	-0.5481***	0.5256***	-0.0129	0.1351
g_A	0.5724***	0.0643	0.4451***	-0.1556	0.0484	-0.5423***

*Significance: ***=95 % ; **=90 % ; *=85 %*
UD = Union Density; BRR = Benefit Replacement Rates; CI = Combined Indicator

The impact of the union density on wage inequality in Germany is, as reported in table 7, much higher than in the U.S.. At first, it seems as a surprise that union density is positively correlated with German wage inequality. But, on has to notice that, because of the high coverage of a collective wage setting institution (see table 1 above), high skilled workers earn a kind of a markup on these centralized wages. I.e. if the general wage level increase, the wages of high skilled employees arise more. Therefore, this high significant correlation seems reasonable. A further explanation for the (almost) positive correlation of benefit replacement rates and inequality in Germany is that they are part of a general social security system, which have to be paid by the worker and the firm (e.g. in Germany). Furthermore, high skilled workers effort to the social security system is relatively small compared to lower skill groups. An increase in the rates paid to the social security system decreases the growth of wages of lower skill groups but raises (relatively) the growth of wages of higher educated workers. Of course, further examinations of the correlation between benefit replacement rates as a determining factor of $\beta_{0,t}$ have to be done.

In the following we distinguish between again between male and female wage inequality and examine the determinants of $\beta_{0,t}$ for both genders.

Table 9: Signs of Correlations: $\beta_{0,t}$ with Labor Market Indicators, U.S., Males

	Bachelor vs. no Bachelor								
	Union Density			Ben. Repl. Rates			Combined Indicator		
	64-99	64-79	81-99	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{\text{R\&D}}{\text{GDP}}$									
R&D + Pat.									
g_A									
	Bachelor vs. High School								
	Union Density			Ben. Repl. Rates			Combined Indicator		
	64-99	64-79	81-99	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{\text{R\&D}}{\text{GDP}}$			+						
R&D + Pat.									
g_A		−							
	High School vs. No High School								
	Union Density			Ben. Repl. Rates			Combined Indicator		
	64-99	64-79	81-99	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{\text{R\&D}}{\text{GDP}}$			− − −			+ +			
R&D + Pat.			− − −			+			
g_A			− − −			+++			

Significance: +++ / − − − =95 % ; ++ / − − =90 % ; + / −=85 %

The detailed results are reported in tables 27 to 29 (see Appendix A)

For the trend of the wage inequality between high and low educational groups we found no significant results. This changes if one considers lower educated workers, there we found negative correlation between union density and the trend in inequality and, furthermore, a positive correlation for benefit replacement rates. In general, the results of the low correlation between the trend of male wage inequality and labor market institutions are supported by Gosling and Lemieux (2001), who reports that less male workers are members of trade unions than female workers.

Table 10: Signs of Correlations: $\beta_{0,t}$ with Labor Market Indicators, U.S., Females

	Bachelor vs. no Bachelor								
	Union Density			Ben. Repl. Rates			Combined Indicator		
	64-99	64-81	81-99	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{R\&D}{GDP}$		+							
R&D + Pat.		+							
g_A									
	Bachelor vs. High School								
	Union Density			Ben. Repl. Rates			Combined Indicator		
	64-99	64-81	81-99	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{R\&D}{GDP}$		+++							
R&D + Pat.		+++							
g_A		+++							
	High School vs. No High School								
	Union Density			Ben. Repl. Rates			Combined Indicator		
	64-99	64-81	81-99	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{R\&D}{GDP}$	− − −	+	−	− − −		− − −	− − −		− − −
R&D + Pat.	−	−	−	− −		− − −	− − −		− − −
g_A	− − −	− −					− −		− −

Significance: +++ / − − − =95 % ; ++ / − − =90 % ; + / −=85 %

The detailed results are reported in tables 27 to 29 (see Appendix A)

As an influencing variable on the time trend of female wage inequality labor market institutions fail, in particular if one considers higher skilled women. On the other hand, we observe significant negative correlations for lower skilled women.

Table 11 below reports the obtained correlation coefficients for Germany. The results indicate a negative correlation between union density and the trend of male wage inequality whereas the sign changes when female wage inequality is studied. For both genders we obtained negative correlations between benefit replacement rates and, furthermore, the combined indicator with the trend of wage inequality.

Table 11: Correlation $\beta_{0,t}$ and Labor Market Institutions, Germany

	Males					
	1974-1995			1980-1995		
	UD	BRR	CI	UD	BRR	CI
R&D	-0.3444**	-0.2286	-0.7661***	0.8256***	-0.0129	0.1154
R&D + Pat.	-0.0220	-0.2849**	0.0167	-0.2409	-0.4251**	-0.1779
g_A	-0.1649	-0.1605	0.1758	-0.5895***	-0.2355	-0.2542
	Females					
	UD	BRR	CI	UD	BRR	CI
R&D	-0.1743	-0.2967**	-0.2089	-0.2393	-0.3387**	-0.3166*
R&D + Pat.	0.1684	-0.2690*	-0.5381***	0.6289***	-0.2315	-0.0853
g_A	0.1749	-0.2186	-0.4921***	0.6364	-0.1786	-0.0320

*Significance: ***=95 % ; **=90 % ; *=85 %*
UD = Union Density; BRR = Benefit Replacement Rates; CI = Combined Indicator

Beside the direct correlation between the growth trend of wage inequality and labor market institutions one has to consider business cycle effects, because in a growing economy it is, on the one hand, much easier for trade unions to increase wages for lower skilled workers and a growing economy leads to higher wages for high skilled workers. The effect on wage inequality can be threefold, increasing, decreasing or constant. Therefore, we analyze the determinants of $\beta_{0,t}$ by estimating the following equation:

$$\hat{\beta}_{0,t} = \gamma_0 + \gamma_1 \widehat{LMI} + \gamma_2 \widehat{GDP}. \tag{19}$$

In particular, we control for the impact of labor market institutions ($\gamma_1 \widehat{LMI}$) and for the influences of the business cycle ($\gamma_2 \widehat{GDP}$) whereas γ_0 accounts for unobservable variables.[20]

For the U.S. we obtain the following results. Note that the labor market institution is approximated by union density. Furthermore, we differentiate between male and female wage inequality where the time varying $\beta_{0,t}$ is derived from.

Table 12 report the sign of significant coefficients, determining the evolution of

[20]Note that $\widehat{LMI}$ and $\widehat{GDP}$ denote the growth rates of the respective variable.

$\beta_{0,t}$ for the time period between 1964 and 1995.[21]

Table 12: Determinants of $\beta_{0,t}$, U.S., 1964-95

		Overall								
		Union Density			BRR			Comb. Ind.		
		γ_0	γ_1	γ_2	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2
Bachelor / No Bachelor	R&D	+++			+++		−	+++		−
	R&D + Pat	+++		−	+++		−−	+++		−
	g_A	+++		−−	+++		−−	+++	−−	
Bachelor / High School	R&D	+++	+	−−−	+++		−−−	+++		−−−
	R&D + Pat	+++		−−−	+++		−−−	+++		−−−
	g_A	+++		−−−	+++		−−−	+++	−−−	
High School / No High School	R&D	+++	−	+	+++		−−	+++		++
	R&D + Pat	+++		+++	+++		+++	+++		+++
	g_A	−−−		+++	−−−		+++	−−−		++
		Males								
		Union Density			BRR			Comb. Ind.		
		γ_0	γ_1	γ_2	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2
Bachelor / No Bachelor	R&D	+++		−	+++		−	+++		−
	R&D + Pat	+++		−−−	+++		−−	+++		−−
	g_A	+++	−	−−−	+++		−−−	+++	−−−	
Bachelor / High School	R&D	+++		−−	+++		−−	+++		−−
	R&D + Pat	+++		−−−	+++		−−−	+++		−−−
	g_A	+++	−−	−−−	+++		−−−	+++	−−−	
High School / No High School	R&D	+++			+++			+++		
	R&D + Pat	+++			+++			+++		
	g_A	+++			+++	+	+	+++		+
		Females								
		Union Density			BRR			Comb. Ind.		
		γ_0	γ_1	γ_2	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2
Bachelor / No Bachelor	R&D	+++			+++			+++		
	R&D + Pat	+++			+++			+++		
	g_A	+++		−	+++			+++		−
Bachelor / High School	R&D	+++		−−−	+++		−−	+++		−−
	R&D + Pat	+++		−−−	+++		−−−	+++		−−−
	g_A	+++		−−−	+++		−−−	+++	−−	
High School / No High School	R&D	−	−−−			−	+		−−−	
	R&D + Pat	−−−		+++	−−	−	+++	−−	−	+++
	g_A	−−−	−−−		+++	+	+	+++		+

Significance: +++ / −−− : 95 %, ++ / −− : 90 % , + /− : 85 %
The detailed results are reported in tables 30 to 34 in Appendix A.

[21]Estimating eq. (19) without GDP growth, not reported here, leads to very similar results for γ_0 and γ_1.

For all groups we found an almost highly significant γ_0 which indicates that many unobservable variables that influences the trend of wage inequality positively exist. However, the Sign changes for low skilled females. Furthermore, for both genders, we found similar results for the higher skill groups, i.e. a positive trend variable,a low influence of labor market institutions and negative sign of GDP - growth. This result changes if one considers the lower skill group, i.e. $\frac{\text{High School}}{\text{No High School}}$.[22]

The regression results for Germany are shown in table 13.

Table 13: Determinants of $\beta_{0,t}$, Germany, 1974-95

	Overall								
	R&D - Exp.			R&D - Exp. + Pat.			g_A		
	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2
BRR	0.0053***	-0.1300***	-0.0408	0.0023**	-0.1354**	0.0218	-0.0022*	-0.1636***	-0.0365
UD	0.0055***	0.0065	-0.0308	0.0022	-0.0277	0.0379	-0.0024*	-0.0356	-0.0167
CI	0.0049***	-0.0838*	-0.0255	-0.0015	-0.1505**	0.0409	-0.0032**	-0.1807**	-0.0135
	Males								
	R&D - Exp.			R&D - Exp. + Pat.			g_A		
	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2
BRR	0.0052***	-0.0104**	-0.0139	-0.0071***	-0.0736	-0.0563*	-0.0119***	-0.1339**	-0.0056*
UD	0.0059***	0.0471	-0.0130	-0.0081***	0.0821***	-0.0634**	-0.0117***	-0.0002	-0.0445
CI	0.0054***	0.0802	-0.0057	0.0078***	0.0911	-0.0545*	-0.0123***	-0.0938	-0.0398
	Females								
	R&D - Exp.			R&D - Exp. + Pat.			g_A		
	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2
BRR	0.0101***	-0.1382*	0.0221	0.0099***	-0.1012	0.0194	0.0224***	-0.0707	-0.0043
UD	0.0089***	-0.1177***	0.0532	0.0089***	-0.0972**	-0.0009	0.0221***	-0.0271	0.0062
CI	0.0078***	-0.3619***	0.0520	0.0080***	-0.3006***	-0.0430	0.0214***	-0.1509**	0.0093

*Significance: ***=95 % ; **=90 % ; *=85 %*

Compared to the U.S. the results reported in table 13 show a more diffuse picture. In particular, if we consider the sign of γ_0, because it changes if one varies the indicator for technological change. On the other hand, we observe (significant) negative signs for the parameter capturing the influence of labor market institutions. That means, a decrease in labor market institutions leads to an increase in educational wage inequality. Furthermore, the results of table 13 show that female wage inequality depends more on the influence of labor market institutions than male wage inequality.

[22] Detailed results are reported in tables 30 to 34 in appendix A.

6 Conclusion

As raised by Card and DiNardo (2002) that the unicausal explanation that skill biased technological change fails to explain the trend of wage inequality we have introduced further indicators in order to explain the differences in the evolution of wage inequality between the U.S. and Europe.

By introducing various indicators of labor market institutions we could show that one has to distinguish between short or medium run and long - run effects. As shown by the data, in the short run, for example between 1980 and 1999 the influence of labor market institutions determining inequality became more significant than in a longer time horizon.

Furthermore, as expected, labor market institutions have even more influence on lower skilled workers, which are generally more covered by institutional arrangements, than high skilled workers, e.g. managers.

In order to explain main differences between U.S. and German wage inequality one has to state, that labor market institutions play a much higher role in Germany than in the U.S. which results in the higher correlation between inequality and institutions. A detailed analysis is left for future, more microeconometric orientated work. However, the attempt of this study to generate further insights in the aggregate behavior of wage inequality by introducing various kinds of labor market institutions in the empirical examination lead to the result that technological change is the major source, in the U.S. as well as in Europe, to explain the long run trend of wage inequality whereas institutions accounts for short run changes in the trend of inequality.

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A Regression Results

Table 14: Results OLS - Regressions

		β_0	β_1	β_2
U.S., 1964-95				
$\frac{\text{High School}}{\text{no High School}}$	R&D Intens.	0.0001	-0.0516	0.0095
	R&D + Pat.	0.0008	-0.0701*	0.0100
	g_A	0.0044	-0.1693	0.0140
$\frac{\text{College}}{\text{no College}}$	R&D Intens.	0.0149***	0.1416*	-0.1769**
	R&D + Pat.	0.0157***	0.0081	-0.2009***
	g_A	0.0120	0.1404	-0.1964***
$\frac{\text{College}}{\text{no College}}$	R&D Intens.	0.0085***	0.3135***	0.0282
	R&D + Pat.	0.0084**	0.1412**	-0.0461
	g_A	-0.0090	0.6226*	0.0747
Germany, 1974-95				
$\frac{\text{high Pos.}}{\text{low Pos.}}$	R&D Intens.	0.0025**	0.0614**	-0.0755*
	R&D + Pat.	0.0010	0.1433***	-0.0459
	g_A	0.0025	-0.0016	-0.0540

*Significance: ***=95 % ; **=90 % ; *=80 %*

Greiner et al. (2003) applied a robust estimation procedure to the equation of the wage premium. Because of the numerical procedure they were enabled to estimate the elasticity of substitution directly.

Table 15: Estimation of Eq (13), U.S. (1964-99)

	U.S. Wage Premium			***U.S. College Premium***		
Proxy for Knowl.	β_1	β_2	β_3	β_1	β_2	β_3
R&D - Intens.	0.0207	0.0720	2.7716	0.0166	0.2959	2.6621
std. error	0.0069	0.1586	0.9879	0.0574	0.1375	1.3149
R&D + Patents	0.0212	0.0066	2.7229	0.0169	0.1645	2.6602
std. error	0.0071	0.1330	0.9412	0.0062	0.1256	1.4131
A	0.0177	0.1278	2.7506	0.0118	0.2226	2.8822
std. error	0.0177	0.5936	0.9698	0.0189	0.6125	1.8292

For Germany, they obtained the following results:

Table 16: Estimation of Eq (13), Germany (1974-98)

Approx. of Knowl.	β_1	β_2	β_3
R&D - Intens.	0.0097	0.1271	1.7536
std. error	0.0019	0.0475	0.2505
R&D + Patents	0.0122	−0.1139	1.6965
std. error	0.0024	0.0595	0.2586
A	0.0067	0.2165	1.9261
std. error	0.0022	0.0940	0.3143

Table 17: Estimation of Eq (13), Germany (1974-98), Males and Females

	Males, Greiner et al. (2003)			Males, OLS		
Approx. of Knowl.	β_1	β_2	β_3	β_1	β_2	β_3
R&D - Intens.	0.0036	0.1378	1.9641	0.0001	0.06242	0.03024
std. error	0.0017	0.0456	0.2616	(p: 0.54)	*(p:0.0604)*	(p: 0.303)
R&D + Patents	0.0013	0.2125	2.2098	-0.0009	0.0867	0.0436
std. error	0.0017	0.0812	0.3099	(p: 0.72)	*(p:0. 12)*	(p: 0.22)
A	-0.0164	0.4972	2.0487	0.0053	-0.1330	0.0882
std. error	0.0052	0.1191	0.2842	*(p: 0.129)*	*(p: 0.11)*	*(p: 0.078)*
	Females, Greiner et al. (2003)			Females, OLS		
Approx. of Knowl.	β_1	β_2	β_3	β_1	β_2	β_3
R&D - Intens.	0.0157	-0.0278	2.6398	-0.0013	0.1672	0.1724
std. error	0.0039	0.0803	0.6962	(p: 0.69)	*(p: 0.0006)*	*(p: 0.0004)*
R&D + Patents	0.0143	0.2079	2.6220	-0.0018	0.2732	0.1225
std. error	0.0037	0.1248	0.5609	(p: 0.74)	*(p:0.0021)*	*(p: 0.0262)*
A	0.0297	-0.3010	2.5321	0.0105	-0.1785	0.0641
std. error	0.0089	0.1725	0.5256	*(p: 0.098)*	*p: 0.12)*	0.200

Table 18: Overall Wage Inequality and Union Density, U.S.

Bachelor versus no Bachelor Degree					
		β_0	β_1	β_2	β_3
	R&D	0.0163***	0.0830	0.1668*	-0.0173**
64-99	R&D+ Pat.	0.0160***	0.0170	0.0105	-0.2009***
	g_A	0.0122	0.0176	0.1447	-0.1964***
	R&D	0.0213***	0.1405	0.2163	-0.2222**
64-81	R&D+Pat.	0.0196***	0.0681	-0.0394	-0.2666***
	g_A	0.0204	0.0732	-0.0202	-0.2656***
	R&D	-0.0723***	-0.5040**	1.345***	0.7640***
81-99	R&D+ Pat.	-0.0251*	-0.4935**	-0.0024	0.5239**
	g_A	-0.0241*	-0.4527*	0.0757	0.5029**
Bachelor versus High School Degree					
	R&D	0.0103***	0.0858	0.3377***	0.0162
64-99	R&D+ Pat.	0.0082*	-0.0079	0.1399*	-0.0444
	g_A	0.0099	-0.0479	0.6193*	-0.0826
	R&D	0.0143***	0.1253	0.5133***	-0.1045
64-81	R&D+Pat.	0.0117**	0.0123	0.1583	-0.3162*
	g_A	0.0156	0.0068	-0.1646	-0.3943*
	R&D	-0.0012	-0.1822	0.1779	0.2923
81-99	R&D+ Pat.	-0.0029	-0.2709	0.0276	0.3112*
	g_A	-0.0332	-0.2927	0.9460	0.4553**
High School versus no High School Degree					
	R&D	0.0004	0.0206	-0.0451	0.0109
64-99	R&D+ Pat.	0.0011	0.0213	-0.0670	0.0113
	g_A	0.0047	0.3718	-0.1614	0.0159
	R&D	0.0013	0.1130	-0.8549	-0.2166
64-81	R&D+Pat.	0.0004	0.1208	-0.1989*	-0.0297
	g_A	0.0149**	0.1669**	-0.5309*	-0.0350
	R&D	0.0001	-0.2965*	0.0016	-0.3485**
81-99	R&D+ Pat.	0.0005	-0.2975*	-0.0124	-0.3512**
	g_A	-0.0162	-0.2618*	0.6339*	-0.3657**

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 19: Overall Wage Inequality and Benefit Replacement Rates, U.S.

		β_0	β_1	β_2	β_3
Bachelor versus no Bachelor Degree					
65-95	R&D	0.0172***	-0.0307	0.2042**	-0.1906***
	R&D+ Pat.	0.0188***	-0.0362	-0.1048	-0.2275***
	g_A	0.0160	-0.0319	0.0647	-0.2210***
65-80	R&D	0.0265***	-0.0915**	0.4357*	-0.2261***
	R&D+Pat.	0.0006	-0.0124	-0.0612	0.0714
	g_A	0.0242*	-0.1013**	-0.1432	-0.2796***
80-95	R&D	-0.0006	0.0128	0.1857	0.2268
	R&D+ Pat.	0.0119	0.0077	-0.3329**	0.1846
	g_A	-0.0288	0.0473	0.0961*	0.3869*
Bachelor versus High School Degree					
65-95	R&D	0.0111***	-0.0226	0.3781***	0.0109
	R&D+ Pat.	0.0105***	-0.0244	0.0628	-0.0492
	g_A	-0.0038	-0.0153	0.5034	0.0257
65-80	R&D	0.0179***	-0.0058	0.5959***	-0.2217
	R&D+Pat.	0.0099	-0.0055	0.0679	-0.3633
	g_A	0.0103	-0.0004	-0.0294	-0.3907
80-95	R&D	0.0103**	0.0009	0.2821***	0.1229
	R&D+ Pat.	0.0186***	0.0018	-0.2213*	0.0983
	g_A	0.0018	0.0190	0.4475	0.0894
High School versus no High School Degree					
64-95	R&D	-0.0006	0.0054	-0.0625	0.0096
	R&D+ Pat.	0.0003	0.0045	-0.0867	0.0101
	g_A	0.0026	0.0035	-0.1193	0.0138
65-80	R&D	0.0059	-0.0046	0.1402	0.0263
	R&D+Pat.	0.0028	-0.0068	-0.0626	0.0199
	g_A	0.0205***	-0.0150	-0.6845***	0.0262
80-95	R&D	-0.0000	-0.0087	-0.0379	-0.0702
	R&D+ Pat.	0.0026	-0.0136	-0.0757	-0.1064
	g_A	-0.0183	0.0126	0.6133	-0.0231

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 20: Overall Wage Inequality and Combined Indicator, U.S.

		β_0	β_1	β_2	β_3
Bachelor versus no Bachelor Degree					
65-95	R&D	0.0187***	0.4236	0.2073**	-0.1963***
	R&D+ Pat.	0.0198***	0.3679	-0.0682	-0.2319***
	g_A	0.0106	0.5242	0.3338	-0.2191***
65-80	R&D	0.0268***	-0.0186	0.4944*	-0.2282**
	R&D+Pat.	0.0218***	0.2124	0.0641	-0.2914***
	g_A	0.0203	-0.2199	0.0251	-0.2898***
80-95	R&D	0.0022	0.7915**	0.2076*	0.2477
	R&D+ Pat.	0.0111	0.3487	-0.2556	0.1846
	g_A	-0.0324*	1.0444***	1.2220**	0.3731**
Bachelor versus High School Degree					
65-95	R&D	0.0122***	0.3316	0.3812***	0.0078
	R&D+ Pat.	0.0116***	0.4066	0.1006	-0.0553
	g_A	-0.0108	0.5841*	0.7986**	0.0826
65-80	R&D	0.0171***	-0.4827	0.6350***	-0.2285
	R&D+Pat.	0.0093	-0.2328	0.0629	-0.3786*
	g_A	0.0146	-0.3078	-0.1991	-0.4485
80-95	R&D	0.0106***	0.7371**	0.3105***	0.1966*
	R&D+ Pat.	0.0171***	0.4086	-0.1322*	0.1259
	g_A	0.0079	0.8614**	0.8187*	0.1878
High School versus no High School Degree					
64-95	R&D	-0.0010	-0.1144	-0.0630	0.0107
	R&D+ Pat.	-0.0004	-0.2130	-0.1040	0.0126
	g_A	0.0036	-0.1750	-0.1868	0.0169
65-80	R&D	0.0064*	0.2259	0.1220	0.0239
	R&D+Pat.	0.0037	0.2282	-0.0662	0.0182
	g_A	0.0198***	0.0222	-0.6643**	0.0282
80-95	R&D	-0.0012	-0.1074	-0.0446	-0.0423
	R&D+ Pat.	0.0013	-0.2325	-0.1086	-0.0645
	g_A	-0.0159	0.0594	0.5641	-0.0480

*Significance: ***=95 % ; **=90 % ; *=85 %*

Gender Wage Inequality

Table 21: Female Wage Inequality and Union Density

		β_0	β_1	β_2	β_3
Bachelor versus no Bachelor Degree					
	R&D	0.0065**	0.1297	0.2494**	-0.0054
64-99	R&D+ Pat.	0.0077*	0.0466	0.0947	-0.0742*
	g_A	-0.0112	0.0316	0.3814	-0.0694*
	R&D	0.0084*	0.2644*	0.3196*	-0.0587
64-81	R&D+Pat.	0.0066	0.1877	0.2082	-0.0851**
	g_A	0.0089	0.1733	-0.1671	-0.0858**
	R&D	-0.0136	-0.1320	0.0929	0.3813*
81-99	R&D+ Pat.	-0.0140	-0.1790	-0.1106	0.4517*
	g_A	-0.0720***	-0.1148	1.6752**	0.6530***
Bachelor versus High School Degree					
	R&D	-0.0055*	-0.1392	0.1149	0.0122
64-99	R&D+ Pat.	-0.0073**	-0.1605	0.1070	-0.0092
	g_A	-0.0203**	-0.1783*	0.5400*	-0.0070
	R&D	0.0104**	0.1305	0.0981	0.0130
64-81	R&D+Pat.	0.0112**	0.1549	0.0637	0.0099
	g_A	0.0125	0.1624	0.0327	0.0103
	R&D	0.0010	0.0487	0.0464	0.1487
81-99	R&D+ Pat.	-0.0005	0.0326	0.1296	0.1654
	g_A	-0.0268	0.0954	1.0715*	0.1363
High School versus no High School Degree					
	R&D	0.0095*	0.2166*	0.2413**	0.0036
64-99	R&D+ Pat.	0.0077	0.1301	0.0494	-0.0104
	g_A	0.0003	0.1211	0.2539	0.0313
	R&D	0.0126**	0.3811**	0.3622*	-0.0808
64-81	R&D+Pat.	0.0099*	0.3086**	0.1211	-0.1712
	g_A	0.00367**	0.3712**	-0.9912	-0.3935*
	R&D	-0.0045	-0.1217	0.0892	0.2061
81-99	R&D+ Pat.	-0.0047	-0.1801	-0.1136	0.2817
	g_A	-0.0323	-0.1440	0.8529	0.3192

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 22: U.S. Female Wage Inequality and LMI = BRR

		β_0	β_1	β_2	β_3
Bachelor versus no Bachelor Degree					
65-95	R&D	0.0098***	-0.0433	0.2818***	-0.0599
	R&D+ Pat.	0.0089**	-0.0463	0.0861	-0.0785*
	g_A	0.0019	-0.0400	0.2887	0.0745*
65-80	R&D	0.0042	-0.0824*	0.1416	-0.0817*
	R&D+Pat.	0.0053	-0.0944*	0.2584	-0.0934**
	g_A	0.0038	-0.0865*	-0.0750	-0.0907**
80-95	R&D	0.0011	0.0022	0.2076*	0.2250
	R&D+ Pat.	0.0116	-0.0013	-0.3169**	0.1999
	g_A	-0.0309	0.0430	1.1251*	0.3150*
Bachelor versus High School Degree					
65-95	R&D	0.0078*	-0.0393	0.2741**	0.0303
	R&D+ Pat.	0.0069	-0.0432	0.0075	0.0215
	g_A	0.0018	-0.0394	0.1802	0.0406
65-80	R&D	0.0046	-0.1288**	0.2845	0.1443
	R&D+Pat.	0.0025	-0.1436**	0.2604	0.1419
	g_A	-0.0106	-0.1368**	0.3664	0.1822
80-95	R&D	0.0129*	0.0137	0.1941	-0.0098
	R&D+ Pat.	0.0218***	0.0097	-0.4146**	0.0660
	g_A	0.0094	0.0235	0.2261	0.0313
High School versus no High School Degree					
65-95	R&D	-0.0041	-0.0086	0.1055	0.0144
	R&D+ Pat.	-0.0056*	-0.0069	0.1612*	0.0120
	g_A	-0.0186*	-0.0045	0.5442	0.0108
65-80	R&D	-0.0013	0.0984**	0.4995**	0.0298**
	R&D+Pat.	-0.0101**	0.0829*	0.0077	0.0184
	g_A	-0.0099	0.0831*	-0.0095	0.0185
80-95	R&D	0.0065	-0.0803*	0.0035	-0.2399**
	R&D+ Pat.	0.0037	-0.0759*	0.0761	-0.2118*
	g_A	-0.0254	-0.0391	1.0962*	-0.1583

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 23: U.S. Female Wage Inequality and LMI = Combined Indicator

		β_0	β_1	β_2	β_3
Bachelor versus no Bachelor Degree					
65-95	R&D	0.0092***	-0.0609	0.2752***	-0.0597
	R&D+ Pat.	0.0082**	-0.0771	0.0812	-0.0777*
	g_A	0.0008	-0.0678	0.3039	-0.0738*
65-80	R&D	0.0031	-0.1185	0.1188	-0.0819*
	R&D+Pat.	0.0042	-0.1412*	0.2431	-0.0919**
	g_A	0.0014	-0.1274	-0.0142	-0.0892**
80-95	R&D	0.0012	0.0078	0.2076*	0.2267
	R&D+ Pat.	0.0115	0.0063	-0.3164**	0.2035
	g_A	-0.0299	0.0769	1.1249*	0.3153*
Bachelor versus High School Degree					
65-95	R&D	0.0076*	-0.0429	0.2703**	0.0192
	R&D+ Pat.	0.0065	-0.0633	0.0064	0.0138
	g_A	0.0006	-0.0556	0.2078	0.0358
65-80	R&D	0.0032	-0.1826*	0.2145	0.0786
	R&D+Pat.	0.0017	-0.2143*	0.2239	0.0895
	g_A	-0.0113	-0.2121*	0.3721	0.1451
80-95	R&D	0.0134*	0.0336	0.1942	-0.0102
	R&D+ Pat.	0.0223***	0.0326	-0.4153**	0.0658
	g_A	0.0096	0.0499	0.2470	-0.0318
High School versus no High School Degree					
65-95	R&D	-0.0044	-0.0405	0.0945	0.0139
	R&D+ Pat.	-0.0058**	-0.0381	0.1554*	0.0116
	g_A	-0.0172*	-0.0254	0.4857	0.0103
65-80	R&D	0.0005	0.1843**	0.5553**	0.0303*
	R&D+Pat.	-0.0092*	0.1349*	0.0184	0.0173
	g_A	-0.0079	0.1356*	-0.0604	0.0177
80-95	R&D	0.0046	-0.1599**	0.0009	-0.2503**
	R&D+ Pat.	0.0018	-0.1533**	0.0812	-0.2210*
	g_A	-0.0242	-0.0922	1.0217*	-0.1732

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 24: U.S. Male Wage Inequality and Union Density

		β_0	β_1	β_2	β_3
Bachelor versus no Bachelor Degree					
	R&D	0.0057	-0.0004	0.3462***	0.1684
64-99	R&D+ Pat.	0.0038	-0.1073	0.0997	0.1340
	g_A	-0.0157	-0.1321	0.6886*	0.1870
	R&D	0.0177*	0.0456	0.5704***	-0.0165
64-81	R&D+Pat.	0.0193	-0.1082	0.0544	-0.2111
	g_A	0.0122	-0.1249	0.2631	-0.2054
	R&D	-0.0010	-0.3476	0.1547	0.5986***
81-99	R&D+ Pat.	-0.0123	-0.4311*	0.0336	0.5256***
	g_A	-0.0455**	-0.4269**	1.0954*	0.6472***
Bachelor versus High School Degree					
	R&D	0.0099*	0.0294	0.3786***	0.0504
64-99	R&D+ Pat.	0.0068	-0.0706	0.1689**	0.0098
	g_A	-0.0166	-0.1283	0.8344**	-0.1291
	R&D	0.0196***	0.0096	0.5341***	-0.3122
64-81	R&D+Pat.	0.0175***	-0.1178	0.1140	-0.5225*
	g_A	0.0145	-0.1331	0.0907	-0.5322**
	R&D	0.0022	-0.2017	0.2269*	0.3041*
81-99	R&D+ Pat.	-0.0025	-0.3211	0.1272	0.3283*
	g_A	0.0266	-0.3282	0.9219	0.4243**
High School versus no High School Degree					
	R&D	0.0057	-0.0004	0.3462***	0.1684
64-99	R&D+ Pat.	0.0038	-0.1073	0.0997	0.1340
	g_A	0.0157	-0.1321	0.6886*	0.1870
	R&D	0.0177*	0.0456	0.5704***	-0.0165
64-81	R&D+Pat.	0.0193	-0.1082	0.0544	-0.2111
	g_A	0.0122	-0.1249	0.2631	-0.2054
	R&D	-0.0010	-0.3476	0.1547	0.4986***
81-99	R&D+ Pat.	-0.0123	-0.4311*	0.0034	0.5257***
	g_A	-0.0455**	-0.4269**	1.0954*	0.6472***

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 25: U.S. Male Wage Inequality and Combined Indicator

		β_0	β_1	β_2	β_3
Bachelor versus no Bachelor Degree					
65-95	R&D	0.0085	-0.0428	0.3690***	0.1206
	R&D+ Pat.	0.0127*	-0.0624	-0.0533	-0.0122
	g_A	-0.0045	-0.0439	0.4995	0.0840
65-80	R&D	0.0422***	0.0061	0.9120***	-0.3395
	R&D+Pat.	0.0156	-0.0735	-0.0085	-0.1621
	g_A	-0.0010	-0.0771	0.4459	-0.0544
80-95	R&D	0.0059	-0.0159	0.2435**	0.2527*
	R&D+ Pat.	0.0182**	-0.0120	-0.2645*	0.1274
	g_A	-0.0172	0.0318	0.8705	0.3452*
Bachelor versus High School Degree					
65-95	R&D	0.0111***	-0.0425	0.4028***	0.0227
	R&D+ Pat.	0.0109***	-0.0623	0.0368	-0.0574
	g_A	-0.0057	-0.0451	0.5897	0.0195
65-80	R&D	0.0339***	0.0766	0.8853***	-0.5594***
	R&D+Pat.	0.0164*	0.0021	0.0497	-0.5105*
	g_A	0.0012	-0.0121	0.4040	-0.3227
80-95	R&D	0.0099**	-0.0358	0.2991***	0.1333
	R&D+ Pat.	0.0178***	-0.0251	-0.1487	0.0457
	g_A	0.0015	-0.0048	0.4535	0.1073
High School versus no High School Degree					
65-95	R&D	-0.0004	0.0311	-0.1308	0.1214
	R&D+ Pat.	0.0064	0.0160	-0.2454***	0.0060
	g_A	0.0102	0.0224	-0.3869	0.1198
65-80	R&D	-0.0046	-0.0648	-0.0627	0.2791**
	R&D+Pat.	-0.0032	-0.0595	-0.0367	0.2645*
	g_A	0.0160*	-0.0631	-0.8724***	0.3302***
80-95	R&D	0.0048	0.0372	-0.1359	-0.0236
	R&D+ Pat.	0.0188**	0.0069	-0.4221***	-0.1996
	g_A	0.0062	0.0252	-0.0340	-0.0808

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 26: U.S. Male Wage Inequality and LMI = BRR

		β_0	β_1	β_2	β_3
Bachelor versus no Bachelor Degree					
65-95	R&D	0.0092*	-0.0153	0.3742***	0.1101
	R&D+ Pat.	0.0139*	-0.0179	-0.0517	-0.0315
	g_A	-0.0050	-0.0045	0.5485	0.0725
65-80	R&D	0.0407***	-0.0131	0.8968***	-0.3137
	R&D+Pat.	0.0156	-0.0399	-0.0063	-0.1548
	g_A	-0.0000	-0.0398	0.4231	-0.0554
80-95	R&D	0.0062	0.0146	0.2406**	0.2530*
	R&D+ Pat.	0.0184**	-0.0128	-0.2603*	0.1297
	g_A	-0.0247	0.0521	1.0918*	0.3872**
Bachelor versus High School Degree					
65-95	R&D	0.0117***	-0.0201	0.4079***	0.0154
	R&D+ Pat.	0.0117***	-0.0216	0.0414	-0.0749
	g_A	-0.0060	-0.0088	0.6231	0.0062
65-80	R&D	0.0325***	0.0287	0.8858***	-0.5372**
	R&D+Pat.	0.0166*	0.0068	0.0462	-0.5249*
	g_A	0.0026	0.0007	0.3744	-0.3520
80-95	R&D	0.0107**	-0.0075	0.2970***	0.1236
	R&D+ Pat.	0.0183***	-0.0039	-0.1499	0.0388
	g_A	-0.0005	-0.0133	0.5331	0.1102
High School versus no High School Degree					
65-95	R&D	-0.0010	0.0270	-0.1336	0.1271
	R&D+ Pat.	0.0059	0.0189	-0.2425***	0.0133
	g_A	0.0092	0.0187	-0.3644	0.1229
65-80	R&D	-0.0038	-0.0386	-0.0454	0.2778**
	R&D+Pat.	-0.0027	-0.0372	-0.0331	0.2620*
	g_A	0.0174**	-0.0445*	-0.9013***	0.3239***
80-95	R&D	0.0034	0.0503	-0.1458	0.0085
	R&D+ Pat.	0.0174*	0.0302	-0.4102***	-0.1621
	g_A	-0.0001	0.0494	0.0144	-0.0375

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 27: Correlation $\beta_{0,t}$ with Union Density, U.S.

	Males			Females		
Bachelor vs. no Bachelor						
	64-99	64-81	81-99	64-99	64-81	81-99
$\frac{R\&D}{GDP}$	0.11	-0.02	0.09	0.04	0.31**	-0.05
R&D + Pat.	-0.05	-0.15	-0.04	-0.03	0.25*	-0.17
g_A	-0.07	-0.21	-0.04	-0.08	0.19	-0.15
Bachelor vs. High School						
	64-99	64-81	81-99	64-99	64-81	81-99
$\frac{R\&D}{GDP}$	0.11	-0.06	0.28*	0.13	0.42***	0.04
R&D + Pat.	-0.05	-0.20	0.08	0.06	0.35**	-0.06
g_A	-0.12	-0.29*	0.10	0.04	0.41***	-0.04
High School vs. no High School						
	64-99	64-81	81-99	64-99	64-81	81-99
$\frac{R\&D}{GDP}$	-0.02	0.06	-0.54***	-0.34***	0.29*	-0.21*
R&D + Pat.	-0.06	0.07	-0.44***	-0.21*	-0.22*	-0.21*
g_A	0.05	0.15	-0.51***	-0.34***	-0.37**	-0.17

*Significance: ***=95 % ; **=90 % ; *=80 %*

Table 28: Correlation $\beta_{0,t}$ with BRR, U.S.

	Males			Females		
Bachelor vs. no Bachelor						
	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{R\&D}{GDP}$	0.09	0.13	0.07	-0.09	-0.13	-0.06
R&D + Pat.	0.04	0.06	0.02	-0.10	-0.17	-0.02
g_A	0.07	0.07	0.08	-0.10	-0.16	-0.04
Bachelor vs. High School						
	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{R\&D}{GDP}$	0.02	0.16	-0.06	0.07	0.04	0.13
R&D + Pat.	-0.01	0.06	-0.06	0.05	0.02	0.12
g_A	0.02	0.08	-0.01	-0.00	0.02	0.01
High School vs. no High School						
	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{R\&D}{GDP}$	0.16	-0.06	0.35**	-0.30***	-0.16	-0.50***
R&D + Pat.	0.14	-0.02	0.28*	-0.24**	-0.16	-0.38**
g_A	0.15	-0.05	0.35**	-0.18	-0.13	-0.28*

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 29: Correlation $\beta_{0,t}$ with Combined Indicator, U.S.

Bachelor vs. no Bachelor						
	Males			Females		
	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{R\&D}{GDP}$	0.07	0.12	0.03	-0.08	-0.03	-0.05
R&D + Pat.	-0.02	0.04	-0.04	-0.10	-0.08	-0.04
g_A	0.00	0.02	0.02	-0.12	-0.07	-0.07
Bachelor vs. High School						
	Males			Females		
	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{R\&D}{GDP}$	0.01	0.16	-0.05	0.07	0.11	0.14
R&D + Pat.	-0.06	0.03	-0.09	0.04	0.07	0.12
g_A	-0.05	0.21	-0.04	-0.01	0.09	0.01
High School vs. no High School						
	Males			Females		
	64-95	64-79	80-95	64-95	64-79	80-95
$\frac{R\&D}{GDP}$	0.12	-0.08	0.23	-0.35***	-0.15	-0.56***
R&D + Pat.	0.08	-0.03	0.16	-0.26**	-0.15	-0.43***
g_A	0.13	-0.05	0.23	-0.23**	-0.36	-0.36**

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 30: Determinants of $\beta_{0,t}$, LMI = UD , U.S. 1964-1999

	Bachelor vs. no Bachelor Degree					
	Males			Females		
	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2
R&D	0.0287***	-0.1248*	0.0233	0.0161***	-0.0799	0.0045
R&D + Pat.	0.0296***	-0.2079***	-0.0833	0.0149***	-0.1133	-0.0492
g_A	0.0225***	-0.2395***	-0.1031*	0.0120***	-0.1634*	-0.0920
	Bachelor vs. High School Degree					
	Males			Females		
	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2
R&D	0.0219***	-0.1496**	0.0166	0.0214***	-0.2171**	0.0259
R&D + Pat.	0.0206***	-0.2271***	-0.0902	0.0207***	-0.2608***	-0.0343
g_A	0.0108***	-0.2019***	-0.1489**	0.0296***	-0.2483***	-0.0396
	High School vs. no High School Degree					
	Males			Females		
	γ_0	γ_1	γ_2	γ_0	γ_1	γ_2
R&D	0.0166***	0.0550	0.0044	-0.0058*	-0.1289	-0.1999***
R&D + Pat.	0.0216***	0.0312	-0.0183	-0.0095***	-0.2337***	-0.0728
g_A	0.0205***	0.1028	-0.0541	-0.0329***	-0.0709	-0.1925***

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 31: Determinants of $\beta_{0,t}$ LMI = BRR, U.S. Females

		γ_0	γ_1	γ_2
Bachelor versus no Bachelor Degree				
64-95	R&D	0.0177***	-0.0188	-0.0766
	R&D+ Pat.	0.0168***	-0.0202	-0.0886
	g_A	0.0141***	-0.0233	-0.1346
64-79	R&D	0.0123**	-0.0261	-0.0961
	R&D+ Pat.	0.0105**	-0.0307	-0.0867
	g_A	0.0039	-0.0286	-0.0869
80-95	R&D	0.0184***	-0.0062	0.1074
	R&D+ Pat.	0.0183***	-0.0022	0.0649
	g_A	0.0172***	-0.0061	0.0285
Bachelor versus High School Degree				
64-95	R&D	0.0222***	0.0015	-0.2097**
	R&D+ Pat.	0.0218***	-0.0016	-0.2341***
	g_A	0.0310***	-0.0112	-0.2321**
64-79	R&D	0.0208***	-0.0190	-0.3271***
	R&D+ Pat.	0.0184***	-0.0223	-0.3188***
	g_A	0.0242***	-0.0186	-0.2782***
80-95	R&D	0.0202***	0.0219	0.0669
	R&D+ Pat.	0.0210***	0.0221	0.0227
	g_A	0.0313***	0.0017	0.0472
High School versus no High School Degree				
64-95	R&D	-0.0036	-0.0511**	0.1535*
	R&D+ Pat.	-0.0080**	-0.0336*	0.2466***
	g_A	-0.0315***	-0.0262	0.1148
64-79	R&D	0.0187***	0.0005	0.3879***
	R&D+ Pat.	-0.0111*	-0.0048	0.3317**
	g_A	-0.0406***	-0.0408	-0.2799*
80-95	R&D	0.0003	-0.0878***	0.0983
	R&D+ Pat.	-0.0063*	-0.0607**	0.1719
	g_A	-0.0265***	-0.0371	0.0212

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 32: Determinants of $\beta_{0,t}$ (LMI = BRR), U.S. Males

Bachelor versus no Bachelor Degree				
		γ_0	γ_1	γ_2
	R&D	0.0295***	0.0057	-0.1104*
64-95	R&D+ Pat.	0.0310***	-0.0029	-0.1678**
	g_A	0.0237***	0.0011	-0.1907***
	R&D	0.0333***	-0.0016	-0.1633**
64-79	R&D+ Pat.	0.0288***	-0.0036	-0.1366
	g_A	0. —	-0. —	-0.—
	R&D	0.0278***	0.0087	-0.1016
80-95	R&D+ Pat.	0.0321***	0.0011	-0.1803
	g_A	0.0251***	0.0113	-0.2116*
Bachelor versus High School Degree				
	R&D	0.0229***	-0.0048	-0.1451**
64-95	R&D+ Pat.	0.0222***	-0.0109	-0.1892***
	g_A	0.0125***	-0.0094	-0.2510***
	R&D	0.0203***	0.0063	-0.0960
64-79	R&D+ Pat.	0.0159***	0.0004	-0.0786
	g_A	0.—	0.—	0.—
	R&D	0.0242***	-0.0134	-0.1730
80-95	R&D+ Pat.	0.0257***	-0.0139	-0.2524**
	g_A	0.0176***	-0.0067	-0.3173***
High School versus no High School Degree				
	R&D	0.0158***	0.0272	0.0789
64-95	R&D+ Pat.	0.0210***	0.0187	0.0446
	g_A	0.0195***	0.0278*	0.1122*
	R&D	0.0304***	-0.0216	-0.1895**
64-79	R&D+ Pat.	-0.0302***	-0.0152	-0.1634*
	g_A	0.—	0.—	0.—
	R&D	0.0083**	0.0599**	0.2276**
80-95	R&D+ Pat.	0.0154***	0.0417**	0.2215**
	g_A	0.0199***	0.0565**	0.2739***

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 33: Determinants of $\beta_{0,t}$ (LMI = CI), U.S. Females

		γ_0	γ_1	γ_2
Bachelor versus no Bachelor Degree				
	R&D	0.0175***	-0.0326	-0.0801
64-95	R&D+ Pat.	0.0167***	-0.0416	-0.0962
	g_A	0.0140***	-0.0530	-0.1461*
	R&D	0.0114**	-0.0261	-0.0802
64-79	R&D+ Pat.	0.0098*	-0.0350	-0.0753
	g_A	0.0032	-0.0326	-0.0764
	R&D	0.0183***	-0.0052	0.1069
80-95	R&D+ Pat.	0.0182***	-0.0771	0.0622
	g_A	0.0171***	-0.0160	0.0233
Bachelor versus High School Degree				
	R&D	0.0222***	-0.0010	-0.2114**
64-95	R&D+ Pat.	0.0219***	-0.0141	-0.2408***
	g_A	0.0310***	-0.0310	-0.2408***
	R&D	0.0204***	-0.0230	-0.3213***
64-79	R&D+ Pat.	0.0182***	-0.0335	-0.3177***
	g_A	0.0237***	-0.0193	-0.2697**
	R&D	0.0204***	0.0504	0.0825
80-95	R&D+ Pat.	0.0212***	0.0417	0.0345
	g_A	0.0313***	0.0079	0.0501
High School versus no High School Degree				
	R&D	-0.0039	-0.1066***	0.1337
64-95	R&D+ Pat.	-0.0084**	-0.0597*	0.2395***
	g_A	-0.0315***	-0.0641*	0.0992
	R&D	-0.0191***	0.0135	0.3992***
64-79	R&D+ Pat.	-0.0117*	0.0021	0.3461**
	g_A	-0.0405***	-0.0128	0.2743*
	R&D	0.0021	-0.1757***	0.0473
80-95	R&D+ Pat.	-0.0070*	-0.1207**	0.1369
	g_A	-0.0269***	-0.0866**	0.0057

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 34: Determinants of $\beta_{0,t}$ (LMI = CI), U.S. Males

Bachelor versus no Bachelor Degree				
		γ_0	γ_1	γ_2
64-95	R&D	0.0297***	0.0028	-0.1134*
	R&D+ Pat.	0.0312***	-0.0258	-0.1802**
	g_A	0.0240***	-0.0218	-0.2041***
64-79	R&D	0.0334***	-0.0086	-0.1687**
	R&D+ Pat.	0.0292***	-0.0171	-0.1466*
	g_A	0.0221***	-0.0244	-0.1729*
80-95	R&D	0.0279***	-0.0011	-0.1047
	R&D+ Pat.	0.0321***	-0.0271	-0.1925
	g_A	0.0252***	0.0111	-0.2197*
Bachelor versus High School Degree				
64-95	R&D	0.0229***	-0.0129	-0.1492***
	R&D+ Pat.	0.0223***	-0.0381	-0.2022***
	g_A	0.0127***	-0.0438	-0.2685***
64-79	R&D	0.0204***	0.0088	-0.0969
	R&D+ Pat.	0.0163***	-0.0094	-0.0875
	g_A	0.0033	-0.0143	-0.1109
80-95	R&D	0.0248***	-0.0288	-0.1821
	R&D+ Pat.	0.0255***	-0.0464	-0.2686**
	g_A	0.0176***	-0.0370	0.3316***
High School versus no High School Degree				
64-95	R&D	0.0162***	0.0403	0.0801
	R&D+ Pat.	0.0213***	0.0228	0.0426
	g_A	0.0198***	0.0481	0.1172*
64-79	R&D	0.0308***	-0.0058	-0.2048*
	R&D+ Pat.	0.0304***	-0.0358	-0.1723*
	g_A	0.0363***	-0.0433	-0.1968**
80-95	R&D	0.0089**	0.0853*	0.2473**
	R&D+ Pat.	0.0159***	0.0563	0.2339**
	g_A	0.0115***	0.0851**	0.2946***

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 35: Germany 1973-1998, Overall Wage Inequaity

LMI = Union Density				
	γ_0	γ_1	γ_2	γ_3
R&D	0.0022*	0.0331	0.0511*	-0.0649
R&D + Pat.	0.0015	0.0436	0.1428**	-0.0638
g_A	-0.0009	0.0281	0.0649	-0.0495
LMI = BRR				
	γ_0	γ_1	γ_2	γ_3
R&D	0.0014	-0.1080*	0.0728***	-0.0584
R&D + Pat.	0.0009	-0.0514	0.1472**	-0.0585
g_A	-0.0055	-0.0751	0.1507	-0.0459
LMI = CI				
	γ_0	γ_1	γ_2	γ_3
R&D	0.0017	-0.0354	0.0617**	-0.0669
R&D + Pat.	0.0013	0.0207	0.1471**	-0.0689
g_A	-0.0115	-0.1496	0.2695*	-0.0505

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 36: Germany 1973-1998, Males,

LMI = Union Density				
	γ_0	γ_1	γ_2	γ_3
R&D	0.0023*	-0.0710*	0.1085***	0.0463
R&D + Pat.	0.0016	-0.0448	0.1998***	0.0437
g_A	0.0107	0.0008	-0.1736	0.1059**
LMI = BRR				
	γ_0	γ_1	γ_2	γ_3
R&D	0.0032***	0.0297	0.0956***	0.0279
R&D + Pat.	0.0025**	0.1045	0.2023***	0.0227
g_A	0.0134**	0.1349*	-0.2217*	0.1078**
LMI = CI				
	γ_0	γ_1	γ_2	γ_3
R&D	0.0022*	-0.1431*	0.0118***	0.0343
R&D + Pat.	0.0018	-0.0304	0.2012***	0.0317
g_A	0.0206**	0.1895	-0.3684*	0.1205**

*Significance: ***=95 % ; **=90 % ; *=85 %*

Table 37: Germany 1973-1998, Females,

LMI = Union Density				
	γ_0	γ_1	γ_2	γ_3
R&D	-0.0006	-0.0526	0.1461***	0.1105***
R&D + Pat.	-0.0016	-0.0195	0.2899***	0.1070**
g_A	0.0032	-0.0166	-0.0181	0.0344
LMI = BRR				
	γ_0	γ_1	γ_2	γ_3
R&D	-0.0006	-0.0279	0.1445***	0.1211***
R&D + Pat.	-0.0010	0.0876	0.2837***	0.1036**
g_A	0.0083	0.1259*	-0.1075	0.0201
LMI = CI				
	γ_0	γ_1	γ_2	γ_3
R&D	-0.0012	-0.1448*	0.1589***	0.1186***
R&D + Pat.	-0.0016	0.0025	0.2905***	0.1110**
g_A	0.0105	0.1041	-0.1575	0.0290

*Significance: ***=95 % ; **=90 % ; *=85 %*