Co-determination and Innovation

by

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Abstract

This paper examines the effect of the German co-determination law of 1976 (MitbestG) on the innovative activity of German firms. Co-determination applies to firms with 2000 employees or more. Data from 1971-1990 on 162 firms are used to compare the number of patents granted to co-determined firms before and after the introduction of the law. Several control variables are applied and in particular, in order to avoid a possible bias from specific effects of firm size, we compare the co-determined firms with others before and after 1976. The results do not support the view that co-determination slows down technological progress and reduces innovativeness.

JEL Classification: J5, L2, O3

Key Words*:* Co-determination, Innovation, Patents

1. Introduction

Since the introduction of the first co-determination laws in Germany in the fifties, their effects have been the subject of much discussion and controversy. Irrespective of this discussion, the laws have been extended, most recently as part of works constitution act in 2001[1]. Furthermore, the European Union is thinking about introducing similar rules at a European level. Although the European regulations will have less far-reaching effects on workers' rights than the German ones, the German experience should be of interest for policy making.

The discussion at EU level started during the 90's. Although it is still unclear, exactly what form this should take, it was always agreed upon that the regulations should not exceed the German level, but remain below it. The Davignon group of experts on the co-determination issue suggested in 1997 that co-determination laws should be determined by the firms themselves. The EU should just secure a minimum of rights for the employees. However, the Davignon group put forward a co-determination law similar to the German one with worker representatives as members of the supervisory board. In a related vein, the commission "Mitbestimmung", a group of experts on co-determination laws, argued (Final report of the Commission for Co-determination, Chapter 10, our translation):

> *"Co-determination in the future must be arranged as part of the self organization of society; also any potentially legal reforms must be orientated toward this example."*

The expected effects of co-determination are discussed quite intensively and with very distinct views. An important issue arising during the discussion about the effects of co-determination is technological progress. It is frequently supposed that at the very least co-determination will increase the time needed to reach decisions. This may well negatively affect the introduction time of process and product innovations. Other, non- co-determined firms might react more flexibly and the larger co-determined firms would in this case lose innovative potential.

[1] Works Constitution Act Revision of 22.6.2001.

However, a direct effect of co-determination may also exist as workers might oppose the introduction of process innovations, if they fear negative effects on employment. Product innovations might also be affected, since product innovations go hand in hand with a reorganization of work and the workers will presumably dislike any new organization. On the other hand, it is frequently argued that co-determination improves information management in a firm, and improved information will most probably have a positive impact on technological progress. In our view, it remains an empirical question as to whether co-determination has a negative or positive effect on innovation.

In contrast to the intense theoretical discussion and the research on the effects of works councils, very few empirical studies exist which examine the effects of co-determination. The purpose of this paper is to study the effects of the German co-determination law of 1976 on technological progress, estimated at firm level. Our measure for technological progress is the number of patents granted to a particular company.

2. Institutional Facts

Aside from countries like the Netherlands, Luxembourg or Denmark, Germany has the furthest reaching regulations concerning worker co-determination. The two most important acts are the works constitution act and the co-determination law. The workers rights at plant level are determined by the works constitution act from 1972 (BetrVG 1972). According to this law, in firms with five or more workers, the employees can ask for the introduction of a works council. The works council has co-determination rights on “hiring and firing” decisions, on technological change and many other issues. The co-determination rights depend in part on the size of the plant. For example, if the plant has 100 employees or more, the management is required to inform the works council about major economic developments. The works councils are not allowed to negotiate about wages, but there may be indirect ways of influencing the wage level.

A second size effect is determined by the fact that many small firms do not have a works council at all and that the probability of its existence strictly increases with the number of employees. In firms with less than 20 employees only 5% have a

works council. However, 99% of the larger plants with 1000 or more employees do have a works council[2].

In contrast to the works constitution act, the co-determination law is put into practice in all firms where it can be applied. It is based on three different laws. The coal and mining industry has had full parity co-determination since 1951[3]. The most significant regulation is that on the supervisory board, 50% of the seats go to the workers (in the case of a conflict, an external member who is said to be neutral decides). In addition, the member of the top management who is responsible for the employees (personal director) must be approved by the workers (or their representatives).

The first version of the works constitution act was passed in 1952. Aside from the rights discussed above, there is also a co-determination right according to this law. Firms with 500 to 2000 employees must give one third of the seats in the supervisory board to the workers.

The third co-determination law and perhaps the one with the most important effects on the economy as a whole is the co-determination law of 1976 (MitbestG). It applies to firms with at least 2000 employees. In such companies, the employees have the right to a 50% representation on the supervisory board. However, in contrast to the regulations in the coal and mining industry, in case of a conflict the chairman of the supervisory board, who is determined by the capital owners, has two votes. Hence one must speak in this case of quasi-parity. Another difference with respect to the coal and mining industry is that the personal director does not require the approval of the employees.

It is possible that the co-determination law has no effect at all, since in the case of conflict the capital owners still have the majority of the votes. However, the practice of co-determination means that nearly all decisions are reached unanimously and thus the board tries to reach a consensus. The employees might ask for the approval of one issue as “compensation”, when the interests of the employees are affected.

In our view, there appears to be two main differences between co-determination based on the works council and the supervisory board: The works council does not exist in many firms and the decision of the workforce to ask for it is unlikely to be accidental. This means that firms with a works council must not be

[2] Addison, Schnabel and Wagner (2000), Niedenhoff (1997).

representative for the whole economy, but subject to a selection process and research must take this into account. Firms with a works council might be those with particularly bad industrial relations. They might, however, be those with a stable workforce, low turnover rates, highly qualified workers, as these workers are interested in the firm in question and take on responsibility. On the other hand, the co-determination law is mandatory. There is no choice and therefore the effects of this kind of regulation is not "contaminated" by selection effects of one kind or another.

Secondly, the works council is responsible for social affairs and industrial relations and here it has some powerful rights, but the "hard" economic topics like investment and so on are still within the responsibility of top management. The works councils are informed only concerning economic developments (if the plant has 100 or more employees) but that is all. In contrast, the co-determination law requires a participation of the workers on all essential decisions at the highest level within the firm. The most important right is perhaps the appointment of the top management and the renewal or non-renewal of their contracts. Moreover, investment or dismissals above a certain limit have to be approved by the supervisory board. Hence, this is much more than information.

In practice there is a considerable overlap between the works council members and the members of the supervisory board appointed by the employees. While considerable empirical research on the effects of the works council exists, there are very few results on co-determination. Given the general relevance of the question as to how mandatory co-determination affects firm performance in the light of the controversial hypotheses and the EU's interest in introducing a similar scheme at European level, the analysis should find some attention.

2. Theoretical Considerations

2.1 General Discussion

The theoretical discussion is quite controversial and apparently also affected by ideological positions. In the first step, one might ask whether co-determination will have any effect. As mentioned above, in the case of a conflict the capital owners still

[3] The "Montanmitbestimmungsgesetz" in Germany is thereby the oldest still existing law of this kind.

have the majority of the votes. With this in mind, why should co-determination have any effect at all?

The commission “Mitbestimmung” also discusses this point and argues that the overwhelming majority of all decisions are unanimous. The supervisory board attempts to reach decisions which are acceptable to all members. Consensus is perhaps not a bad idea if decisions have to be reached in the company, and the workforce will show improved motivation if they recognize that their interests are also being taken into account. (Final report of the Commission Co-determination Chapter 8, Nr. 2 and Nr. 5). Information of the employees and the extent to which they can participate in discussion appear to be useful in reaching fair decisions. In practice, it is highly probable that the views on “fairness” will differ between capital owners and workers. However, unanimous decisions will be accepted more easily by the employees as being fair, and equity considerations might well have their affect productivity (cf. for example in a different context Akerlof and Yellen 1990).

Even if the result is a cooperative one, decisions will certainly take longer if a consensus is needed; compromises will in part limit the interests of the capital owners and flexibility is necessarily reduced. It is clearly possible that such an environment reduces the innovativeness of an organization. Co-determination may well lead to a tendency to maintain the status quo in order to avoid any conflict. Such a scenario is obviously the contrary of an innovative situation. Hence consensus may well have some positive aspects here and there, but this strategy may at the same time have a negative impact on innovation.

Concerning mandatory co-determination, there are two schools in economics with very different opinions. According to the property rights theory, decision rights must be concentrated among those persons who bear the risk. In a market economy these are still the capital owners. Workers are assumed to have a different time horizon, at least not the infinite horizon of maximizing the present value of the firm. According to this argument, long-term investments are not in the interest of the workforce, and this is a point against R&D expenditures. A *technological immobility* and an overemphasis on employment related aspects are thus expected by some people (Final report of the Commission Co-determination, Chapter 8). Von Weizsäcker (1983, p.146) also shares this opinion and explicitly considers co-determination on the supervisory board and its effect on innovativeness (our translation):

> *"The ability of an enterprise to react flexibly to changed conditions, to become aware of innovation possibilities, to weight risks against opportunities is affected very strongly by its internal organization and decision structure.* [...] *Co-determination divides the decision rights in the enterprise and therefore in fact leads to a reduction of its decision and co-ordination strength."*

It is most likely in cases where the supervisory board has to decide about large-scale redundancies and/or the closure of plants that the workers' representatives will try to delay decisions. However, such a delay may lead to the bankruptcy of the whole firm (Weizsäcker, 1983). Members of the commission co-determination also consider this problem (Final Report of the Commission Co-determination, Chapter 8, Nr. 20, our translation):

> *"Such an organisational structure has the disadvantage not only of depending on time-consuming consultation processes - the working of which must be cultivated carefully - but it is also inclined to decide rather conservatively."*

The property rights theory, in general, dislikes intervention by government into the decision rights of firms. The argument is that if it were efficient, then it would emerge in an evolutionary way by itself (see among others Jensen and Meckling 1979). Clearly this argument is relevant, although there are possible situations where the market mechanism does not work. Additional support for a skeptical view concerning this law might come from a political-economic perspective. The co-determination law of 1976 was passed during the SPD/FDP (social democrats and liberals) government. Traditionally, the social democrats are associated with unions and one could argue that this government introduced this law in order to do the unions a favor, even if the whole economy does not benefit from it. This has some logic, if one believes in rent-seeking.

The participation theorists, on the other hand, argue that the market process does not necessarily lead to a first best solution. Co-determination enables the use of information from the employees, which would otherwise be lost. Furthermore, it will lead to a more cooperative solution, and the conflict between capital owners and the workers is reduced if not solved. According to this view, productivity will increase as a result, and such firms will be successful on the market.

Freeman and Lazear (1995) offer a number of arguments as to why the market solution may be inefficient. They state that any participation rights are connected with a redistribution and that it is this redistribution process which impedes voluntary agreement. The authors start from the assumption that the organization has a rent R, which depends on the bargaining power of the workers x. The rent first rises and then declines in x. The share $\tau(x)$ of the rent goes to the workers and this share also depends on x, with an increasing share if x rises.
The firm maximizes:

$$(1-\tau(x))R(x) \qquad \text{and this implies}$$

$$\underbrace{-\tau'(x)R(x)}_{<0}+\underbrace{(1-\tau(x))R'(x)}_{>0}=0\,.$$

Therefore there is not enough co-determination if rent maximization is the aim.

On the other hand the incentives of the workers are:

$$U=\tau(x)R(x)$$

and this in turn yields:

$$U'=\underbrace{\tau'(x)R(x)}_{>0}+\underbrace{\tau R'(x)}_{<0}=0$$

Then we have too much co-determination if again the rent should be maximized $(R'(x)=0)$.

Levine and Tyson (1990) develop a model related to the market for lemons. They assume that on the labor market there are good and bad workers. Lemons seek employment in co-determined firms, as they expect to receive a remuneration there which is based on the average productivity. The better workers will prefer employment at firms which are not co-determined, as they can receive a wage based on their individual (higher) productivity. If the firms are unable to identify the lemons, they will not introduce co-determination by themselves. For this reason, co-determination will not be introduced even if it has some positive aspects for the firm as a whole. A mandatory requirement for co-determination solves this problem[4].

[4] The model contradicts the observation that rather human-capital intensive companies introduce participation rights voluntarily.

As mentioned above, a frequent argument quoted in favor of co-determination is the supposed possibility of using information from the workers which would otherwise be lost. We will not restart the discussion as to why this is not possible by introducing voluntary participation schemes.

The commission co-determination (final report, Ch. 3 and 8) supports the view of productivity enhancing effects of co-determination (our translation):

> *"Despite all the difficulty of an accurate measurement, many critics of co-determination also accept the peace-keeping and productive effects of consent and co-operation, which are supported by co-determination rights, in principle."*

Finally, one may ask whether the discussion on co-determination is always based on a purely rational argumentation. Sometimes the owners are not willing to share their decision rights, simply because they like to decide on their own. This may or may not be efficient, but that is not the reason for them to behave in this way.

Theory is unable to answer our question and it remains a task for empirical research. Therefore, in this respect (and not necessarily in other ones), we follow Junkes and Sadowski (1999, S.63, our translation):

> *"Theoretically there is (still) no generally accepted answer to the question of the economic effects of laws of co-determination. Rather, it appears necessary to look for empirically measurable effects concerning supervisory board co-determination laws in Germany."*

2.2 A Model on Co-determination and Innovation

We start from a model on co-determination developed by Kraft (1998, 2001) and extend it to include R&D expenditures. In contrast to Kraft (2001) we are only able to solve the model for rather simple situations: we assume a duopoly with symmetric bargaining power and the firms either bargain or maximize profits without co-determination, but we do not consider asymmetric solutions with one bargainer and

one profit-maximizer. However, we include product differentiation, which was omitted in the earlier studies.

Bargaining on Employment in Contrast to Profit Maximization

The purpose of this section is a simple comparison between bargaining over employment and profit maximization with respect to the incentives to perform R&D. The starting point of the theoretical analysis is the assumption that wages are determined by an exogenous process at industry level, which is consistent with the German institutional setting. Exogenous means not influenced at individual firm level, as is the case if wages are negotiated at economy-wide level.

Decisions are reached by negotiations between the employees and the firm owner. We are only able to solve the model for symmetric bargaining power. Hence, this is a difference to Kraft (1998, 2001).

Employment is determined at the level of the individual firm. The bargaining solution will be compared to the situation where employment is fixed by the employer alone. Bargaining takes place between the firm owner(s) and representatives of the employees. This might be the union or any other representative body. Industry unions, on the other hand, are not considered. This scenario is consistent, for example, with German co-determination, where representatives of the firm's employees decide. In most cases, these are members of the German unions, but this is no precondition for such a task.

We assume a duopoly situation with Cournot-Nash optimization. As Booth (1995, 95) observes: "It appears to be an empirical regularity that imperfections in the labor market are correlated with imperfections in the product market". Unions will only be able to negotiate employment (or wage) increases above the competitive level if there is some rent or surplus to be distributed. Thus it does not appear to be a purely academic exercise to investigate bargaining power by unions (or other workers' representatives institutions) within the context of oligopoly. The two firms 1 and 2 produce an identical product. Demand is determined according to a negatively sloped inverse demand curve of this particular shape:

$$P = d - b(q_i + \theta q_j). \tag{1}$$

Of course *P* stands for the price and q_i (q_j) is output by firm 1 (firm 2). The slope of the demand curve is determined by the parameter *b* and in contrast to earlier work we include here product differentiation by the term $0 \le \theta \le 1$. If $\theta = 0$ we have two monopolies and with $\theta = 1$ the products are homogenous.

We start with bargaining, assuming the bargaining process to be represented by the well-known Nash-bargaining solution. As shown by Binmore, Rubinstein and Wolinsky (1986), the simple Nash solution may still be used as the equilibrium outcome of a sequence of non-cooperative moves. Thus this specification is more general than it initially appears.

The union has utility *Z(w,L)* which depends positively on both, employment *L* and wages. Specifically following e.g. McDonald and Solow (1981) or Dowrick (1990), we set:

$$Z(w,L) = LU(w),$$

where *U* is a differentiable utility function. Given that the wage is determined elsewhere, only employment remains to be maximized.

Aside from wages per output unit, the costs *c* for material and other inputs arise. R&D expenditures are considered similarly to a specification proposed by d'Aspremont and Jaquemin (1988) and applied by many others. According to them the innovative activities (called *x*) reduce production costs and are therefore used for process innovations. The costs of innovative activity are $\gamma \frac{x^2}{2}$ and the term γ is called efficiency parameter. The profit equation in this case is:

$$\max \pi_i = \left[d - \left(q_i - \theta q_j \right) - w - c + x \right] q_i - \gamma \frac{x^2}{2}$$

The variable costs accordingly are $C_i = \left(c - x + w \right) q_i$. The second order conditions require that $\gamma > 2/\left(\theta + 2 \right)^2$ and we assume that this condition is satisfied.

Usually this specification is applied to process innovation, but it can also be used for product innovation. In this case we interpret R&D expenditures as measures to improve the quality of a particular good. Now x shifts the demand curve to the right and we specify this situation as an increase of d. The profit equation is then

$$\max \pi_i = \left[d + x - \left(q_i - \theta q_j \right) - w - c \right] q_i - \gamma \frac{x^2}{2},$$

which is exactly the same as above.

In order to proceed, a concrete and extremely simple production function is applied: q=*L* (cf. for a similar assumption Dowrick 1989, 1990 and Bughin 1995). Now the bargaining as well as the profit maximization process is easily described. We use the Nash-bargaining solution. Bargaining is represented by the following product in the case of symmetric bargaining power:

(2) $$\max V = \left[\left[d - \left(q_i - \theta q_j \right) - w - c + x \right] q_i - \gamma \frac{x^2}{2} \right] \left[\mathrm{U}(\mathrm{w},\mathrm{L}) q_1 \right]$$

The threat points have been set to zero for both parties following a popular simplification found, among others, in Fershtman (1985), Bughin (1995) or Booth and Chatterji (1995). This seems to be defensible for the employer, as no capital and thus sunk costs are considered. On the other hand it implies that other employment opportunities outside of this particular industry are disregarded.

It is only bargained on employment, not on *x*. The model becomes trivial there if it is also bargaining about R&D, as the employees always have an incentive to increase x, as output then rises. After logarithmization this equation is maximized with respect to q_i, which leads to the reaction function:

(3) $$q_{ib} = \frac{4}{3} \frac{\gamma (d - \theta q_j - w - c)}{2\gamma - 1} .$$

Symmetric Bargaining or Profit-Maximizing Firms

As mentioned above, we are only able to solve the model for symmetric bargaining or symmetric profit maximization. The asymmetric solutions with one firm bargaining and one firm maximizing profits are too complicated for an explicit solution with two endogenous variables *q* and *x*.

If both firms are bargainers and behave according to Cournot-Nash they end up with the following output level:

(4) $$q_{ib} = 4\frac{\gamma \cdot (d - w - c)}{4\gamma \cdot \theta + 6\gamma - 3};\ \ i = 1,2\ .$$

The firms choose optimal employment (output) as well as optimal x simultaneously. It is then solved for x:

(5) $$x_{ib} = 4\frac{(d - w - c)}{4\gamma \cdot \theta + 6\gamma - 3};\ \ i = 1,2\,.$$

Hence the resulting profits for each firm are:

(6) $$\pi_{ib} = 4\gamma(d - w - c)^2 \cdot \frac{(2\gamma - 1)}{(4\gamma \cdot \theta + 6\gamma - 3)^2};\ i = 1,2\,.$$

In order to compare the bargaining outcome with the 'traditionally' assumed employment determination, we next consider profit maximization without any restriction (*ß*=1). The firm is simply maximizing $\pi = (d - b(q_i + \theta q_j) - w)q_i$, which yields the following reaction function:

(7) $$q_{iP} = \frac{\gamma(d - \theta q_j - w - c)}{2\gamma - 1};\ \text{i}\neq\text{j}.$$

Output and expenditures for *x* are in this case:

(8) $$q_{iP} = \frac{\gamma(d - w - c)}{\gamma \cdot \theta + 2\gamma - 1} \quad \text{and}$$

(9) $$x_{iP} = \frac{(d - w - c)}{\gamma \cdot \theta + 2\gamma - 1}$$

and profits will be:

(10) $$\pi_{iP} = \frac{1}{2} \cdot (d - w - c)^2 \cdot (2\gamma - 1) \cdot \frac{\gamma}{(2\gamma + \gamma \cdot \theta - 1)^2}\ .$$

Comparison of R&D Expenditures, Output Levels and Profits

In a further step we want to compare profits, R&D expenditures and output levels of bargainers and profit maximizers. The comparison is somewhat easier if the ratio is considered instead of the difference. Dividing equations (5) and (9) and in a second step (4) and (8) we get:

$$\frac{q_{ib}}{q_{iP}} = \frac{x_{ib}}{x_{iP}} = 4 \cdot \frac{\gamma \cdot \theta + 2\gamma - 1}{4\gamma \cdot \theta + 6\gamma - 3}. \tag{11}$$

It can be shown that - independent of the value of θ - at $\gamma = 0.5$ the investment in x and the output are the same for the bargainer and the profit maximizer. For values of γ larger than 0.5 the bargainers' innovative activity and output is *always* larger than that of the profit maximizers. As one can see from equations (6) and (10), values of $\gamma < 0.5$ are irrelevant because otherwise the profit would be negative. We find this is a surprising result.

The comparison between the different profits is slightly more complicated. From equations (6) and (10) we get:

$$\frac{\Pi_{ib}}{\Pi_{iP}} = 8 \cdot \frac{(\gamma \cdot \theta + 2\gamma - 1)^2}{(4\gamma \cdot \theta + 6\gamma - 3)^2}. \tag{12}$$

In this case there are many different combinations of γ and θ possible, which lead to equal profits for bargainer and profit maximizer. But again, it can be shown that for values of $\gamma > 0.5$ the profit of the profit maximizer is higher. For values lower than 0.5, combinations of γ and θ exist where the bargainer realizes a higher profit *but these situations are irrelevant*. As mentioned above, the profit for the bargainer and the profit maximizer is only positive if $\gamma > 0.5$ and so if a profit is made at all, the profit maximizers realize the larger ones.

Hence it is quite likely that the bargaining firm has higher expenditures for R&D even if R&D is not the subject of negotiations. The reason for this is that the bargaining firm has an incentive for firm size, as long as this is connected with

employment. Both process and product innovation have a positive impact on size and this determines the result.

4. Empirical Study

4.1 Earlier Research

To the best of our knowledge, there has been no empirical study concerning the effects of co-determination on innovativeness. However, there are three kinds of related research: 1) Studies on the effects of works councils in Germany, 2) studies on the impact of unions on innovative activity for the US and Great Britain and 3) research on the impact of co-determination on productivity and profitability of German firms.

As explained earlier, works councils are not mandatory and therefore one way to estimate the effect of a works council is the comparison of firms with and without one. The first study on works councils and innovation is by FitzRoy and Kraft (1990). They use a small sample of German firms, interact the existence of a works council with the rate of unionization and find a negative impact of this variable for innovation. Addison, Schnabel and Wagner conduct a number of empirical studies on innovation. Addison, Schnabel and Wagner (2001) is a recent summary of their research results and they find no significant effect of the existence of works councils on innovation.

Many theoretical studies on unions point to a negative impact of unionization because unions raise wages and this is financed by appropriating the quasi-rents earned on capital[5]. This acts like a tax and will therefore increase the costs of reduced investments. This is a problem particularly for intangible investments like R&D and a classical “hold-up” problem arises. A difference between the effect of a union and co-determination might be that in Germany wages are determined elsewhere but not on the supervisory board. Wage councils may have an effect on wages but the supervisory board does not discuss remuneration (with the notable exception of the salaries of the directors).

There are many studies from the US which usually report a negative impact of unionization on innovation. Examples (among others) are Conolly, Hirsch and Hirschey (1986), or Fallick and Hasset (1999) on investment. A recent study for Great

[5] A well-known example for this view is Grout (1984).

Britain (Menezes-Filho, Ulph and van Reenen 1998), however, finds that unions can have positive effects in some cases. A negative impact is only estimated if union density is very high or unions bargain only about wages.

The first study on co-determination by FitzRoy and Kraft (1993) found a negative impact on productivity for a small sample and only one year before and one after introduction of the co-determination law. FitzRoy and Kraft (2002) show that in a panel of (West) German firms, the change from one third parity to full parity of labor representation on the supervisory board (after the Co-determination Act of 1976) resulted in a small but statistically significant increase in total factor productivity. On the other hand, Gorton and Schmid (2000) find a negative effect of parity co-determination on equity returns and other profit measures in cross sections of German firms before and after unification. However, since parity co-determination only applies to firms with over 2000 employees, it is difficult to distinguish effects on wages from the well-known employment size-wage effect which holds independently of co-determination or union organization. Other firm-specific effects cannot be investigated in the Gorton and Schmid (2000) cross sections, though they do include total assets.

4.2 Basics of Our Empirical Study

Our empirical study concentrates on the effect of co-determination on technical progress. Innovation is measured by the number of patents that a firm has granted during a period. The identification of innovative activity of a firm is a frequently discussed topic. An other popular measure is R&D intensity, that is the ratio of R&D expenditures to total sales volume as an input to the innovation process. An alternative as the output of the innovation process is the share of sales due to newly developed products. All variables have strengths and weaknesses and we decide in favor of patents as this also takes into account the success of the research process. It is possible that co-determination does not lead to less R&D expenditures, but that these activities do not imply a similar research output because not co-determined firms are faster and apply earlier for patents and receive them as well. Our number of patents includes both the national and the European patents, which were introduced in 1978.

We compare the years before the introduction of the co-determination law 1972-1976 with the periods 1981-1990 after the law became effective. In both time

periods the large and after 1976 co-determined firms are compared with smaller ones. As co-determination is inevitably connected with firm size we want to identify the impact of it by comparing the relative performance of co-determined firms in relation to other firms.

Aside of co-determination a number of control variables are used. Clearly firm size has to be taken into account. We use the number of employees and the number of employees squared. A description of the variables and relevant statistical data are shown in tables one and two.

Table 1. *Definition of Variables*

Firm Level Data	**Definition**
KapInt	Capital intensity (Capital fixed and working per employee)
Emp	Number of employees
Emp2	Square of the number of employees
COD80	Co-determination dummy Dummy = 1 if employment $\geq$ 2000 and year > 1976 (Firm is actually co-determined)
COD	Dummy=1 if employment $\geq$ 2000
InvAge	Inverse of Firm Age
Fixedeff	Average patent distributions of the pre sample period (1968-1971)
Fixeddu	Dummy = 1 if Fixedeff > 0

Industry Level Data	**Definition**
Conc6	Concentration Ratio on the Four-Digit Industry Level
Import	Import ratio – Value of Imports divided by Sales Volume on the two digit industry level (SYPRO 2)
Export	Export ratio – Value of Exports divided by total Sales on the Firm Level
Industrydummies	Industry dummies based on four digit industries (SYPRO 4)

Table 2. *Descriptive Statistics:*

	Patents	Export	Import	Emp	KapInt	Conc6	Age
Mean	11.28	0.33	0.25	8186	111.18	27.58	106.04
Standard Deviation	31.65	0.21	0.18	23750	166.41	18.34	63.09

Table 2 shows the mean values and the standard deviations for our sample. It becomes obvious that patents have a high standard deviation. This is an indicator that we have a high dispersion and this has consequences for the research methodology to be discussed below. Clearly there are industries with very low innovation and others like for example chemistry or automobiles, which have a very high number of patents.[6] The average number of employees in our sample is 8000, which implies co-determination for a large number of firms. Our largest firm has 280.000 employees, while we also have small firms with less than 500 workers.

We have a specific size problem. Co-determination is connected to firm size and although we use size and size squared, there might be a size advantage or disadvantage, which is relevant for firms with about 2000 employees. Such an effect can be differentiated from the co-determination impact if - as we do - a before and after comparison is undertaken. We use the dummy-variable COD for firms, which are co-determined in the eighties also for this firms in the seventies. This variable is expected to catch possible size effects. In addition we use the variable COD80, if the firm in question is actually co-determined in the eighties. Thus the coefficient of this variable is expected to estimate the “pure” impact of co-determination aside of any size (dis)advantage.

The co-determination law had to be implemented until 1978. We use data from 1981 onwards as the time period of restructuring might take longer and as patents

measure the innovativeness only with some lag, since they are the outcome of an R&D process. Co-determination will (if at all) at first influence the research process and this in turn will affect the innovative output after some time. Because of this possible delay we use data until 1990.

We use information about 162 firms from the manufacturing sector. 62 of them are co-determined after 1976 and 100 are not. The panel has 2072 observations overall. The following model with the dependent variable P (patents) is used[7]:

$$P = \beta_0 + \beta_1 \cdot Emp + \beta_2 \cdot Emp^2 + \beta_3 \cdot Konz6 + \beta_4 \cdot KapInt + \beta_5 \cdot Import + \beta_6 \cdot Export + \beta_7 \cdot COD + \beta_8 \cdot COD80 + \beta_9 \cdot InvAge + Industry\ Dummies$$

As mentioned above, COD has unit value for the years 1971-1990, while COD80 has unit value only in the years 1981-1990. The coefficient of COD is expected to show possible size effects, which are relevant at an employment level of 2000 or more and COD80 should estimate the real effects of the law in question. Hence in the eighties, for the co-determined firms, the sum of the coefficients β_7 and β_8 is relevant.

The other variables are standard in studies on innovative activity. Employment and employment squared are used to check for size effects. In many studies it is estimated that innovative activity rises with size, but at a decreasing rate and above a certain size level the innovativeness is reduced[8] (Kamien, Schwarz, 1982). Acs and Audretsch (1988) show that the innovative output of small and medium-sized firms in comparison to the large ones may depend on the particular industry.

Concentration ratios are also found in many investigations. It is a long discussion that concerns the impact of market concentration, with controversial opinions and also very controversial results. We do not intend to participate in this discussion but just use CONC6 as a control variable. Involvement in international trade is related to this variable. Export and import ratios are use to take account of the firm's engagement in international competition.

Mansfield, Romeo and Wagner (1979) examine large-scale American enterprises and show that with a rise of exports the innovation efforts also rise.

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[6] The strongly differing values of the capital intensities also underline this fact.
[7] The count data model necessary for estimating such an equation is explained below.
[8] This question has its roots in suggestions by Schumpeter (1942) and later Galbraith (1952). The basic hypothesis is that the simple and cheap inventions have been made, and that nowadays all research and innovation activities require substantial financial resources. Large firms are supposed to have advantages here over small and medium-sized firms.

Hirschey and Caves (1981) also conclude that international expansion and innovation activity are positively related. Bertschek (1995) explicitly examines what kind of influence is exerted by import ratios. Using a large sample of 1270 German enterprises from the manufacturing industry, she finds that imports have a positive effect on innovativeness. The variable firm age is included, as many firms are established to market an innovation and over time the innovativeness will perhaps be reduced. Hansen (1992) finds support for this hypothesis. As a share of our firms are very old, we do not use the absolute value but, as a simple method to take account of non-linearities, the inverse of firm age is included.

Capital intensity is used, as this variable may express the technological opportunity of the firm. With a high capital intensity, it is probable that technology plays a major role. If capital is sunk to a degree, this variable may also stand for barriers to entry[9]. Earlier studies show that capital intensity has a positive impact on innovativeness [cf. Crepon, Duguet and Mairesse (1998) or Zimmermann and Schwalbach (1991)]. Finally, industry dummies are included, as clearly the potential for innovation is very different depending on the industry and one must take this into account.

4.3 Econometric Methodology

Patent data are a classic example for count data. In this case the dependent variable assumes different discrete values including the value zero. The analysis is usually based on count data models. A popular approach is the Poisson model, which applies the Poisson distribution for the data generating process. This model is relatively easy to implement. The disadvantage is the assumption that the conditional expected value is equal to the variance. In many cases this assumption is violated, as over-dispersion occurs.

Much less frequently the opposite case of under-dispersion arises, i.e. the situation that the conditional variance is smaller than the conditional expectancy value. In the case of over-dispersion there is a danger of an underestimation of the true variances of the parameter estimations. The Poisson model can be enlarged by help of a stochastic component and if a gamma-distribution is assumed, the Negative Binomial model is calculated. This model includes the Poisson distribution for specific parameter values. It can be determined whether the Poisson model or the more

[9] Cf. for the theory of sunk costs and barriers to entry Baumol, Panzar und Willig (1982).

general negative binomial model should be applied by means of the Cameron and Trivendi (1990) test. It is based on testing the assumption of a mean value which is equal to the variance and is therefore easy to implement. In our case, the Cameron and Trivedi (1990) test clearly points to the relevance of the negative binomial model.

Count data models are based on the assumption that the exogenous variables describe the move from 0 to 1 in much the same way as, for example, from 186 to 187. However many firms do no research at all and therefore they will never have a patent. Hence, in many cases there is a fundamental difference between observations with the value zero and those which have one or more patents.

For this reason, the so-called zero-inflated models have been developed. This is an enlargement of the basic Poisson or Negative Binomial model. In the first step, it is analyzed whether the dependent variable is zero or larger than zero. Any observation larger than zero is adjusted to one, and then either a Logit or a Probit model is applied. In the second step, the Poisson or Negative Binomial model is applied for those observations, where the dependent variable is one or larger. The count data models start here at one, not at the value zero.

In contrast to the original ZIP model we follow Mullahey (1986) and make a further generalization. Because of the tendency of over-dispersion we do not use the Poisson model, but the more general negative binominal distribution, which permits over dispersion. The Vuong statistic tests for the appropriability of the zero-inflated models instead of standard count data models.

Table 3: Results of the NegBin and ZINB Models

	NegBin		ZINB	
	Coefficient	**t-Value**	**Coefficient**	**t-Value**
Cod	1.30	9.49	1.12	7.31
Cod80	0.13	1.00	0.32	2.33
Export	1.44	5.52	1.26	4.71
Import	1.65	1.85	1.16	1.28
Emp	0.0544	16.13	0.055	15.49
Emp2	-0.0002	-9.96	-0.0002	-9.41
KapInt	0.003	1.89	0.0015	0.96
Konz6	0.019	1.12	-0.01	-0.74
InvAge	0.39	0.97	0.94	1.91
Constant	-2.38	-3.12	0.41	0.61
Log-likelihood	-4802.489		-4740.496	
Vuong-Statistik[10]			5.4258	
Predictable Zeros	818.5		877.3	
Alpha (Over-dispersion)	1.51 → Over-dispersion			

In the first step of the empirical part of the analysis, the NegBin and the ZINB estimators are estimated using pooled data. As one can recognize from Table 3, the results depend on the econometric model. The negative binomial model leads to an insignificant coefficient of COD80. However, with the zero-inflated model this variable

[10] The test developed by Vuong (1989) was applied for the first time by Greene (1994) to the question of whether ZIP or ZINB approaches have to be preferred in relation to the classical Poisson or negative Binomial models. In our case the high value of 5,4258 shows a dominance of the ZINB model. The superiority of ZINB is also supported by the fact that by using ZINB in comparison to NegBin a larger share of the 946 observations with the value zero can be explained.

becomes significant. The Vuong statistic points to the superiority of the ZINB model, so that we conclude at this stage of the analysis that co-determination has not reduced the innovative activity of German firms.

4.3 Econometric Panel Models

Every panel study must take account of the relevance of fixed effects, although this is not a trivial task in the case of count data. As it is well known, firms may have permanent differences with respect to innovative activity. Some are active research companies, while others have no particular ambition to be the innovative leaders. Therefore, firm-specific effects are quite likely in the given context and they must be analysed somehow.

Fixed effects models for count data models like that developed by Hausman, Hall and Griliches (1984) cannot be applied in our case, as the co-determination status does not change for any firm. This implies that the individual effect cannot be differentiated from the effect of the co-determination variable.

A solution to this problem is the approach developed by Blundell, Griffith and van Reenen (1999). In their model, the values from a pre-sample period on patents is used to identify the individual effect. This is a very useful suggestion in our case, as information from a pre-sample period is available. Blundell, Griffith and van Reenen (1999) propose a new method for considering firm-specific effects. They argue that the fixed effect is expressed as the stock of past innovations. Hence, if the stock of past innovation is used in the estimations, the individual effects are analyzed. They suggest using the pre-sample mean of innovations for every firm. They compare this estimation procedure with alternative methods proposed by Chamberlain (1992) and Wooldridge (1997) which are based on quasi-differenced methods of moments. Using Monte-Carlo simulations, they conclude that their method produces lower mean square errors than quasi-differencing.

Using for simplicity the standard Poisson model for count data, the estimation equation for the number of patents (*P*) can be written as:

$$P_{it} = \exp\left[x_{it}^{'}\beta + \eta_i \right] + \nu_{it}, \tag{14}$$

where x_{it} is the vector of observable explanatory variables and β stands for the coefficient vector. The term η_i represents an unobservable individual firm specific effect, which reflects permanent differences in innovative activity. The error term ν_{it} is assumed to have zero mean and finite variance.

If the pre-sample size is assumed to be $0,-1,-2,....,-\theta$, averages of the variables in equation (14) over the pre-sample period are:

$$(15) \quad \frac{\sum_{t=0}^{-\theta} P_{it}}{-\theta} = \frac{\sum_{t=0}^{-\theta} \exp(x_{it}^{'}\beta + \eta_i)}{-\theta} + \frac{\sum_{t=0}^{-\theta} \nu_{it}}{-\theta}.$$

In the limit the probability is (taking logs):

$$(16) \quad \ln\left[p\lim \frac{\sum_{t=0}^{-\theta} P_{it}}{-\theta} \right] = \ln\left[p\lim \frac{\sum_{t=0}^{-\theta} \exp(x_{it}^{'}\beta + \eta_i)}{-\theta} \right] + \eta_i .$$

Blundell, Griffith and van Reenen (1999) show that for a multivariate normal distribution of x_{it} for every i with mean $\phi\eta_i$ and variance covariance matrix Ω_x one can write:

$$\ln\left[p\lim \frac{\sum_{t=0}^{-\theta} P_{it}}{-\theta} \right] = \beta'\phi\eta_i + \beta'\Omega_x\beta/2 + \eta_i .$$

And this can be simplified to $\eta_i = \vartheta + \ln\left[p\lim \frac{\sum_{t=0}^{-\theta} P_{it}}{-\theta} \right]$. If this relation is inserted into (14) we have

$$(17) \quad E\left\langle P_{it} \,\middle|\, x_{it,}\eta_i \right\rangle = \exp(x_{it}^{'}\beta + \vartheta + \zeta \ln \bar{P}_{i0}),$$

where ϑ adjusts the constant term in β. Clearly the question arises as to what the pre-sample period is. Blundell *et al* use the first period number of innovations as the relevant figure and add a dummy variable, which has unit value if a firm has any innovation during the period in question. We use the number of patents in the periods 1968-1971 as the relevant pre-sample information. The results are shown in Table 4:

Table 4: Results of the NegBin and ZINB Models

	NegBin		**ZINB**	
	Coefficient	**t-Value**	**Coefficient**	**t-Value**
Fixedeff	0.01	5.39	0.01	6.31
Fixeddu	1.15	10.83	0.96	8.25
Cod	0.95	6.76	0.69	4.90
Cod80	0.26	1.95	0.46	3.57
Export	1.31	5.56	0.65	2.80
Import	2.47	3.34	1.68	1.97
Emp	0.029	5.40	0.029	5.73
Emp2	-0.0001	-5.14	-0.0001	-5.15
KapInt	0.0013	1.04	0.0008	0.87
Konz6	0.03	2.37	-0.01	-0.92
InvAge	-1.22	-2.26	-1.00	-1.84
Log-likelihood	-4727.89		-4703.49	
Vuong-Statistic			1.98	
Alpha (Over-dispersion)	1.51 $\rightarrow$ Over-dispersion			

Again, the methodology has some effect on the results. On the other hand, the test statistics point to the use of ZINB and clearly a panel model is also useful in our case. In both of these cases COD80 is positively significant. The co-determination variable is never significantly negative. We interpret this result in the following way: We

cannot find any evidence that co-determination has a negative impact on innovative activity. If anything a positive impact is estimated.

The control variables have the expected influence. Size has a positive but diminishing impact. Exports as well as imports have an effect. As expected, capital intensity has a positive influence, however this effect is only (weakly) significant in one case. Concentration is significant in just one of four specifications and therefore of low relevance in our sample. Firm age has a negative impact, but the coefficient is only sometimes significant.

The reader might ask how large the effect of codetermination is, and this is a simple method to check for the plausibility of the results. In order to quantify the influence of codetermination, the marginal effects have to be calculated. They are defined as:

$$\frac{\partial E\left[y \mid x\right]}{\partial x} = \lambda_i \beta$$

The term λ_i is the expected value of the dependent variable. All marginal effects are calculated at the mean values of all explanantory variables. It may be questioned, whether marginal effects are meaningful for dummy variables. As an alternative, one may calculate the marginal effect of a dummy variable called *d* by the difference of two estimates: $E\left[y \mid \bar{x_0}, d = 1 \right] - E\left[y \mid \bar{x_0}, d = 0 \right]$, where $\bar{x_0}$ denotes the means of all others variables. The difference is the marginal effect and one realizes that it is practically similar as if the derivative of *d* is taken as if it were a contiunous variable and using $\lambda_i \beta$. The marginal effects are presented in table 5.

Table 5: Marginal Effects

	Marginal Effects	
	Negative-Binomial-Regression	**ZINB-Regression**
Cod	1.83	1.55
Cod80	0.42	0.82
Export	2.12	1.99
Import	4.12	2.95
Emp	0.05	0.08
Emp2	-0.0002	-0.0003
KapInt	0.015	0.001
Konz6	0.05	0.03
InvAge	-2.28	-2.14
Fixedeff	0.01	0.02
Fixeddu	2.02	2.32

The marginal effect of the most important variable Cod80 is .42 (NegBin) and .82 (ZINB). These estimates have to be compared with the mean values of the number of patents. In the case of NegBin the mean value is 11.28 and for ZINB the respective value is 20.76 as here only the firms with one or more patents are used during the second step of the estimations and the marginal effect refers to this part of ZINB. The marginal effects are in both cases less than 5% of the mean values and therefore the marginal effect is of moderate magnitude and seems to be realistic.

5. Conclusion

This paper discusses and estimates the effects of co-determination on innovative activity. The theory leads to ambiguous hypotheses concerning the impact of co-determination. We present a simple model applying Nash-bargaining on employment determination and R&D. Co-determined firms are compared with standard profit-maximizing companies and it turns out that in our model the co-determined firm will carry out more R&D.

In the second part, we present the results of an empirical study. The sample consists of 162 firms over the periods 1972-1976 and 1981-1990. Innovation is measured by the number of patents. We use the negative Binomial and the Zero-Inflated Negative Binomial models for estimation and combine these models with the Blundell, Griffith and van Reenen (1999) approach to include fixed effects.

Our results point to the conclusion that co-determination has no negative impact on innovativeness. If at all, rather a positive effect can be estimated. Hence we cannot support the frequently heard presumption that co-determination will reduce flexibility and by this the innovative potential of companies. The marginal effects show that codetermination has no large inpact.

This study presents empirical results concerning very controversially discussed hypotheses. However, there is still a lot to do. Perhaps other studies can check the robustness of our results by using other measures for innovativeness.

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