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Master Thesis International Economics

Brexit Related Uncertainty and Firm Productivity:

A study in the Netherlands

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Abstract

The Brexit referendum and the process to an EU-UK deal must have led to economic uncertainty amongst many, especially firms with ties to the UK. Uncertainty can either have a positive or a negative effect on firm productivity. That is why this paper researches the effect of the Brexit related uncertainty on firm TFP of (British) firms in the Netherlands. Additionally, it analyses whether the expectations of entrepreneurs partially account for the effect. This study considers an existing measure (exchange rate volatility) and a fairly new measure (social media signals) as indicators for the Brexit related uncertainty, and uses firm level data on TFP to investigate the research question. Despite finding evidence for both positive and negative effects of the Brexit related uncertainty on firm TFP, and British firms to experience a larger positive effect, the results are not robust against some changes in the data.

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1   Introduction

1.1 Problem definition and research objective

On the 23rd of June, 2016 a majority of the voters (52%) chose for the United Kingdom's (UK) exit from the EU, which is called the Brexit. The process of the Brexit negotiations between the EU and the UK was long and uncertain. In addition to the uncertainty about whether there would be a Brexit, there could have been a lack of certainty about the scenarios of the Brexit: the soft Brexit, the hard Brexit or the no-deal Brexit. As regards the soft Brexit, the UK would stay a member of the single market. In this case the consequences are minimal. In the case of a hard Brexit, the UK would not be a part of the single market and would follow the rules of the World Trade Organization (Menon, & Fowler, 2016). A no-deal Brexit implies that no new trade agreement would be reached before the Brexit officially would take effect. In this situation a new trade agreement would be reached as soon as possible (BBC, 2020).

Uncertainty could either lead to an increase or a decrease in firm productivity. A firm's investments are one of the main drivers of producing more efficiently (Syverson, 2010). Following the real options effect, an increase in uncertainty influences a firm's investments negatively (Bernanke, 1983). If the investments decrease, firm productivity is also likely to decrease. Conversely, firm investments may increase when uncertainty increases when a firm has convex marginal returns of investments. Following the Oi-Hartman-Abel effect (Oi, 1961; Hartman, 1972; Abel, 1983) firms tend to increase investments when uncertainty about the returns increases. This could have led to an increase in firm productivity.

Therefore, this thesis investigates the effect of the Brexit related uncertainty on total factor productivity (TFP) of goods companies in the Netherlands. In theory, the Brexit could have multiple effects. First, the direct devaluation of the British pound after the referendum (Bloomberg, 2016) could have made it less attractive for British firms to invest in their plants in the Netherlands. Simultaneously, it was more attractive for Dutch firms to invest in the UK. Secondly, the Brexit related uncertainty and the expectations for the future could also have influenced the investment choices of the firms as described in the previous paragraph. Firm productivity could also be affected by factors other than investments. For example, Brexit could have influenced the vertical and/or horizontal linkages of a firm. However, these other mechanisms are not investigated in this thesis.

To answer the research question, a regression model with firm fixed effects is estimated. The measure for productivity is provided by Statistics Netherlands (CBS). This is an estimated measure of total factor productivity (TFP) based on a Cobb-Douglas production function. The data on TFP is at firm level and ranges from 2010 through 2019. To measure the Brexit related uncertainty, I use

the exchange rate volatility of the British pound and a Brexit uncertainty indicator based on social media posts. The uncertainty measures do not vary between firms, but only over time. A similar method as Hassan, Hollander, Van Lent & Tahoun (2021) is used to compute the Brexit uncertainty indicator. They counted the number of times "Brexit" occurred in a neighborhood of 10 words of (a synonym of) "risk" or "uncertainty" in earning call transcriptions of firms. I filter social media posts that also include "Brexit" in a neighborhood of 10 words of (a synonym of) "risk" or "uncertainty". In this way the posts that indicate Brexit related uncertainty remain in de dataset.

Additionally, I examine if the expectations measured in the Business Cycle Survey (*COEN*) have a role in the impact of the Brexit related uncertainty on the productivity of companies. With the Brexit related questions in the *COEN*, entrepreneurs in non-financial sectors in the Netherlands give their opinion about the expected effect of Brexit on their turnover, business operations, trade and investments. I investigate whether the expectations correlate with both firm TFP and the Brexit related uncertainty, and then add them as a control in the main regression. In this way it can be assessed whether the expectations of entrepreneurs may have explained the possible link between the Brexit related uncertainty and firm TFP.

Lastly, I also study if the effect of the Brexit related uncertainty differs for the British firms in the Netherlands. Since the Brexit is about the UK leaving the EU, British firms are expected to be affected more than the other firms in the Netherlands.

1.2 Contribution
The contribution of this paper is twofold. To begin with, this paper contributes to the scarce literature of the effect of uncertainty on productivity. The results of these papers vary from a negative effect to a positive effect of uncertainty on firm TFP. The researches also have different mechanisms for their results. Li, Guo & Chen (2021) found that the decrease in productivity is working through the real options effect and a decline in technological innovation. The real options effect was first mentioned by Bernanke (1983), who argued that uncertainty leads to firms waiting to invest and get more information.

There are also papers that found a positive relationship between uncertainty and firm productivity. Escribano & Stucchi (2014) argued that small firms are motivated to increase their productivity during periods with high uncertainty. Small firms have a higher change to exit the market compared to bigger firms. Appelbaum (1991) found a positive effect of price uncertainty in the output market on productivity, which was mainly caused by a technical change.

Secondly, this paper contributes to the literature on the economic consequences of the Brexit. Dhingra, Ottaviano, Sampson & Van Reenen (2016a) and Dhingra, Ottaviano, Sampson & Van Reenen (2016b) made a framework of the possible consequences of potential Brexit scenarios. Dhingra et al. (2016a) predicted a decrease in FDI, since the EU's single market makes it more attractive for foreign investors based in the EU to invest in the UK. Dhingra et al. (2016b) predicted lower trade, and thus lower Gross Domestic Product (GDP) for the UK, due to higher tariffs and non-tariff barriers.

Crowley, Exton & Han (2019) and Graziano, Handley & Limão (2020) provide evidence that the Referendum led to a decrease in trade via decreased firm entry and increased firm exit in 2016. Manasse, Moramarco & Trigilia (2020) found an association of Referendum result and a depreciation of the British pound. Hill, Korczak & Korczak (2019) suggested that multinationals have lower exposure to Brexit related uncertainty, because they are more able to diversify the political risk compared to smaller firms. This paper used stock market data around the Brexit referendum to model Brexit related uncertainty. Lastly, Hassan et al. (2021) found that the international firms that are most exposed to Brexit lost market value, and lowered hiring and investment. They used the number of times Brexit was mentioned in earning call transcriptions within a range of 10 words from (a synonym of) risk or uncertainty.

As the UK is one of the main investors in the Netherlands with 213 billion euros (Franssen & Jaarsma, 2019), this thesis is also relevant for policy makers. In the short term, changes in productivity can influence the GDP of a country. However, productivity is also crucial for the long-term growth of a country (Krugman, 1994). And since the overall productivity of the developed countries is slowing down (Adalet McGowan, Andrews, Criscuolo & Nicoletti, 2015), the Brexit related uncertainty may reinforce this. Therefore, this research provides insights on what effect economic policy uncertainty has on factors that influence the economy or economic growth in a country.

1.3 Thesis structure

The remaining of this paper is structured as follows. In section 2 a short summary about the most important Brexit events will be given. The relevant literature will be discussed in section 3. Section 4 provides information about the data, followed by the methodology in section 5. The results will be shown and discussed in section 6. The robustness checks and the conclusion of the paper will be provided in section 7 and 8, followed by the limitations and suggestions for future research in section 9.

2 **Brexit**

2.1 Brexit timeline

First, some information about the events regarding the Brexit will be given. Table 1 gives a summary about the most important Brexit events and the likelihood of the Brexit for each event. This table follows the timeline given by the Dutch government (Government of the Netherlands, 2021). The Brexit referendum was held in June 2016. In March 2017 the UK invoked Article 50. By invoking Article 50, the UK officially indicated to withdraw from the EU. The article contains provisions for the procedures the country should follow if it wants to leave the EU. At that time it was also known that the negotiations on the withdrawal of the UK would take two years.

After the negotiations about the transition period in 2017 and 2018, the Brexit date was postponed several times in 2019. The House of Commons voted down the Brexit multiple times. In October 2019 the UK and the EU reached a Brexit agreement. However, the British parliament wished to consider the new Brexit legislation before approving the Brexit agreement, which caused the Brexit date to 31 January 2020.

Table 1: Brexit timeline

Event	Date	Likelihood Brexit
Brexit referendum	23/06/2016	Positive
May's plan to withdraw from Article 50	7/12/2016	Positive
The British parliament voted for withdrawing from Article 50	08/02/2017	Positive
Phase 1 of the negotiations between the EU and UK	19/06/2017	Positive
Provisional agreement about the transition period after the Brexit	19/03/2018	Positive
Brexit is voted down by the British parliament	15/01/2019	Negative
Brexit is voted down by the British parliament for the second time	12/03/2019	Negative
Brexit is voted down by the British parliament for the third time	29/03/2019	Negative
The British parliament agreed to consider the Brexit legislation	22/10/2019	Positive

Boris Johnson wins the UK general elections. This makes it more likely that the Brexit agreement will be approved soon, since Johnson stated to get Brexit done	12/12/2019	Positive
The UK left the EU and entered the transition period	31/01/2020	Positive
The transition period ended and the new relationship between the UK and the EU begins	01/01/2021	Very positive

Source: Government of the Netherlands, 2021.

2.2 Impact Brexit on Dutch entrepreneurs

After the Brexit referendum the likelihood of a no-deal Brexit was probably volatile. VNO-NCW wrote in December 2018 that the likelihood of a no-deal Brexit was increasing (VNO-NCW, 2018). In case of a no-deal Brexit a Dutch firm who traded with the UK would have to review the entire business of its firm, which could have brought high costs with it. The extra costs created by the uncertainty about the Brexit scenario can be lowered by being well prepared. That is why the Government of the Netherlands offered the Dutch enterprises relevant information and tips to prepare the enterprises for the Brexit as well as possible. In addition, the worst case scenario (no-deal Brexit) was elaborated on all possible topics.

The communication went also from the entrepreneurs to the negotiators of the Brexit agreement. The Dutch Ministry of Foreign Affairs and the Taskforce contributed to the negotiations about the Brexit agreement. The Dutch ministry of Economic Affairs was committed to no unfair competition, equal rules for all firms and integrity of the internal market.[1] For example, a British investor in the Netherlands cannot be treated worse than domestic investors. The three goals of this collaboration were to inform, to alert and to activate the entrepreneurs.

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[1] This information is based on a conversation with officials that were part of the Brexit team.

3   Literature review and hypothesis developing

3.1 Uncertainty and productivity

In the first part of this section the literature on uncertainty and productivity will be revised. Productivity is defined as output divided by input. In other words, productivity is equal to efficiency of producing. The higher the productivity, the more efficient a firm can produce its output. This thesis will focus on total factor productivity, which is the productivity of all the inputs used in the production process. Since this thesis will mainly focus on firm productivity, we will not discuss the literature on industry productivity.

Even though the theoretical literature on firm productivity and uncertainty is rather scarce, the main mechanism can be explained through the possible delay or increase in investments. Productivity can be influenced by many different factors, such as firm structure, higher quality inputs or experience. However, many researchers suggest that the increase in productivity is mainly driven by investments (Syverson, 2010). Investments such as capital investments, particularly information technology investments, and Research & Development (R&D) investments can increase productivity. Investments are sacrifices in the current period to get positive returns in future periods. Most of the time these investments are irreversible (or very costly to reverse in later periods), which makes the investment a sunk cost once made. According to the investment theory under certainty, an investment should be taken if the Net Present Value (NPV) of the investment is bigger than zero.

There are two mechanisms through which uncertainty affects investment. The mechanisms predict the opposite effect of each other. First, the real options effect will be discussed. Once uncertainty enters the model, the optimal investment decision and the optimal investment time are different from the basic neoclassical model. With uncertainty, the investment decision is also influenced by some potential bad news in the future, which makes the investor regret his investment. If the average expected severity of the bad news is higher, the willingness to invest will decrease (Bernanke, 1983). If the investor also has the choice to invest in the next period, the investor could give up some short term return in exchange for some extra information. On the one hand, uncertainty is lowered by gaining some more information, which increases the likelihood of investing. On the other hand, while delaying the investment by gaining some information, the investor is giving up short term returns. According to McDonald & Siegel (1986) the optimal trade-off is at the point where the NPV is more than twice the investment costs. When investments are delayed, it decreases the efficiency, and thus, the productivity of the firm.

The second effect is the Oi-Hartman-Abel effect (Oi, 1961; Hartman, 1972; Abel, 1983). In this model the firm invests until it reaches the point where the value of marginal unit of capital is equal

to the marginal costs of investment. Uncertainty only increases investments if the value of the marginal unit of capital is convex (Abel, 1983). For uncertainty about the prices or costs to affect investments, the assumption that the value of marginal unit of capital is convex in the price of output or costs must hold (Abel, 1983). Thus, if the marginal returns of investments are convex in price, the average return of investments increase in ex ante uncertainty about the returns.

To make the concept of a convex marginal return of capital in price or costs more clear, an illustration of a convex function will be given. Figure 1 represents a convex function $f(x)$, which is increasing in x. The larger x gets, the lower the increase in $f(x)$ is. This leads to the fact that the expected value of two points on the function $f(x)$ is larger than the function of the expected value of x. This can be denoted as $E[f(x)] > f(E[x])$, which is called Jensen's inequality. In this case the function is the marginal return of capital and x is equal to a stochastic variable such as the price of output or costs. Due to uncertainty about the returns of investments, the returns of investments increase when they are convex (Pindyck & Solimano, 1993). This means that the expected future marginal revenue increases. Investments increase and thus, productivity increases.
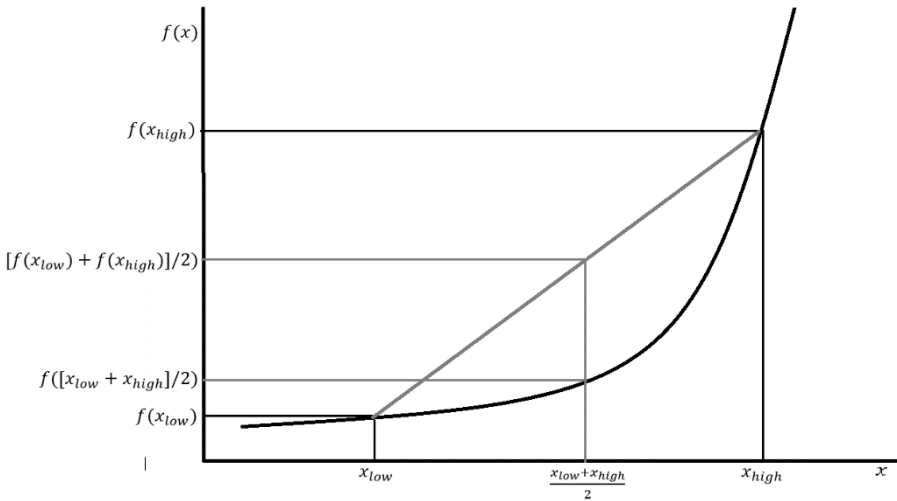
Figure 1: Jensen's inequality

The convexity of the marginal return of investment is ensured by constant returns to scale and the substitutability of capital with other factors (Pindyck, 1993). A firms has constant returns to scale when their output increases by the same amount as the increase in input. Firms under perfect competition usually tend to have constant returns to scale, since they are price takers. Additionally, the production function usually has other production factors as labor. When one of the two assumptions do not hold, the marginal return of investment is not convex anymore. For example, a

monopoly usually has increasing returns to scale, since it is a price setter. Therefore, the assumption of having a convex marginal return of investments does not hold under imperfect competition. In such cases uncertainty is likely to have a negative effect on investments.

The net effect of the two mechanisms depends on the size of the opportunity costs created by waiting for some more information relative to the size of the value of the marginal unit of capital (Pindyck & Solimano, 1993). If the increase in return by waiting to invest is higher than the increase in the value of the marginal unit of capital, firms with a convex return of investments curve are more likely to delay the investments. Bertola (1998) found that the net effect of uncertainty on firm investments seems to be rather negative. For the net effect to be positive, the expected discounted value of marginal profits should be larger than sum of the costs of installation of the investments and the value of waiting.

Li, Guo & Chen (2021) investigated the effect of economic policy uncertainty on TFP of Chinese firms. They found a negative relationship between policy uncertainty and firm TFP. They mentioned two effects that were leading this relation. The first mechanism is through the resource allocation efficiency of firms. Due to uncertainty, the information asymmetry between firms and banks increases, which increases the costs of financing and thus decreasing their expected future cash flow. The resource allocation efficiency of firms also gets worsened by the real options effect, which is discussed earlier. The second mechanism is working through the decrease in technological innovation of firms due to uncertainty. When uncertainty increases, firms will try to reduce the risk by lowering R&D investments. This has a negative effect on the innovation of firms.

Escribano & Stucchi (2014) suggest that the overall productivity tends to converge in recession. This is because smaller firms are threatened to exit the market, which increases the incentive to be more productive. Smaller firms have smaller economies of scale and do not have a parent company to have access to knowledge and capital. Even after controlling for the less productive firms leaving the market, the results stay the same. Since uncertainty appears to increase during recessions (Bloom, 2009), it can be implied that in this case an increase in uncertainty correlates with an increase in firm productivity of smaller firms.

Furthermore, Appelbaum (1991) researched the effect of price uncertainty on firm productivity. He stated that output price uncertainty tends to have a positive effect on firm productivity. When the production is characterized by a degree of economies of scale and the firms are risk averse, uncertainty is likely to affect investments positively. Under uncertainty firms try to increase the supply, which lowers the average costs.

Relating this literature to the Brexit, uncertainty could either increase or decrease firm productivity. Since the outcome of the Brexit referendum was unexpected, it can be suggested that the severity of a bad outcome was low (but not zero). In this case the bad outcome is the UK leaving the EU. The real option effect from Bernanke (1983) suggest that the severity of the bad outcome increased the costs of investing, since it could be cheaper to wait for the outcome of the Brexit referendum to gain more information. This could decrease firm productivity of the firms located in the Netherlands. The Oi-Hartman-Abel effect from Oi (1961), Hartman (1972) and Abel (1983) suggests that the investments could have increased, because the referendum uncertainty increased the expected value of the marginal unit of investment. This effect could increase firm productivity. Apart from the changes in investments, the Brexit related uncertainty could also affect firm productivity through other channels.

After the Brexit referendum the uncertainty about the outcome of the referendum was gone, but a new kind of uncertainty grew; uncertainty about the Brexit scenario. This uncertainty could be varying over the period after the referendum until the new relationship of the EU and the UK began. The same mechanisms through which uncertainty can work through, also apply for the uncertainty created by the Brexit agreements. The uncertainty can be seen in the expectations of entrepreneurs, which is measured in the *COEN*. If the effect was working through the real option effect, entrepreneurs could have expected lower turnover, an effect on business operations and/or affect their trade with the UK or other countries. If Oi-Hartman-Abel effect is working, the entrepreneurs could have expected higher turnover, but also an effect on their business operations or trade with countries. These expectations could be an extra sign in whether the Brexit related uncertainty affected firm productivity.

3.2 Determinants of productivity

In this section of part 3 the determinants productivity will be elaborated. Apart from uncertainty to affect productivity, other determinants can influence productivity. Since this paper uses firm level data, the focus will remain on control variables on firm level. Table 2 shows a list of the expected effect of determinants of productivity. The variables that do not change over time, can easily be controlled for with firm fixed effects. I do not have access to data on financial dependence and debt ratio.

Table 2: List of determinants of productivity

Determinant investments	Expected sign	Related literature
Firm size	+	Bloom et al. (2018); Li et al. (2021)
Capital/labor ratio	-	Bloom et al. (2018)

Financial dependence*	+/-**	Choi, Furceri, Huang & Loungani (2018)
Firm age	+	Escribano & Stucchi (2014)
Incorporated firm	+	Escribano & Stucchi (2014)
Mergers (demergers)	+(-)	Escribano & Stucchi (2014)
Entrants (exiting) firms	+(-)	Escribano & Stucchi (2014)
Debt ratio	+	Li et al. (2021)

Notes: + denotes a positive relationship between investments and the determinant. – denotes a negative relationship between investments and the determinant.

*Financial dependence is defined by the ratio of total capital expenditures minus current cash flow to capital expenditures (Choi et al., 2018).

**Positive (negative) relationship between aggregate uncertainty and the sector-level TFP growth for industries with low (high) external finance dependence.

4   Data

4.1 Brexit related uncertainty

4.1.1 Exchange rate volatility

First, information about the data to measure uncertainty regarding Brexit is provided. This thesis uses two measures for Brexit related uncertainty. The first one is exchange rate volatility of the British pound. The exchange rate volatility is used as a proxy for uncertainty, because the literature suggests that there is a stable link between them. Laakkonen (2007) and Omrane & Savaşer (2017) found an increase in exchange rate volatility due to macroeconomic news. News that gave conflicting information on the state of the economy was found to significantly increase volatility more than consistent news (Laakkonen, 2007). Krol (2014) stated that economic policy uncertainty can increase exchange rate volatility. If there is high uncertainty regarding the policies of other countries, variables like money supply and interest rate in the domestic country changes, which leads to exchange rate volatility (Zhou, Fu, Jian, Zeng & Lin, 2020).

Exchange rate volatility will be measured as the variance of the exchange rate in a year. The formula for the variance of the exchange rate is as follows:

$$\sigma_t^2 = \frac{\sum_{i=1}^{n_t}(x_d^i - \bar{x})^2}{n - 1} \tag{1}$$

$$\bar{x} = \frac{\sum_{i=1}^{n} x_d^i}{n} \tag{2}$$

σ_t^2 = the variance of the exchange rate in year t. x_t^i = the exchange rate i at day d. $\bar{x}$ = the mean of the exchange rate. n_t = the total number of values in a year. n = the total number of values.

The data is retrieved from the International Monetary Fund (IMF). It consists of daily data on the exchange rate of the British Pound to the Special Drawing Rights (SDRs). The SDR is an international reserve asset created by the IMF. It consists of a mix of the US dollar, Euro, Chinese Yuan, Japanese Yen and the British Pound (IMF, 2021) The daily data is transformed to yearly data on volatility during the period between 2010 and 2020.
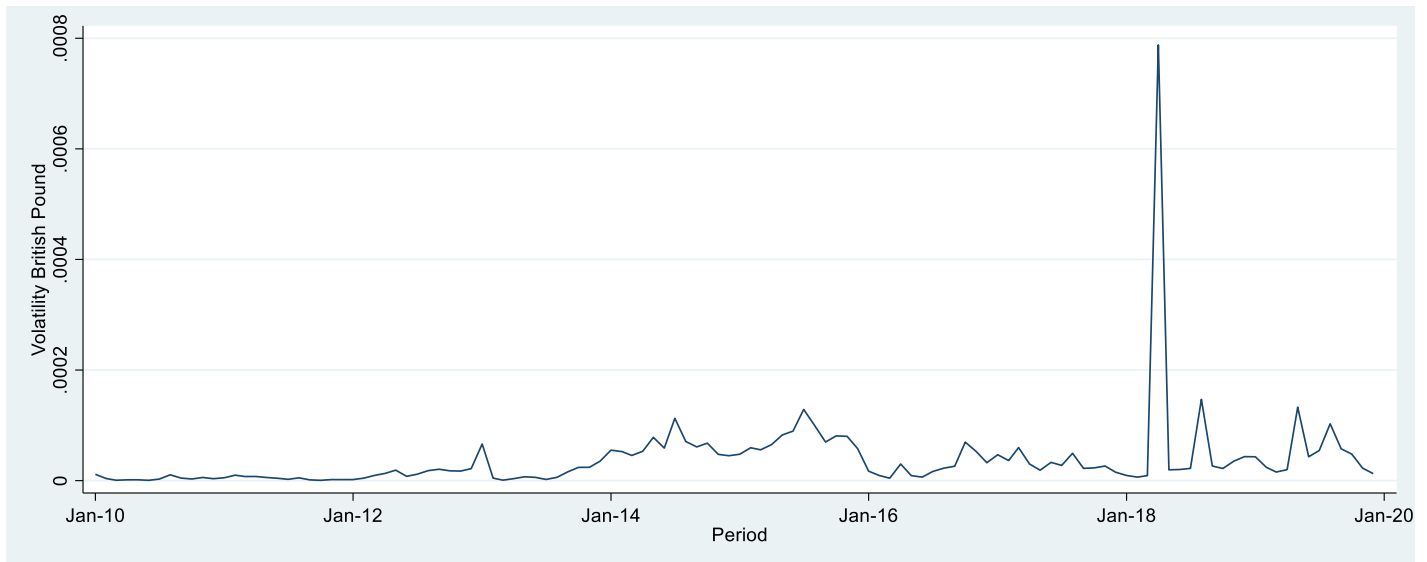
Figure 2: Exchange rate volatility of the British Pound.

Figure 2 shows the trend of the volatility of the British Pound between 2010 and 2020. In this figure the sentiment is aggregated at a monthly level to show that this sentiment associates with Brexit related uncertainty. Throughout the period the volatility increased from January 2014, showing spikes in July 2015 and April 2018. The volatility of the British Pound was relatively low in 2016 compared to 2015 and 2018. After the Brexit referendum took place in June 2016, the exchange rate of the British Pound decreased and stayed low for a while. In April 2018 the volatility of the British Pound rose sharply. During 2018 the European Union and the United Kingdom were busy discussing a draft withdrawal agreement, which was reached in November 2018.

4.1.2 Brexit uncertainty index (BUI)

Another proxy for Brexit uncertainty is the Brexit uncertainty index. This indicator is created with a database of social media posts. Daas (2020) stated that the social media indicator gives up-to-date insights, because social media posts are available quickly. This thesis follows a similar methodology for the Brexit uncertainty indicator as used in the paper of Hassan, Hollander, Van Lent & Tahoun (2021). They use earning call transcriptions of firms to measure Brexit related uncertainty of each firm and count the mentions of "Brexit" in a neighborhood of 10 words of (a synonym for) "risk" or "uncertainty". In this way the posts that are not about Brexit related uncertainty, but do contain the words "Brexit" in combination with (a synonym of) "risk" or "uncertainty", are excluded. This thesis uses a social media database instead of earning call transcriptions, and computes a general proxy for Brexit related uncertainty. The words in the query will be in Dutch.

The Brexit uncertainty index (BUI) is compiled by CBS using the database of Coosto (2021). Coosto is a company that collects public social media posts and has access to all social media posts,

which are millions. I do not have information about the entire database of Coosto.[2] First, I enter a Brexit related query to select the Brexit uncertainty related posts in the period from January 2015 until December 2019. The query consists of the following words: "Brexit *onzeker**, Brexit *risico**, Brexit *onbekend**, Brexit *dreiging**, Brexit *onduidelijk**, Brexit *twijfel**, Brexit *angst**, Brexit *onvoorspelbaar**, Brexit *afwachten**, Brexit *onrustig** and Brexit *aarzel**".[3] The star behind every synonym of risk or uncertainty ensures that every variant of that word is included.

Figure A1 in Appendix A shows the dataset after entering the query described before, which consists of 103,051 words. This dataset consists of Brexit related posts including (a synonym of) "risk" or "uncertainty". In this set the distance between "Brexit" and (a synonym of) "risk" or "uncertainty" is indefinite. In figure A1 it can be seen that there is no clear trend or cycle in the total number of posts. These posts come from 11,873 different websites. Table A1 in Appendix A describes the number of posts of each type of source.

Second, a random sample of 10.000 posts is taken to execute the method, otherwise it would take too much time. Since the sample is taken randomly, it represents the underlying 103.051 posts. From the sample (10.000 posts) the number of posts are selected that contain "Brexit" in combination with (a synonym of) "risk" and "uncertainty" within a neighborhood of 10 words. The new selection contains 1572 posts that meet the criteria described in formula 3 between January 2015 and December 2019.

The Brexit uncertainty indicator for one year is computed as follows:

$$BUI_t = N_t^{BU} \tag{3}$$

BUI_t = Brexit uncertainty indicator in year t. N_t^{BU} = the number of posts which contain the word "Brexit" in a neighborhood of 10 words (a synonym of) "*risico*" (risk) or "*onzekerheid*" (uncertainty) in year t.

When the Brexit uncertainty indicator increases, the Brexit related uncertainty is higher. N_t^{BU} is not divided by the total number of Brexit related posts, since it would show large, positive spikes if N_t^{BU} and the total number of Brexit related posts are low and equal to each other.

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[2] In order to see all social media posts available I have to enter a query with all existing words. This is not possible, since it is time consuming.

[3] Translation of the Dutch words: *onzeker* = uncertain; *risico* = risk; *dreiging* = threat; *onduidelijk* = unclear; *twijfel* = doubt; *angst* = fear; *onvoorspelbaar* = unpredictable; *afwachten* = to wait; *onrustig* = restless; *aarzel* = hesitate.
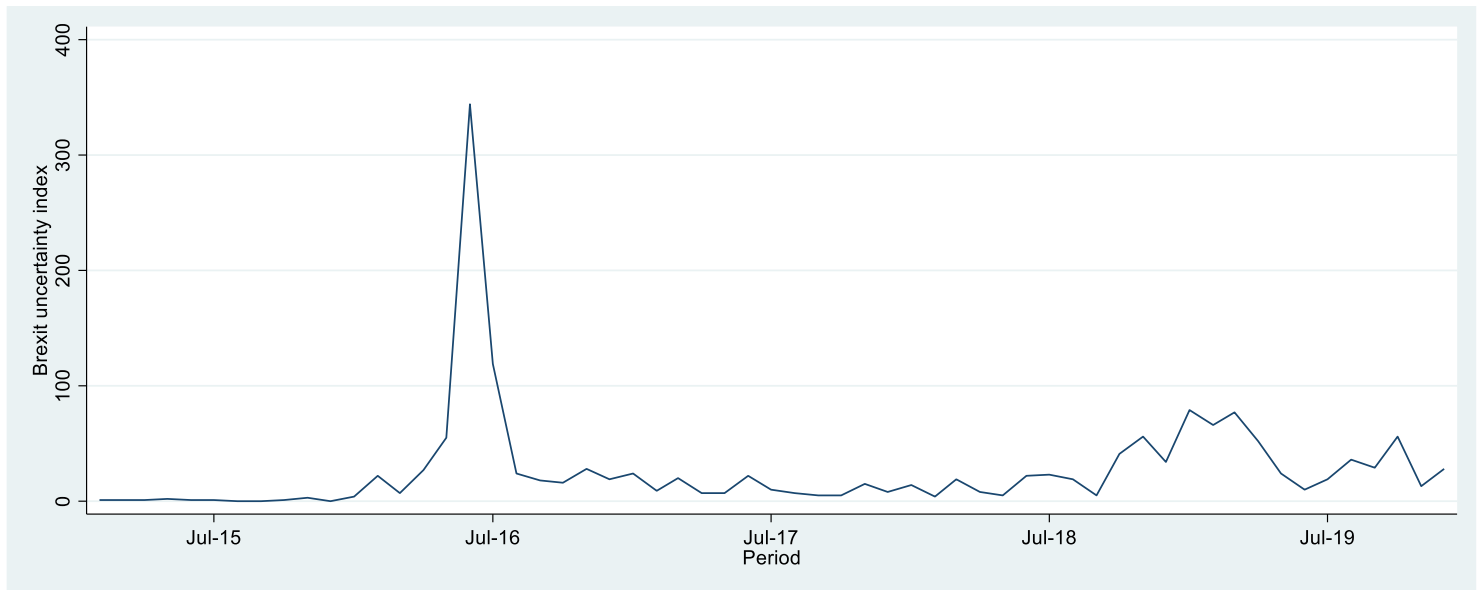
Figure 3: Brexit uncertainty index compiled by social media posts.

Figure 3 shows the trend of the BUI based on social media posts. In this figure the index is aggregated at a monthly level to show that the BUI associates with Brexit related events. The overall trend of the BUI increased over time, which means that the Brexit related uncertainty became larger. In 2015 the index is (close to) zero. In June 2015 the index shows a large spike, which coincides with the Brexit referendum held in June 2016. After July 2016 the BUI stayed low and increased after June 2018. In the period between June 2018 and February 2019 the EU and the UK worked on the withdrawal agreement. In March 2019 the agreement was voted down by the British Parliament three times, which coincides with a decrease in the BUI. After July 2019 the index increases again. This coincides with the withdrawal agreement being approved by the EU and UK in October 2019. At the same time the UK Parliament and the EU Parliament still had not approved the agreement, which could be a trigger for uncertainty.

4.2 Productivity

In this thesis the dataset productivity is adopted from the CBS. The dataset consists of yearly data from approximately 25,000 firms located in the Netherlands, which are active in the period 2015 to 2019. From these firms, 421 firms are under British control. Due to a lack of data, the firms who sell services are excluded, therefore the focus will be on firms which only sell goods. Each firm is classified by size class, and the first, second and third digit of the Dutch industry classifier (SBI). The control variables used in the regression analyses are part of the Business Demographic Framework (BDK) composed by the CBS. It contains micro data of firms located in the Netherlands from each year. The variable firm size has a value between 10 and 93, where each value is labeled by the firm size. In table A2 in Appendix A the labels of all values of firm size are described.
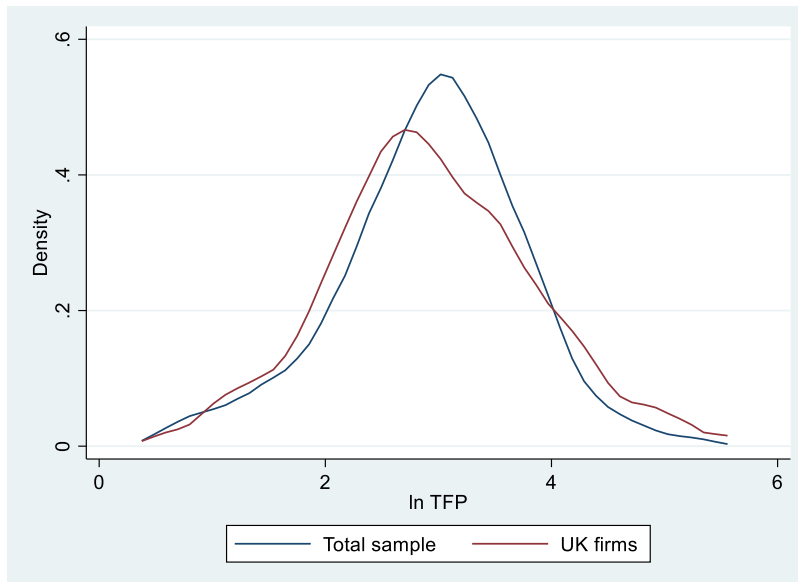
Figure 4: Kernel distribution of ln TFP
Notes: Outliers are deleted. Sample includes the firms which are left over
after matching the data on TFP with the data on the *COEN*.

Figure 4 shows the kernel distribution of the log of TFP for the total sample and the British firms. The outliers are deleted from the sample, since the analysis is done on the sample without the outliers. Additionally, only the firms in the dataset on TFP which matched with the data on the *COEN* are included in the sample. When matching the TFP data with the *COEN* data, approximately 1440 firms remain. This is the same sample the analysis is based on. Both curves are both close to a normal density curve. The density curve of the British firms is slightly skewed to the right. The concentration of the observations of the total sample lies around three, whereas it is closer to two for the British firms.

Table 3: Descriptive statistics TFP

All firms located in the Netherlands

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Total					
TFP	2,800	2.9373	0.8179	0.5133	5.4209
Year: 2017					
TFP	1,393	2.9485	0.8066	0.5363	5.4081
Year: 2018					
TFP	1,391	2.9388	0.8204	0.5133	5.4209
Year: 2019					
TFP	16	1.8382	0.8764	0.7013	3.5664
British firms located in the Netherlands					
Variable	Observations	Mean	Standard deviation	Minimum	Maximum
TFP	109	2.9384	0.8888	0.8316	5.4209

Table 3 shows the descriptive statistics of the log of TFP for both British firms and all firms in the matched dataset. The summary statistics on the entire dataset are also stated for each year. Additionally, the outliers are not included. The average TFP of British firm located in the Netherlands is slightly higher compared to the average TFP of the whole dataset. A possible explanation might be that all the British firms located in the Netherlands have access to capital, knowledge, network and Research & Development (R&D) of a larger parent company. Furthermore, the range between the minimum and maximum value of the TFP is larger for the whole dataset compared to the British firms. And the standard deviation is higher for the British firms, which means that the TFP of the British firms has a wider spread. This can also be seen in figure 4. Remarkably, the coverage of the firms in 2019 is extremely low.

The data also include dummies for a quick grower and an independent SME. A firm is defined as a quick grower if the firm has an average annual growth rate of at least 10 percent for three consecutive years (CBS, 2021a). A firm is an independent SME if it does not belong to a Dutch concern of more than 250 employees or firms who are not under foreign control (CBS, 2021b). The dummy for a quick grower is not added as a control, since it is an dependent variable, and thus, a

bad control. Including a bad control could possibly lead to inaccurate regression coefficients. The dummy for an independent SME is not added as a control, since it is most likely that the dummy stays constant over time. Hence, this variable is already included in the firm fixed effects.

In this thesis the measurement for the productivity will be provided by the CBS. Productivity is defined by the TFP of firms located in the Netherlands. TFP includes the productivity of all input factors in the production and is measured based on a Cobb-Douglas production function. Specification 4 denotes the Cobb-Douglas production function and specification 5 denotes the TFP based on equation 4.

$$Y_{i,t} = A_{i,t} * L_{i,t}^{\alpha} K_{i,t}^{(1-\alpha)} \tag{4}$$

$$TFP_{i,t} \equiv A_{i,t} = \frac{Y_{i,t}}{L_{i,t}^{\alpha} K_{i,t}^{(1-\alpha)}} \tag{5}$$

$TFP_{i,t}$ = Total factor productivity of firm i in period t. $Y_{i,t}$ = The value added from all factors of firm i in period t. $L_{i,t}$ = the labor input of firm i in period t. $K_{i,t}$ = the capital input of firm i in period t.

As specification 5 shows, the TFP is specified as the real added value relative to the input, where 2015 is used as a base year. Labor input is defined as the average number of employees on a firm's own payroll in fulltime-equivalent (fte), excluding hired staff and temporary workers, and including lent personnel. Capital input is defined as the depreciation expense, assuming that it is proportional to the firm's capital input. The Cobb-Douglas production function assumes constant returns to scale, meaning that the factor shares (α and $1 - \alpha$) of labor and capital add up to 1. These factor shares differ for each industry and are measured by the share of capital expenses to total expenses.

4.3 Business Cycle Survey

In the *COEN*, Dutch entrepreneurs from the non-financial business community give their expectations and judgments about various economic indicators. The expectations relate to the next three months, and the judgments and realizations to the previous three months. In order to analyze how entrepreneurs viewed a possible Brexit, three questions were discussed in the *COEN* on this subject from 2017 till the end of 2019. The entrepreneurs gave an expectation about the possible influence that Brexit would have on various aspects in the business world or indicated what consequences Brexit had for their company. The Brexit related questions are elaborated in table 4.

At question 1 firms can only choose one answer option. At question 2 and 3, firms can choose multiple answer options.

Table 4: Brexit questions and answer options from the *COEN*

Questions	Answer options
1. What is the expected impact of Brexit on your turnover for the next three months?	a. Very positive; b. Positive; c. Neutral; d. Negative; e. Very negative.
2. In which aspects do you expect Brexit to affect your business operations in the next three months?	a. Freedom of movement of goods and services; b. Workforce (free movement of people for personnel) c. Profitability d. Locations in the United Kingdom e. Competitive position; f. Other, including indirect effects; g. The Brexit has little to no impact on my business operations.
3. How do you expect the Brexit to impact your business in the next three months?	a. More trade with the United Kingdom; b. Less trade with the United Kingdom; c. More trade with other countries; d. Less trade with other countries; e. More investments; f. Less investments; g. Not or different.

These questions are answered by 2500 firms located in the Netherlands. When the *COEN* is matched with the data on productivity, approximately 63 British firms located in the Netherlands are included in the dataset. Originally the *COEN* data is quarterly, but the *COEN* data will be averaged at a yearly level. Also, the data consist of imputed answers, which are removed for the analysis. Otherwise it was hard to take the average of the answers in the *COEN*.

The selection criteria where the *COEN* data is based on is provided by the CBS. The population of the quarterly sample of the *COEN* consist of all local business units in commercial sectors registered at the Dutch Chamber of Commerce (KVK). A local business unit is defined as a business unit in combination with a zip code number and zip code letter in the region in which the company is registered. First, the yearly sample is taken directly from the population. The population is stratified by region, industry and firm size, and consists of 20,000 firms which are observed once a year.

From this sample the quarterly sample is taken. The quarterly data sample is further stratified by industry and firm size.[4]

In figure 5 the BUI and the exchange rate volatility for each year between 2017 and 2019 are plotted. To get the BUI and the volatility of the UK pound in one graph, both measures are scaled. The BUI is divided by 1000 and the volatility of the UK pound is multiplied by 1000. The plots of the Brexit related uncertainty measures are compared to the expectations of entrepreneurs. Figure 6 shows the boxplots of the first and second question and figure 7 shows the plots of the third question.

First going in on question 1, a large majority of the entrepreneurs did not expect Brexit to influence their turnover in the current quarter throughout the whole period. This answer option is not included in the graph. The second most chosen answer is the expectation of Brexit negatively influencing the turnover in the current quarter. From the first quarter of 2017 the percentage of entrepreneurs that expected a negative effect of the Brexit on their turnover in the current quarter decreased. From the last quarter of 2018 the percentage entrepreneurs that expected the Brexit to affect their turnover in the current quarter negatively increased, which goes along with an increase of the BUI.

Continuing with question 2, answer option 7 is not included in the graph. Throughout the whole period, the percentage entrepreneurs which expected Brexit to affect their business operations in the current quarter has the same trend as the percentage entrepreneurs which expected Brexit to affect their turnover negatively in the current quarter. In the fourth quarter of 2019 almost 20 percent of the respondents expected an effect of Brexit on their business operations. The most chosen answer throughout the whole period is the freedom of movement of goods and services followed by other effects.

In figure 7, answer option 7 is also not included in the graph. Throughout the whole period the most chosen answer are an expectation of less trade with the UK, less investments and more trade with other countries, respectively. The percentage entrepreneurs that chose the other answer options are (close to) zero. The trends of the expectation of less trade with the UK and less investments look like the trends described of question 1 and question 2. The expectation to trade more with other countries and the expectation to trade less with other countries stays constant after the second quarter of 2017.

On average, the trend of the BUI is likely to parallel the trends of the expectations of the entrepreneurs. The trend of the volatility of the UK pound has a different trend. From 2017 to 2019,

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[4] This information is taken from a private document provided by the CBS, where the methodology of the selection criteria is further elaborated.

the volatility did increase, but in 2018 the value increased a lot. The spike in 2018 can be explained by the spike in the second quarter of 2018 when looking at figure 2.
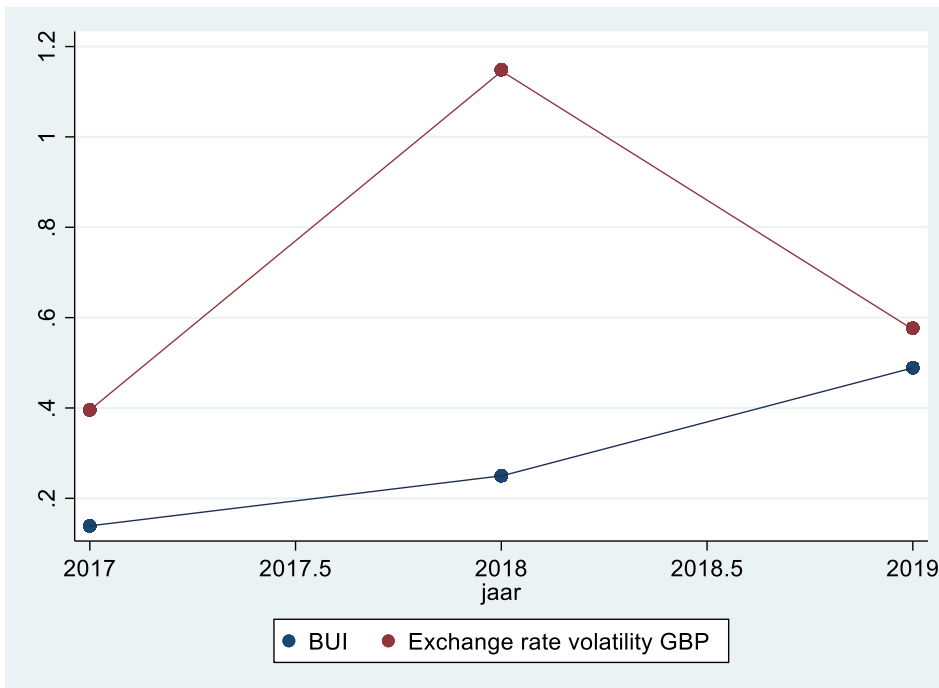
Figure 5: Plot of BUI and exchange rate volatility of the British pound.
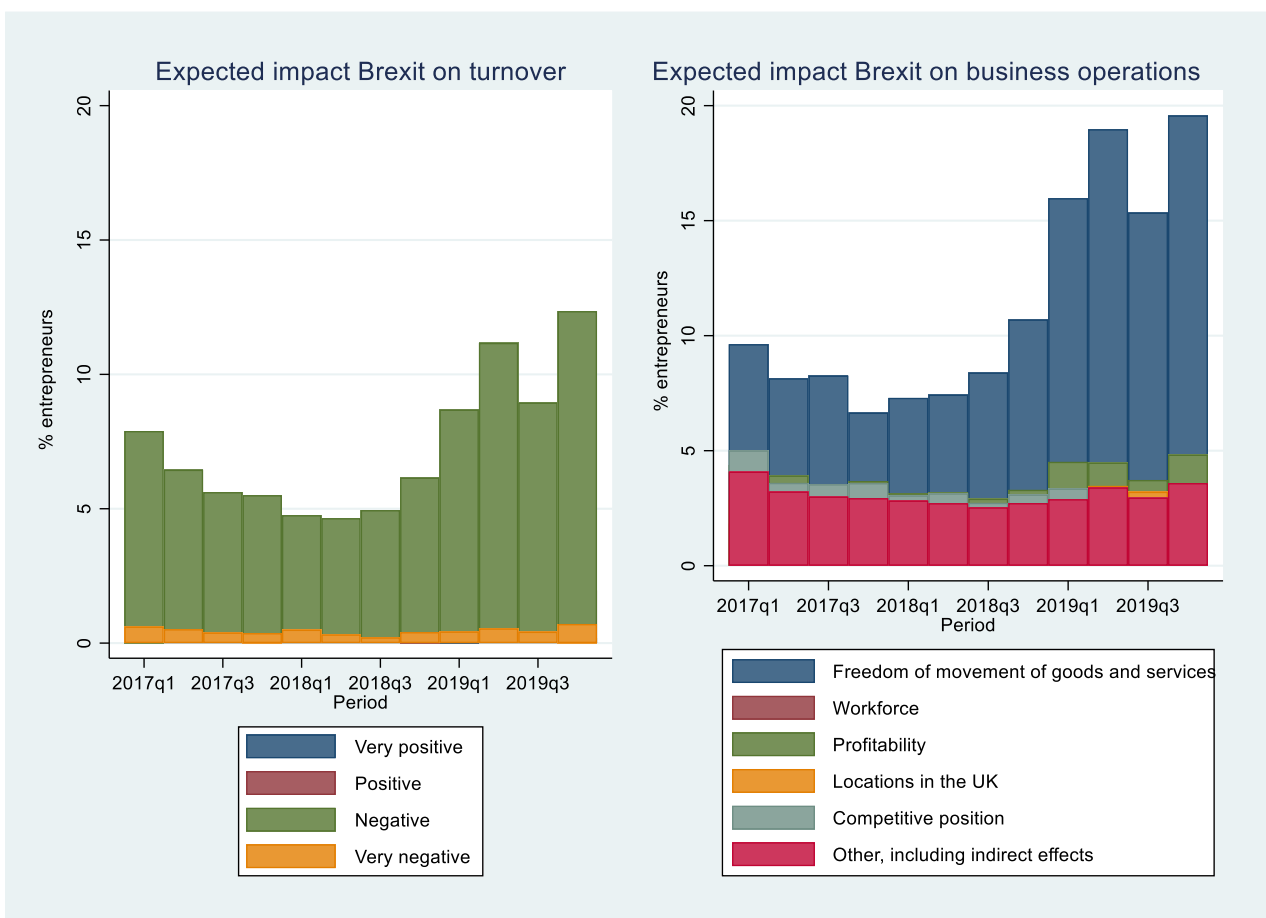
Figure 6: Boxplots of the expectation of Brexit affecting the turnover and business operations.
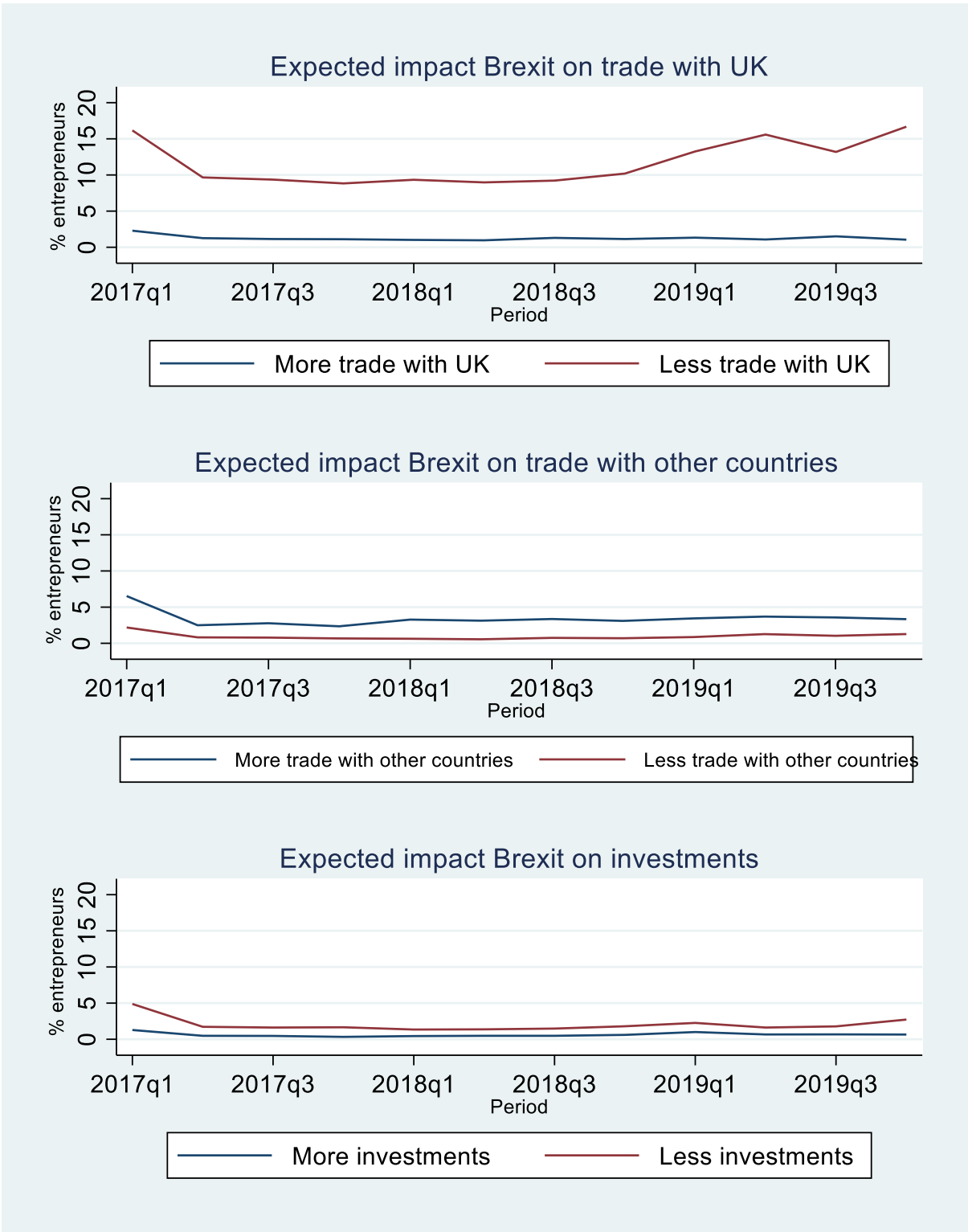
Figure 7: Plots of the expectation of Brexit affecting trade and investments

This thesis also investigates whether the effect of the Brexit related uncertainty on firm TFP differs for the British firms in the Netherlands compared to the whole sample of firms in the Netherlands. Since this thesis also researches if a possible effect can be (partially) be explained by the *COEN*, this part is going to describe the differences in expectations between British firms and non-British firms in the Netherlands. Because the distinction between UK and non-UK firms has to be made, the data on the *COEN* has to be matched with the data on productivity. This means that some of the observations from the *COEN* drop out, since the data on productivity does not perfectly match with the data on *COEN*.

Figure 8 plots the percentage entrepreneurs that expected Brexit to have a negative or very negative impact on their turnover in the current year for each year in the dataset. In 2017 a lower percentage of British entrepreneurs (3.1%) expected a (very) negative impact on their turnover compared to non-British entrepreneurs (4%). In 2018 this percentage was higher for British firms compared to non-British firms and in 2019 the difference between the percentages was larger than in 2018. Figure 9 plots the percentage entrepreneurs that expected Brexit to have little to no impact on their business operations. In 2017 the percentage entrepreneurs was about equal. In 2018 this percentage increased for the non-British entrepreneurs, but decreased for the British entrepreneurs. In 2019 the percentage decreased for both British and non-British firms, however, the decrease was larger for the British firms.

Figure 10 plots the percentage British and non-British entrepreneurs that chose each answer option from question 3. More entrepreneurs expected less trade with the UK than more trade with the UK due to Brexit. In 2018 the percentage non-UK entrepreneurs that expected less trade with the UK decreased compared to 2017, but the percentage for UK entrepreneurs increased. In 2019 the percentage of both UK and non-UK entrepreneurs increased. Even though the percentage entrepreneur with the expectation to trade less with the UK due to Brexit, the percentage British entrepreneurs that expected more trade with the UK due to Brexit increased a little. Furthermore, a higher percentage entrepreneurs expected more trade with other countries than less trade with other countries due to Brexit. The percentage of both British and non-British entrepreneurs decreased in 2018 and increased in 2019. In 2018 the decrease in the percentage of non-UK entrepreneurs that expected less trade with other countries due to Brexit was larger compared to UK entrepreneurs after which both percentages increased in 2019. However, these changes in percentages are very low.

Lastly, the percentage entrepreneurs than expected higher investments is larger than the percentage entrepreneurs that expected lower investments. It is remarkable that the percentage of British firms that expected less investments in the current year decreased between 2017 and 2019, although the

change is very low. After a decrease in 2018, this percentage increased for the non-British entrepreneurs in 2019.
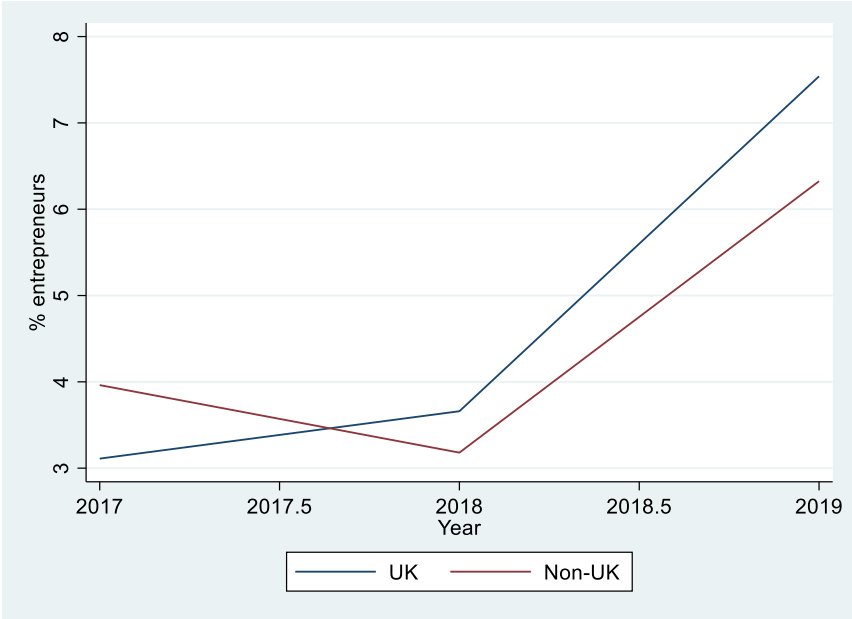
Figure 8: Expectation of Brexit having a negative or very negative impact on turnover, British firms vs. total sample.
Notes: The expectations of entrepreneurs are aggregated at a yearly level.
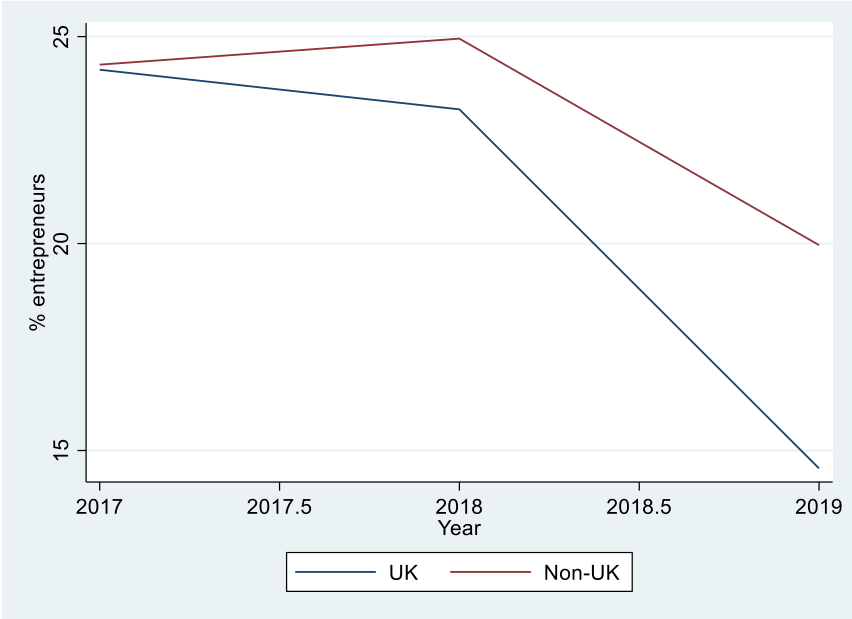
Figure 9: Expectation of Brexit having little to no impact on business operations, British firms vs. total sample.
Notes: The expectations of entrepreneurs are aggregated at a yearly level.
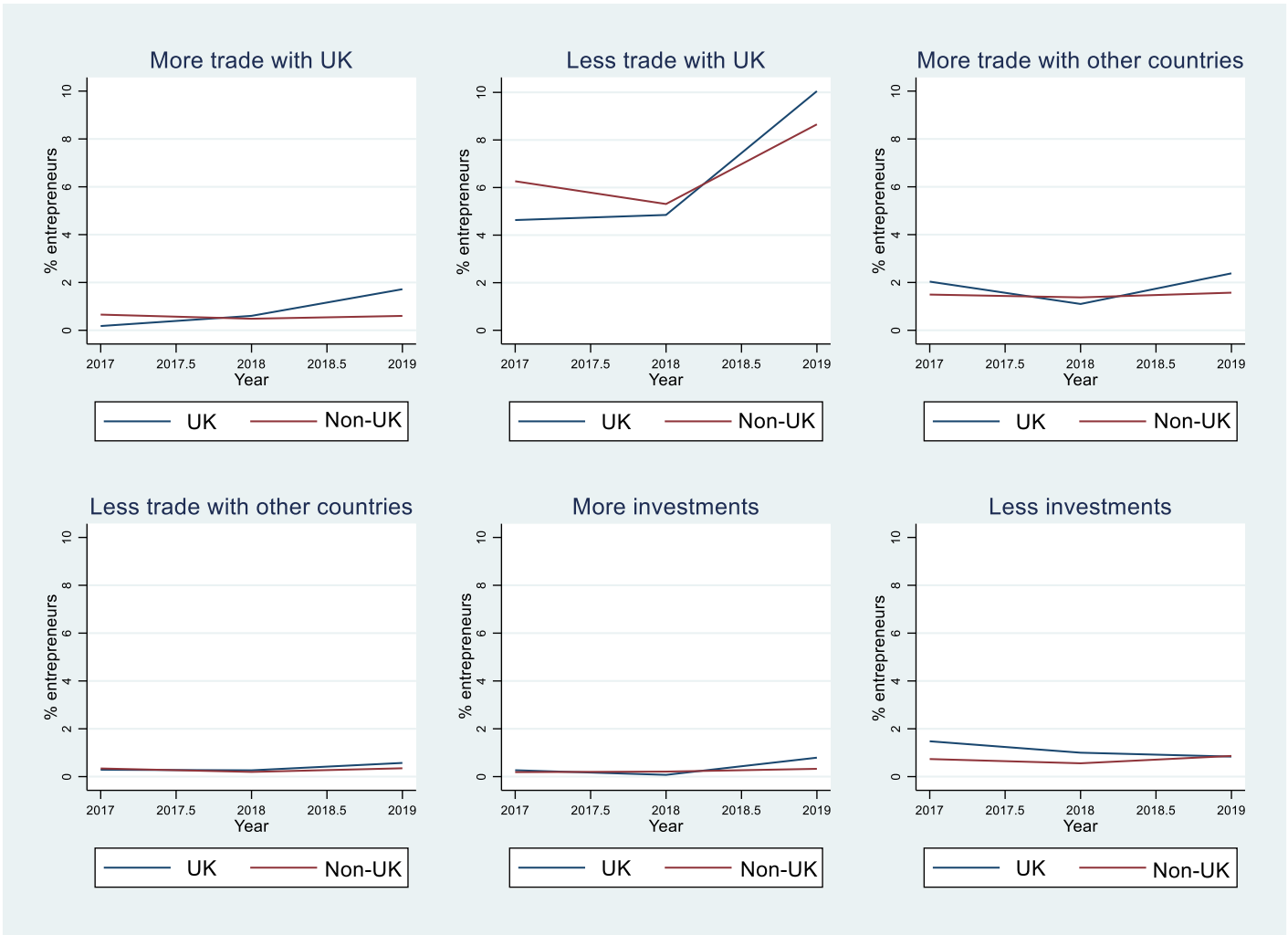
Figure 10: plots Q57 British firms vs total firms.
Notes: The expectations of entrepreneurs are aggregated at a yearly level.

5 Methodology

In this section the method to answer the research question is described. This thesis uses two proxies to model the Brexit related uncertainty, which will be combined in the main specification. One proxy may pick up uncertainty that the other proxy does not. This way it can be checked to what extent each proxy of uncertainty affects firm productivity. In addition to the basic analysis of the effect of the Brexit related uncertainty on the firm productivity of (British) firms located in the Netherlands, it will also be examined whether the expectations of these entrepreneurs play a role.
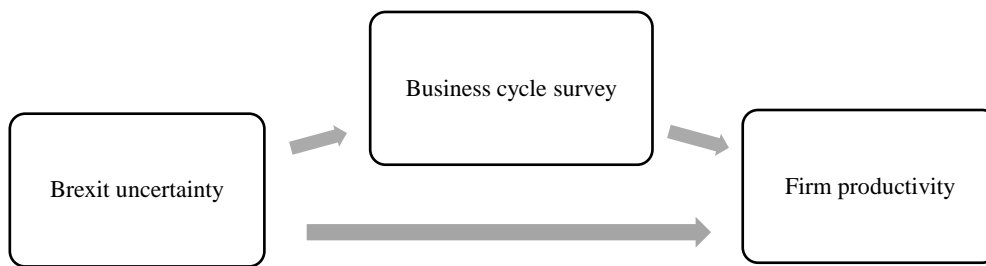
Figure 11: Flowchart impact Brexit related uncertainty on firm productivity

Figure 11 shows the relationship between the Brexit uncertainty and productivity. This thesis investigates four relationships. Firstly, it will be researched whether the Brexit related uncertainty had an direct impact on firm productivity. Secondly, the link between the Brexit related uncertainty and the outcomes of the *COEN* will be investigated. In this way it can be checked whether the exogenous uncertainty has effect on firm-level expectations. Thirdly, the relation between the outcomes of the *COEN* on firm productivity will be analyzed. Lastly, the effect of the Brexit related uncertainty on firm productivity controlling for the outcomes in the *COEN* will be assessed. In this way it can be seen whether the effect of the Brexit related uncertainty runs through the expectations of business owners.

To assess the direct effect of the Brexit related uncertainty on productivity, the following specification will be regressed:

$$\ln TFP_{i,t} = \beta_0 + \beta_1 \ln \sigma_t^2 + \beta_2 \ln BUI_t + \delta_{i,t} + \alpha_i + e_{i,t} \tag{6}$$

$TFP_{i,t}$ = the total factor productivity of firm i in year t. α_i = firm fixed effects to control for all the time-invariant firm characteristics. σ_t^2 = the exchange rate volatility of the British pound in year t. BUI_t = the Brexit uncertainty index based on social media signs in year t. $\delta_{i,t}$ = control dummies for firm size. The natural logarithm is used for the dependent and independent variables to interpret the results easily.

To specifically look if the effect of the Brexit related uncertainty significantly differs for the British firms in the Netherlands, specification 7 will be estimated. It is expected that the Brexit related uncertainty has a larger impact on British firms. In the estimation an interaction effect will be used, so the estimation will be based on the whole sample of firms, instead of the sample of just the British firms in the Netherlands

$$\ln TFP_{i,t} = \beta_0 + \beta_1 \ln \sigma_t^2 + \beta_2 \ln BUI_t + \beta_3 \gamma_i + \beta_4[\gamma_i * \ln \sigma_t^2] + \beta_5[\gamma_i * \ln BUI_t] + \delta_{i,t} + \alpha_i + e_{i,t} \qquad (7)$$

γ_i = a dummy which denotes whether the firm is under British control.

The variables of interest are the interaction terms, where β_4 and β_5 denote the difference in the effect of the Brexit related uncertainty on firm TFP between British firms and non-British firms in the Netherlands. β_3 is the effect of being a British firm in the Netherlands. Since this does not change over time, it is already included in the firm fixed effects.

Specification 8 denotes the regression which will be used to research whether the expectations from firms in the *COEN* are influenced by the Brexit related uncertainty. This regression will also be estimated using yearly data. Due to some difficulties with STATA[5], it was not possible to estimate the regression using quarterly data.

$$COEN_{n,i,t} = \beta_0 + \beta_1 \ln \sigma_t^2 + \beta_2 \ln BUI_t + \delta_{i,t} + \alpha_i + e_{i,t} \qquad (8)$$

$COEN_{n,i,t}$ = the outcomes from the answer options of the *COEN* question n for firm i in year t. For the question about the expectation of Brexit affecting the turnover, the answer options are averaged, since entrepreneurs can only choose one answer option. The value of the averaged variable varies from 1 to 5, where 1 is very positive and 5 is very negative. As regards the questions about the expectation of Brexit affecting their business operations, trade and investments, each answer option is included in the regression and has a value of 0 or 1.

To find out if there is a relationship between the answers in the *COEN* and productivity of firms, the regression in specification 9 will be estimated.

$$\ln TFP_{i,t} = \beta_0 + \beta_1 COEN_{n,i,t} + \delta_{i,t} + \alpha_i + e_{i,t} \qquad (9)$$

To examine if the exogenous Brexit related uncertainty has an impact on productivity and whether that effect runs through the answers in the *COEN*, the regression in specification 10 will be estimated.

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[5] When trying to clean the *COEN* data, STATA could not set the panel data due to multiple values per time period. I would take too much time and effort to fix the problem.

$$\ln TFP_{i,t} = B_0 + \beta_1 \ln \sigma_t^2 + \beta_2 \ln BUI_t + \beta_3 COEN_{n,i,t} + \delta_{i,t} + \alpha_i + e_{i,t} \qquad (10)$$

If β_1 and β_2 change after adding the *COEN* variables, the effect of the Brexit related uncertainty on firm TFP can be partially explained by the expectations of entrepreneurs.

Lastly, if firm TFP is likely to be affected by expectations of entrepreneurs, it will be analyzed whether the effect of the Brexit related uncertainty on TFP significantly differs for the British firms, while controlling for the expectations of the entrepreneurs. Estimation 11 describes the regression estimation.

$$\ln TFP_{i,t} = \beta_0 + \beta_1 \ln \sigma_t^2 + \beta_2 \ln BUI_t + \beta_3 \gamma_i + \beta_4 [\gamma_i * \ln \sigma_t^2] + \beta_5 [\gamma_i * \ln BUI_t] \qquad (11)$$
$$+ \beta_6 COEN_{n,i,t} + \delta_{i,t} + \alpha_i + e_{i,t}$$

6 Results

In section 6 the results of the research will be presented and discussed. This section contains four parts where the results of each regression estimation is presented. But first there will be checked whether there may be collinearity between variables in the regression estimation. When two variables in the regression estimation are highly correlated with each other, the estimates of the regression coefficients may be inaccurate. Table 5 shows the correlations between the variables of interest. The correlation between $\ln BUI_t$ and $\ln \sigma_t^2$ is large, but not larger than 0.99. STATA will automatically drop one variable when the correlation is higher than 0.99. Therefore, both variables will be included in the analysis. Remarkably, the correlation between these variables without the log is 0.36, which can also be seen in figure 5.

The correlation between $\ln BUI_t * UK\ dummy$ and $\ln \sigma_t^2 * UK\ dummy$ is lower than -0.99, which indicates collinearity between the variables. This can be explained by the fact that all observations where the UK dummy is equal to zero, is zero for both interaction terms. The values of the BUI are larger than one, which turn the values of the BUI positive after taking the log. The values of the exchange rate volatility turn negative after taking the log, since the values of the exchange rate volatility ranges between zero and one. Accordingly, the correlation is negative. Because of the strong correlation between the interaction terms, the analysis on the British firms will be done with one of the two variables each time.

Table 5: Correlation table

	$\ln BUI_t$	$\ln \sigma_t^2$	$\ln BUI_t$ $* UK\ dummy$	$\ln \sigma_t^2$ $* UK\ dummy$
$\ln BUI_t$	1.0000			
$\ln \sigma_t^2$	0.9649	1.0000		
$\ln BUI_t$ $* UK\ dummy$	-0.0015	0.0026	1.0000	
$\ln \sigma_t^2$ $* UK\ dummy$	0.0267	0.0234	-0.9914	1.0000

6.1 Brexit related uncertainty & productivity

In the first part the effect of the Brexit related uncertainty on firm productivity of firms located in the Netherlands will be researched. The results of this analysis are stated in table 6. In column 1, the log of the BUI is used as independent variable, without firm size dummies. In column 2, the independent variable is the log of the exchange rate volatility of the UK pound. In column 3, both

measures of the Brexit related uncertainty are included in the regression estimation. In column 4, firm size dummies are added.

The coefficients of the log of BUI and the log of exchange rate volatility in column 1 and 2 are not significant. When combining them in column 3, both coefficients are significant at a 1 percent significance level. The coefficient of log BUI increases further and the coefficient of log exchange rate volatility decreases further. Remarkably, the signs of the coefficients are the opposite. This result indicates that the proxies for the Brexit related uncertainty account for different effects on firm TFP. It means that it appears that the firm TFP of firms located in the Netherlands is likely to increase with 0.33 percent if the Brexit uncertainty index rises with 1 percent. But also, firm TFP is likely to decrease with 0.19 percent if the exchange rate volatility increases with 1 percent. Adding firm size dummies does not meaningfully affect the estimated coefficients.

Table 6: Effect of Brexit related uncertainty on firm TFP

$\ln TFP_{i,t}$	(1)	(2)	(3)	(4)
$\ln BUI_t$	0.0089		0.3338***	0.3319***
	(0.0173)		(0.0819)	(0.0823)
$\ln \sigma_t^2$		-0.0033	-0.1864***	-0.1848***
		(0.0097)	(0.0460)	(0.0461)
Firm size	No	No	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Obs	2,800	2,800	2,800	2,800
R^2	0.0009	0.0000	0.0103	0.0352

Notes: Standard deviation in parentheses; ***$p < 0.01$;

Table 7 shows the same analysis for British firms in the Netherlands. The first column shows the results for the regression estimation with the interaction term of the UK dummy and the BUI including firm fixed effects. In the second column firm size dummies are added. In the third column the results for the analysis including the interaction term of the UK dummy and the exchange rate volatility and firm fixed effects. In column 4 the firm size dummies are added. The interaction terms of the Brexit related uncertainty proxies and the UK dummy are the variables of interest. The coefficients of the dummy for UK owned firms are omitted due to collinearity, because they are already included in the firm fixed effects.

Both the interaction terms are statistically significant, even before adding firm size dummies. Looking at the coefficient in column 2, it suggest that British firms in the Netherlands have a 0.15

percent point higher TFP due to the Brexit related uncertainty than other firms in the Netherlands. Following the coefficient in column 4, the TFP of British firms did probably increase by 0.09 percent point more than non-British firms due to the Brexit related uncertainty. Additionally, the coefficients of $\ln BUI_t$ and $\ln \sigma_t^2$ are not significant anymore, since they are not combined with the other proxy.

The explanatory power becomes slightly larger after adding firm size dummies, indicating that the regression models in column 2 and column 4 fit the data better than the model without controls. Also the standard deviations of the variables of interest increase a little, which means that the coefficients of the model in column 2 and column 4 are slightly less accurate than the other models. However, the increases in the explanatory power and the standard deviation are inconsiderably low.

Table 7: Effect of Brexit related uncertainty on firm TFP of British firms

$\ln TFP_{i,t}$	(1)	(2)	(3)	(4)
$\ln BUI_t$	0.0028	0.0036		
	(0.0177)	(0.0179)		
$\ln \sigma_t^2$			-0.0071	-0.0067
			(0.0099)	(0.0100)
$UK\ dummy$	Omitted	Omitted	Omitted	Omitted
$\ln BUI_t$ $* UK\ dummy$	0.1559*	0.1485*		
	(0.0892)	(0.0896)		
$\ln \sigma_t^2$ $* UK\ dummy$			0.0946*	0.0904*
			(0.0491)	(0.0494)
$Firm\ size$	No	Yes	No	Yes
$Firm\ FE$	Yes	Yes	Yes	Yes
Obs	2,800	2,800	2,800	2,800
R^2	0.0000	0.0016	0.0000	0.0009

Notes: Standard deviation in parentheses; ***p < 0.01; *p < 0.1.

In general, the results in table 6 and 7 suggest that the Brexit related uncertainty had a positive and a negative effect on firm TFP of firms located in the Netherlands. Also, the effect of the Brexit related uncertainty (measured by the BUI) on the TFP of British firms in the Netherlands is larger than the other firms in the Netherlands. The increase in TFP can have several reasons. Following the literature, this result could agree with the Oi-Hartman-Abel effect (Oi, 1961; Hartman, 1972; Abel, 1983), where firms increase their investments under uncertainty. While assuming that the marginal unit of capital is convex in the price of output or costs must hold (Abel, 1983), the marginal

unit of capital increases (Pindyck & Solimano, 1993). The expected future marginal revenue increase, investments increase, which increases firm productivity. In reality, the assumption of the convexity of the marginal unit of capital may not hold. If that is case, the increase in productivity may not be via the Oi-Hartman-Abel effect. It could also be possible that the firms in the Netherlands got the incentive to be more productive to cover the potential costs of a Brexit, which agrees with Escribano & Stucchi (2014). Intuitively, firms who are defined as an independent SME have a higher incentive to be more productive.

The regression results also suggest that the Brexit related uncertainty (measured by the exchange rate volatility of the UK pound) had a negative impact on firm TFP. Again, this negative relation can have different reasons. This effect is most likely coming from the real options theory, where firms delay their investments when uncertainty rises. The investment decision is influenced by the potential bad news in the future (the hard or no-deal Brexit), which could make the investor regret his investment.

6.2 Brexit related uncertainty & expectations of entrepreneurs

The next step is to analyze whether the effect of the Brexit related uncertainty on firm TFP can be explained by the expectations of entrepreneurs in the Netherlands. In part 2 of section 6, the relation between the Brexit related uncertainty on the expectations of entrepreneurs will be researched. The expectations of entrepreneurs are measured through the *COEN*. The results of the regression analysis are stated in table 8, 9 and 10. In each column of table 9 and 10 the dependent variable is an answer option from one of the Brexit related questions. The regression estimations in all columns include firm fixed effects and firm size dummies.

Table 8 shows the regression output for the answer options of the question "What is the expected impact of Brexit on your turnover for the next three months?". The coefficients of the two uncertainty proxies have the opposite sign. The coefficient of the BUI indicates that an 1 percent increase of the BUI was likely to increase the average expected effect of Brexit on the turnover with 0.0006 points. This means that the average expected effect of the Brexit on the turnover got less positive and/or more negative with 0.0006 points when the BUI increased by 1 percent. The opposite holds for the coefficient of the exchange rate volatility of the UK pound.

Table 9 reports the output of the regression estimation for the second Brexit related question "In which aspects do you expect Brexit to affect your business operations in the next three months?". It appears that an increase of the BUI (exchange rate volatility of the UK pound) is likely to increase (decrease) the number of entrepreneurs that expect Brexit to affect their freedom of movement of

goods and services, their workforce and their locations in the UK. For example, the number of entrepreneurs that expect Brexit to influence their freedom of movement of goods and services increases by 0.0006 if the BUI increases by 1 percent. The coefficient of BUI in the regression model for the expectation of profitability is not significant. However, the coefficient of the exchange rate volatility of the UK pound is. The coefficients of the Brexit related uncertainty in column 5 are statistically significant. Remarkably the coefficients of both the BUI and the exchange rate volatility have a negative sign. From table 7, it also appears that the BUI (exchange rate volatility of the UK pound) has a negative (positive) and statistically significant effect on the expectation of Brexit having no impact on the business operations.

Table 10 shows that an increase of 1 percent of the BUI tends to increase the number of entrepreneurs that expected to trade less with the UK in the current quarter due to Brexit with 0.0003. As for the number of entrepreneurs who did not expect the Brexit to influence their trade or their investments in the current quarter, a 1 percent increase of the BUI tends to decrease it with 0.0002. Surprisingly, the coefficients of the BUI in the other columns are not statistically significant. The majority of the coefficients of the exchange rate of the UK pound, however, are. Notably, these results suggest that an increase of 1 percent of the exchange rate volatility leads to an decrease of 0.0003 in the number of entrepreneurs that expected more trade with the UK. Additionally, an 1 percent increase in the exchange rate volatility leads to a 0.0002 decrease in the number of entrepreneurs that expected less trade with the UK. Also, an increase of the exchange rate volatility of 1 percent decreases in the number of entrepreneurs that expected less trade with other countries with 0.00002; Lastly, the same change leads to a 0.00002 decrease in the number of entrepreneurs who expected less investments due to the Brexit.

Table 8: Effect of Brexit related uncertainty on expectations of entrepreneurs' turnover

Average expectation on entrepreneurs turnover over a year	
$\ln BUI_t$	0.0679***
	(0.0077)
$\ln \sigma_t^2$	-0.0668***
	(0.0085)
Firm size	Yes
Firm FE	Yes

	Obs	4,747
	R^2	0.0035

Notes: Standard deviation in parentheses; ***p < 0.01;

Table 9: Effect of Brexit related uncertainty on expectations of entrepreneurs' business operations

Dep. var.: Expectations of Brexit affecting business operations	(1) Freedom of movement of goods and services	(2) Workforce	(3) Profitability	(4) Locations in UK	(5) Competitive position	(6) Other, including indirect effects	(7) Little to no impact
$\ln BUI_t$	0.0578***	0.0027***	0.0021	0.0079***	-0.0055***	-0.0017	-0.0421***
	(0.0027)	(0.0010)	(0.0016)	(0.0014)	(0.0015)	(0.0013)	(0.0028)
$\ln \sigma_t^2$	-0.0305***	-0.0023**	-0.0070***	-0.0041***	-0.0033*	-0.0022	0.0315***
	(0.0030)	(0.0011)	(0.0017)	(0.0016)	(0.0017)	(0.0014)	(0.0031)
Firm size	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	4,747	4,747	4,747	4,747	4,747	4,747	4,747
R^2	0.0702	0.0002	0.0011	0.0123	0.0003	0.0001	0.0236

Notes: Standard deviation in parentheses; ***p < 0.01; **p < 0.05.
In each column the dependent variable is one of the expectations from the question "In which aspects do you expect Brexit to affect your business operations in the next three months?".

Table 10: Effect of Brexit related uncertainty on expectations of entrepreneurs' trade and investments

Dep. var.: Expectations of Brexit affecting business	(1) More trade with UK	(2) Less trade with UK	(3) More trade with other countries	(4) Less trade with other countries	(5) More investments	(6) Less investments	(7) Not or different
$\ln BUI_t$	0.0003	0.0254***	0.0005	0.0007	0.0001	0.0004	-0.0226***
	(0.0009)	(0.0025)	(0.0013)	(0.0007)	(0.0005)	(0.0009)	(0.0027)
$\ln \sigma_t^2$	-0.0026***	-0.0259***	-0.0023*	-0.0017**	-0.0007	-0.0023**	0.0315***
	(0.0007)	(0.0027)	(0.0014)	(0.0007)	(0.0006)	(0.0010)	(0.0029)
Firm size	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	4,747	4,747	4,747	4,747	4,747	4,747	4,747
R^2	0.0003	0.0083	0.0009	0.0002	0.0001	0.0011	0.0188

Notes: Standard deviation in parentheses; ***$p < 0.01$; **$p < 0.05$;
In each column the dependent variable is one of the expectations from the question "How do you expect the Brexit to impact your business in the next three months?".

Summed up, it seems that the Brexit related uncertainty was likely to affect the expectations of entrepreneurs on various aspects of their business. The results show that the exogenous Brexit related uncertainty was likely to impact the expectations of entrepreneurs on firm level. Specifically, the expectations of the Brexit on the turnover and business operations are impacted by the Brexit related uncertainty. Additionally, there is evidence that the Brexit related uncertainty measured by the exchange rate volatility probably had impact on the expectations entrepreneurs about the effect of the Brexit on trade and investments. There is less evidence when the Brexit related uncertainty is measured by the BUI. Since not all coefficients are statistically significant, it cannot be said for all the expectations that they are likely to be impacted by the Brexit related uncertainty.

6.3 Expectations of entrepreneurs & firm TFP

In part 3 of section 6 the relation between the expectations of entrepreneurs and the TFP of firms will be analyzed. The expectations of entrepreneurs located in the Netherlands is measured by three questions of the *COEN*. The results of the regression analysis of the effect of the answers on the *COEN* question on firm TFP are given in table 11, 12 and 13. In the first column of each table the basic regression is estimated including firm fixed effects. In the second column firm size dummies are added.

Recalling question 1, "What is the expected impact of Brexit on your turnover for the next three months?", table 11 shows the regression output regarding this question. The coefficients of the expectations of entrepreneurs are not statistically significant, even after adding firm size dummies. In the tables 12 and 13 the same analysis is done with the other two questions. The second question is "In which aspects do you expect Brexit to affect your business operations in the next three months?", where the first six answer options are matters in a firm's business operations that can be affected. From this table it appears that the TFP of firms who expected Brexit to have an impact on the freedom of movement of goods and services was higher than the TFP of firms who did not expected this. Also firms who expected Brexit to affect their competitive position were likely to have an higher TFP than firms who did not.

Table 13 reports the regression outcomes for the question "How do you expect the Brexit to impact your business in the next three months?". None of the coefficients are statistically significant. The results in table 11, 12 and 13 do not give clear evidence that there is a relationship between firm TFP and the expectations of entrepreneurs measured in the *COEN*.

Table 11: Correlations of the expectations of entrepreneurs about Brexit affecting their turnover on TFP

$\ln TFP_{i,t}$	(1)	(2)
The expectation of Brexit affecting turnover		
Very positive	0.5920	0.5390
	(1.1864)	(1.1889)
Positive	-0.5446	-0.5895
	(0.8602)	(0.8624)
Neutral	-0.0547	-0.0889
	(0.8073)	(0.8086)
Negative	0.0876	0.0565
	(0.8075)	(0.8091)
Very negative	Omitted	Omitted
Firm size	No	Yes
Firm FE	Yes	Yes
Obs.	2,872	2,872
R^2	0.0015	0.0218

Notes: Standard deviation in parentheses; **$p < 0.05$.
In each column the expectations from entrepreneurs from the question "What is the expected impact of Brexit on your turnover for the next three months?" are added as independent variables in the regression estimation.

Table 12: Effect of Business Cycle Survey answers of question 2 on TFP

$\ln TFP_{i,t}$	(1)	(2)
The expectation of Brexit affecting business operations		
Freedom of movement of goods and services	0.4127**	0.4199**
	(0.1989)	(0.1991)
Workforce	-0.0192	-0.0165
	(0.3292)	(0.3301)
Profitability	0.0415	0.0345
	(0.2317)	(0.2317)
Locations in the UK	-0.0457	-0.0599
	(0.2648)	(0.2651)

Competitive position	0.3910*	0.3898*
	(0.2347)	(0.2355)
Other, including indirect effects	0.4615	0.4389
	(0.2909)	(0.2913)
Little to no impact	0.2725	0.2637
	(0.2358)	(0.2360)
Firm size	No	Yes
Firm FE	Yes	Yes
Obs.	2,872	2,872
R^2	0.0009	0.0086

Notes: Standard deviation in parentheses; **$p < 0.05$.
Each column the expectations from entrepreneurs from the question "In which aspects
do you expect Brexit to affect your business operations in the next three months?"
are added as independent variables in the regression estimation.

Table 13: Effect of Business Cycle Survey answers of question 3 on TFP

$\ln TFP_{i,t}$	(1)	(2)
The expectation of Brexit affecting business		
More trade with UK	0.2906	0.2626
	(0.4238)	(0.4243)
Less trade with UK	0.1204	0.1103
	(0.3234)	(0.3237)
More trade with other countries	0.1170	0.1116
	(0.3067)	(0.3080)
Less trade with other countries	0.0384	-0.0388
	(0.4650)	(0.4653)
More investments	0.9139	0.8284
	(0.7159)	(0.7228)
Less investments	-0.1727	-0.1996
	(0.4106)	(0.4116)
Not or different	0.0609	0.0477
	(0.3363)	(0.3366)
Firm size	No	Yes
Firm FE	Yes	Yes

Obs.	2,872	2,872
R^2	0.0006	0.0226

Notes: Standard deviation in parentheses; ***p < 0.01; **p < 0.05; *p < 0.01.
In each column the expectations from entrepreneurs from the question "How do you expect the Brexit to impact your business in the next three months?" are added as independent variables in the regression estimation.

6.4 Brexit related uncertainty, expectations of entrepreneurs and firm TFP

So far, the set of results in part 1 of section 6 suggest that the Brexit uncertainty is both positively and negatively related to firm TFP of firms located in the Netherlands. In part 2 of section 6, the Brexit related uncertainty was regressed on each answer option from the questions. The exogenous Brexit related uncertainty was likely to affect the expectations of entrepreneurs at the firm level. In part 3 of section 6, it cannot be said with certainty that there is a stable link between firm TFP and the expectations of entrepreneurs. Though the results in section 6.3 suggest that the expectations of entrepreneurs do not correlate with firm TFP, this part of section 6 investigates the relationship between Brexit uncertainty and firm TFP, while controlling for the expectations of entrepreneurs. In this way there can be tracked down with certainty whether the relation between Brexit related uncertainty and firm TFP can be (partially) explained by the expectations of business owners.

Table 14 reports the regression output for the regression regarding the relation between Brexit related uncertainty and firm TFP including controls for the answers of the first question from the *COEN*. The log of the BUI is used as independent variable in column 1, without firm size dummies. In column 2, the independent variable is the log of the exchange rate volatility of the UK pound. In column 3, both measures of the Brexit related uncertainty are included in the regression estimation. In column 4 the dummies for firm size are added.

Just like part 1 of section 6, the coefficients of the proxies for Brexit related uncertainty in column 1 and 2 are not significant. When combined in column 3, the coefficients are statistically significant at a 1 percent significance level and still indicate a positive (negative) link between the BUI (exchange rate volatility of the UK pound) and firm TFP. When adding firm size dummies in column 4, both coefficients remain significant. As expected, none of the coefficients of the answer options are statistically significant. The coefficient of the Brexit related uncertainty proxies are not meaningfully affected compared to column 4 of table 6. Thus, there is no evidence that the expectations for the entrepreneurs did explain the effect of the Brexit related uncertainty on firm TFP. Additionally, the explanatory power of column 4 in table 6 larger than in column 4 from table 14. This indicates that the model of table 6 fits the data better than the model in table 14.

Tables 15 and 16 have the same construction as table 14. The results in these tables also suggest that the expectations of entrepreneurs do not play a role in the effect of the Brexit related uncertainty on. When combined, the coefficients for the BUI (exchange rate volatility) denote a positive (negative) and significant relationship between Brexit related uncertainty and firm TFP. Again, the coefficients for the answer options of questions 2 and 3 are not significant.

Table 14: Effect of Brexit related uncertainty on firm TFP, including dummies for Business Cycle Survey answers of question 1

$\ln TFP_{i,t}$	(1)	(2)	(3)	(4)
$\ln BUI_t$	0.0109		0.3393***	0.3367***
	(0.0176)		(0.0820)	(0.0825)
$\ln \sigma_t^2$		0.0026	-0.1887***	-0.1867***
		(0.0099)	(0.0460)	(0.0462)
Very positive	0.5865	0.6304	0.6295	0.5279
	(1.1199)	(1.1202)	(1.1109)	(1.1145)
Positive	-0.5682	-0.5018	-0.5488	-0.6350
	(0.8151)	(0.8152)	(0.8085)	(0.8120)
Neutral	-0.0792	-0.0046	-0.0081	-0.0760
	(0.7661)	(0.7664)	(0.7601)	(0.7626)
Negative	0.0203	0.0760	0.0671	-0.0023
	(0.7643)	(0.7645)	(0.7582)	(0.7609)
Very negative	Omitted	Omitted	Omitted	Omitted
Firm size	No	No	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Obs	2,800	2,800	2,800	2,800
R^2	0.0020	0.0016	0.0113	0.0155

Notes: Standard deviation in parentheses; ***$p < 0.01$;
In each column the expectations of entrepreneurs from the question "What is the expected impact of Brexit on your turnover for the next three months?" are added as independent variables in the regression estimation.

Table 15: Effect of Brexit related uncertainty on firm TFP, including dummies for Business Cycle Survey answers of question 2

$\ln TFP_{i,t}$	(1)	(2)	(3)	(4)
$\ln BUI_t$	0.0127		0.3361***	0.3340***
	(0.0176)		(0.0824)	(0.0830)
$\ln \sigma_t^2$		-0.0014	-0.1857***	-0.1840***
		(0.0099)	(0.0463)	(0.0465)
Freedom of movement of goods	0.3066	0.3057	0.2888	0.3011
	(0.1908)	(0.1909)	(0.1894)	(0.1897)
Workforce	-0.1952	-0.2055	-0.2116	-0.2138
	(0.3279)	(0.3280)	(0.3254)	(0.3264)
Profitability	0.0116	-0.0061	-0.0019	-0.0116
	(0.2245)	(0.2247)	(0.2229)	(0.2231)
Locations in the UK	-0.0261	-0.0243	-0.1319	-0.1304
	(0.2540)	(0.2541)	(0.2534)	(0.2539)
Competitive position	0.3459	0.3292	0.3119	0.3142
	(0.2243)	(0.2245)	(0.2227)	(0.2235)
Other, including indirect effects	0.4075	0.3929	0.3599	0.3533
	(0.2761)	(0.2763)	(0.2742)	(0.2748)
No to little impact	0.1130	0.1123	0.0922	0.0896
	(0.2253)	(0.2253)	(0.2236)	(0.2239)
Firm size	No	No	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Obs	2,800	2,800	2,800	2,800
R^2	0.0005	0.0007	0.0019	0.0230

Notes: Standard deviation in parentheses; ***$p < 0.01$;
In each column the expectations of entrepreneurs from the question "In which aspects do you expect Brexit to affect your business operations in the next three months?" are added as independent variables in the regression estimation.

Table 16: Effect of Brexit related uncertainty on firm TFP, including dummies for Business Cycle Survey answers of question 3

$\ln TFP_{i,t}$	(1)	(2)	(3)	(4)
$\ln BUI_t$	0.0123		0.3380***	0.3363***
	(0.0178)		(0.0823)	(0.0830)
$\ln \sigma_t^2$		-0.0019	-0.1874***	-0.1860***
		(0.0100)	(0.0463)	(0.0466)
More trade with UK	0.3464	0.3293	0.3300	0.3025
	(0.4048)	(0.4049)	(0.4016)	(0.4024)
Less trade with UK	0.1747	0.1735	0.1706	0.1592
	(0.3139)	(0.3140)	(0.3115)	(0.3121)
More trade with other countries	0.1103	0.1167	0.1528	0.1493
	(0.2926)	(0.2927)	(0.2905)	(0.2920)
Less trade with other countries	0.2061	0.1943	0.1091	0.1090
	(0.4930)	(0.4942)	(0.4906)	(0.4914)
More investments	0.9229	0.9343	0.9455	0.8192
	(0.6759)	(0.6760)	(0.6705)	(0.6776)
Less investments	-0.1422	-0.1457	-0.2003	-0.2375
	(0.3897)	(0.3898)	(0.3869)	(0.3881)
Not or different	0.1014	0.1218	0.1204	0.1063
	(0.3260)	(0.3261)	(0.3235)	(0.3240)
Firm size	No	No	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Obs	2,800	2,800	2,800	2,800
R^2	0.0002	0.0004	0.0055	0.0167

Notes: Standard deviation in parentheses; ***p < 0.01;
In each column the expectations of entrepreneurs from the question "In which aspects do you expect Brexit to affect your business operations in the next three months?" are added as independent variables in the regression estimation.

Table 17, 18 and 19 show the results for the analysis on the British firms in the Netherlands. In table 17 the expectations about Brexit influencing the turnover are added as control variables. In table 18 the expectations about Brexit affecting the business operations are added and in table 19 the expectations about Brexit having an impact on trade and investments are added. The first column of each table includes the interaction term of the UK dummy and the BUI without firm size dummies. In the second column firm size dummies are added. The third column includes the interaction term of the UK dummy and the exchange rate of the UK pound. In the fourth column firm size dummies are added as a control.

Compared to the coefficients of the interaction effect of the BUI and the UK dummy before adding the *COEN*, the coefficients of the interaction term did not meaningfully change after adding the *COEN* controls. The results suggest that there is no evidence that the expectations of entrepreneurs (partially) explain the difference in which the Brexit related uncertainty affects the TFP of British firms more than non-UK firms in the Netherlands. When replacing the interaction term of the BUI and the UK dummy with the interaction term of the exchange rate volatility and the UK dummy, the same conclusion holds.

To sum up the findings from this section, the results suggest that the Brexit related uncertainty is likely to both increase and decrease firm TFP of firms located in the Netherlands. Additionally, the TFP of British firms in the Netherlands is more likely to have a higher increase than the TFP of non-British firms in the Netherlands. When adding the *COEN* controls, the coefficients of the Brexit uncertainty proxies do not meaningfully change and the coefficients of the *COEN* control are not statistically significant. Thus, the results suggest that there is a relationship between the Brexit related uncertainty and firm TFP. However, there is no evidence that it is (partially) explained by the expectation of entrepreneurs about their turnover, business operations, trade and investments.

Table 17: Effect of Brexit related uncertainty on firm TFP, including dummies for the expectations about Brexit affecting a firm's turnover

$\ln TFP_{i,t}$	(1)	(2)	(3)	(4)
$\ln BUI_t$	0.0047	0.0056		
	(0.0180)	(0.0182)		
$\ln \sigma_t^2$			-0.0065	-0.0060
			(0.0101)	(0.0102)
UK dummy	Omitted	Omitted	Omitted	Omitted
UK dummy $* \ln BUI_t$	0.1514*	0.1432*		
	(0.0893)	(0.0897)		

			$0.0926*$	$0.0880*$
UK dummy $*\ln\sigma_t^2$			(0.0492)	(0.0494)
Very positive	0.6057	0.5065	0.6524	0.5610
	(1.1189)	(1.1225)	(1.1187)	(1.1224)
Positive	-0.5347	-0.6229	-0.4644	-0.5467
	(0.8146)	(0.8180)	(0.8143)	(0.8178)
Neutral	-0.0477	-0.1141	0.0317	-0.0300
	(0.7655)	(0.7681)	(0.7656)	(0.7682)
Negative	0.0405	-0.0201	0.0992	0.0443
	(0.7636)	(0.7601)	(0.7636)	(0.7663)
Very negative	Omitted	Omitted	Omitted	Omitted
Firm size	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Obs	2,800	2,800	2,800	2,800
R^2	0.0000	0.0011	0.0000	0.0005

Notes: Standard deviation in parentheses; ***p < 0.01;
In each column the expectations of entrepreneurs from the question "What is the expected impact of Brexit on your turnover for the next three months?" are added as independent variables in the regression estimation.

Table 18: Effect of Brexit related uncertainty on firm TFP, including dummies for the expectations about Brexit affecting a firm's business operations

$\ln TFP_{i,t}$	(1)	(2)	(3)	(4)
$\ln BUI_t$	0.0067	0.0075		
	(0.0180)	(0.0182)		
$\ln\sigma_t^2$			-0.0052	-0.0048
			(0.0101)	(0.0102)
UK dummy	Omitted	Omitted	Omitted	Omitted
UK dummy $*\ln BUI_t$	$0.1514*$	$0.1429*$	$0.0922*$	
	(0.0894)	(0.0898)	(0.0493)	
UK dummy $*\ln\sigma_t^2$				$0.0874*$
				(0.0495)
Freedom of movement of goods	0.3033	0.3159	0.3017	0.3142
	(0.1906)	(0.1909)	(0.1906)	(0.1909)
Workforce	-0.1670	-0.1727	-0.1746	-0.1820
	(0.3280)	(0.3290)	(0.3280)	(0.3290)
Profitability	-0.0015	-0.0002	-0.0211	-0.0198

	(1)	(2)	(3)	(4)
	(0.2245)	(0.2247)	(0.2245)	(0.2247)
Locations in the UK	-0.0158	-0.0147	-0.0151	-0.1142
	(0.2538)	(0.2542)	(0.2537)	(0.2542)
Competitive position	0.3416	0.3473	0.3238	0.3311
	(0.2241)	(0.2248)	(0.2242)	(0.2249)
Other, including indirect effects	0.4112	0.3997	0.3961	0.3837
	(0.2758)	(0.2765)	(0.2760)	(0.2766)
No to little impact	0.1117	0.1103	0.1104	0.1093
	(0.2250)	(0.2254)	(0.2250)	(0.2254)
Firm size	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Obs	2,800	2,800	2,800	2,800
R^2	0.0000	0.0028	0.0000	0.0020

Notes: Standard deviation in parentheses; ***$p < 0.01$;
In each column the expectations of entrepreneurs from the question "What is the expected impact of Brexit on your turnover for the next three months?" are added as independent variables in the regression estimation.

Table 19: Effect of Brexit related uncertainty on firm TFP, including dummies for the expectations about Brexit affecting trade and investments

$\ln TFP_{i,t}$	(1)	(2)	(3)	(4)
$\ln BUI_t$	0.0060	0.0068		
	(0.0182	(0.0184)		
$\ln \sigma_t^2$			-0.0059	-0.0055
			(0.0102)	(0.0103)
UK dummy	Omitted	Omitted	Omitted	Omitted
UK dummy $* \ln BUI_t$	0.1516*	0.1448*		
	(0.0895)	(0.0900)		
UK dummy $* \ln \sigma_t^2$			0.0928*	0.0890*
			(0.0494)	(0.0497)
More trade with UK	0.3386	0.3108	0.3203	0.2937
	(0.4045)	(0.4052)	(0.4044)	(0.4052)
Less trade with UK	0.1785	0.1697	0.1775	0.1700
	(0.3136)	(0.3143)	(0.3136)	(0.3142)
More trade with other countries	0.1156	0.1106	0.1236	0.1188
	(0.2923)	(0.2938)	(0.2923)	(0.2939)

Less trade with other countries	0.1917	0.1950	0.1762	0.1806
	(0.4935)	(0.4942)	(0.4936)	(0.4944)
More investments	0.9428	0.8225	0.9567	0.8365
	(0.6753)	(0.6826)	(0.6753)	(0.6826)
Less investments	-0.1206	-0.1597	-0.1229	-0.1592
	(0.3895)	(0.3908)	(0.3895)	(0.3908)
Not or different	0.1150	0.1002	0.1372	0.1227
	(0.3258)	(0.3264)	(0.3258)	(0.3264)
Firm size	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Obs	2,800	2,800	2,800	2,800
R^2	0.0000	0.0009	0.0000	0.0004

Notes: Standard deviation in parentheses; ***$p < 0.01$;

In each column the expectations of entrepreneurs from the question "What is the expected impact of Brexit on your turnover for the next three months?" are added as independent variables in the regression estimation.

7   <u>Robustness tests</u>

In this section, a number of robustness tests are performed to find out whether the results are robust to some changes in the data. To begin with, the first part of the analysis is done on the dataset where the TFP data and *COEN* data are matched. In this setting that ranges from 2017 until 2019, the correlation between the log of the BUI and the log of the exchange rate volatility is -0.9649. Even though the correlation is not lower or equal than -0.99, it may be causing the coefficients to be inaccurate. The correlation between the variables is only 0.3036 in the setting where the *COEN* data is not matched with the TFP data (range from 2015-2019). To ensure that the same results also holds for the whole TFP dataset, the first part of the analysis will be done again with a different dataset.

The results are shown in table B1 in Appendix B. Column 1 presents of the regression estimation without the interaction terms. In column 2 and 3 the interaction terms are added separately. The magnitude of the regression coefficients in column 1 is much lower compared to table 6. Remarkably, the coefficient of the exchange rate volatility is positive instead of negative. The coefficients of the interaction effects are not significant anymore. This suggest that the results change when redoing the analysis on a different dataset.

Second, the coverage of firms with 10 to 20 employees in the TFP data (firm size 40 in table A2) varies over time, which may influence the results. Therefore, the regression analysis will be done again, excluding firms with 10 to 20 employees. To be more specific, estimations 6, 7 and 10 will be repeated. The results are presented in table B2 in Appendix B. The overall results remain the same.

Lastly, the coverage of the number of firms is incredibly low in 2019. That is why estimations 6, 7 and 10 will be done, excluding the year 2019. The results are stated in table B2 in Appendix 2. Remarkably, the exchange rate volatility is omitted due to collinearity, even though it is not highly correlated with the other variables in the analysis. Therefore there cannot be said that the results regarding the effect of the Brexit on firm TFP of all firms in the Netherlands are robust against excluding year 2019. However, the results on the UK firms in the Netherlands remain the same.

8   Conclusion

In this thesis the effect of the Brexit related uncertainty on firm TFP of (British) firms in the Netherlands is researched. Additionally, I investigated whether the expectations of entrepreneurs of the impact of Brexit on their turnover, business operations, trade and investments could (partially) explain this relation. Even though TFP can be affected through many channels, firm investments are most likely to have an impact on firm TFP (Syverson, 2010). The existing literature suggests that uncertainty can either have a positive or negative impact on firm TFP (Li, Guo & Chen, 2021; Escribano & Stucchi, 2014; Appelbaum, 1991).

Using an existing measure (the exchange rate volatility) and a fairly new measure (social media signals) as a proxy for Brexit related uncertainty, the research question has been tested by estimating fixed effects regressions. From the results it seems that there is evidence for both an increase and decrease of firm TFP due to the Brexit related uncertainty. The BUI was likely to have a positive impact on firm TFP, whereas the exchange rate volatility was likely to have a negative impact. Additionally, the British firms in the Netherlands were more likely to have a larger increase in TFP than non-British firms. There is no evidence that the expectations of the entrepreneurs were one of the drivers through which the Brexit related uncertainty affects firm TFP.

Despite the evidence in the results section, this conclusion is not accurate. The results are not robust against some changes in the data. First off, it cannot be said that the Brexit related uncertainty had an effect on firm TFP. When estimating the regression analysis of the Brexit related uncertainty on firm TFP on the full TFP data instead of the new data where data on the *COEN* is matched, the results change. This conclusion is also not robust against dropping time period 2019 from the dataset. Secondly, the conclusion about the British firms in the Netherlands who probably experienced a larger increase in firm TFP due the Brexit related uncertainty is also not robust. The results change after replacing the merged dataset with the full TFP data. Therefore, it cannot be said with certainty that the Brexit related uncertainty had an impact on firm TFP of (British) firms in the Netherlands.

9 Limitations & suggestions for future research

9.1 Limitations

This thesis has several limitations. Beginning with the proxies for the Brexit related uncertainty, the exchange rate volatility of the British pound and the BUI are not perfect measurements of the Brexit related uncertainty. The exchange rate volatility may also pick up other trends which are not related to Brexit. The BUI, which is based on social media messages in the Netherlands, may not be representable for the entire Dutch population. Since not everyone in the Netherlands is active on social media, the signs from social media only represent a part of the whole population. The second potential pitfall of using social media signs is that the data may contain fake posts. However, due to the large number of posts, it is not likely to be a problem.

Also, as stated before, the capital input in the TFP measure is defined as the depreciation expense. The assumption that it is proportional to the firm's capital input might not be true for all firms in real life. Additionally, this thesis used a simpler method to measure TFP. It is not clear through which factor TFP was affected. The literature shows us that there are better ways to measure TFP, for example by estimating an Ordinary Least Squares regression (OLS). However, current research is still trying to come up with a better method, since the existing measures has its own pitfalls.

Furthermore, the analysis in this thesis controlled for firm size and firm fixed effects. However, it is hard to control for firm specific variables that change over time. Also, the regression analyses in this thesis did not control for time influenced shocks, which could also have an effect on firm TFP. Since the data ranges until 2019 and the covid-19 pandemic started in the second quarter of 2020, the pandemic was likely not to influence the TFP.

Another drawback of the study is that the Brexit related questions in the *COEN* data were only available from 2017 until 2019. The Brexit related uncertainty probably started before the Brexit referendum. The effect of the Brexit related uncertainty on firm TFP while controlling for the expectations of entrepreneurs could only be examined from 2017. When having data for a larger time period, there could also be analyzed what the effect was of the Brexit related uncertainty on firm TFP for a mid-term period.

Lastly, the data of service industries was not complete, hence this research was done on the goods industry. Also, due to lack of time I could not use the data of the different industries to assess whether the effect of the Brexit related uncertainty on firm TFP was different in a specific industry.

9.2 Suggestions for future research

Based on the limitation from this thesis, several suggestions for future research can be made. First of all, a different measure for the Brexit related uncertainty could be used. For example, Baker, Bloom & Davis (2016) used newspaper coverage frequency as an indicator for the Brexit related uncertainty. For such a research to be done in the Netherlands, a similar method as Rotteveel & Ballegeer (2021) from *De Nederlandsche Bank* (DNB) can be used. They used newspapers which contained words with a certain sentiment from *Het Financieele Dagblad* to predict the state of the economy. The same method can be used to filter Brexit related newspapers which contain words like uncertainty or risk.

Secondly, the use of social media signals to measure economic variables is a new method in the economic research field. With the internet becoming more popular and a growing percentage of the population using social media, social media posts may lead to interesting insights. Therefore, it is recommendable to further research how social media can be used as an indicator to measure economic variables such as economic uncertainty.

Additionally, different measures for TFP could be used. Earlier I stated that TFP could be measured by OLS. However, the basic OLS regression based on the Cobb Douglas production function raises simultaneity bias and selection bias. Olley & Pakes (1996) improved the method by getting rid of these biases. To execute this method data on investments is needed.

Also, it is recommendable to use a larger time period to analyze possible long-term effects of the Brexit related uncertainty on firm TFP. Furthermore, more frequent measures of investment sentiments at the firm level are needed to have variation in both time periods and firm level. Lastly, the same research can be done on the service industries so assess whether the same results in this thesis also apply in those industries.

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Appendix A
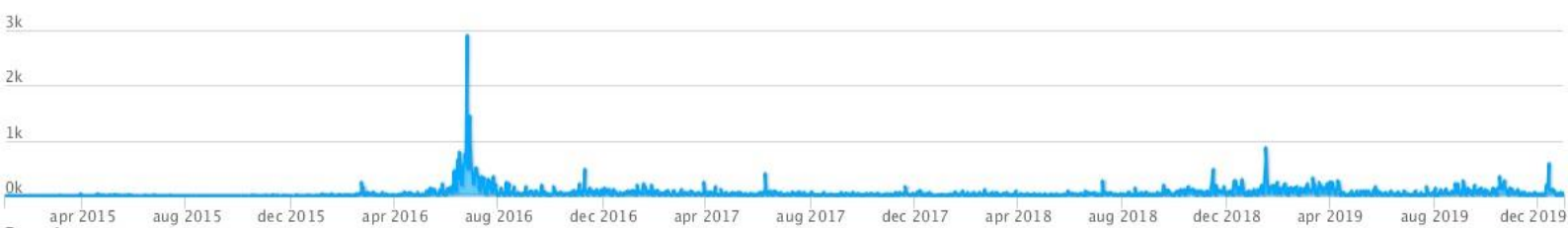
Figure A1: Graph of the original dataset of the Brexit uncertainty index. Source: Coosto.

Table A1: Sources social media posts

Source type	Number of posts
News articles	60,255
Twitter	19,024
Blog	13,942
Forum	9,498
YouTube	313
Pinterest	13
Review	3

Table A2: Firm size labels

Value	Number of working persons
10	1
21	2
22	3 – 4
30	5 – 9
40	10 – 19
50	20 – 49
60	50 – 99
71	100 – 149

72	150 – 199
81	200 – 249
82	250 – 499
91	500 – 999
92	1000 – 2000
93	2000 or more

Notes: The firm size is adopted from the business demographics from CBS.

Appendix B

Table B1: Robustness test A

$\ln TFP_{i,t}$	(1)	(2)	(3)
$\ln BUI_t$	0.0137***	0.0138***	0.0137***
	(0.0009)	(0.0009)	(0.0009)
$\ln \sigma_t^2$	0.0050**	0.0050**	0.0048**
	(0.0023)	(0.0023)	(0.0023)
$UK\ dummy * \ln BUI_t$		-0.0070	
		(0.0056)	
$UK\ dummy * \ln \sigma_t^2$			0.0130
			(0.0147)
Obs	92,377	92,377	92,377
R^2	0.1176	0.1175	0.1175

Notes: Standard deviation in parentheses; ***$p < 0.01$; **$p < 0.05$.
Each regression includes firm fixed effects and firm size dummies.

Table B2: Robustness tests B

$\ln TFP_{i,t}$	(1)	(2)	(3)	(4)	(5)	(6)
Robustness tests						
Dropping firm size 40						
$\ln BUI_t$	0.2840***	-0.0006		0.2891***	0.2850***	0.2903***
	(0.0836)	(0.0175)		(0.0836)	(0.0842)	(0.0840)
$\ln \sigma_t^2$	-0.1595***		-0.0074	-0.1618***	-0.1584***	-0.1611***
	(0.0468)		(0.0098)	(0.0468)	(0.0471)	(0.0471)
$UK\ dummy * \ln BUI_t$		0.1398*				
		(0.0881)				
$UK\ dummy * \ln \sigma_t^2$			0.0841*			
			(0.0486)			
$COEN\ 1$				Included		
$COEN\ 2$					Included	
$COEN\ 3$						Included
Obs	2,631	2,631	2,631	2,631	2,631	2,631
R^2	0.0000	0.0000	0.0000	0.0005	0.0001	0.0004
Dropping year 2019	(1)	(2)	(3)	(4)	(5)	(6)
$\ln BUI_t$	-0.0031	-0.0098		-0.0018	-0.0004	-0.0008
	(0.0177)	(0.0174)		(0.0174)	(0.0174)	(0.0176)
$\ln \sigma_t^2$	Omitted		-0.0054	Omitted	Omitted	Omitted
			(0.0096)			
$UK\ dummy * \ln BUI_t$		0.1654*				
		(0.0858)				
$UK\ dummy * \ln \sigma_t^2$			0.0911*			
			(0.0475)			
$COEN\ Q1$				Included		
$COEN\ Q2$					Included	
$COEN\ Q3$						Included
Obs	2,784	2,784	2,784	2,784	2,784	2,784
R^2	0.0792	0.0081	0.0120	0.0649	0.0639	0.0102

Notes: Standard deviation in parentheses; ***p < 0.01; **p < 0.05; *p < 0.1.
Each regression includes firm fixed effects and firm size dummies.

The fourth column includes all the expectations of entrepreneurs about their turnover. The answer options range from very positive to very negative. The fifth column includes all expectation of entrepreneurs about their business operations. The answer options are: freedom of movement of goods and services, workforce, profitability, locations in the UK, competitive position, other, and little to no impact, respectively. The sixth column include all the expectations of entrepreneurs about their trade and investments. The answer options are: more trade with the UK, less trade with the UK, more trade with other countries, less trade with other countries, more investments, less investments and not or different, respectively.