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Wage effects of R&D tax incentives: Evidence from the Netherlands

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Abstract

This paper examines the impact of the Dutch R&D tax incentives program, known as WBSO, on the wages of R&D workers. In our model these wages are partly determined by the government's WBSO tax disbursements. We construct detailed firm- and time specific R&D tax credit rates as a function of the R&D tax incentives scheme to capture the wage effects of the government R&D support. An instrumental-variables econometric model is estimated using an unbalanced firm-level panel data covering the period 1996-2004. After controlling for firm and industry effects and business cycle fluctuations, R&D tax incentives are found to increase R&D wages. The R&D wage effect of these incentives is smaller than their effect on real R&D investment, but it is still sizeable. The elasticity of the R&D wage with respect to the fraction of the wage supported by the WBSO scheme is estimated at 0.1.

Key words: price effect of tax incentives; tax credits; panel data model; R&D wages
JEL Codes: O32, O38, H25, J30, C23

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1. Introduction

Economists keep challenging the usefulness of R&D tax incentive programs. They raise two objections: government supported R&D may crowd out private R&D funding or get dissipated in higher R&D wages instead of stimulating real R&D spending. Many empirical studies have examined the first question and concluded that there is some additionality, in the sense that firms increase their R&D spending by more than the money they get from government in support of R&D (see Hall, 2002 and Arundel et al., 2008) for reviews of empirical studies). Few empirical studies have looked into the price effect as opposed to the volume effect of R&D tax incentives. The evaluation of the magnitude of this price effect is the objective of this paper.

The inelastic supply of R&D workers, which increases their leverage in negotiated wage settlements, suggests that the wage effect of government R&D support can be substantial. Goolsbee (1998) has shown that similar to the price effects for physical goods, these R&D wage effects are sizable[1]. Using Current Population Survey data he estimates that a 10% increase in total federal R&D expenditure leads to a 3% increase in wages of R&D workers in the US. Low user cost elasticities and inelastic labor supply of R&D workers in the short run can therefore put limits on the efficacy of government intervention to stimulate private R&D.[2]

Few studies have attempted to quantify the effect of R&D tax incentives on R&D wages, in part because of the heavy data requirements for such an exercise. Marey and Borghans (2000) attempt to quantify a wage effect of R&D tax incentives by applying a co-integration analysis using sectoral data from the Netherlands. They report an average estimate of the elasticity of R&D wages with respect to total R&D expenditures of 0.52 in the short run and 0.38 in the long run. Haegeland and Møen (2007) estimate on Norvegian data that per Euro of tax credit 33 Eurocent go into higher average wages for R&D personnel. The wage effect is especially characteristic for SMEs.

[1] Goolsbee (1997) argues that the low price elasticities of physical investment that are often found in empirical research can be explained by the fact that the short-run increased investment induced by tax incentives are mainly due to higher prices of the capital goods rather than to increases in the quantity of investment. According to his estimates a 10% investment tax credit can increase equipment price by as much as 3.5% – 7% in the short run.

[2] See Romer (2000) for an elaboration on this point.

In this paper we revisit the R&D wage effect of R&D tax credits using two different models applied to Dutch firm data. In one model we compare the elasticities of real and nominal R&D labor using a dynamic factor demand model and firm specific user costs of R&D. The other model is borrowed from the stream of literature in labor economics that argues that wages are at least partly determined by sharing in the rents generated by efficiency wages, the employer's ability to pay, features of the product market, trade liberalization and technological innovations (Abowd and Lemieux, 1993; Blanchflower, Oswald and Sanfey, 1996; Krueger and Summers, 1988; van Reenen, 1996). We argue that similar to sharing in rents, employers can share in R&D tax credits with scientists, engineers and the supporting personnel operating in R&D units, resulting in a price effect of R&D tax incentives.

In our empirical analysis we use an unbalanced firm-level panel dataset constructed from the annual R&D surveys, and production statistics from the Central Bureau of Statistics of the Netherlands. The richness of the merged dataset allows us to construct detailed R&D user costs as a function of R&D tax incentives, providing sufficient variation in both the cross-section and time dimensions to identify the effects of the tax incentive program on R&D wages.

Our main empirical finding is that there is a significant price effect of the Dutch R&D tax incentive program. Random and fixed-effects instrumental variable models in which unobserved firm effects, industry effects, and business cycles fluctuations are controlled for and the endogeneity of the R&D tax credits is taken into account produce a tight range of estimates of the elasticity of R&D wages with respect to the tax disbursements, between 0.09 and 0.11 in the short run and 0.11 and 0.12 in the long run. Both are statistically and economically significant. Our estimates indicate that for each Euro that government spends in stimulating R&D as much as 12 Eurocents in the short run and 8 Eurocents in the long run may go into R&D wages.

The rest of the paper is organized as follows. Section 2 presents some initial evidence of the presence of a wage effect and then goes on to propose a theoretical model to relate wages to the R&D tax incentives. Section 3 lays out our empirical modeling approach, describes the way we assembled our data set and explains how we constructed the variables used in the empirical analysis. Section 4 presents our empirical results and discusses several alternative regression specifications and sensitivity checks. Section 5 offers some concluding remarks.

2. The theoretical framework

In 1994 the Dutch Government introduced the tax incentives scheme for the promotion of private R&D known under the acronym of WBSO, standing for The Wage tax and Social Insurance Act (Wet bevordering speur - en ontwikkelingswerk) [3]. Firms can apply for the wage tax deductions based on their annual R&D wage bill. The scheme is quite known and widely used by Dutch firms. In 2005 alone the Dutch government spent about 400 million Euros on WBSO. Anecdotal evidence collected via interviews with the firms' R&D managers suggests that especially large firms encourage their R&D managers to apply for WBSO support complementary to the firm's regular R&D program[4].

In order to get a feeling of a possible effect of the Dutch R&D tax incentives on R&D wages besides R&D quantity, we start from the dynamic factor demand model for R&D from Lokshin and Mohnen (2007), replacing real R&D by nominal R&D. In the absence of a price effect, the elasticities of real and nominal R&D to variations in the user cost of R&D generated by changes in R&D tax incentives should be the same. Lokshin and Mohnen (2007) estimated the following demand equation for R&D:

$$\frac{R_{it}}{K_{it-1}} = \gamma \frac{R_{it-1}}{K_{it-2}} + \sigma u_{it} + t_t + v_{it} \qquad (1)$$

where R_{it} is the i^{th} firm's (real) R&D expenditure at period t, $K_{i,t-1}$ the beginning of period R&D stock and u_{it} the firm's user cost of R&D in period t.

[3] An overview of the WBSO parameters for all the years we use to estimate the model is given in Table 2. In 2004, there were two brackets with the corresponding rates of 42% on the first 110 thousand Euros in firm R&D wage expenditures, followed by 14% on the remaining amount below the ceiling, set at 7.9 million Euros of tax credits.

[4] These interviews with companies' R&D managers were conducted within a broader assessment project of the effectiveness of WBSO; their outcomes are reported in Ministry of Economic Affairs, 2007.

If R&D flow is expressed in nominal terms, the numerator of the dependent variable in (1) can be written as a product of the R&D wage rate (price) w, and the R&D labor (quantity) L, divided by the R&D labor share in total R&D s_L. We can reasonably assume that the labor share in total R&D is approximately constant over time. The effect of R&D tax incentives, via changes in the user cost of R&D, on nominal R&D can hence be decomposed into a price effect and a quantity effect.

We obtain a nominal short-run elasticity of -0.35 and a nominal long-run elasticity of -0.76, both statistically significant. By comparing these nominal effects with the estimated real effects (short run elasticity of -0.28 and long-run elasticity of -0.72), reported in Lokshin and Mohnen (2007, Table 4, column 5), we arrive at a price effect of changes in the user cost of R&D of approximately 20% in the short run and 7% in the long run.

This exercise suggests that there is a non-negligible price effect created by the Dutch R&D tax incentives provision. Our hypothesis is that the price effect arises as a result of firms and R&D workers sharing in the R&D tax credits received from the government. There are various ways to justify this tax credit sharing. Firms may use it as an incentive for their R&D workers to apply for R&D tax credits. It may reflect imperfections in the labor market for scientists and engineers, inelastic supply resulting in wage increases, search costs or bargaining power on the labor supply side. The point here is not that firms reduce their own R&D effort by government money (crowding out) but that additional R&D expenditures are split in quantity and price effects. To test this hypothesis, we start from an efficient bargaining model, in which the wage of R&D workers is partly determined by sharing in the R&D tax credits. Essentially we want to test the magnitude of the sharing parameter.

To assess whether there is a price effect of R&D tax credits, we follow the previous studies and apply a Nash asymmetric bargaining model[5]. Assuming risk-neutral preferences on the part of the

[5] A bargaining or rent-sharing approach to wage determination is widely used in the empirical labor literature (e.g., Abowd and Lemieux, 1993; Blanchflower et al., 1986; Hildreth and Oswald, 1997; van Reenen, 1996; Veugelers, 1989).

employees, an expression for the real wage w of R&D workers in firm i results from maximizing the following bargaining problem:

$$\max_{w,L} \theta = \beta \log\{[u(w) - u(\overline{w})]L\} + (1-\beta)\log d(w,L), \tag{2}$$

where $u(w)$ is the R&D worker's utility from wage w, $\overline{w}$ is an alternative wage that can be earned in case bargaining breaks down, L is R&D employment (which could also be interpreted as a probability of employment), and d is the R&D tax credit disbursement. Parameter β ($0 \leq \beta \leq 1$) is the sharing parameter. It measures the fraction of the R&D tax credits that accrues to R&D workers in addition to their opportunity wage. The situation when $\beta = 0$ represents the case when the entire disbursement accrues to the firm and the R&D tax incentive program has no effect on R&D wages. On the other hand, a situation when $\beta > 0$ means that tax credit disbursement leads to increased R&D wages[6].

Solving the first-order condition of problem (2) with respect to wages gives the following 'structural' equation[7]:

$$w \cong (1-\beta)\overline{w} + \beta(d/L) = \overline{w} + \beta[(d/L) - \overline{w}] \quad . \tag{3}$$

[6] If $\beta = 1$ the R&D worker would choose to set the wage rate equal to d/L, assuming the latter to be higher than the alternative wage.

[7] Expression (4) directly relates R&D wages to the excess of tax credit disbursements over the opportunity wage. In the labor economics literature the tax credit disbursements are replaced by rents. Different measures of rents have been considered, such as profits per employee (Arai, 2003; Blanchflower et al., 1996; Hildreth and Oswald, 1997), value added per employee (Dobbelaere, 2004), and Tobin Q (Salinger, 1984; Van Reenen, 1996). Parameter β, as explained, represents the bargaining power of workers. It can be considered as a constant to be estimated, but it can also be made heterogeneous and modeled to depend on variables such as sectoral unemployment rates, price index, proxies for product market concentration (e.g., Dobbelaere, 2004; Veugelers, 1989). Van Reenen (1996) estimates rents as a function of firms' innovation output and R&D input.

We are interested in finding out the extent of the sharing of the tax credit disbursement between firms and R&D workers. The percentage of the R&D wage that is reduced because of the tax credit scheme (d_R) is a sufficient statistic for the measure of disbursement, which as explained in Lokshin and Mohnen (2007), looks as follows in the case of the Dutch WBSO tax incentive scheme, ignoring for the sake of clarity the firm and time subscripts:

$$d_R = D_1\left[a\min\left(\frac{R_L^1}{s_L R},1\right) + eb\min\left(1-\frac{R_L^1}{s_L R},\frac{c}{s_L R}\right)\right] \tag{4}$$

where s_L is the percentage of labor costs in total R&D, R; $a = \omega_1^1(1-D_2)+\omega_2^1 D_2$, $b = \omega_1^2(1-D_2)+\omega_2^2 D_2$, $c = (R_L^2 - aR_L^1)/b$, $D_1 = 1$ if the firm uses the WBSO credit facility, else $D_1 = 0$; $D_2 = 1$ if the firm is eligible for a starter's rate[8], else $D_2 = 0$ and $e = 1$ if $s_L R > R_L^1$, else $e = 0$. The last inequality determines whether a firm's total R&D wage bill ($s_L R$) exceeds the length of the first bracket, R_L^1. If the amount of R&D labor falls below level R_L^1, the first bracket rate can be used, above that level the second rate is applicable up to a total permissible deduction of R_L^2. In case of start-up firms, the first bracket rate is a bit more generous.

The parameters that enter (4), i.e., R, s_L, D_1 and D_2, are all firm-specific and time varying but the corresponding indexes are omitted for tractability. The values of ω_1^1 (first bracket tax rate for non-starters), ω_2^1 (first bracket tax rate for firms that are classified as starters), ω_1^2 (second bracket tax rate for firms that are non-starters), ω_2^2 (second bracket tax rate for starters), R_L^1 (length of the first bracket ceiling expressed in terms of deductible R&D labor costs), R_L^2 (ceiling in WBSO disbursements, for example, in 2001, $p_R R_L^1$ amounted to 90.756 €) are given in Table 2.[9]

[8] If a firm satisfies two criteria, to be younger than 5 years and have participated in the WBSO program no more than three times, it can use a higher first-bracket R&D tax rate (for example in 2004, 60% instead of 40% for non-starters). These criteria are checked by SenterNovem, an administrative agency in charge of the tax incentives, at the time of application.

[9] We cannot take the provision for starters in (4) into account because therefore we would need data from SenterNovem, but as indicated in Ministry of Economic Affairs (2007), the number of starters is limited.

Expression (4) determines the rate at which an R&D-performing firm can reduce its R&D labor costs by using the R&D tax incentives. We can use it to compute the amount of WBSO disbursement, in Euros, which a firm receives back from SenterNovem, the administrative agency in charge of R&D tax incentives. The agency's decisions are taken to be completely exogenous in our model, as they are in practice[10]. The WBSO disbursement per R&D worker in firm i is nothing but (4) times the average R&D wage rate.

3. Econometric model, data and descriptive statistics

A. ECONOMETRIC SPECIFICATION

The theoretical discussion in the previous section suggests the following reduced-form equation for wages:

$$W = f\left(d_R, \beta, \overline{w}\right) \qquad \partial f / \partial d_R > 0, \partial f / \partial \overline{w} > 0, \; 0 \leq \beta \leq 1, \qquad (5)$$

where d_R is a measure of R&D tax credit, $\overline{w}$ is the alternative wage and β is the sharing parameter to be estimated.

In rent-sharing models of wage determination the equilibrium wage is determined by internal as well as external factors. The latter can be thought of as opportunity costs or the going wage in other sectors of the economy (e.g., Blanchflower, Oswalf and Sanfey, 1996; van Reenen, 1996). The importance of controlling for the alternative wage depends on the extent to which the skills of R&D workers are firm or industry specific, i.e. substitutability of R&D skills within or across industries. It could be set to zero, an approach taken by Vandenbussche et al. (2001). Ideally, it should reflect the marginal productivity of labor (MPL) prevailing in each industry. MPL is difficult to measure in practice and we therefore follow the example of van Reenen (1996) and

[10] The principle function of SenterNovem is to process administration related to WBSO applications and to verify that the R&D projects submitted for approval conform to the regulations set for this R&D support scheme.

include average sector R&D wage as a proxy for alternative wage. Alternatively, we could interpret our results as a premium over the industry wage determined by an inelastic R&D labor supply curve.

Previous contributions found that wages are positively correlated with firm size, firm profits and capital intensity. A positive effect of profits on wages can arise as a result of the rent-sharing at the firm level and collective wage bargaining at the industry level (Blanchflower et al., 1996; Forslund, 1994; Hildreth and Oswald, 1997; Holmlund and Zetterberg, 1991). Abowd, Kramarz and Margolis (1999) using a large employer-employee French panel dataset find that firms that pay higher wages are more capital intensive, productive and profitable. Arai (2003) using a matched employer-employee data from Sweden finds a significant positive effect of average firm's profits and its capital-labor ratio on wages after controlling for worker individual characteristics. Given equal union status, several authors have found that there is a wage premium for workers employed by large firms. Large firms can enjoy more market power and be more successful in attracting higher-quality workers (Albaek et al., 1998; Melow, 1982; Brown and Medoff, 1989).

Based on these findings in the literature, we specify the following estimating equation:

$$\ln W_{it} = b_1 \ln d_{R,it} + b_2 (K/L)_{it} + b_3 \ln Size_{it} + b_4 RD\,\mathrm{int}_{it} + b_5 \ln \overline{w}_{jt} + \mathbf{d}Z_{jt} + \varepsilon_{it} \qquad (6)$$

Because most of the heterogeneity in wages is likely to come from firm and sectoral differences and not from variations in the time dimension, we use several random as well as fixed effects methods to estimate equation (6) with unobservable industry-specific and firm-specific effects.

To allow for unobserved firm-level heterogeneity in wages across industries and firms within industries and an impact of common macro-economic shocks, the error term ε_{it} in equation (6) includes industry specific effects ν_j, a (nested) effect μ_i of the i-th firm in the j-th industry, and a year-specific intercept λ_t, in addition to serially uncorrelated measurement errors u_{it}:

$$\varepsilon_{it} = \lambda_t + \mu_i + v_j + u_{it} \qquad \text{for } j = 1,\ldots,M; i = 1,\ldots,N \;; t = 1,\ldots,T_i \;.$$

The dependent variable in equation (6) $\ln W$ is the logarithm of the real R&D wage rate. To construct it we divide the total real R&D labor costs by total firm R&D employment (cf. Hildreth and Oswald, 1997). Both the total wage bill and the number of R&D employees are taken from the R&D survey database. Wages are expressed in real terms, i.e. R&D variables are deflated by a weighted average composed for 50% of the GDP deflator and for 50% of the R&D wage deflator. A similar approach is taken by Bloom et al. (2002.).

We include *K/L*, the capital-to-labor ratio, as a control variable. There are several reasons for doing so. According to Bronars and Famulari (2001) complementarity between capital and skilled labor will lead capital intensive firms to hiring more skilled workers (with a higher productivity of labor). Second, the higher capital-to-labor ratio is expected to increase the the workers' bargaining power and therefore to positively affect their wage rate. When labor costs are negligible vis-à-vis the cost of capital, employers' resistance to wage demand is expected to be smaller (Arai, 2003). According to the efficiency wage theory, a higher capital-labor ratio can also lead to an increase in the cost of production and prompt firms to accord a wage premium to their employees in order to decrease these costs and improve performance (e.g., Akerlof and Yellen, 1986).

RDint is R&D intensity, measured as the firm's real R&D expenditures divided by total sales. Controlling for the R&D intensity at the firm level is likely to be important considering the possibility of high-ability and consequently high-wage workers systematically "sorting" out into more R&D intensive firms. Previous empirical studies report significant differences in the ability of specific groups of workers to command higher wages (e.g., Black and Strahan, 2001; Nekby, 2003). R&D intensity and wages could be correlated if scientists and engineers and the supporting personnel operating in R&D units constitute a relatively important group within a firm. According to Sap (1993) the relative importance of a group can under certain conditions determine the bargaining power of this group. A higher R&D intensity ratio captures to some extent the importance of R&D workers within a firm.

To control for firm size we include *lnSize*, the logarithm of the firm's number of employees. Brown and Medoff (1989) offer several explanations rooted in 'compensating differentials' as well as institutional theory for the positive correlation between firm size and wage premium. These factors capture the desire of larger employers to 'follow a strategy of positive labor relations' as well as their advantage over smaller rivals in attracting higher labor quality.

We further include controls for business cycle influences on R&D investment by using industry-specific business cycle indicators: for investment potential (i.e. solvability and return on total assets) and indicators for perceived competition, turbulence and economic development. These business-cycle variables at the industry level are collected in vector **Z** in expression (6). Many studies have uncovered cyclicality of wages over the business cycle (see Abraham and Haltiwanger, 1995, for a review; Bils, 1985; Kean et al., 1988; Solon et al., 1994). Cyclical wage movements can be the result of technology shocks shifting short-run demand curves against fixed supply curves or of the movements along a fixed short-run labor demand curve. Bowlus et al., (2002) point out that this cyclical behavior of wages may be difficult to capture with aggregated data because of the potential compositional changes in a firm's labor force over the business cycle. In our case, such compositional changes are likely to be limited because we look at a specific narrow subset of firm's labor force. In the short run a firm may change relative skill composition of its R&D employees by, for example, attracting more senior research staff as opposed to research assistants. We control for this by including a ratio of researchers to research assistants.

We use expression (4), to compute d_R, using information about the R&D cost composition provided by CBS and the parameters of the WBSO scheme taken from Ministry of Economic Affairs (2007). Table 1 provides descriptive statistics on the variables used in the estimation. Table 2 provides details on the parameters of the R&D tax incentive scheme. A positive relationship is expected between the R&D tax credit disbursements and the wage rate, if there is a price effect of the tax incentives program.

[INSERT TABLE 1 HERE]

[INSERT TABLE 2 HERE]

Before concluding this section, we want to indicate two potential sources of bias in our specification. The average wage rate on the left-hand side of (6) is a result of aggregating the individual wage rates over all R&D employees within a firm, i.e. $\ln W_{at} = \ln\left(\sum_i w_{it} h_{it} / \sum_i h_{it}\right)$. We do not have data on the individual worker wages and relying on aggregated firm data does not allow us to control for differences in R&D workers' characteristics such as seniority and schooling. As opposed to other studies that estimated a wage equation at the firm or industry level (e.g. Forslund, 1994; Hildreth and Oswald, 1997) we look at the more homogenous subset of R&D employees. As a result of the aggregation we estimate an average R&D wage effect of R&D tax incentives. The aggregation bias is mitigated if R&D incentives affect all R&D workers of a firm, which is the case for the WBSO provision.

The construction of R&D tax credit disbursements using equation (4) is another potential cause of bias. The amount of R&D tax credit disbursements depends partially on the wage rate of R&D workers. This partial endogeneity of the disbursement measure is likely to bias downwards the coefficient of R&D tax credit disbursement in equation (6). We will use instrumental variable techniques, explained in a later section, to try to alleviate the endogeneity problem. Inability to control for individual worker characteristics amounts to an omitted variables bias (see Abowd et al., 1999, for discussion).

B. DATA SAMPLE

The empirical analysis makes use of the Dutch Central Bureau of Statistics' annual R&D surveys in combination with production statistics. The R&D surveys contain information on the type and the amount of R&D expenditures and the census data contain information on output and labor, as well as output deflators. We merge the two data sources using a unique firm identification number. These data sources and the process of merging them are explained in detail in Ministry of Economic Affairs (2007). In the estimation we use an unbalanced panel of yearly firm observations between 1996 and 2004.

In this study we estimate a price effect for a small subset of all employees. The average number of R&D workers per firm is about 20 in our sample. If we take into account only full-time researchers (and omitting research assistants) the mean is about 10 employees. In percentage terms R&D workers make up on average in our sample 7.8% of total employment per firm (3.8% if we exclude research assistants). About 70% of firms in the sample have at most 10 R&D employees. If we count only full-time researchers this share becomes 85%. On average, across the years, the sectoral real R&D wage rate grew at 3.7% per annum, from an average of a little over 20 Euro/hour in 1997 to about 26 Euro/hour. The average annual inflation rate was about 2.5%. The standard average deviation of the average wage is about 3. It actually decreased over time in our sample, mainly because the sample composition tilted towards larger firms. The cross-sectional variation of the average firm wage within sectors is large (average standard deviation of about 10) and accounts for most of the heterogeneity in wages.

The measurement of R&D tax credit disbursement is a crucial part of this paper. For each firm and each year available in the sample we compute the R&D tax credit rate that a firm can benefit from. Not all firms, however, apply for this R&D tax credit, but this information is not available in our dataset. We assume that all potential users of the tax credits are actual users. Since our sample is biased towards large firms, we expect the tax credit effect on wages to be overestimated. We may attribute high wages to tax credits when actually no tax credits are claimed. However, we expect this bias to be small.[11] The R&D tax incentive facility primarily targets small and medium sized enterprises. Among some 10200 firms that applied for WBSO in 2004, 46% had fewer than 10 employees, while the share of firms with 10-50 employees was 32% and the shares of medium-sized firms (50-250 employees) and large firms (250 and more employees) were 16% and 5% respectively. The share of the smallest firms, those with fewer than 10 employees, has grown from 1995 to 2004 from 30% to 46%. The shares of all other size

[11] We assume in our model that each firm eligible for WBSO makes use of it. To know which firms do not claim any tax credits, we would need the information from SenterNovem. In Ministry of Economic Affairs (2007) we estimate that about 90 percent of the firms with full time R&D workers (persistent R&D performers) are WBSO users.

classes have declined in the same period: for the size class 10-50 employees from 37% to 32%; for that of 5-249 employees from 24% to 16%, and for that of more than 250 employees from 9% to 5%. Enterprises from all manufacturing and service sectors can apply for WBSO. In 2004 there was the following distribution of WBSO users by sector: agriculture (7%), food (5%), chemicals (11%), machines (29%), other manufacturing (22%), ICT (11%), and other services (14%). This distribution has stayed more or less constant from 1996 till 2004 (see Ministry of Economic Affairs, 2007).

For all size classes the coverage has gradually increased from the inception of the tax incentives program in 1994 to 2004, both in terms of the number of firms applying and the number of total applications by these firms. From 1997 to 2004 there was a 29% increase in granted applications for the tax credits.

When we split the number of observations in our sample in three categories of firm size we see that the distribution of our sample across size classes remains stable over time[12]. The middle size group (50 to 250 employees) represents around 59%. Largest firms (over 250 employees) are over-represented in our sample. The smallest size group (fewer than 10 employees) is under-represented due to the absence of innovation and R&D survey data from CBS over the whole period for firms with less than 10 employees. According to SenterNovem, 70% of the WBSO receivers are firms with less than 250 employees. In our final sample the number of observations from firms in that size class is close to 60% of the total. In the end, our dataset covers only a fraction of the total population of WBSO receivers: on average, across years, firms in our sample account for 15% of total WBSO expenditures and almost 25% of all R&D performed in the Netherlands.

Table 2 lists the main parameters of the WBSO program for the period covered by our estimation sample. The WBSO budget has increased by almost 80%, and the number of approved for funding projects has grown by almost 60% from 1996 to 2004.

[12] We selected only those firms that perform R&D on a continuous basis, the so called ‘hard-core’ R&D performers because in odd years CBS only collects data for ‘hard-core’ R&D performers.

In the empirical analysis the following industries are used with their standard industrial classification code (SBI) in parentheses: food, beverages and tobacco (15-16), textile, apparel and leather (17-19), Paper and paper products (21), printing (22), Oil (23), chemicals and pharmaceuticals (24), rubber products and plastics (25), non-metallic products (26), Basic metals (27), fabricated metal products (28), machines and equipment (29), electrical products (30-33), motor vehicles (34-35), other manufacturing (36-37), construction (45), catering (50), wholesalers (50), retailers (52), communication (60-64), and business services (70-74).

4. Results

Table 3 reports the results of Equation (6) with both random and fixed firm and industry effects.

[INSERT TABLE 3 HERE]

As a benchmark case, in column (1) we report the results from a panel regression with firm-specific random effects in which the R&D tax credit disbursement variable is treated as exogenous. The individual effects are significantly different from zero. The Hausman test rejects the null that the R&D tax credit disbursement is exogenous ($\chi^2(1)$ is 6.67) and, therefore, instrumental variable techniques are required. We estimate the generalized two-stage least squares model with individual effects. We apply the Balestra and Varadharajan-Krishnakumar version of the estimator, which uses the exogenous variables as instruments after they have been passed through the feasible GLS transform because of the error component structure (Baltagi, 2005). In equation (6) estimated in levels (results listed in columns 1-4) we instrument the level of disbursement with the first-difference in disbursement, output and the share of R&D workers in a firms' total employment. We exploit as orthogonality conditions only the stationarity of the series, in other words the orthogonality between the levels of the error terms and the differences in the instruments.

We use a Sargan test to check the validity of our instruments. The Sargan test statistic is small (0.96, p-value 0.61) and therefore we cannot reject the validity of the instruments. Furthermore, the Cragg-Donald F-statistic (429.05, 10% critical value is 22.30) rejects the null of weak instruments. We also checked whether capital-to-labor ratio and R&D intensity variables are endogenous and need to be instrumented. The obtained C-statistic (2.71, p-value 0.26) is quite small and therefore we cannot reject the null of exogeneity of both of these variables. We find that the elasticity of tax credit disbursement increases slightly from 0.07 to 0.09 after instrumenting the R&D tax credit disbursements. The coefficients on capital-to-labor ratio, firm size and alternative wage do not change much and remain statistically significant in the generalized two-stage least squares model

In columns (3)-(5) we report the results from alternative specifications regarding the firm and industry effects (fixed or random). When we use fixed industry effects (these results are listed in column 3) by including industry dummies as regressors in addition to random firm effects (Column 2) the fit of the model increases slightly (the Akaike information criterion drops from -2.8 to -2.84) and the joint F-test on the industry dummies rejects the null that their coefficients are jointly zero. The coefficients on the firm-specific variables (disbursement, size, capital-labor ratio, and R&D intensity) remain practically unchanged compared to the model with firm random effects only. The industry-level variable, alternative wage, becomes statistically insignificant.

In column (4) we report the results when both firm and industry effects are random. In this model the firm-specific effects are nested random (of the j-th firm within i-th industry) in the random industry-specific effects. The industry individual effect is much larger than the firm effect, and both random effects are statistically significant σ_{ui}=0.07 (standard error 0.01) and σ_{uj}=0.17 (standard error 0.01). The coefficients of the explanatory variables do not change much compared to the previous column.

Finally, in column (5) we report the results from the 'fixed-effects' model. The inclusion of firm and industry fixed effects implies that any variation in the disbursement variable now comes entirely from within-firm differences across time. We estimate the model in first-differences (by first differencing equation (6) in two consecutive periods). Through differencing we eliminate the fixed effects, i.e. unobserved time-invariant variables at the worker, firm and industry level. We instrument for the disbursement variable in first-differences with the lagged levels in disbursement, output and the share of R&D workers in total firm's employment. Here we exploit the orthogonality between the differences in the residuals and the levels of the instruments. The elasticity of disbursement increases slightly to 0.12 compared to the random-effects models. The elasticity of the R&D wage with respect to the alternative wage is now significant at the 10% level compared to the random-random model.

Both capital-to-labor ratio and firm size are very significant in all versions of the model, suggesting that R&D wages are higher in larger and more capital-intensive firms. The coefficient on the R&D intensity measure on the other hand, is never significant, suggesting that more R&D intensive firms do not necessarily pay higher wages to their R&D workers compared to less R&D intensive firms[13]. When we include quadratic terms of capital-to-labor ratio and firm size, we find a concave relationship between wages and these two variables, although the quadratic term of size is only weakly significant.

Several other experiments were carried out to check the robustness of the findings. To check for interaction effects we also included the interactions terms of capital-to-labor ratio and size and R&D intensity and size in addition to the simple terms and other controls. The coefficient on the former interaction term was negative and significant both in the random and first-differenced models, albeit very small in absolute value, suggesting that there is a negative R&D wage premium in the largest and most capital intensive firms. The coefficient on the latter cross-term was not significant, while the other coefficients hardly changed. To check for the effect of potential compositional changes in a firm's labor force over the business cycle, such as its skill composition, we included as an additional control variable the ratio of senior research staff over total R&D employees. This variable was not found to be significant in any of the specifications.

The alternative wage variable is significant in the random-effects models, and is not, as expected, when industry-fixed effects are added to the model. It is significant at the 10% level with a much

[13] We also estimated a version of the model taking the logarithms of capital-to-labor ratio and R&D intensity. This change did not affect the estimate of disbursements.

smaller coefficient in the version of the model estimated in first-differences (column 5). Some of the business-cycle control variables were found significant in models with time dummies after controlling for firm and industry effects. The ratio of new entrants and exits/spin-offs is negative and significant in the random effects model and the index of perceived competition in the first-differenced models. These two outcomes are hardly surprising, suggesting that a relatively high exit rate in a sector and higher competition depress R&D wages. The joint test of significance of these business cycle variables is 13.16 in the random effects model (column 3) rejecting the null and 7.19 in the differenced model (column 5) failing to reject the null.

The theoretical model (2) is essentially static. Several previous studies estimated a dynamic version of (6) justifying this persistence by, for example, the slow adjustment of wages to external shocks (e.g., Hildreth and Oswald, 1997). We have re-estimated our equation (6) by including lagged terms for the wage and the disbursement terms. We have used a one-step difference and efficient system GMM (Arellano and Bond, 1991; Blundell and Bond, 1998) estimators. The results from these dynamic models are presented in Table 4. We use the lagged values of the endogenous variables (i.e. lagged wage rate and disbursement) in addition to exogenous variables as instruments. The Sargan test of over-identifying restrictions does not reject the validity of the instruments (56.52, p-value 0.28 for system GMM and 38.4, p-value 0.36 for difference GMM). Arellano-Bond AR tests indicate no autocorrelation in the first differences of the residuals. The estimated coefficient on the lagged wage variable is 0.21 (standard error of 0.03) in the system GMM and 0.16 (standard error 0.04) in the difference GMM models, suggesting quick adjustment in wages. The coefficient on the disbursement variable is 0.10 (standard error of 0.03) in the difference GMM and 0.11 (standard error of 0.03) in the one-step system GMM. These values imply a long-run elasticity of wages with respect to disbursement of 0.12 – 0.13, that is statistically significant. Higher order lags for disbursement were not found to be significant.

It is worth mentioning that our results of the price effect of R&D tax incentives are consistent with the findings reported in the labor literature of wage determination. Hildreth and Oswald (1997) estimated an elasticity of wages with respect to profits per worker of about 4% using firm-level data. Abowd and Lemieux (1993) report an elasticity of about 20%. Van Reenen (1997) applied three different measures of rents (profits per head, Tobin Q and the difference between real sales per worker and average industry wage), created through product innovation, to examine the impact of innovation induced rents on wages using a panel of British firms. He reports an elasticity of wages to innovation rents of about 0.29 for the quasi-rent measure, 0.05 for the profits per head measure and 0.04 for Tobin's Q rent measure. Blanchflower et al. (1996) estimate an elasticity of wages with respect to profit per employee of 0.08 using U.S data. Studies that used matched worker-firm data typically found smaller rent-sharing effect. For example, Arai (2003) reports an elasticity of about 2% for Swedish data after controlling for fixed effects and instrumenting profits. Martins (2006) finds an elasticity of wage with respect to profits per employee in the range of 0.09 – 0.18 with Portuguese data. The recent exception is Kramarz (2007) who reports a bargaining power parameter of 0.5 for the French data.

5. Conclusions

This paper examines the price effect of the Dutch R&D tax incentive program known as WBSO. This program is intended to stimulate R&D, with special provisions for small firms and startups, by granting firms deductions from their social security contributions in proportion to their annual R&D wage bill. A recent evaluation of the WBSO program (Ministry of Economic Affairs, 2007) and an earlier study of ours as part of this evaluation (Lokshin and Mohnen, 2007) concluded that it was effective in stimulating business R&D, at least in the short run. Here we find evidence that there is also a wage effect of the R&D tax incentives program. Part of the R&D tax credits get transmitted into higher R&D wages because of inelastic labor supply, search costs for scientists and engineers, incentives given to R&D employees or bargaining power of R&D employees.

To estimate the magnitude of the price elasticity we have used a symmetric Nash bargaining model borrowed from the literature on labor economics and we have constructed firm- and time-specific R&D tax credit rates. Using a rich unbalanced firm-level panel data covering the years 1996-2004 we have estimated random and fixed-effects instrumental variable models in which we have controlled for unobserved firm and industry effects, business cycles fluctuations as well as the endogeneity of the R&D disbursement measures. We obtain a tight range of estimated elasticities of wages with respect to the R&D tax credit disbursement of the order of 10% in the short run and 12% in the long run.

Our estimates are smaller than those found for total government R&D by Goolsbee (1998) and those in Marey and Borghans (2000) for total sectoral R&D. Three factors could explain the differences between our estimates and theirs. First, ours concern only indirect tax incentives and not total government R&D or total private and public R&D, which firms may find easier to obtain and be more inclined to share with their R&D workers. Second, these authors use aggregate R&D data and hence their price effect could contain spillover effects. Third, they use time-series whereas we use panel data. Our estimates are thus likely to be less contaminated by trend factors.

The existence of a wage effect of R&D tax credits suggests that the efficiency of the R&D tax incentive program could be enhanced if the wage effect could be avoided. What goes into higher wages for scientists and engineers could go into more real expenditures on research and development.

Table 1 Variable constructions and descriptive statistics

Variable	Construction	Mean	Standard Deviation
Variables at the firm level			
Wage rate	Total wage bill divided by the number of hours, in logarithm	3.02	0.27
Capital-labor ratio	Capital stock divided by the number of employees (in 1000 Euros per employee)	12.75	18.72
R&D intensity	Total own firm's R&D expenditures divided by sales	0.05	0.32
Firm size	Number of employees in logarithm	4.95	1.04
Disbursements measure	WBSO rate, computed as in (4), in logs	-1.86	0.49
Variables at the industry level			
Alternative wage	Average sectoral R&D wage rate, in logarithm	3.14	0.13
Investment potential: solvability	Average solvability at industry level	36.10	11.13
Investment potential: return	Average return on total assets at industry level	2.68	7.31
Perceived competition	Index scaled between 0 (perceived competition is very low) and 100 (very high. Mean perception of competition of entrepreneurs at industry level	45.60	2.08
Turbulence	Ratio of new entrants and exits and spin-offs at industry level	11.64	3.21
Turnover	Annual mutation of added value at industry level	6.47	3.75

Note: The descriptive statistics are sample means for the years 1996-2004. The industry level data other than the alternative wage were provided to us by EIM.

Table 2 Overview of WBSO program parameters

Year	WBSO budget (in mln. Euro)	Length of the first bracket (in Euro of R&D)	Tax credit rate in first bracket (in %)	Tax credit rate in second bracket (in %)	Ceiling (in mln. Euro of tax credits)	WBSO Tax credit on one Euro of labor R&D costs
1997	227	68067	40	12.5	6.8	0.17
1998	281	68067	40	17.5	6.8	0.19
1999	293	68067	40	13	6.8	0.20
2000	302	68067	40	13	6.8	0.21
2001	337	90756	40 or 60 (s)	13	7.9	0.22
2002	367	90756	40 or 70 (s)	13	7.9	0.20
2003	323	90756	40 or 60 (s)	13	7.9	0.19
2004	365	110000	40 or 60 (s)	14	7.9	0.19

Source: Ministry of Economic Affairs (2007); (s) stands for 'starters'

Table 3. Instrumental variable estimation of the wage equation (4), static model

	(1)	(2)	(3)	(4)	(5)
	R&D tax credits treated as exogenous	GMM, levels	GMM, levels	GMM, levels	GMM, first differences
Tax credit disbursements	0.066*** (0.08)	0.085*** (0.013)	0.088*** (0.013)	0.086*** (0.013)	0.124*** (0.014)
Capital-labor ratio * 10^{-2}	0.141*** (0.220)	0.141*** (0.022)	0.149*** (0.023)	0.146*** (0.022)	0.491*** (0.036)
R&D intensity * 10^{-2}	0.741 (1.187)	0.884 (1.194)	0.067 (1.205)	0.400 (1.198)	1.325 (1.144)
Size (in logs)	0.048*** (0.006)	0.051*** (0.006)	0.047*** (0.006)	0.048*** (0.006)	0.031 (0.020)
Alternative wage	0.187*** (0.049)	0.188*** (0.049)	0.032 (0.061)	0.082 (0.058)	0.081* (0.046)
Standard error of firm specific effect	0.18*** (0.01)	0.18*** (0.01)	0.17*** (0.00)	0.18*** (0.01)	-
Standard error of industry effect	-	-	-	0.07*** (0.01)	-
Business cycle control variables	Included	Included	Included	Included	Included
Time dummies	Included	Included	Included	Included	Included
Firm effects	Random	Random	Random	Random	Fixed
Industry effects	None	None	Fixed	Random	Fixed
Sargan test of over-identifying restrictions (p-value)	-	0.96 (0.62)	2.60 (0.27)	0.97 (0.62)	0.10 (0.95)
Number of firms	1286	1286	1286	1286	1286
Number of observations	3485	3485	3485	3485	3485

Notes: Estimation period is 1996-2004. Standard errors are in parentheses.
*** Indicates significance at 1%, ** at 5%, * at 10% level.
F-test of the joint significance of the industry dummies in column (3) is 219.19, which is significant.

Table 4 Estimation of a dynamic version of the wage equation (4)

	(1)	(2)
	System GMM	Difference GMM
Wage rate$_{-1}$	0.212*** (0.034)	0.164*** (0.043)
Disbursements	0.097*** (0.024)	0.112*** (0.028)
Capital-labor ratio * 10^{-2}	0.002* (0.001)	0.005 (0.003)
R&D intensity * 10^{-2}	0.006 (0.006)	0.001 (0.004)
Size (in logs)	0.045*** (0.007)	0.042 (0.029)
Alternative wage	0.199*** (0.049)	0.083 (0.060)
Business cycle control variables	Included	Included
Time dummies	Included	Included
Sargan test of over-identifying restrictions (p-value)	56.52 (0.28)	38.38 (0.36)
Number of firms	1286	798
Number of observations	3485	2121

Notes: Estimation period is 1996-2004. Standard errors are in parentheses.
*** Indicates significance at 1%, ** at 5%, * at 10% level.

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