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The impact of right-to-work laws on R&D

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Abstract

This paper examines the impact of right-to-work laws on firms' innovative behavior, and more specifically through their R&D expenditures and patents. Relying on a difference-in-differences approach, and using a sample of 2408 observations of 291 U.S. firms, we find that the R&D ratio increased after the passage of a right-to-work law. Furthermore, relying on historical patent data between 1990 and 2006, we find that the introduction of the Right-to-work laws increased firms patenting behavior in absolute numbers, but also in their value. Altogether, this paper evidences that firms' innovative behavior may be inversely related to the employee protection, which may be of use for policy makers.

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1 Introduction

This paper studies the impact of right-to-work laws on research and development. A right-to-work law prohibits collective bargaining agreements that demand mandatory fees from employees and therefore only union members must pay a fee, as such reducing labor union strength relative to the firm's management. Prior research is ambiguous on the consequences of right-to-work laws on worker's wages and benefits (Gould & Kimball, 2015; Stevans 2007; Eisenach, 2015), but does indicate that their introduction leads to a substantial decrease in unionization (Hogler, Schulman & Weiler, 2004). We extend previous literature by questioning whether or not this reduction in labor union power, through right-to-work laws affects the firm's innovative behavior. R&D or innovation is one of the key drivers of economic performance because it is an important factor of economic growth both at a microeconomic and a macroeconomic level. At a microeconomic level, a business can get a competitive advantage by responding to more sophisticated customer needs. At a macroeconomic level, innovation will positively influence the variables capital, labor and multifactor productivity, that lead to economic growth (OECD, 2001). Previous studies evidence that R&D expenditures diminish under higher degrees of unionization (Bradley, Kim & Tian, 2016; Chen, Kacperczyk & Ortiz-Molina, 2011), arguably because of (i) union rent-seeking power (Hirsch & Link ; 1987), which allows unions to extract higher wages and (ii) the union's capacity of boycotting potential innovation that may lead to future job loss (Stiglitz, 2014; Doucouliagos 2012). Given the negative relationship between union power and R&D expenditures, we exploit exogenous changes in RTW laws to find whether or not the relationship between union power and R&D expenses changes. Finally, we also expect that the adoption of a right-to-work law leads to an increase in patents and patent citations. So, we expect that both the inputs and outputs of R&D will increase after the adoption of a right-to-work law.

There are several reasons why the topic of this paper is relevant. A first reason is that we both investigate the impact of right-to-work laws on the inputs and the outputs of innovation. More specifically, we investigate how right-to-work laws influence the R&D expenditures, but also patent and patent citations. In fact, to the best of our knowledge, this paper is the first to study firm's patenting behavior (and consequently R&D output) as a consequence of changes at the state legal framework. Further this paper contributes to the literature on R&D which is an important key driver for economic growth, so positively influencing R&D can lead to economic growth. Finally this research is also relevant because the Trump administration is in favor of right-to-work laws. Trump wants to improve the American business climate and beliefs that right-to-work laws will help doing this by giving employees and companies "*the flexibility to do what's in the best interest for job creators*" (Bernstein & Spielberg, 2017). Trump is in favor of introducing these right-to-work laws in all American states which means that our results are not only relevant for the individual states but can be extrapolated to the United States.

To test our hypotheses, we use unionization data of the FMCS database and Compustat data for the R&D expenditures and control variables. We also use data from the NBER patent citation database for the number of patents and forward citations. We use four difference-in-differences models with each a different dependent variable namely: R&D expenditures, R&D ratio, patents and patent forward citations. We contribute to the research on right-to-work laws by showing that the introduction of a right-to-work law increases the number of patents and patent citations and by giving an indication that there is a positive impact on the R&D ratio. This means that right-to-work laws positively influence a companies innovativeness by increasing its patenting behavior in absolute numbers, but also in their value. This can possibly indicate that companies were less innovative before the introduction of right-to-work laws for strategical reasons such as union rent-seeking. This can have important implications for policymakers.

The rest of this paper is organized as follows. In section two the relevant academic literature is presented and contains info on right-to-work laws, the link between right-to-work laws and unionization and the link between unionization and R&D. The third section consists of our research question and the relevance of this research. Section four contains info on how we do our research and consists of the hypotheses, the data and variables and the methodology. In

section five the results are presented and to conclude we give some limitations and practical implications in section six.

2 Academic literature

This section gives an overview of the relevant literature on the topic right-to-work laws and R&D. It consists of four major parts. In the first part we discuss right-to-work laws and the impact on several economic factors. Next, there is some information on the link between right-to-work laws and unionization. In the third part the link between unionization and R&D is discussed.

2.1 Right-to-work laws

In 1935 the Congress enacted the National Labor Relations Act, also known as the Wagner Act, that regulates collective bargaining in the private sector. This law gives employees the right to organize themselves and to organize union elections. Moreover, it also permits collective bargaining agreements between unions and employers that require all employees to pay a fee to the union. In 1947, the Taft-Hartley Act amended the National Labor Relations Act so that states can choose to adopt laws, better known as right-to-work laws, that prohibit these mandatory fees (Collins, 2012). Matsa (2010) states that: "*RTW laws outlaw employment contract provisions that require employees to join or financially support a union*." This can lead to a free rider problem because nonunion employees will get the same benefits as union employees, but without paying a fee. In 2017, there are 28 states with a right-to-work law with Missouri as the latest state to adopt this law (National right to work legal defense foundation, 2017). According to Leef (2015) more and more states adopt right-to-work laws for two main reasons. First, it can help them to attract firms. He says that there is a correlation between business and economic growth in right-to-work states. Second, workers are less convinced of the benefits of joining a labor union.

There is a lot of research on the economic impact of right-to-work laws, but this is often inconclusive. A first relation that is investigated is the one between right-to-work laws and wages on the one hand, and employment on the other. Gould & Kimball (2015) and Stevans (2007) argue that workers in right-to-work states earn less than workers in other states. These workers in right-to-work states are also less likely to have benefits such as health insurance and pension coverage paid by their employer. Other studies contrarily state that right-to-work laws have no impact on wages (Moore,1980), (Hogler, 2011) or even have a positive impact on wages (Eisenach, 2015). In his paper, Reed (2003) says that wages are significantly higher in right-to-work states if past economic conditions of the states are considered. According to him, states that adopted a right-to work law were poorer than the other states. Another relation that researchers investigate is the impact of right-to-work laws on employment. Some authors find no significant difference in employment between right-to-work states and other states (Bruno, Zullo, Manzo & Dickson, 2015; Stevans, 2007) while some others find a positive relation between right-to-work and employment (Eisenach, 2015; National Institute for Labor Relations Research, 2014). Eren & Ozbeklik (2011) explain the lack of consensus in the literature of right-to-work laws. They state that: "*From a research perspective, the lack of consensus is predominantly driven by the difficulty of distinguishing the effects of RTW laws from state characteristics, as well as other state policies that are unrelated*."

Second, prior research studied the relationship between right-to-work laws and stock prices. Unionized companies in states without a right-to-work law have a lower stock price and profitability compared to other American companies. These unionized companies have higher costs, such as higher wages, that they cannot fully transfer to their customers because this would lead to a competitive disadvantage. This leads to a lower return and a higher risk (Marciukaityte, 2018). Abraham & Voos (2000) use the event study methodology on the passage of a right-to-work law in Louisiana and Idaho. They find that there is a significant increase, between 2,2 and 4,5%, in

the shareholder returns after the passage of the RTW law in Louisiana. For Idaho, the authors find similar results, but these are less conclusive. Consequently, Abraham & Voos (2000) conclude that the passage of a right-to-work law increases shareholder wealth and expected profits. Finally, they also conclude that right-to-work laws are not only symbolic laws or in other words: "*reflecting preexisting anti-union attitudes (…), and unworthy of enormous resources devoted to them*". Meaning that these laws do matter for companies and labor unions.

Third, there also exists research on the impact of right-to-work laws on investments. Marciukaityte (2017) uses a differences-in-differences approach and finds that unionized companies located in states without a right-to-work law invest less but they increase their capital intensity. By replacing employees with capital, these firms depend less on employees so that they can reduce the influence of the union. Reduced investments could be compensated by a more efficient use of resources, but this is not the case in these states without a right-to-work law. The results of these reduced investments and increased capital intensity are reduced production and employment (Marciukaityte, 2017).

2.2 RTW laws and unionization

Prior research shows that right-to-work laws negatively affect unionization degrees (Elwood & Fine, 1987; Hogler et al., 2004). More specifically, Elwood and Fine (1987) argue that: "*right-to-work laws have a sizable initial impact on organizing that decays over time"*. A more recent study (Hogler et al. 2004) states that right to work laws lead to a decrease in unionization by almost 9 percentage points. The authors use several control variables for labor relations, social relations defined as: "*willingness to live by the norm of one's community and to punish those who do not*" and political ideology in their union density equation to find the net effect of right-to-work laws on unionization. Eren & Ozbeklik (2011) investigate the impact of the passage of a right-to-work law in Idaho and Oklahoma that respectively adopted this law in 1985 and 2001. According to their research, in Oklahoma the enactment of a right-to-work law resulted in a 14.5 % reduction in union membership. Eisenach (2015) summarizes the previous research on this topic and states that most researchers find a negative relation between right-to-work laws and unionization.

Collins (2012) discusses the link between right to work laws and unionization and compares the number of union members in right-to-work and other states, also called union security states. According to this comparison, the rate of employees who are unionized in union security states is almost three times that of right-to-work states. The author suggests 3 hypotheses, that were used in the past, that may be a possible explanation for the difference in unionization. Collins (2012) also says that these hypotheses are not mutually exclusive, so a combination of these hypotheses can form an explanation. The first hypothesis is "*the tastes hypothesis*". This implies that states that already have an opposition to unions are more likely to adopt a right-to-work law and this means that: "*RTW laws have no independent effect on labor organizing.*" Second, there is the "*free-rider hypothesis*" that suggest that prohibiting mandatory payments to the union, leads to a decline in payments. Consequently, the employees that still want to be a trade union member, will have to pay more. This can lead to one of the following two outcomes. On the one hand, these higher fees can become greater than what the former unionized employees want to pay for representation which will eventually lead to an excessive fee for the remaining union members. On the other hand, the remaining union members can refuse to pay these higher fees, but this will probably lead to a reduction in representation services offered by the union. The third hypothesis is "*the bargaining power hypothesis*" that: "*suggests that RTW laws reduce the bargaining power of unions and lead to reduced membership in the long run*." This means that unions are less likely to organize because they know that only a part of the employees represented by them will pay a fee. There is evidence for each of these hypotheses which indicates the complexity of determining the effect of right-to-work laws on unionization (Collins, 2012)

2.3 Unionization and R&D

R&D can be defined as (Oxford Dictionaries, s.d.) "*work directed towards the innovation, introduction, and improvement of products and processes*." R&D or innovation is one of the key drivers of economic performance because it is an important factor of economic growth both at a microeconomic and a macroeconomic level (OECD, 2001).

Bradley et al. (2016) investigate the impact of unions on innovation. They use the number of new patents and the number of patent citations as a proxy of innovation. The authors use patents instead of R&D expenditures because they want to focus on innovation output and not only on one of the inputs. They take the time lag of about two years between the patent application and the patent grant into account. Bradley et al. (2016) find that the number of patents and patent citations declines after passing a union election. There is more specific a decline of 8,7 % in patents and 12,5 % in patent citations. The authors give some explanations for this phenomenon namely: "*A reduction in R&D expenditures, reduced productivity of existing and newly hired inventors, and the departure of innovative individuals*." Furthermore, they also find that firms replace their innovation activities from states where union elections were successful. Other authors use R&D rates[1] as the dependent variable to determine the relation between unions and R&D and find a substantially negative relation between unionization and R&D (Betts, Odgers & Wilson, 2001).

Chen et al. (2011) state that higher unionization leads to a smaller part of the investment budget spend on R&D than on physical assets. A possible explanation is the fact that employees are more risk averse than for example shareholders. Risky projects can lead to higher share prices, but the employees will not receive any additional compensation. Moreover, these projects increase the chance of bankruptcy which leads to an income loss for the employees. R&D expenditures are riskier than expenditures on fixed assets. This can be explained by the fact that the future benefits of R&D investments are more uncertain than those of capital expenditures (Kothari, Laguerre & Leone, 2002). Hirsch & Link (1987) use union rent-seeking as an explanation for the negative relation between unionization and innovative activity. "*Rent-seeking is the use of the resources of a company, an organization or an individual to obtain economic gain from others without reciprocating any benefits to society through wealth creation*" (Investopedia, s.d.). This means that the unionized employees demand higher wages without for example an increase in their productivity.

An explanation for union rent-seeking is the inefficient bargaining relationship between the trade union and the company. This inefficiency exists because both parties do not have the same objective. They want to maximize their own wealth. If there was an efficient bargaining relationship, the union and the enterprise would have the same objective namely maximizing the present value of the firm. Rent-seeking has a similar effect on the returns from R&D investments as a tax and will therefore lead to a lower rate of return. Theoretically, the firm will protect its return stream from rent-seeking to the level where there is an equilibrium between the marginal protection cost and the marginal benefit. In other words, they will minimize the protection cost and their loss to the union. As a result, unionized firms will invest less in innovative activities (Hirsch & Link, 1987). Other authors also use rent-seeking as an explanation for this negative relation between unionization and innovative activity. Van Reenen (1996) for example wrote a paper about the impact of innovation on wages. He finds that there are higher average wages in innovating companies and gives three possible explanations for the fact that employees take a piece of the innovative returns. First, there passes more time between the R&D expenditure and their results compared to for example investments in tangible capital. Second, workers have a shorter time

[1] $R\&D\ rate = R\&D\ expenditures/output$

horizon than other stakeholders like for example shareholders. Third, innovative success is often unpredictable and based on luck.

Besides union rent-seeking there can also be another reason for a reduction in innovation caused by unions. In his paper, Stiglitz (2014) states that in the past some groups in society resisted innovation because they belief that innovation leads to unemployment and poverty. He states that "*in practice there are always winners and losers"*. Some innovations will reduce the need for unskilled workers which also leads to a decrease in their wages. The skilled employees on the other hand might have an increase in their wage. There will probably be no compensation from the skilled workers towards the unskilled workers which leads to an increase in the inequality in the society. Finally, Doucouliagos (2012) concludes that unions can affect whether or not a company adopts a technology and the magnitude of this innovation which means that (strong) unions have the power to boycott innovations.

3 Research question and contribution

This paper investigates the impact of right-to-work laws on R&D. The goal of our research is to find out whether the innovative activity of a company is influenced by the passage of a right-to-work law. In the past, other authors did investigate the impact of right-to-work laws on several other economic factors such as employment, wages, stock prices and so on.

So, the first reason why this research is relevant is that this is the first paper to study the impact of right to work laws on R&D. The paper that most closely resembles our study is that of Marciukaityte (2017) who shows that unionized companies located in states without right-to-work laws invest less but they increase their capital intensity. Based on the literature, we can state that there is some research on the relation between right-to-work laws and unionization on the one hand and unionization and R&D on the other hand. Further, we use multiple dependent variables in our models namely R&D expenditures which is an input of innovation but also patents and forward citations which are outputs of innovation. This makes it possible to determine whether the R&D resources are used more efficient after the adoption of a RTW law. When for example the R&D expenditures increase after the adoption of a right-to-work law, but the patents and forward citations remain constant, there is not an increase in innovation but possibly even a decrease in the efficiency of the usage of resources. So, by using both inputs and outputs, it is possible to determine the real impact of these right-to-work laws on R&D.

A second reason why this research is relevant is the importance of R&D as a key driver of economic performance. As mentioned before, R&D can lead to economic growth by creating a competitive advantage at microeconomic level and by positively affecting capital, labor and multifactor productivity at macroeconomic level (OECD, 2001). A third reason why this research is relevant is that it contributes to the literature on the effect of government policies on the business world. Political decisions can have more important consequences than one might think at first and it is therefore important that politicians take these consequences into consideration. With 3 more states that adopted a right-to-work law in the past 2 years, research on the economic consequences of right-to-work laws is still relevant (National right to work committee, 2017). As mentioned in the literature, these right-to-work laws are American laws which means that in this research we will use data on U.S. firms and focus on the implications in the U.S., but our findings can also be relevant and applied to other countries that want to pass similar labor laws.

A final reason that this research is relevant is that the topic becomes more important since Trump became president. The Trump administration wants to improve the American business climate and one of the actions they plan to take, is improving "*the states' attractiveness to job creators".* One of the ways to do this, is introducing right-to-work laws. As Patterson (2017) states: *"Right-to-work is but a first step toward state competitiveness. But it will be an increasingly necessary step in the Trump Era"*. The press secretary of the president stated after the election that: *"The president believes in right to work. He wants to give workers and companies the flexibility to do what's in the best interest for job creators."* (Bernstein & Spielberg, 2017). So, with a president that is in favor of right-to-work laws, our research can help people to better understand the consequences of these laws and possibly help them to form an opinion.

4 Research

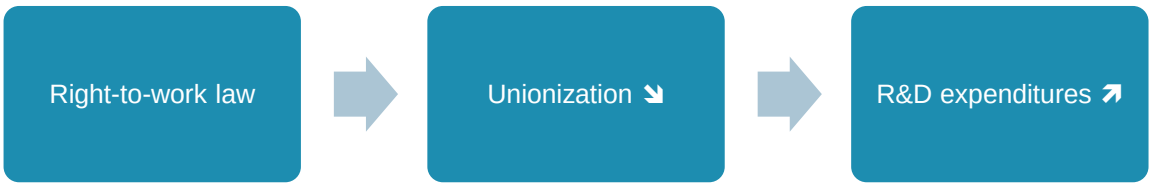
In this part we will discuss how we do our research and it consists of three major parts. First, the two main hypotheses and their sub hypotheses are discussed based on the literature. The next part deals with the data and variables we use in our models and finally, the last part discusses the methodology used to answer the hypotheses.

4.1 Hypotheses

As mentioned in the literature study, unionization leads to a decrease in R&D investments. This phenomenon is according to several researchers (Betts et al., 2001; Hirsch & Link,1987; Van Reenen, 1996) caused by union rent seeking. In short, this means that that unionized employees demand higher wages which has a similar effect on the returns from R&D investments as a tax and will consequently lead to a lower rate of return. This will lead to a decrease in innovative investments or in other words R&D expenditures. Another reason for the decrease in innovation might be the union's capacity of boycotting potential innovation that may lead to future job loss (Stiglitz, 2014; Doucouliagos 2012)

Further, there is a lot off research on the relation between right-to-work laws and unionization. Researchers found mixed results, but most of them (Elwood & Fine, 1987; Hogler et al., 2004; Eisenach, 2015) found that there is a negative relation between right-to-work laws and unionization. Combining these 2 findings leads to the following reasoning: the adoption of a right-to-work law will result in a decrease in unionization which will lead to an increase in R&D investments (Figure 1).

Figure 1: Right-to-work law, unionization and R&D expenditures



This leads to the following hypothesis:

H1a: Right-to-work laws lead to an increase in R&D expenditures.

As mentioned earlier, Marciukaityte (2017) investigated the relation between right-to-work laws and investments. One of the conclusions of this paper is that unionized companies located in states without right-to-work laws invest less but they increase their capital intensity. Another researcher (Chen et al., 2011) states that higher unionization leads to a smaller part of the investment budget spend on R&D than on physical assets. In this paper, we want to test whether the percentage of R&D expenses compared to the total investments increases after the passage of right-to-work laws. This leads to the following hypothesis:

H1b: Right-to-work laws lead to an increase in R&D expenditures relative to the total investments.

As mentioned earlier, the authors who investigated the relation between unionization and R&D or innovation did not only use R&D expenditures as a proxy of R&D. Researchers such as Bradley et al. (2016) used the number of patents and patent forward citations as a proxy for R&D. The usage of patents has the benefit that a researcher can investigate the output or effectiveness of the R&D expenditures. We want to investigate whether the passage of a right-to-work law has not only a positive effect on the inputs of R&D, namely R&D expenditures, but also on the outputs namely patents and patent citations. Bradley et al. (2016) found a negative relation between unionization and patents and patent citations. So, we expect that the number of patents and patent citations will increase after the passage of a right-to work law. This leads to the following hypothesis:

H2a: Right-to-work laws lead to an increase in a firm's average quarterly granted patents.

H2b: Right-to-work laws lead to an increase in the value of the firm's quarterly granted patents.

4.2 Data and variables

4.2.1 Data

We study the impact of right-to-work laws on innovation using R&D and patent information. To create the right-to-work dummy variable, we use the right-to-work states timeline from the National right to work committee (2017). Further, unionization data is obtained from the FMCS database and is used to create a sample for hypothesis 1a and 1b. For the control variables and data on the R&D expenditures we use Compustat. Finally, we also use the patent citation database of the NBER (National Bureau of Economic Research) for the number of patents and forward citations. The data from the different databases are matched using the companies GVKEY code and the year and quarter of the observation. The observation period of our first sample goes from 2005 to 2015[2]. After merging the FMCS database and the Compustat data there are 2408 observations. In the sample period there are three states that pass a right-to-work law namely Indiana in February 2012, Michigan in March 2013 and Wisconsin in March 2015 (National right to work committee, 2017). The observation period of the patent and forward citation sample goes from 1990 up till 2006 and contains 5498 observations for the patent data and 6321 observations for the forward citation data with only one state that passes a right-to-work law, namely Oklahoma in 2001. We use quarterly data for our research.

4.2.2 Measurement of innovation

There are different proxies for R&D so by choosing the right one(s), it is possible to make the right conclusions. Often, papers that investigate R&D use firm-level R&D expenditures to measure innovation but there are drawbacks for using this unit of measurement namely the fact that (Ayaydin, Thewissen & Torsin, 2017): "*R&D expenditures are generally proxied by using accounting data and are thus often inaccurate due to the lack of accounting regulation and standards concerning R&D reporting*". Bradley et al. (2016) also suggest that R&D expenditures are not sufficient as a measurement of R&D because it is only one of the inputs of R&D which can lead to false conclusions. A solution for this problem is using patents, which makes it possible to see how effective resources are used or in other words what the output of the R&D expenditures

[2] This sample is used to answer hypothesis 1a and 1b.

is. Ayaydin et al. (2017) use the variable Green patents in their research proxied by: "*The average number of green patents firm q was granted in quarter q of year t*". So, It is possible to take the number of patents but the problem here is that not all patents have the same value, their technical impact for example can be very different. By using a patent's forward citations, which can be defined as: "*the number of citations made by future patents to the current patent*", it is possible to solve this problem. Ayaydin et al. (2017) do this by using the variable Patent Value which is proxied by "*the logarithm of the average number of forward citations across all n patents firm i received in quarter q of year t*".

4.2.3 Dependent Variables

To answer the research question and to test the hypotheses presented in 4.1, four models are used with four different dependent variables that represent the different measurement approaches of innovation. The first dependent variable is R&D expenditures measured in US dollar which is used to solve hypothesis 1a. The R&D ratio is the dependent variable in the second model which tests hypothesis 1b and is equal to the R&D expenditures divided by the total investments. The third model has the number of patents as the predicted variable and is used to answer hypothesis 2a. Finally, the fourth model uses the average number of forward citations of a patent and makes it possible to answer hypothesis 2b. Table 1 gives an overview of the discussed variables and section 4.3 contains the models.

4.2.4 Independent variables

For all the models the independent variables are the same. RTW is a dummy-variable with value 1 for right-to-work states. The next explanatory variable is Post which is a dummy variable that has a value 1 in the second period, so after the possible adoption of the right-to-work law. The last variable is POSTRTW and is the interaction term of the previous two variables. Table 1 gives an overview of the discussed variables.

4.2.5 Controls

In this section, we will first discuss the factors that have an impact on R&D according to previous research followed by a brief discussion of the control variables we will use.

Researchers such as Becker (2013), Inderrieden, Laczniak & Pecotich (1990) and Liu (2011) investigate which factors potentially influence R&D. The results of these studies are not always very conclusive. Inderrieden et al. (1990) investigate what the determinants of R&D expenditures are. In their research, they investigate whether organizational variables, environmental measures, organizational strategy measures and individual measures have a significant impact on R&D expenditures and its future success. For the organizational variables, the authors found that: "*R&D expenditures are inversely related to perceptions of past performance and industry performance."* This means that R&D expenditures will increase when the industry faces difficult times. Further, R&D expenditures are positively related to environmental competitiveness. Finally, R&D expenditures are also positively related to the environmental turbulence when an organization has a growth strategy.

Liu (2011) does research on the determinants of R&D expenditures for the bio-pharmaceutical sector[3] in the US. Based on previous research the author investigates whether the following six variables have a significant impact on R&D expenditures: firm size, leverage ratio, sales to cash flow ratio, operating profit margin, sales growth rate and lagged R&D expenditures. She uses a single variable analysis and a multiple variable analysis. Liu finds a significant impact on R&D expenditures for three of the variables, namely firm size, sales growth rate and lagged R&D expenditures, using both analyzes. Firm size is measured by the number of total assets in a company and has a significantly positive impact on R&D expenditures. The sales growth rate has a significantly positive impact on R&D expenditures using the single variable analysis but there is a negative correlation using the multiple variable analysis. Finally, the lagged R&D expenditures[4] are significantly positively related to the R&D expenditures. For the other three variables, Liu only finds a correlation using the multiple variable analysis. The leverage ratio or debt level is slightly positively correlated to the R&D expenditures. While the sales to cash flow ratio and the operating profit margin are slightly negatively correlated to the R&D expenditures

A more recent research of Becker (2013) gives a broad summary of earlier findings on the factors that influence R&D. Based on previous research, the author categorizes the determinants of R&D in 5 broad categories. The first determinant of R&D is individual firm or industry characteristics such as internal finance, which can be measured by a firm's cashflow, and sales. These 2 factors are positively related to R&D. Some other characteristics that can be used are firm age and the country in which a company is active. A second determinant is the competition in product markets which has a positive[5] effect on R&D. This determinant can be measured by different proxies such as the average profitability[6] and foreign entry. Another factor that influences R&D are government R&D policies such as R&D tax credits and subsidies that both have a positive effect. These policies can help to increase R&D expenditures to a socially optimum. Fourth, location and resource related factors also form a determinant, examples are spillovers from research of nearby universities and human capital. For the last determinant, spillovers from foreign R&D, there is limited evidence that supports crowding out which states that R&D activities abroad can lead to positive spillovers from the local firms that can be transferred to the home country.

The control variables are variables that we do not use to answer the hypotheses, but that possibly have a significant impact on the dependent variable. Based on the previous section and the paper of Marciukaityte (2017), the following control variables are used in all the models. The first control variable is profitability which gives an indication of the past performance of a company and is measured by its return on assets. Further, the firm size can be a relevant control variable and is proxied by the natural log of the total assets. The third control variable is the sales growth which can be obtained by taking the difference between this year's sales and last year's sales and dividing this difference by last year's sales. The fourth control variable is the leverage ratio which equals the total debts divided by the total assets. Table 1 gives an overview of the discussed variables.

[3] Liu uses the bio-pharmaceutical industry because this is the most representative industry of innovation.

[4] R&D expenditures of last year

[5] This may have a nonlinear inverted U-curve shape.

[6] $= (value\ added/(labor\ costs + capital\ costs))$

Table 1: Variables

Dependent variables	
H1a: R&D expenditures: measured in US dollar	H2a: Total number of patents per company
H1b: R&D ratio $= \text{R\&D expenditures} / \text{capital expenditures}$	H2b: Average number of forward patent citations per company
Independent variables	
RTW	Dummy variable which is equal to one for firms in states with a right-to-work law and zero otherwise.
Post	Dummy variable which is one for the period after the passage of a right-to-work law and zero otherwise.
POSTRTW	This is the product of the variables RTW and Post.
Control variables	
Profitability[7]	This is measured by the return on assets $= \frac{operating\ income\ before\ depreciation}{total\ assets}$
Firm size	$= ln(total\ assets)$
Sales growth	$= (\frac{sales_1 - sales_0}{sales_0})$
Leverage ratio	$= \frac{debt}{total\ assets}$

Source: based on Inderrieden et al. (1990), Liu (2011) and Becker (2013) and Marciukaityte (2017)

4.3 Methodology

To test the hypotheses, we use a differences-in-differences (with fixed or random effects) model which is a panel-regression method (Marciukaityte, 2017). The treatment group consists of firms located in right-to-work states while the control group consists of firms in the other states. In the following two sections we present our models and the statistical tests that we use.

[7] Source: corporate finance institute, 2017

4.3.1 Models

Model 1: hypothesis 1a

$$\ln(R\&D) = \beta_0 + \beta_1 RTW + \beta_2 Post + \beta_3 RTW * Post + \beta_4 Controls + \varepsilon$$

Model 2: hypothesis 1b

$$\ln(R\&Dratio) = \beta_0 + \beta_1 RTW + \beta_2 Post + \beta_3 RTW * Post + \beta_4 Controls + \varepsilon$$

Model 3: hypotheses 2a

$$\#Patents = \beta_0 + \beta_1 RTW + \beta_2 Post + \beta_3 RTW * Post + \beta_4 Controls + \varepsilon$$

Model 4: hypotheses 2b

$$\#Forward\ citations = \beta_0 + \beta_1 RTW + \beta_2 Post + \beta_3 RTW * Post + \beta_4 Controls + \varepsilon$$

4.3.2 Statistical tests

In this part we will discuss the statistical tests we use on our data and that lead to our models. First, we control for outliers or influential cases by looking at the histograms of the dependent and independent variables. Further we control for multicollinearity based on the correlation between the independent variables.

There are some assumptions that need to be verified to make it possible to interpret the t-statistics and the p-values of the models. A first assumption that needs to be checked, is the normality of the residuals. We will do this by looking at the histogram of the residuals, performing a Jarque-Bera test[8] and controlling some statistics such as the skewness and kurtosis. A second assumption is that there is no endogeneity which means that there is no correlation between the error terms and the independent variables. This can be tested by a Hausman test[9]. If there is endogeneity, only a fixed effects model can be used. The next assumption is that the variance of the error terms is constant which means that there is homoscedasticity. The presence of heteroskedasticity will be tested with an equality of variance test. If there is cross-sectional heteroskedasticity, we will use a white cross-section correction. A last assumption is that there is no autocorrelation which means that the residuals are not correlated (De Prijcker, 2017). We will use the program R to estimate our models and to perform the statistical tests that are mentioned.

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[8] The null hypothesis is that the residuals are normally distributed.

[9] The null hypothesis is that there is a correlation between individual effects (ε_i) and independent variables.

5 Results

5.1 Descriptive statistics

Panel A of Table 2 presents some descriptive statistics of the R&D data and control variables. The first two variables, R&D and R&Dratio include all the observations, also those with value zero[10]. The second two variables, ln(R&D) and ln(R&Dratio) do not include these zero values[11]. Panel B of Table 2 presents the Pearson correlations. Some correlations are not significantly different from zero and the largest value is 0,54 (Post and PostRTW).

Panel A and B of Table 3 present the descriptive statistics of the patent and forward citation data and the control variables. In panel A, the variables ROA and LeverageRatio have some extreme values based on the maximum and the standard deviation. Panel C and D of Table 3 provide the Pearson correlations. In panel C, the correlation between RTW and PostRTW is 0,99. This is fairly high and needs to be taken into account.

[10] These variables are used in the Tobit models to test hypothesis 1a and 1b.

[11] These variables are used in the fixed effects models to test hypothesis 1a and 1b.

Table 2: Summary statistics R&D and R&D ratio

Panel A presents the descriptive statistics of our first sample, based on Compustat and the FMCS database, that is used to study the impact of right-to-work laws on R&D and the R&D ratio. The data from the two databases are matched using the GVKEY (company code) and the year and quarter. The dataset contains 2408 observations if we include all observations and 945 if we do not take zero-values into account. The variable definitions can be found in table 1. Panel B presents Pearson correlations of the relevant variables. *,**,*** denote significance of the t-test at the 10%, 5%, and 1% respectively.

Panel A: Summary statistics of the R&D data, RTW data and controls								
	Min	**1st Q**	**Median**	**Mean**	**3rd Q**	**Max**	**Std. Dev**	**# obs.**
R&D	0,00	0,00	0,00	137,62	68,34	10991,00	511,12	2408,00
R&Dratio	0,00	0,00	0,00	0,29	0,21	23,62	0,90	2408,00
ln(R&D)	-2,44	3,76	4,53	4,60	5,92	9,30	1,80	945,00
ln(R&Dratio)	-6,79	-2,21	-1,02	-1,23	-0,19	3,16	1,51	945,00
RTW	0,00	0,00	0,00	0,43	1,00	1,00	0,49	2408,00
Post	0,00	0,00	0,00	0,30	1,00	1,00	0,46	2408,00
PostRTW	0,00	0,00	0,00	0,11	0,00	1,00	0,32	2408,00
ROA	-0,74	0,10	0,13	0,13	0,16	0,64	0,06	2408,00
ln(Assets)	2,30	7,98	9,34	8,98	9,91	14,99	1,45	2408,00
LeverageRatio	0,00	0,16	0,28	0,28	0,38	1,10	0,18	2408,00
SalesGrowth	-0,75	-0,01	0,02	0,04	0,09	1,48	0,18	2408,00

Panel B: Pearson correlations									
	R&D	**R&Dratio**	**RTW**	**Post**	**PostRTW**	**ROA**	**Ln(Assets)**	**LeverageRatio**	**SalesGrowth**
R&D	1,00								
R&Dratio	0,49***	1,00							
RTW	-0,03	-0,01	1,00						
Post	0,00	0,01	-0,07***	1,00					
PostRTW	-0,04*	-0,03	0,41***	0,54***	1,00				
ROA	0,03	-0,07***	-0,02	-0,04**	-0,02	1,00			
Ln(Assets)	0,28***	-0,01	-0,11***	0,08***	-0,01	0,00	1,00		
LeverageRatio	-0,14***	-0,11***	-0,09***	0,06***	0,01	0,06***	0,02	1,00	
SalesGrowth	0,15***	0,07	-0,02	-0,04	-0,08	0,18***	0,00	-0,07	1,00

Table 3: summary statistics patents and forward citations

Panel A and B present the descriptive statistics for the patent and patent forward citation data that are based on the NBER patent citation database and Compustat and are used to study the impact of right-to-work laws on patents and forward citations. The data from the two databases are matched using the GVKEY (company code) and the year and quarter. The variable definitions can be found in table 1. Panel C and D presents Pearson correlations of the relevant variables. *,**,*** denote significance of the t-test at the 10%, 5%, and 1% respectively.

Panel A: Summary statistics of the patents data, RTW data and controls								
	Min	**1st Q**	**Median**	**Mean**	**3rd Q**	**Max**	**Std. Dev**	**# obs.**
Ln(Patents)	1,00	2,00	4,00	12,20	11,00	416,00	1,27	5498,00
RTW	0,00	0,00	0,00	0,17	0,00	1,00	0,38	5498,00
Post	0,00	0,00	0,00	0,33	1,00	1,00	0,47	5498,00
PostRTW	0,00	0,00	0,00	0,17	0,00	1,00	0,38	5498,00
ROA	-1207,50	0,24	0,65	21,39	1,74	73939,44	1005,14	5498,00
ln(Assets)	-5,81	3,71	5,52	5,18	7,00	11,98	2,57	5498,00
LeverageRatio	1,00	2,26	3,87	38,50	9,23	24368,44	426,67	5498,00
SalesGrowth	-1,00	-0,04	0,02	0,08	0,09	176,53	2,42	5498,00
Panel B: Summary statistics of the forward citation data, RTW data and controls								
	Min	**1st Q**	**Median**	**Mean**	**3rd Q**	**Max**	**Std. Dev**	**# obs.**
Average Patent citations	1,00	3,67	7,54	10,19	13,04	79,00	9,73	6321,00
RTW	0,00	0,00	0,00	0,05	0,00	1,00	0,23	6321,00
Post	0,00	0,00	0,00	0,29	1,00	1,00	0,45	6321,00
PostRTW	0,00	0,00	0,00	0,02	0,00	1,00	0,13	6321,00
ROA	-0,09	0,00	0,01	0,01	0,02	0,06	0,03	6321,00
ln(Assets)	1,72	7,52	8,68	8,51	9,66	13,53	1,75	6321,00
LeverageRatio	0,02	0,42	0,55	0,54	0,67	1,86	0,19	6321,00
SalesGrowth	-1,00	-0,02	0,07	0,28	0,18	690,64	9,04	6321,00

Panel C: Pearson correlations								
	Ln(patents)	**RTW**	**Post**	**PostRTW**	**ROA**	**Ln(Assets)**	**LeverageRatio**	**SalesGrowth**
Ln(patents)	1,00							
RTW	-0,06***	1,00						
Post	-0,04***	-0,01	1,00					
PostRTW	-0,05***	0,99***	-0,01	1,00				
ROA	0,02**	-0,01	0,00	-0,01	1,00			
Ln(Assets)	0,44***	-0,05	-0,02	-0,04***	-0,07***	1,00		
LeverageRatio	0,00	0,00	0,07***	0,00	0,04***	-0,19***	1,00	
SalesGrowth	-0,03**	-0,01	-0,02	-0,01	0,00	-0,09***	0,01	1,00
Panel D: Pearson correlations								
	Average forward citations	**RTW**	**Post**	**PostRTW**	**ROA**	**Ln(Assets)**	**LeverageRatio**	**SalesGrowth**
Averge forward citations	1,00							
RTW	-0,01	1,00						
Post	-0,39***	0,01	1,00					
PostRTW	-0,07***	0,55***	0,21***	1,00				
ROA	0,10***	-0,01	-0,13***	-0,02	1,00			
Ln(Assets)	-0,14***	0,01	0,09***	0,02	0,22***	1,00		
LeverageRatio	-0,12***	0,02	-0,10***	-0,02	0,02**	0,43***	1,00	
SalesGrowth	0,01	0,00	-0,01	0,00	-0,06***	-0,05***	-0,02	1,00

5.2 Multivariate analysis

5.2.1 Hypothesis 1

To test the relationship between right-to-work laws and R&D expenditures and R&Dratio respectively, we estimate the first two models presented in 4.3.1. As mentioned in 4.1, we expect to find a positive impact in both cases.

Table 4 reports the results on the models that we use to test hypothesis 1a and 1b, namely whether right-to-work laws lead to an increase in R&D expenditures and R&D ratio. For each hypothesis we created 2 models namely a Fixed effects and a Tobit model.

Table 4: Impact of right-to-work laws on R&D expenditures and R&D ratio

	Dependent variable:			
	(ln) R&D expenditure		(ln) R&D ratio	
	(Fixed 1)	(Tobit 1)	(Fixed 2)	(Tobit 2)
RTW	−0,025	241,953	−0,161**	0,371*
	(0,032)	(153,696)	(0,069)	(0,204)
Post	−0,236*	42,979	−0,480***	0,479
	(0,124)	(218,816)	(0,080)	(0,287)
POSTRTW	0,094	−220,244	0,271**	−0,713
	(0,080)	(349,897)	(0,115)	(0,464)
ROA	2,873**	995,846	−0,248	0,927
	(1,297)	(1279,881)	(0,984)	(1,664)
Ln(Assets)	0,829***	179,754***	0,132	−0,016
	(0,246)	(47,164)	(0,142)	(0,061)
LeverageRatio	1,859**	−817,523*	2,338***	−1,140**
	(0,820)	(417,997)	(0,523)	(0,545)
salesGrowth	−0,150	−398,565	−0,142	−0,039
	(0,149)	(384,282)	(0,202)	(0,052)
Constant		−2186,695***		−0,473
		(507,805)		(0,649)
Year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Observations	945	2408	945	2408
R^2	0,500		0,300	
Adjusted R^2	0,251		−0,047	
F Statistic	18,372***		7,893***	
Log Likelihood		−1442,169		−411,094
Note:				*p<0.1; **p<0.05; ***p<0.01

This table reports evidence for Hypothesis 1a on the relationship between right-to-work laws and R&D expenditures and 1b on the relationship between right-to-work laws and the R&D ratio. We include the control variables defined in Table 1. Fixed 1 and Fixed 2 do not include zero-values for the dependent variable, Tobit 1 and Tobit 2 do. The models are corrected for heteroskedasticity using White correction. The robust standard errors are presented in parenthesis. *, **,*** denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively, based on a two-sided t-test.

The first model, Fixed 1, has the natural log of the R&D as dependent variable. It is a fixed effects model which is most suitable based on the redundant fixed effects test and the Hausman test. Our main variable, POSTRTW, does not have a significant impact on the dependent variable. The variable Post is significant on a 10 % level. Finally also three of the control variables have a significant and positive impact on the R&D expenditures namely the return on assets, the natural log of the assets and the leverage ratio. The next model, Tobit 1, has R&D expenditures as dependent variable. In this model the variable POSTRTW is not significant, only the natural log of the assets and the leverage ratio have a significant impact on the R&D expenditures. Based on these 2 models, we can reject hypothesis 1a which states that right-to-work laws lead to an increase in R&D expenditures. A possible explanation for the lack of statistical significance of POSTRTW, might be strategic decisions of firms to obscure R&D information which is possible "*due to the lack of accounting regulation and standards concerning R&D reporting*" (Ayaydin et al., 2017).

The next 2 models, Fixed 2 and Tobit 2, investigate the impact of right-to-work laws on the R&D ratio[12]. Model Fixed 2 has the natural log of the R&D ratio as dependent variable and here we also choose a fixed effects model based on the redundant fixed effects test and the Hausman test. In this model, the variables RTW and POST are significant and negative. Furthermore our main variable POSTRTW is significant on a 5% level and has a positive influence on the R&D ratio, so based on this model we can state that after the adoption of a right-to-work law the R&D ratio increases. In this model the only significant control variable is the leverage ratio. The last model in table 4 is Tobit 2 and has the R&D ratio as dependent variable but here, the interaction term POSTRTW is not significant. Both the variables RTW and Post are positively related to the R&D ratio and significant at a 10% level. Further, the control variable leverage ratio is significant at a 5 % level.

From the previous four models and their discussion we conclude that hypothesis 1a can be rejected. The variable POSTRTW is not significant in the models Fixed 1 and Tobit 1. Consequently we state that right-to-work laws do not lead to an increase in R&D expenditures. Model Fixed 2 gives an indication that the R&D ratio increases after the adoption of a right-to-work law, but we cannot make the same conclusion based on model Tobit 2. Because of the ambiguous result, we do not reject hypothesis 1b. So based on our models we can state that there is an indication that right-to-work laws lead to an increase in the R&D ratio but we need to be careful with these results. The R&D data are historically sloppy and consequently we cannot make conclusive inferences. Further research is needed to control our results and make interferences.

5.2.2 Hypothesis 2

To test the relationship between right-to-work laws and the number of patents, we estimate the third model presented in 4.3.1. As mentioned in 4.1, we expect to find a positive impact.

In table 5, we use three models to answer hypothesis 2a namely whether right-to-work laws lead to an increase in a firm's average quarterly granted patents. The dependent variable in these three models is the natural log of the patents and all the models are corrected for heteroskedasticity and autocorrelation. Based on the redundant fixed effects test and the Hausman test we opted for two fixed effects models and one random effects model.

[12] The R&D expenditures divided by the capital expenditures.

Table 5: Impact of right-to-work laws on patents

	Dependent variable:		
	Ln(Patents)		
	(Fixed full sample)	(Fixed no outliers)	(Random windsorized)
RTW	−0,940***	−0,954***	0,0002
	(0,190)	(0,178)	(0,002)
Post	−2,372***	−0,663*	−0,044***
	(0,202)	(0,345)	(0,004)
POSTRTW	0,798***	0,820***	0,002*
	(0,194)	(0,183)	(0,0009)
ROA	0,0001***	0,0001***	−0,000001
	(0,01)	(0,00001)	(0,0000001)
Ln(Assets)	0,259***	0,248***	−0,0003**
	(0,007)	(0,007)	(0,0002)
LeverageRatio	0,0003***	0,0003***	−0,000001
	(0,00009)	(0,00009)	(0,0000004)
salesGrowth	−0,005	−0,005	−0,00002
	(0,013)	(0,010)	(0,0001)
Year fixed effects	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Observations	5498	5463	5498
R^2	0,232	0,224	0.264
Adj. R^2	0,207	0,197	0,262
F Statistic	230,164***	217,408***	262,539***
Note:			∗p<0.1; ∗∗p<0.05; ∗∗∗p<0.01

This table reports evidence for Hypothesis 2a on the relationship between right-to-work laws and patents. We include the control variables defined in Table 1. Fixed full sample is a model based on all 5498 observations, Fixed no outliers is a model based on the observations without outliers and Random widsorized is a model based on our complete dataset but windsorized at 1 and 99%. All models are corrected for heteroskedasticity and autocorrelation using the Newey-West correction. The robust standard errors are presented in parenthesis. *, **,*** denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively, based on a two-sided t-test.

Our main variable, POSTRTW has a significant and positive impact on the number of patents in all the models. This means that the average quarterly granted number of patents per company increases after the passage of a right-to-work law and that we can accept hypothesis 2a. Further, the two fixed effects models show similar results. The variables RTW and Post have a significant and negative impact on the number of patents and all the control variables, except for salesGrowth, have a significant and positive impact on the number of patents.

To test the relationship between right-to-work laws and the average number of forward patent citations we estimate the fourth model presented in 4.3.1. As mentioned in 4.1, we expect to find a positive impact. In table 6, we use two models to answer hypothesis 2b namely whether right-to-work laws lead to an increase in the value of the firm's quarterly granted patents. All models are corrected for heteroskedasticity and autocorrelation. The models have the natural log of the average forward citations per patent as dependent variable. We use a model with the full sample (companies from all states between 1990 and 2006) and a subsample with only companies from Oklahoma and its surrounding states. We choose Oklahoma because this is the only state that

adopted a right-to-work law[13] in the sample period. Our main variable POSTRTW has a significant and positive impact on the average forward citations in the model with the full sample. In the other model there is no impact. So we can state that there is an indication that the passage of a right-to-work law influences the quality or value of a company's patents. Some possible explanations for the increase in patent quality can be an increase in productivity of the inventors, the attraction of new and more innovative people and also an increase in R&D investments (Bradley et al., 2016) as mentioned in 2.3.

Table 6: Impact of right-to-work laws on forward citations

	Dependent variable:	
	Average forward citations	
	(Fixed full sample)	(Fixed subsample)
RTW	−0,147***	−0,237**
	(0055)	(0,095)
Post	−1,151***	−0,017
	(0,022)	(0,320)
POSTRTW	0,246**	−0,032
	(0,099)	(0,166)
ROA	1,19***	−3,576*
	(0,424)	(2,145)
Ln(Assets)	0,043***	0,142**
	(0,007)	(0,055)
LeverageRatio	−0,680***	−1,719***
	(0,059)	(0,367)
salesGrowth	0,002*	−0,072
	(0,001)	(0,196)
Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
Observations	6321	293
R^2	0,313	0,126
Adjusted R^2	0,291	0,172
F Statistic	398,923***	5,682***
Note		∗p<0.1; ∗∗p<0.05; ∗∗∗p<0.01

This table reports evidence for Hypothesis 2b on the relationship between right-to-work laws and patent forward citations. We include the control variables defined in Table 1. Fixed full sample is a model based on all 6321 observations and Fixed subsample is based on the observations of Oklahoma and the surrounding states. All models are corrected for heteroskedasticity and autocorrelation using the Newey-West correction. The robust standard errors are presented in parenthesis. *, **,*** denote statistical significance at the 10 %, 5 %, and 1 % levels, respectively, based on a two-sided t-test.

[13] Oklahoma adopted a right-to-work law in 2001.

All the variables in the first model have a significant impact on the average forward citations, RTW and Post have a negative impact, and all the control variables except for LeverageRatio have a positive impact. Based on our first model, we can state that a right-to-work law leads to an increase an increase in the value of the firm's quarterly granted patents and accept hypothesis 2b.

The results of table 5 and 6 can have important implications because right-to-work laws do not only increase a firms patenting behavior in absolute numbers, but also the value of each patent. This can possibly indicate that companies were less innovative before the introduction of right-to-work laws for strategical reasons, such as avoiding or reducing union rent seeking, a phenomenon explained in 2.3 which briefly means that unionized employees demand higher wages because of the higher expected returns and the higher risk of R&D expenditures. Another explanation can be the union's capacity of boycotting potential innovation that may lead to future job loss (Stiglitz, 2014; Doucouliagos 2012) which is also mentioned in 2.3.We can refer back to the assumption we made in Figure 1, namely that a right-to-work law leads to a decrease in unionization (which means a decrease in the power of the union) and consequently to an increase in innovativeness. So, there is an indication that strong labor unions undermine the innovativeness of companies which can be very important for policymakers. Further research is needed to control for the impact of unionization and verify our assumptions.

6 Limitations and practical implications

We had some data limitations in our research. We used patent and forward citation data from the NBER patent citation database from 1990 up till 2006 and unionization data from 2005 up till 2015 from the FMCS database. So when we combined these datasets we had a sample of only 2 years and consequently we could not investigate the variable unionization and its impact on patents and forward citations. We worked with a sample from 2005 up till 2015 for the R&D data and a sample from 1990 up till 2006 for our patent and forward citation data because of data limitations. We had to make a trade-off between data richness and data reliability because some time needs to pass after a patent is granted to measure its value (namely the number of forward citations). Therefore it is impossible to compare our results on R&D expenditures on the one side and patent and forward citations on the other side. Finally, the R&D data is historically very sloppy and our dataset contained a lot of zero values, which can mean that the actual R&D expenditures were zero or that some values were missing. This means that the results for hypothesis 1a and 1b need to be interpreted with caution.

Our research is one of the first that indicates that right-to-work laws lead to an increase in the absolute value and the quality of innovativeness. This can have implications for policymakers because R&D is a key driver of economic performance and can lead to economic growth. Politicians can consider to introduce a right-to-work law in their state to boost their economy, but when doing this, they also have to consider the other consequences of right-to-work laws as mentioned in 2.1 (such as the impact on wages and fringe benefits). This research is relevant for the entire U.S. since the Trump administration is in favor of right-to-work laws. If this law would be implemented in the entire county, it could lead to a more innovative country and economic growth which can possibly attract foreign companies. Besides some of the benefits of a right-to-work law (such as increased profitability and investments mentioned in 2.1) policymakers also need to take the potential downsides into account such a lower wages and reduced pensions (Gould & Kimball, 2015; Stevans, 2007) which can lead to a lower welfare of (some) families and increase the social inequality.

7 Conclusion

Right-to-work laws have an impact on multiple macro-economic variables such as employment, wages, stock prices and investments and in this research we control whether a right-to-work law influences the absolute value and quality of innovation in a company.

We use two models to answer the question on whether right-to-work-laws lead to an increase in R&D expenditures. The output of these models indicates that right-to-work laws do not lead to an increase in R&D expenditures and so we reject hypothesis 1a. A possible explanation might be the strategic decision of firms to obscure R&D information which is possible "*due to the lack of accounting regulation and standards concerning R&D reporting*" (Ayaydin et al., 2017). Further we have an indication that right to work laws lead to an increase in the R&D ratio but these results are ambiguous because of sloppy R&D data and so we cannot make conclusive interferences, which means that further research is needed in this area.

This research also investigates the impact of right-to-work laws on firm's average quarterly granted patents and on the value of the firm's quarterly granted patents. Our results show that both the number and the value of patents increase after the passage of a right-to-work law. This can possibly indicate that companies were less innovative before the introduction of right-to-work laws for strategical reasons, such as avoiding or reducing union rent seeking which means that unionized employees demand higher wages because of the higher expected returns and the higher risk of R&D expenditures. Another explanation can be the union's capacity of boycotting potential innovation that may lead to future job loss (Stiglitz, 2014; Doucouliagos 2012). So, there is an indication that strong labor unions undermine the innovativeness of companies which can be very important for policymakers.

We contribute to the research area of right-to-work laws by proving that right-to-work laws have an impact on innovation and so we give an indication that strong labor unions undermine a company's innovativeness. Our results are particularly relevant since the president of the U.S is in favor of right-to-work laws. Future research can further investigate this area by for example including the variable unionization in the models and using one dataset instead of multiple, to compare R&D and patent results.

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Press release

Right-to-work laws increase a company's innovativeness and the quality of innovation.

Recent research at the KU Leuven indicated that the number of patents and patent forward citations of a company increases after the introduction of a right-to-work law.

New findings in the right-to-work area

The U.S. right-to-work laws prohibit provisions in labor contracts that oblige employees to join or financially support a labor union, at the state level, and diminish union power. Previous research showed that right-to-work laws have an impact on economic factors such as profitability, investments and stock prices. The findings of KU Leuven show that the introduction of these laws lead to more patents but also increase the quality of these patents. This is relevant because innovation can lead to economic growth which is beneficial for multiple parties such as companies and the consumer.

Consequences for the economy and policymakers

The findings of this research are important for policymakers but also relevant for companies and labor unions. The increase in innovation and in its quality after the introduction of a right-to-work law can indicate that companies are less innovative when there is no right-to-work law because of strategical reasons. A possible explanation is that investments in research and development are risky and unionized employees will demand higher wages because of this risk and the higher expected return than for example for capital investments. After the adoption of a right-to-work law, union power decreases and unionized employees will be less inclined to demand higher wages. Policymakers need to take these results into account when considering to introduce a right-to-work law. For companies, these findings can also be important because they might consider relocating to a state with a right-to-work law to increase their innovativeness. The findings of KU Leuven are particularly interesting since Trump became president of the United States because his administration is in favor of right-to-work laws. They believe that these laws will improve the attractiveness of American states to job creators. Trump is in favor of introducing these right-to-work laws in all American states which means that the results of this research are not only relevant for the individual states but can be extrapolated to the entire United States.

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