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Author(s):
Dibiasi, Andreas; Iselin, David

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Andreas Dibiasi and David Iselin

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KOF

KOF

ETH Zurich
KOF Swiss Economic Institute
LEE G 116
Leonhardstrasse 21
8092 Zurich, Switzerland

Phone +41 44 632 42 39
Fax +41 44 632 12 18
www.kof.ethz.ch
kof@kof.ethz.ch

Measuring Knightian Uncertainty

Andreas Dibiasi
Eurac Research
Drususallee 1
39100 Bozen, Italy
andreas.dibiasi@eurac.edu

David Iselin
ETH Zurich
KOF Swiss Economic Institute
Leonhardstrasse 21
8092 Zurich, Switzerland
iselin@kof.ethz.ch

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Abstract

Uncertainty shapes the trajectory of business cycles and remains a central research topic in Macroeconomics. When studying the impact of uncertainty on the economy, economists use different uncertainty measures. While all indicators approximate uncertainty along some certain dimension, none of the indicators directly captures Knightian Uncertainty. According to Knight, uncertainty represents a situation in which it is no longer possible to form expectations about the future. In this study, we propose a method to directly measure Knightian Uncertainty. Our approach relies on firm-level data and measures the share of firms that are not able to formalize expectations about their future demand. We construct the Knightian Uncertainty indicator for Switzerland and show that the indicator is able to identify times of high uncertainty and detects uncertainty shocks well. We further evaluate the indicator by comparing it to established uncertainty measures. We find that most other indicators are weakly, but statistically significantly correlated with Knightian Uncertainty.

Keywords: Knight; uncertainty; measurement; business survey;
JEL code: D80, D84

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1 Introduction

Uncertainty is an ambiguous concept with no unique definition. Economists refer to uncertainty as the ignorance of future events or define it as the second moment of the distribution of future events. It was introduced into economics in the early 1920s by Knight (1921), and has since then be established as a essential concept in economic theory. In his work on *Risk, Uncertainty and Profit* (1921), Knight made the fundamental distinction between risk and uncertainty. While risk refers to a state where one is able to allocate probabilities over future events, uncertainty describes a state in which agents cannot assign probabilities to future events anymore. Knight's concept of uncertainty is often rephrased as a situation in which it is no longer possible to form expectations about the future. Although the concept of uncertainty was introduced almost a hundred years ago into the economic discussion, relatively little effort has been made to quantify the effects of uncertainty on economic activities until recently. Stronger interest in uncertainty and its consequences has risen since the 80's and downright exploded in the aftermath of the Great Recession. In order to empirically quantify the effects of uncertainty on the economy, economists rely on a wide range of uncertainty indicators. These indicators include proxies such as the volatility of financial markets, the disagreement of forecasters or the news about uncertainty. Most importantly, most of these indicators target the variance of forecasters' predictive distributions. Hence, they assume an existing probability distribution over future events. Thus, most indicators approximate the Knightian's concept of risk rather than Knightian Uncertainty.

In this paper, we intend to go back to the early definition of uncertainty according to Knight and provide a new quantification method of his concept. We use survey data among private companies on their expected and realized demand to identify the share of firms that are not able to formalize expectations about their future. This will be the — to our knowledge — first indicator that directly measures Knightian Uncertainty. It turns out that the Knightian Uncertainty indicator is able to trace times of elevated uncertainty and able to reasonably identify uncertainty shocks. Second, we will compare our new Knightian Uncertainty indicator to established indicators. We find that most other indicators are weakly, but statistically significantly correlated with Knightian Uncertainty. Furthermore, we find that various uncertainty indicators are, despite general believe, far from identical. In fact, it appears that every indicator captures a slightly different component of uncertainty. Using correlation and principal component analysis, we show that most of the indicator appears to capture different dimensions of uncertainty that are weakly correlated with Knightian Uncertainty. We examine the effect of an Knightian Uncertainty shock to investment in Switzerland and find that a one standard deviation shock leads to a negative and statistically significant reduction of investment. Finally, will be the first to construct and provide the most important uncertainty measures for Switzerland.

The structure of this paper is the following. Section 2 revisits the most common approaches to measure economic uncertainty. Section 3 provides a definition of Knightian Uncertainty. In Section 4, we construct the Knightian Uncertainty indicator for Switzerland. In Section 5, we compare the common uncertainty indicators with the new Knigthian indicator and examine their impact on the investment. Section 6 concludes.

2 Measuring Uncertainty

There are various approaches to measure uncertainty. In this chapter, we bundle them together in five different categories. The first category relies on various disagreement measures, the second on the variance in forecast errors, the third on the variance of density of forecasts, the fourth on news-based indicators, and the last on stock market volatilities.

2.1 Disagreement, Disconformity and Discord

One of the most established approaches to measure uncertainty builds upon the use of disagreement in expectations.[1] Economists believe that strong disagreement about what is going to happen tomorrow reflects a high uncertainty today.

From a theoretical perspective, using disagreement to measure uncertainty implies that the variance of means of agents' predictive distributions approximates the average variance of agents' predictive distributions. Statistically, this assumption can be justified within a Bayesian framework. From a Bayesian point of view, the means of forecasters' predictive distributions and the standard deviations of these point forecasts are assumed to provide an accurate measure of the average standard deviation of forecasters' predictive distributions (Ferderer, 1993). Nevertheless, using disagreement to proxy uncertainty relies on the crucial assumption that agents draw their idiosyncratic future states from identical distributions. Violating the assumption of the identical shock distributions risks that disagreement changes not only because of alternations in uncertainty, but also because of compositional changes in the cross-section, i.e. diverging sectoral business cycles. Furthermore, using disagreement to approximate uncertainty may also be justified from a economic theoretical point of view. Ferderer (1993) argues that from a Post Keynesian perspective, forecaster disagreement can be seen as a proxy for the level of Knightian Uncertainty experienced by agents. The intuition being that disagreement is not based on knowledge of objective probability distributions. Thus, it should react to fluctuations in the underlying economic system.

From an empirically perspective, disagreement is estimated by computing the dispersion of expectations, e.g. the standard deviation of point forecasts. Most studies rely thereby on point estimates of professional forecasters as a source of expectations. Worldwide, several public institutions and private firms exist that survey and collect macroeconomic forecasts on a regular basis. Studies using the dispersion of professional forecasts include, among others, Mullineaux (1980), Levi and Makin (1980), Makin et al. (1982), Zarnowitz and Lambros (1987), Ferderer (1993), Bomberger (1996), Giordani and Söderlind (2003) and Boero et al. (2008). Besides dispersion of professional forecasts of macroeconomic variables, Bond et al. (2005) use monthly analysts' earnings forecasts of firms in the UK provided by the Institutional Brokers' Estimate System (I/B/E/S) to show that higher disagreement about future earnings is associated with lower investment activity. Recently, studies applied the approach to proxy uncertainty with the disagreement of forward-looking survey data to business surveys. Using German survey data, Bachmann et al. (2013) use the dispersion of the responses to a forward-looking survey question to approximate uncertainty. Binding and Dibiasi (2017) use the disagreement of Swiss firms about future demand to demonstrate that the abandonment of the Swiss currency peg against the EURO led to an increase in uncertainty.

While earlier empirical studies suggest that there exists a positive correlation between the cross-forecaster standard deviation of point predictions and the average level of uncertainty (Zarnowitz and Lambros, 1987), more recent studies raise concerns about the feasibility to approximate uncertainty with disagreement.[2] Using data from the Bank of England's Survey of External Forecasters,

[1] In the literature we find different terminology to describe disagreement. While Theil (1955) used the term disconformity to refer to disagreement. Ferderer (1993) uses discord to describe disagreement. In this study, we will use disagreement, disconformity and discord interchangeably.

[2] To be fair, Zarnowitz and Lambros (1987) already discuss the limitations to use dispersion as a proxy for uncertainty. However, the authors nevertheless believe in the ability of disagreement to approximate uncertainty.

Boero et al. (2008) investigate the relationship between the point and density forecasts and find only a weak correlation between disagreement and uncertainty. Rich and Tracy (2010) confirm this result using inflation expectations of the Survey of Professional Forecasters by the National Bureau of Economic Research (NBER) and the American Statistical Association (ASA). The authors find only a weak correlation relationship between their entropy-based measure of uncertainty and disagreement of inflation expectations. They conclude that the correlation between disagreement and the entropy-based measure of uncertainty is too weak to support the use of disagreement as a proxy for uncertainty. On the other hand, the European Commission (2013) finds that the disagreement of forward-looking survey questions between the Euro-area manufacturing managers correlates highly with the Policy Uncertainty Indicator based on News articles (see Section 2.4 below).

2.2 Variance of Density Forecasts

Instead of relying on the dispersion of point forecast some studies directly use the variance of forecasters' predictive distributions, assuming that a larger variance implies a larger idiosyncratic uncertainty. Various surveys started to levy the complete distribution of forecasters rather than to collect only point estimates of forecasts. For instance, the Survey of Professional Forecasters does not only survey point forecasts but also levies density forecasts for aggregate output growth in the form of histograms. The questionnaire asks participants to assign probabilities to predefined intervals in which output growth might fall. Hence, one can observe the complete density forecast of a participant. Using the Survey of Professional Forecasters, Engelberg et al. (2009) compare point predictions of participants with their subjective probability distributions. The authors find that most forecasters give point predictions for GDP growth that are consistent with the means, medians, and modes of their density forecast distributions.

Guiso and Parigi (1999) use a similar approach to instrument uncertainty using survey data. The authors use an Italian firm data set in which firms self-report the distribution of their expectation of future demand. The variance of a firm's distribution is interpreted as its uncertainty regarding future demand.

2.3 Volatility of Forecast Errors

Besides relying on disagreement of forward-looking survey questions, economists have exploited the variance of forecast errors to approximate uncertainty. A larger dispersion of firms' forecast errors is associated with a larger variance of firms' demand or technology shocks. This approach is closely related to the recent theoretical literature that regards uncertainty as the variance of firms' shock distributions, i.e. an increase in uncertainty is associated with a larger variance of firms' shock distributions. Furthermore, concentrating on the dispersion of forecast errors has the pleasant side-effect that it obviates the need for the assumption of identical shock distributions.

Bachmann et al. (2013) rely on the dispersion of firm forecast errors of German business survey data. The authors compute, on a firm level, differences between realized changes in production in period t and expected changes in production as stated in period t-1. The variance of these forecast errors is used as a measure of uncertainty. Furthermore, Bachmann et al. (2013) find a strong positive correlation (0.7) between the variance in forecast errors and the ex-ante forecast disagreement.

The indicator proposed by Jurado et al. (2015) represents an additional indicator that exploits the variation in forecast errors to proxy uncertainty. Jurado et al. (2015) define uncertainty as the conditional volatility of the purely unforecastable component of the future value. The authors use a large US dataset (132 macro series and 147 financial time series) to compute forecasts for all series from which they construct series of forecast errors. They estimate stochastic volatilities from the resulting forecast errors series and use the mean over all volatility series as their uncertainty indicator. Jurado et al. (2015) claim that their approach provides a superior econometric estimate of uncertainty because their indicator is independent from the structure of specific theoretical models and does not depend, as in the case of Bachmann et al. (2013), on a single observable economic indicator.

2.4 News Sentiment

A rather novel way to quantify uncertainty represents measuring the perception of uncertainty in news. Especially Baker et al. (2016) contributed to the development and understanding of this indicator. Baker et al. (2016) count newspaper articles containing the word "uncertainty" in combination with other relevant terms. The recent digitization of older newspaper editions allows to construct high-frequency indicators over a long time horizon in an inexpensive way. Baker et al. (2016) construct the indicator for the US and show that newspaper articles turn out to be a reliable source to identify uncertainty shocks. In an similar fashion, Chadefaux (2014) shows that news reports about conflicts dramatically increase prior to the onset of a conflict. He scans historical newspaper articles by a set of keywords and countries and then bundles them to predict conflict outbreaks with relatively high accuracy. Furthermore, Alexopoulos and Cohen (2009) show that uncertainty shocks, based on keyword searches in the New York Times, are an important source of business cycle fluctuations.

Other researchers focus on Google to obtain uncertainty and exposure measures. In an early version of their paper, Baker, Bloom and Davis use Google News to construct their Economic Policy Uncertainty Indicator (Baker et al., 2012). The authors show that the Google based indicator correlates reasonably well with the VIX, a financial-market based uncertainty indicator. Bachmann et al. (2013) use a Google News based sub-indices of Baker et al. (2012) on economic uncertainty for Germany in their study to show how it correlates with other uncertainty measures. Abberger et al. (2014) use Google Trends to compare the public awareness of a popular vote in Switzerland to other important events. Iselin and Siliverstovs (2013) show that data from Google Trends appears to be a good descriptive source, however, it does not perform better then traditional newspapers in terms of improving forecast accuracy. One reason for this could be that traditional newspapers are still a more reliable source and produce less noise, as they can be held responsible for what they publish (Hisano et al., 2013).

2.5 Financial Markets

Finally, various studies derive uncertainty indicators from financial market data. Leahy and Whited (1996) propose to use the standard deviation of daily stock returns to approximate firm-level uncertainty. The authors argue that using a measure based on stock returns should incorporate uncertainty about a large number of future factors, such as possible concerns about future policy, various cost factors and potential technological innovations. Bond et al. (2005) follow their approach and use within-year volatility of firms' daily stock market returns to approximate firm-level uncertainty. They show that higher volatility of share prices is linked to lower short-term investment behaviour. Bloom et al. (2007) use the measure proposed by Leahy and Whited (1996) to show that an increase in uncertainty decreases the reactivity of firms in the presence of irreversbility. The authors further show that stock return volatility is positively correlated with the disagreement of firm-level stock return forecasts.

Besides using the standard deviation of stock returns researcher started to use implied volatility of option prices to proxy uncertainty. The main conceptional difference between the standard deviation of stock returns and implied volatility is that the former is based on already realized values, while the latter represents the expected volatility of future stock prices based on todays' option prices.[3] The most popular index of implied volatility is the VIX. The VIX measures the implied volatility of the S&P 500 index options. Bloom (2009) uses the VXO, a volatility index based on trading of S&P 100 options, to investigate the effects of uncertainty on the real economy.

Using stock market volatility to approximate uncertainty has been subject to severe criticism on various occasions. Most recently, Jurado et al. (2015) argued that innovations in stock market volatility are not necessarily a result of changes in uncertainty about fundamentals, but can also reflect movements in risk aversion or changes in leverage. Similar concerns have been brought forwards by various studies.[4] The general concern with stock market volatility as measure of uncertainty is that stock market returns are subject to "excess volatility". That is, share prices can reflect more than just movements in firms' fundamentals. Hence, they do not necessarily reflect firm-level uncertainty.[5] Another issue with share prices is endogeneity. For example, rather than mirroring uncertainty, lower stock market volatility may in fact be the result of greater optimism about the firm's future prospects, which itself may influence the outcome of interest (i.e. investment) but is not observed by the researcher.

3 Measuring Knightian Uncertainty

Knight (1921) is believed to be the creator of the modern concept of uncertainty (Bloom, 2014).[6] The Chicago economist made a clear distinction between risk and uncertainty. In contrast to risk, uncertainty describes a situation in which economic agents can no longer formulate a probability distribution over a set of events. Risk on the other side characterizes a situation which economic agents know the probabilities over a set of events. Uncertainty, however, describes events with unknown or objectively immeasurable probabilities. Hence, economic agents can no longer formalize expectations under Knightian Uncertainty. The reason for Knightian Uncertainty can be described as twofold, on the one side it can arise from a shrinking information set to a point where information are no longer available. On the other hand it can arise from an increase in the space of possible events to a dimension that goes beyond the scope of most people.

The fact that under uncertainty according to Knight a mathematical representation of uncertainty is no longer possible makes it difficult to grasp and quantify Knightian Uncertainty. Knigthian Uncertainty is itself a broad concept and can change because of various factors. That is, Knightian Uncertainty might comprise uncertainty over things on the macro level such as GDP growth, on the micro level such as firm-growth, and over non-economic issues such as war or climate change (Bloom, 2014). This might explain why there are only few attempts to measure Knightian Uncertainty directly.[7]

[3] Chang and Feunou (2013) provide a detailed discussion on the difference between implied and realized volatility.

[4] Bond et al. (2005),Bloom et al. (2007), Bloom (2009), Bachmann et al. (2013) all reference the potential caveats of using financial market data to approximate uncertainty.

[5] See Shiller (1981) for a discussion on "excess volatility".

[6] Sometimes John Maynard Keynes (Keynes, 1921) is mentioned alongside Knight as creator of the concept of uncertainty, but uncertainty gains more weight later in his General Theory (Keynes, 1936) where he discusses the problem of investment behavior under uncertainty.

[7] Baumgaertner and Engler (2016) and Neufeld (2015) suggest that Knightian Uncertainty in mathematical finance

In our approach, we propose to estimate the fraction of firms that are not capable of forming expectations over the near future. Especially, we will estimate the fraction of firms in an economy that is able to make statements about the development of business conditions in the recent past, but is not able to forecast the evolution of business conditions in the near future. We will do so by using firm level data. That is, we will use firm data from business tendency surveys. Business tendency surveys are regular business surveys with the purpose to levy qualitative information on the current economic situation. Its data are used to monitor the current business situation of an economy and produce short-term forecasts of it economic developments (OECD, 2003). Business tendency surveys follow international standards set by international organisations, including the UN, OECD and the European Union,[8] and various countries implemented the surveys and conduct them on a monthly or quarterly basis. These survey typically cover several dimensions. That is, business tendency surveys contain questions on various economic key figures, such as demand, production and prices. Generally, firms are invited to report how these economic figures have evolved over the last three months and to state how they will evolve in the next three month. We will exploit this particular survey design to identify those firms that do not report expectations but report backward-looking developments.[9]

Formally, we define Knightian Uncertainty the following way. Let y be function of x that returns value one in case a firm is able to provide information on x in a given period t and zero otherwise.

$$y(x_{i,t}) = \begin{cases} 1 & \text{if firm i is able to provide information on variable } x \text{ in period t} \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

Then Knightian Uncertainty in period t is defined as follow

$$Knight_t = \frac{\sum_i^N \mathbb{1}(y(E(x^{t+1})_{i,t}) = 0) | y(x_{i,t}^{t-1}) = 1)}{\sum_i^N \mathbb{1}(y(x_{i,t}^{t-1}) = 1)} \tag{2}$$

where x refers to demand.

4 Knightian Uncertainty in the Context of Swiss Data

The recurring nature of business tendency surveys allows us to construct the Knightian Uncertainty measure over a long time horizon on a monthly basis. We use KOF Business Tendency Survey data to construct the Knightian Uncertainty indicator for Switzerland. KOF Swiss Economic Institute conducts monthly and quarterly business tendency surveys covering a large part of the Swiss private sector. Currently, the institute conducts firm surveys in eight different sectors. Table 1 provides an overview of the surveys conducted by KOF and summarizes them with respect to their industry coverage and frequency. Five surveys are currently conducted on a monthly basis, while three surveys are conducted on a quarterly basis. Three surveys changed from quarterly to monthly frequency

can be modelled by considering a set of different probability measures rather than fixing a unique law for a price process, are exceptions.

[8] Within the European Union (EU) and in the applicant countries the Directorate General for Economic and Financial Affairs provides a user guide on how to conduct regular harmonised surveys for different sectors (European Commission, 2017).

[9] The way we measure Knightian Uncertainty might potentially underestimate the true Knightian Uncertainty. De Bruin et al. (2000) show that individuals tend towards the middle category, when facing events with lower perceived control. One possible explanation of this observed phenomenon is that individuals seek to increase perceived control over their environment. Unfortunately, De Bruin et al. (2000) do not elucidate on the effects of item non-response.

in recent years. The institute provides access to the anonymized firm-level data of these surveys that we use to construct our indicator. Besides the answers to the questions of the questionnaire, the data also provides information on item non-response, i.e. the data allows to identify if a firm did not answer one or several questions during a specific survey wave. This feature is essential for constructing the Knightian Uncertainty indicator.

Description	Industry coverage (NACE Code)	Microdata since	Frequency	Quarterly until
Manufacturing Survey	10-33	Sep 1983	monthly	
Construction Survey	41-43	Oct 1994	monthly	Apr 2011
Wholesale Trade Survey	46	Jul 2007	quarterly	
Retail Trade Survey	47	May 2005	monthly	
Hotel & Catering Survey	55-56	Jan 1989	quarterly	
Financial & Insurance Service Survey	64-66	Jul 2001	monthly	Jul 2010
Project Engineering Survey	711	Apr 1996	monthly	Apr 2011
Service Sector & Catering Survey	49-53,58-63,68-70,712, 72-75,77-82,86-88,90-96	Jul 2006	quarterly	

Table 1: Sectors covered by uncertainty indicators in this study.

Notes: Overview of all sectors covered with our uncertainty indicators in this study. We provide a more extensive overview in the Appendix. Column (2) states the NACE 2-digit sectors that are covered by a survey. Column (3) summarizes the starting dates of firm-level data that are currently available and column (4) provides the frequency at which a survey is conducted. Column (5) provides information on changes in frequency.

We use firm-level data on expected demand of all surveys listed in Table 1 to construct the Knightian Uncertainty indicator for Switzerland. The choice of relying on expected demand is twofold. First, we believe that expected demand is the relevant variable for this indicator. One could construct the indicator based on expectations of other variables such as production, employment or prices. However, assuming that most firms are not setting market prices, expectations about production, employment and prices should be a function of expected demand. This makes expected demand appear the natural choice for the indicator. Second, all business tendency surveys entail a question on expected demand. Furthermore, all surveys also include at least one question that provides information on how firm specific demand evolved in the recent past. Questions that levy the development of past demand allow us to identify those firms that are not able to formalize expectations about future demand, but are providing information on past demand. The share of firms that do not formalize expectations but report recent development forms the core of the Knightian indicator. Below we present two exemplary questions on expected and realized demand as included in KOF Business Tendency Surveys.[10]

Over the next 3 months, the demand for our services will

- ☐ increase
- ☐ remained unchanged
- ☐ decrease

Over the last 3 months, the demand for our services has

- ☐ increased
- ☐ remained unchanged

[10]These two question can be found in the KOF Construction Survey. Although between surveys questions on expected and realized demand may change slightly with respect to their wording, they are the same with respect to their content. All questionnaires are publicly available under https://www.kof.ethz.ch/en/surveys/business-tendency-surveys.html.

□ decreased

While it is straight forward to explain the intuition behind the Knightian Uncertainty indicator, we are confronted with various decisions that need further explanation. The following part of this section will provide a detailed summary on the exact calculation procedure.[11]

In a first step, we construct the Knightian Uncertainty indicator for every survey according to Equation 2. This leaves us with eight sectoral indicators of different length and frequency. Varying time-length and frequency complicates the aggregation to a Swiss indicator. In order to render aggregation possible we implement the following steps: In a first step, we bring all indicators to the highest frequency, i.e. we transform all quarterly data to monthly series.[12] There exists various ways to interpolate the missing months of the quarterly series. Beside keeping the quarterly values constant for each month or linearly interpolating them, one can use more sophisticated methods that rely on other indicators to estimate the movements of the missing values. In our preferred specification, we use the temporal disaggregation procedure proposed by Chow and Lin (1971). This methods is suited for stationary or co-integrated series and hence appropriate for our case. The method relies on other indicators to approximate the high frequency movements in the low frequency series. Specifically, we use the chow-lin-maxlog variation based on generalized least squares (GLS) methods.[13] We use available monthly Knightian Uncertainty indicators to estimate the missing monthly movements in the quarterly series. For each quarterly series we use the series with the highest correlation on the quarterly basis to approximate monthly changes. Column (2) of Table 2 summarizes which monthly indicator was used to disaggregate a quarterly series and Column (3) states the time period of an indicator that was temporally disaggregated.

(1) Description	(2) Temporal Disagg. using	(3) Temporal Disagg. from	(4) Retrapolation using	(5) Value added Mio. CHF	(6) (2015) Share
Manufacturing Survey				112228	20.44%
Construction	Manufacturing	Oct 1994 to Apr 2011	Manufacturing	34405	6.27%
Wholesale Trade	Retail Trade	Jul 2007 to now	Retail Trade	60919	11.10%
Retail Trade			Manufacturing	25015	4.56%
Hotel & Catering	Manufacturing	Jan 1989 to now	Manufacturing	10850	1.98%
Financial & Insurance Service	Manufacturing	Jul 2001 to Jul 2010	Manufacturing	59907	10.91%
Project Engineering	Construction	Apr 1996 to Apr 2011	Manufacturing	11627	2.12%
Service Sector	Hotel & Catering	Jul 2006 to now	Hotel & Catering	234057	42.63%

Table 2: Temporal Disaggregation and Retrapolation.

In a second step, we need to bring all sectoral indicators to the same length. In order to solve this problem we retrapolate each series based on a method proposed by Wei (1994). In case an indicator was temporally disaggregated, we retrapolate each series based on the indicators that we used to temporally disaggregate the quarterly series. Otherwise, we use the indicator with the highest correlation to retrapolate a sectoral indicator. Column (4) of Table 2 indicates which indicator was used to retrapolate a series. All series are retrapolated until September 1983, i.e. the start of the earliest indicator.[14]

[11]While in the paper we provide a thorough description of the construction of the indicator, we are unable to provide a complete picture of all practical choices. We invite every one to look at our R-Script for the exact technical implementation of the indicator. All scripts will be provided on our website.

[12]In Appendix B.1, we investigate the sensitivity of this approach. Particularly, we bring all indicators to the lowest frequency, i.e. we transform all monthly data to quarterly series, and compute a quarterly Knightian Uncertainty indicator. Our analysis shows that both indicators display the same trajectory of Knightian Uncertainty.

[13]We use chow-lin-maxlog implementation by the R package developed and maintained by Sax and Steiner (2013).

[14]The aggregate Knightian Uncertainty indicator does change substantially if we transform quarterly to monthly

Finally, once all series are of the same length and frequency we aggregate the sectoral indicators to one Swiss Indicator. When aggregating we weigh each sectoral indicator according to its relative value added. That is, we construct a valued added weighted average of the sectoral indicators to obtain an aggregate indicator. Column (5) and (6) of Table 2 summarize the value added figures for 2015 for all sectoral indicators. The indicator based on the service sector has the largest relative weight with almost 43%, followed by the manufacturing sector (20%). The indicator resulting from the hotel & catering (2%) and the project engineering (2%) are attributed the lowest weights. Due to data availability, we able to adjust the value added weights only once a year. E.g. the value added figure for 2000 is kept constant throughout 2000, the value added figure from 2001 is kept constant throughout 2001, etc.[15]

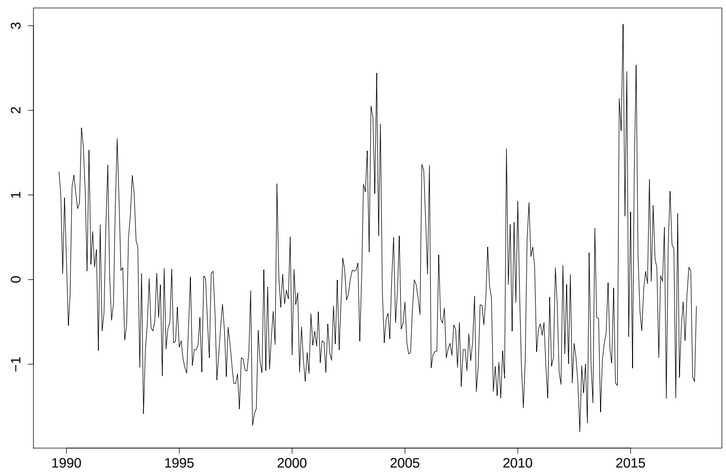

Figure 1: Knightian Uncertainty Indicator (since 1989)

After aggregating, we demean and normalize the indicator to unit-variance. Figure 1 presents the Knightian Uncertainty indicator for Switzerland since 1989.[16] The indicator is highly volatile, but produces noticeable higher values during various periods. The indicator presents a relatively high uncertainty at the beginning of the 1990s possibly reflecting national turmoil, including the burst of Swiss construction bubble and the Swiss banking crisis, as well as international events such as the Invasion of Kuwait and the subsequent Gulf War. Thereafter Knightian Uncertainty continuously decreases until 1997/98, where it spikes again during the Russian Crisis (Aug 1998) and the Kosovo War (Mar 1998 to Jun 1999). The latter event triggered a large wave of immigration towards Switzerland. At the early 2000's the indicator returns to low levels only to spike again in the aftermath of the dot-com bubble and the subsequent recession (2002Q4 to 2003Q2). The Iraq War (Mar 2003) and economic turbulences in Germany might be the reason for the prolonged high uncertainty observed during 2002 to 2004. The indicator decreases once again in the subsequent years. Interestingly, the indicator only increases slightly during the Great Recession in 2008 (2009

series by keeping the quarterly values constant for each month and retrapolate using the long-term mean of each series.

[15]Results to not significantly change if keep the weights constant for five years. E.g. the value added figure for 2000 is kept constant until 2004, the value added figure from 2005 is kept constant until 2009. Results do also not change if we keep the values of 2015 constant for all years. However, attributing an equal weight to every indicator changes the indicator substantially.

[16]We compute the aggregated Knightian Uncertainty indicator since 1989 because before 1989 the indicator would reflect essentially the Knightian indicator of the manufacturing sector. See Table 1.

in Switzerland). Possible reflecting the fact that Switzerland managed the crisis reasonably well in an international comparison. The Knightian Uncertainty indicator reaches it all-time high during the years 2014 and 2015. These years were marked by an overvalued Swiss Franc badgering the Swiss export sector, the European Immigration Crisis and various votes in Switzerland that among others threatened to overthrow the bilateral relationship between Switzerland and the European Union. We conclude that the Knightian Uncertainty indicator does surprisingly well when it comes to identify periods of high uncertainty. A caveat represents the high volatility making it difficult to attribute a sudden increase to an increase in uncertainty or a natural fluctuation. The following section will further examine the Knightian Uncertainty indicator and compare it to alternative uncertainty indicators.

5 Comparison of Knight with Established Uncertainty Measures

In this chapter, we compare the Knightian Uncertainty indicator to alternative measures of uncertainty. In order to facility this comparison we construct common other uncertainty measures for Switzerland. Due to the lack of space and to increase the readability of the paper we abstain from a detailed description of all indicators and will compare the Knightian Uncertainty indicator to a selection of five uncertainty indicators. We include a detailed and complete discussion of all indicators in the Appendix. We start with summarizing each of the five indicators that we use in our analysis.[17] We will then continue with the comparison by graphically and statistically comparing the Knightian Uncertainty indicator to alternative measures.

Dispersion of Professional Forecasts

Besides relying on the dispersion of firms' expectations, one can also use the dispersion of point forecasts of professional forecasters. The intuition behind this indicator is the same as the intuition behind Theil's Disconformity Index, i.e. higher uncertainty about the future is associated with higher dispersion of its forecasts. However, using the dispersion of professional forecasts to approximate uncertainty relies, as in the case of all dispersion measures, on the assumption that variance of the mean forecasts correlates positively with the mean of the variance of the forecasts.

As mentioned earlier, there exists several public institutions and private firms that survey and collect macroeconomic forecasts on a regular basis. In Switzerland, KOF Swiss Economic Institute conducts the KOF Consensus Forecast. The KOF Consensus Forecast represents a quarterly survey that collects forecasts for the Swiss economy from professional forecasters and has been conducted since the autumn of 2000. The participants of the survey provide their forecasts for several economic variables over different horizons.[18] In our case, we use the question on future real GDP growth. Figure 2 plots the standard deviation[19] of forecasters' estimates of real GDP growth for the next year. The indicator shows that the variation of forecasts increases substantially during recessions. Switzerland faced a recession during the fourth quarter 2002 until the second quarter 2003 and from the first quarter 2009 until the last quarter of 2009.

[17]We include an extensive discussion of the calculation of each indicator in the Appendix. Furthermore, all data will be provided on our website kof.ethz.ch/uncertainty.

[18]Table 8 in the Appendix provides an overview of the different macroeconomic and financial variables that are included in the survey.

[19]The present indicator uses the standard deviation as a measure of dispersion. However, one can chose different dispersion measures. In the Appendix we compute the same indicator using the interquartile range.

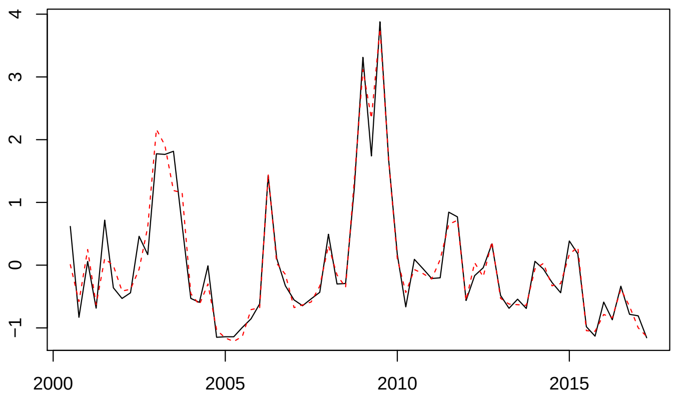

Figure 2: Dispersion of Professional Forecasts.

Notes: This figure depicts the standard deviation of point forecasts of real GDP growth of professional forecasts in Switzerland. The solid black line represents original values, the red dotted line plots the seasonally adjusted indicator. Both indicators are demeaned and normalized to unit variance.

Theil Disconformity Index

The literature suggests disagreement in expectation of economic agents as an additional approach to approximate uncertainty. The intuition behind this approach is that a higher dispersion of expectations represents a more uncertain economic environment.

One way to obtain the expectation of economic agents is to use business tendency survey data. We will once again rely on KOF Business Tendency data. However, in the case of this indicator we rely on aggregated series of expected demand rather than firm-level data. There exist different ways to compute disagreement in qualitative survey data.[20] Following different studies in the literature we use the variation in demand expectations of firms to approximate uncertainty. We calculate Theil's disconformity index for qualitative business surveys. The index dates back to Cramer and Theil (1954) and represents the variance of qualitative surveys. Figure 3 depicts the Theil Disconformity Index of expected demand since 1985.

[20] Mokinski et al. (2015) provide a recent overview of common approaches to measure disagreement in qualitative survey data.

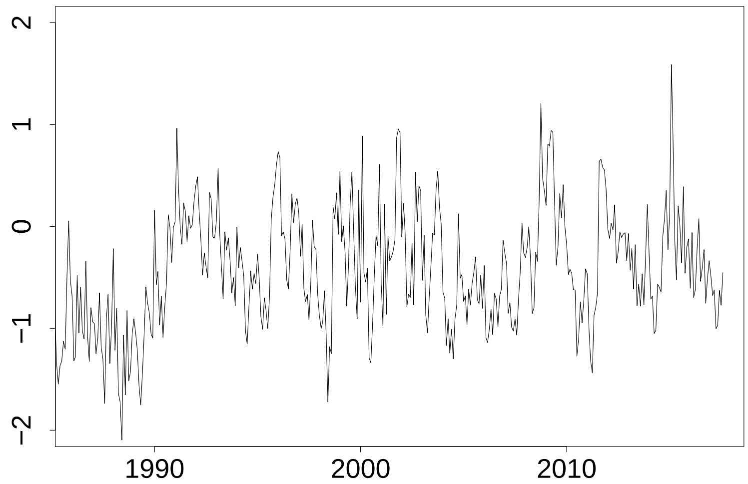

Figure 3: Theil Disconformity Index of Expected Demand (since 1985).

Notes: The indicator is demeaned and normalized to unit variance.

Dispersion of Firms' Forecast Errors

The dispersion of forecast errors of economic relevant variables represents an alternative approach to approximate uncertainty. This approach follows the conjecture that times of high uncertainty are accompanied with a high variation in forecast errors. Bachmann et al. (2013) computed the monthly dispersion of production forecast errors of German manufacturing firms to examine the role of uncertainty on the real economy. In the spirit of Bachmann et al. (2013), we use Swiss business tendency survey data to construct the dispersion of firm-level forecast error. The underlying dataset is identical to the data used to construct the Knightian Uncertainty indicator. In contrast to Bachmann et al. (2013), who build their measure based on expected and realized production, we focus on expected and realized demand. The reason to focus on demand rather than production lies in the relevance and the high sectoral coverage of the question.[21] KOF Business Tendency Surveys invite firms to report a qualitative estimate of how their demand will possibly evolve over the next three months. In additions, firms also report how their demand developed over the last three months. This allows us to verify a firm's demand forecast and construct a forecast error for each single firm. Following Bachmann et al. (2013), we calculate the monthly dispersion of firm forecast errors.[22] Figure 4 depicts the aggregate indicator for Switzerland.

[21]We prefer expected demand to expected production for two reasons. First, expected production is a function of expected demand and hence the relevant variable to consider. Second, the question on demand is not only asked to manufacturing firms, but similarly to firms of other industries.

[22]We include a detailed description of the indicator in Appendix (see A.4.1).

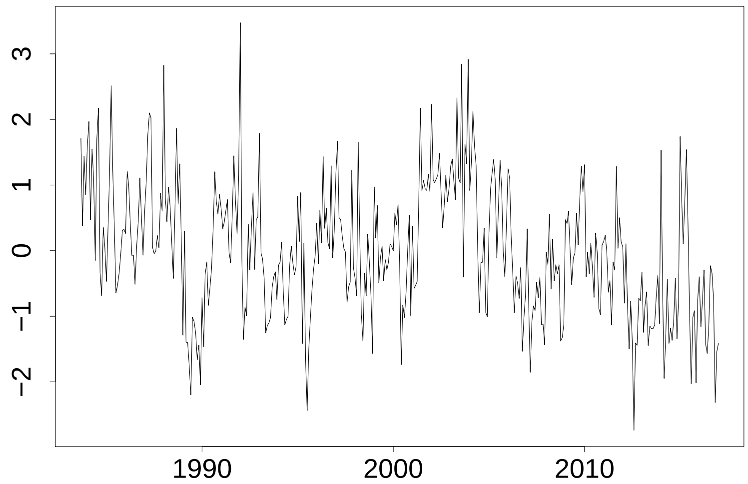

Figure 4: Firm Forecast Error Dispersion. The indicator is demeaned and normalized to unit variance.

Notes: The indicator is demeaned and normalized to unit variance.

Economic Policy Uncertainty

The first indicator we present is the Economic Policy Uncertainty (EPU) based on the method proposed by Baker et al. (2015). As part of the ongoing digitalization newspaper outlets continue to digitize historical newspaper editions. Baker et al. (2015) propose to use the digital newspaper archives to measure uncertainty. The authors develop an approach that extracts uncertainty tendency from newspaper articles. They claim that the method is able to capture uncertainty sentiment in newspapers that reflects the true economic policy uncertainty in an economy. The Economic Policy Uncertainty Index for the US has been shown to capture possible uncertainty shocks reasonably well and has by now been constructed for 19 other countries.[23]

We replicate the method proposed by Baker et al. (2015) for Switzerland. We base the EPU indicator for Switzerland on two newspapers, “Le Temps” and “Neue Zürcher Zeitung” and calculate it from January 1st 1900. Technically, the index counts articles that include a constellation of keywords. In order for an article to be included in the count it has to be relevant along three dimensions. First, the article has to be economically relevant. That is, the article needs to concern topics on the economy. Second, the article has to report on uncertainty and finally, the article must address policy. The count includes an article only if it is relevant along these three criteria.[24] In order to calculate the EPU for Switzerland, we retrieve the daily count of newspaper articles reflecting uncertainty from the newspaper archives. Furthermore, we divide the count articles reflecting uncertainty by the total amount of published articles in order to correct for the inflation of daily newspaper articles. Figure 5 depicts the monthly EPU indicator for Switzerland since WW2.

[23] The original Economic Policy Uncertainty Index for different countries is published monthly on policyuncertainty.com. The index is available for Australia, Brazil, Canada, Chile, China, France, Germany, India, Ireland, Italy, Japan, Korea, Netherlands, Russia, Singapore, Spain, Sweden, UK and the US. Furthermore, policyuncertainty.com publishes aggregate indicators for Europe and the world.

[24] Appendix A.1 provides a detailed discussion of the index. Besides an explanation of the technical implementation, we also present the keywords that we use to identify an article reporting on economic policy uncertainty.

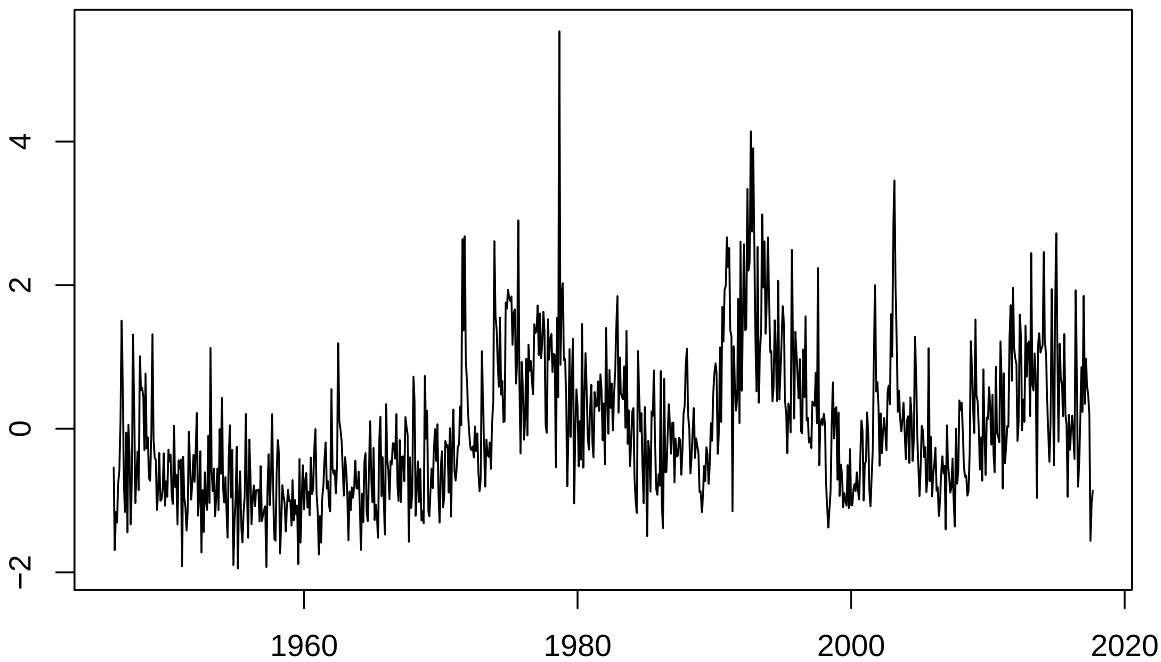

Figure 5: Economic Policy Uncertainty Indicator for Switzerland.

Notes: The figure depicts monthly value of the EPU since January 1946. The indicator is demeaned and normalized to unit variance.

VSMI

Besides newspaper articles, data on firm-level expectations and estimates of professional forecasters, financial markets provide an additional source to approximate uncertainty. Several studies have relied on implied volatility of financial indices as an additional way to proxy uncertainty. In the literature, VIX represents probably the most prominent financial volatility index. The index is constructed using the implied volatilities of numerous S&P 500 index options. For Switzerland, SIX Swiss Exchange calculates the equivalent to the VIX, i.e. the implied volatility (VSMI®) for the Swiss Market Index (SMI®). The main index is determined on the basis of a fixed residual term of 30 days and is available since 1999. However, subindices are calculated for various durations. Figure 6 depicts the VSMI. The indicator peaks during the recessions 2003 and 2009. Furthermore, the indicator also captures the end of the Russian crisis in 1999 and the strong appreciation of the Swiss Franc in 2011. Interestingly, the VSMI does not react strongly to the removal of the currency peg in January 2015.

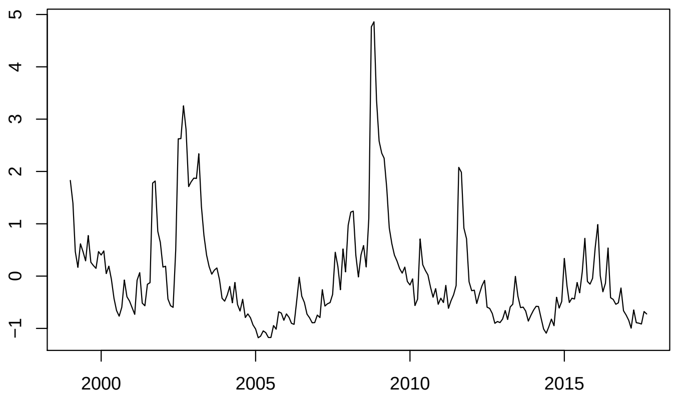

Figure 6: VSMI® - Volatility Index on the SMI®.

Notes: The figure depicts monthly averages of the implied volatility for the Swiss Market Index. We use the VSMI for a fixed duration of 30 days. The indicator is demeaned and normalized to unit variance.

Further Measures of Uncertainty

We construct three additional uncertainty indicators for Switzerland including Bachmann's variation of Theil's Disconformity Index, the Index of Qualitative Variation and an indicator that captures investment realization certainty. We abstain from including these indicators in the study for two reasons. First, Bachmann's variation of Theil's Disconformity Index and the Index of Qualitative Variation are highly correlated with Theil's Disconformity Index. A separate consideration of the two indices would add little additional value to the analysis. Second, the index capturing investment realisation certainty is only available on a yearly basis. Unfortunately, we do not have an appropriate indicator to temporally disaggregate the indicator. Hence, we neglect the indicator for practical reasons, but believe that it comprises an additional dimension of uncertainty that has not been explored yet. Although we do not include these three indicators in our study, we discuss them in the Appendix and publish regular updates on our website.

Table 3 summarizes the uncertainty indicators used in our analysis.

Description	Available Since	Highest Frequency	Available on Sector Level	Provider
EPU Switzerland	01.01.1900	daily	No	KOF
Dispersion Firms Forecast Errors	01.09.1983	monthly	Yes	KOF
Theil Disconformity Index	01.02.1971	monthly	Yes	KOF
Dispersion Professional Forecast Errors	01.07.2001	quarterly	Yes	KOF
VSMI	04.01.1999	daily	No	SIX Swiss Exchange
Knightian Uncertainty Indicator	01.01.1989	monthly	Yes	KOF

Table 3: Uncertainty Indicators for Switzerland.

Notes: Overview of all Uncertainty Indicators for Switzerland that are you in this study. We provide a more extensive overview in the Appendix.

After having introduced the various uncertainty indicators for Switzerland, we will now turn to a comparison of the uncertainty indicators. Especially, we are interested if the Knightian Uncertainty indicator captures the same uncertainty as already established indicators. We will start the comparison by looking at a heat-map. Figure 7 depicts the uncertainty indicators over time. We calculate quarterly averages of the different uncertainty indicators and normalize each indicator to zero mean and unit variance. Uncertainty increases from white to dark blue. In this graph we limit our analysis from October 2000 to March 2017. The indicator limiting this analysis is the dispersion of professional forecasts, which is available only since the end of 2000. Figure 7 reveals that the different uncertainty indicators do not necessarily capture the same amount of uncertainty over time. In fact, there appears to be a considerable amount of variations across the different indicators. However, one can identify two episodes that appear to be captured by every indicator. First, every indicator displays somewhat heightened uncertainty between the end of the year 2002 and the end of the year 2003. Second, all indicators seems to capture the Great Recession in 2008/2009.

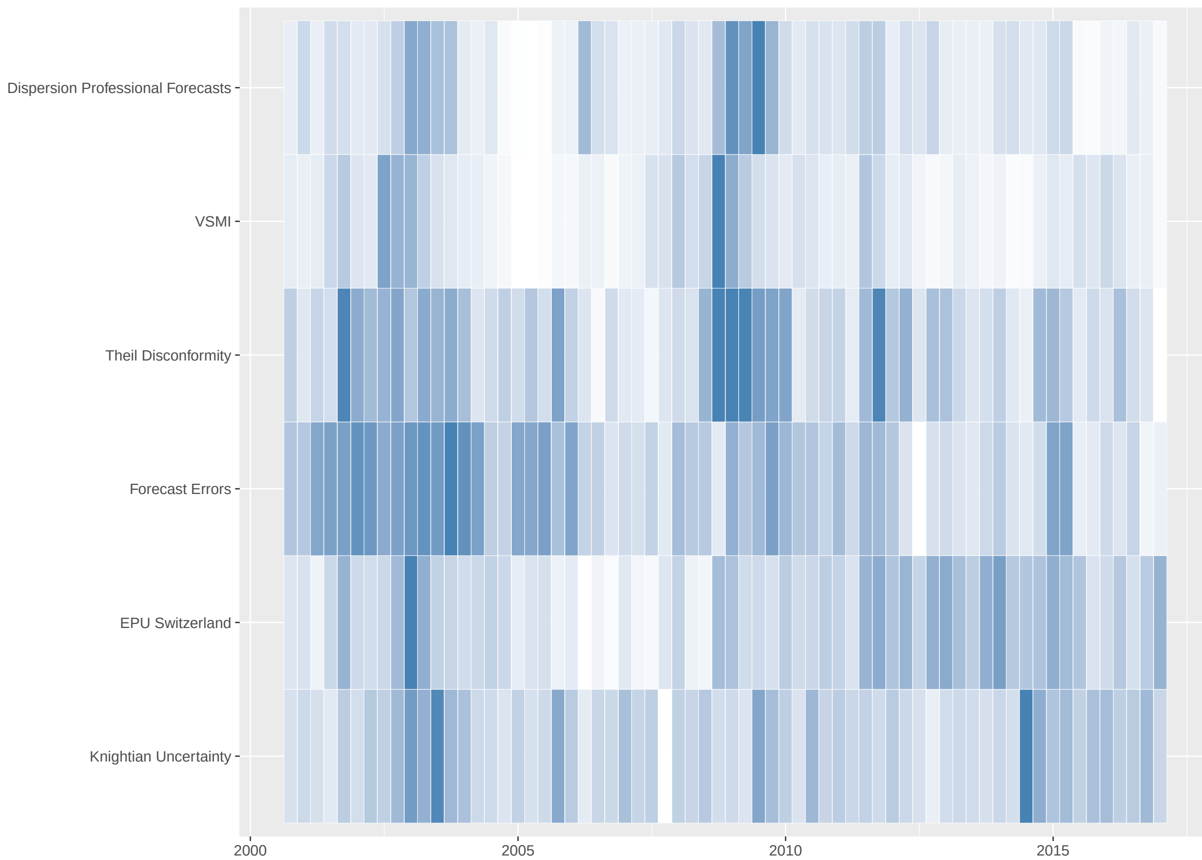

Figure 7: Uncertainty Indicators Heatmap Comparison.

Notes: This figures compares various uncertainty indicators for Switzerland. The figure depicts quarterly averages where dark blue depict high uncertainty and white depicts low uncertainty.

Figure 7 suggests that there might be differences in the variation of the various uncertainty indicators. In order to more structurally evaluate the correlation between the single indicators we calculate the Pearson's correlation coefficients. In this analysis, we exploit the longest available time span between each measure. Table 4 displays the estimated correlation coefficients. We can learn three lessons from Table 4. First, the correlation between the different indicators is generally weak. We only find a correlation of above 0.5 between the two dispersion measures, i.e. Theil's Disconformity Index and the dispersion of professional forecasts, and between VSMI and the two dispersion measures. Second, VSMI represents the only indicator that is statistically significantly correlated with all other indicators. Third, the newly introduced Knightian Uncertainty indicator appears to be able to capture some dimensions of uncertainty. The indicator displays a weak, but statistically significant correlation only with the EPU Switzerland.

	EPU Switzerland	DFFE	Theil Disconformity	VSMI	DPF
EPU Switzerland					
DFFE	0.30***				
Theil Disconformity	0.25***	0.25***			
VSMI	0.25***	0.06	0.52***		
DPF	0.17	0.09	0.56***	0.56***	
Knightian Uncertainty	0.15***	0.04	-0.02	0.02	0.13

*** p ≤ 0.01, ** p ≤ 0.05, * p ≤ 0.10

Table 4: Perason's correlation coefficients.

Notes: The table displays Perason's correlation coefficients. EPU represents the News Policy Uncertainty Index, VSMI the implied volatility of the SMI, Theil represents Theil's Disconformity Coefficient for expected demand and. DPF represents the seasonal adjusted standard deviation of point forecasts of next year's GDP by professional forecasters. DFFE stands for dispersion of firm forecast errors and represents the standard deviation of demand forecast errors by Swiss firms. Knightian Uncertainty represents the Knightian Uncertainty indicator. We use the longest available time span between each measures. P-values are approximated by using the t-distributions.

The low correlation of Knightian Uncertainty with alternative uncertainty measures suggests that the indicator might capture an additional dimension of uncertainty. In order to further explore this question and to identify possible different dimensions, we conduct a principal component analysis (PCA). Table 5 presents the factor loadings of the PCA for five Swiss uncertainty indicators from January 1999 to October 2017. The limiting indicator is VSMI, the financial implied volatility measure is available only since the beginning of 1999.[25] We find that Knightian Uncertainty has the lowest loading in the 1^{st} component and the highest loading in the 2^{nd} component. Hence, the Knightian Uncertainty indicator appears to bear additional information that is orthogonal to the information provided by the alternative uncertainty indicators. Note that, while the 1^{st} component is able to explain 35% of the variance, the 2^{nd} component explains an additional 20% of the variance. These findings indicates that the Knightian Uncertainty indicator might indeed capture a dimension of uncertainty that is not picked up by other indicators.

	1^{st} Component	2^{nd} Component	3^{rd} Component	4^{th} Component	5^{th} Component
EPU Switzerland	-0.42	-0.08	-0.35	0.83	-0.06
DFFE	-0.29	0.37	0.82	0.21	-0.25
Theil Disconformity	-0.63	-0.03	0.08	-0.24	0.73
VSMI	-0.57	-0.3	-0.15	-0.42	-0.62
Knightian Uncertainty	-0.13	0.87	-0.43	-0.17	-0.09
Standard deviation	1.33	1.00	0.99	0.90	0.67
Proportion of Variance	0.35	0.20	0.19	0.16	0.09
Cumulative Proportion	0.35	0.55	0.75	0.91	1.00

Table 5: Factor Loading of Principal Component Analysis.

Notes:This table presents the factor loadings and variance analysis of a R-mode Principal Component Analysis. The calculation is done by using eigenvalues on the correlation matrix. EPU represents the News Policy Uncertainty Index, VSMI the implied volatility of the SMI, Theil represents Theil's Disconformity Coefficient for expected demand and. DFFE stands for dispersion of firm forecast errors and represents the standard deviation of demand forecast errors by Swiss firms. Knightian Uncertainty represents the Knightian Uncertainty indicator.

The comparison of different uncertainty indicators raises the important question which uncertainty indicator one should used in an analysis. Although, all indicators react to specific events that in

[25]The results are robust with respect to the chosen time horizon. In a robustness check that we provide in Table 10 in the Appendix, we neglect VSMI and conduct the PCA using the remaining indicators since January 1991. The qualitative conclusion of the results remains unchanged.

hindsight can be attributed to be potentially uncertainty enhancing, none of the indicators appears to perfectly capture all the spikes of another indicator still less to attribute the same amplitude to these events. We believe that while there exists a certain correlation between all these indexes, it might not be sufficient to only rely on one single uncertainty indicator, but rather use various indicators for robustness.

In a final exercise, we investigate the effects of the uncertainty indicators on investment. We chose to examine the effects of uncertainty on investment in equipment and machinery as it represents the component of aggregate demand that most strongly reacts to innovations of uncertainty (Bloom, 2017). To examine the impact of uncertainty shocks on investment in equipment and machinery in Switzerland, we estimate five VARs on quarterly data from 1991Q1 to 2017Q3. That is, we re-estimate the same VAR five times using five different uncertainty indicators, including the Knightian Uncertainty indicator, Economic Policy Uncertainty indicator, Theil's Disconformity Index, the dispersion of firms forecast errors and the first principal component from the PCA conducted above.[26] Equation 5 presents the basic structure of the VAR. The variables in the estimation order are log(SMI Swiss stock market index), uncertainty, the 3-Month-Libor, log(nominal wage index), log(consumer price index), log(unemployment), and log(investment in equipment and machinery). This specific ordering is inspired by Bloom (2009) and based on the conjecture that shocks immediately affect the stock market and uncertainty, then prices (wages, the consumer price index, and interest rates), and eventually quantities, such as employment and output. Including the stock-market index as the first variable in the VAR ensures the impact of stock-market index is already controlled for when looking at the impact of uncertainty shocks. We detrend all variables (except the uncertainty indicators) using the Hodrick–Prescott (HP) filter ($\lambda = 1,600$).

$$(VAR-7)\begin{bmatrix} \text{log(Investment)} \\ \text{log(Unemployed)} \\ \text{log(CPI)} \\ \text{log(Wage)} \\ \text{3-Month-Libor} \\ \text{uncertainty} \\ \text{log(SMI)} \end{bmatrix} \tag{3}$$

Figure 8 presents the Cholesyk orthogonalized impulse responses of investment in machinery and equipment to a one standard deviation shock. Thereby, the black line displays the average response of investment. The red lines features the two standard deviation confidence bands. While there appears to exist some degree of heterogeneity across the impulse responses, investment reacts surprisingly similar to different uncertainty indicators. Generally, investment shows hardly any reaction within the first quarter after the shock. For most indicators, investment starts to decline two quarters after a shock and remains negative an additional two years. Two and a half to three years after the initial shock, the negative effects of the uncertainty shock fade out. Theil's Disconformity Index represents an exception to this patter, a one standard deviation shock to the indicator causes a short drop in investment in quarter two to four followed by a somewhat persistent overshoot that lasts up to ten quarters.

With respect to magnitude, a one standard deviation shock leads to a drop in investment of around 0.6 percentage points. Note that the most extreme uncertainty shocks peak at 2 to 4 standard

[26] In this analysis, we do not include the VSMI and the dispersion of professional forecasts as these indicators are available only since 1999 and 2001 respectively. We consider these time span as too short to produce meaningful results in a quarterly VAR.

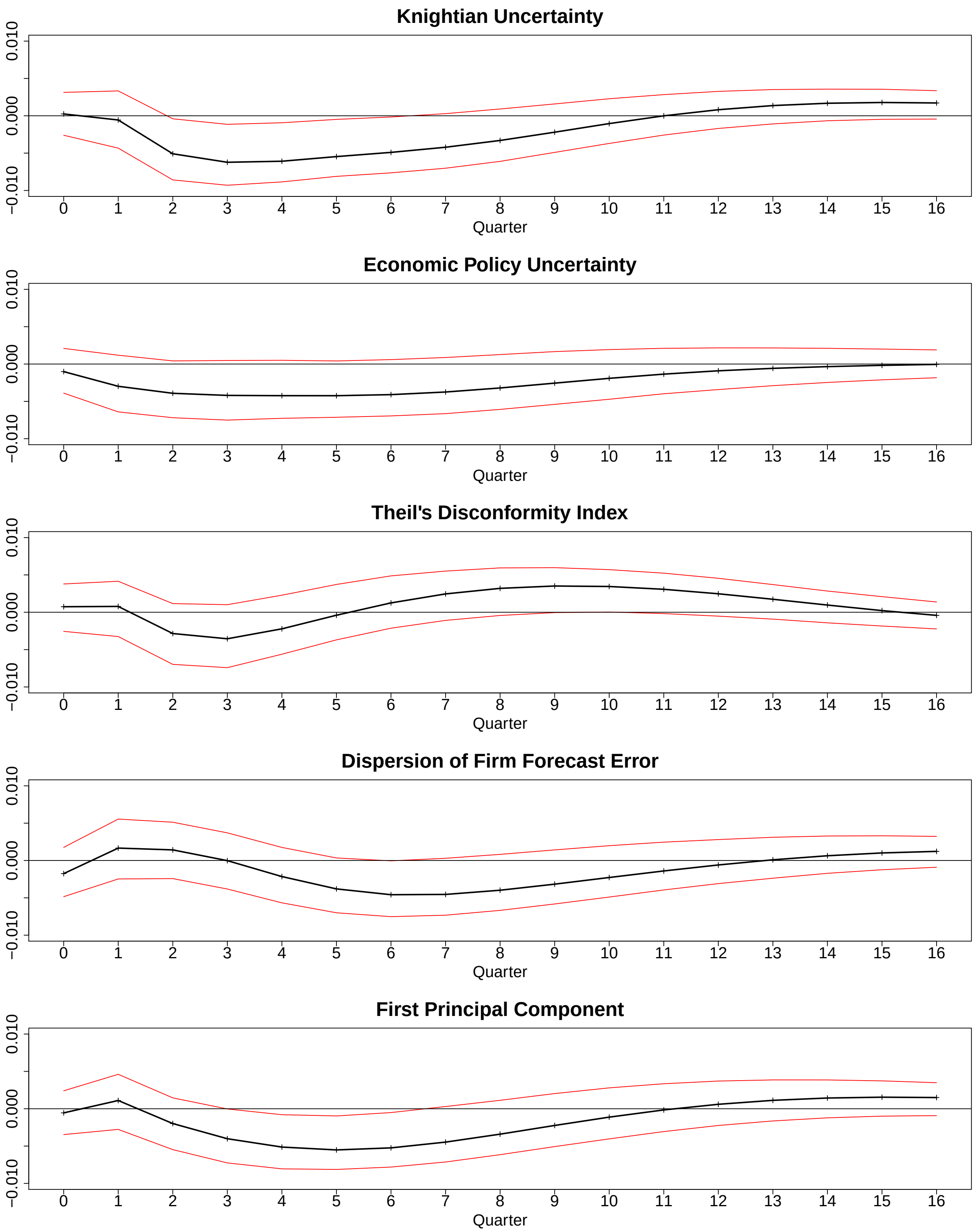

Figure 8: Impulse Response of Investment in Machinery and Equipment.

Notes: This figure depicts VAR Cholesky orthogonalized impulse responses of Machinery and Equipment to a one standard deviation shock of different uncertainty indicators. The black line with crosses depicts the average response. The red lines depict the 90% confidence intervals. We bootstrap confidence intervals using 10000 draws.

deviations depending on the indicator. Hence, one needs to scale the impulse responses accordingly in order to get the reaction of investment to extraordinary shocks. Finally, the impulse response of investment to a Knightian Uncertainty shock leads to statistically significant reduction of investment two quarters after the shock. The slump in investment remains statistically significantly negative for five quarters before the effect slowly disappears.

6 Conclusion

Knight (1921) is considered as the founder of the modern interpretation of uncertainty. He defines uncertainty as a state in which it is no longer possible to formalize expectations about the future. In the aftermath of the Great Recession, uncertainty has again been identified as a major driver behind economic activities. This led to the creation of many new uncertainty indicators that intend to depict uncertainty in a Knightian sense. However, most of these indicator have in common that they rely on proxies rather than measuring Knightian Uncertainty literally. In this study, we proposed a new indicator that measures Knightian Uncertainty. Our approach is simple, it relies on firm-level survey data that allow us to identify the share of firms that are not able to formalize expectations about the future. We show that the our indicator is able to capture important economic events. We further compare the new Knightian Uncertainty indicator to established indicators in the literature. Using correlation and principal component analysis, we show that most of the indicator appears to capture different dimensions of uncertainty that are weakly correlated with Knightian Uncertainty. Finally, we examine the effect of an Knightian Uncertainty shock to investment in Switzerland and find that a one standard deviation shock leads to a negative and statistically significant reduction of investment.

References

Abberger, K., Dibiasi, A., Siegenthaler, M., and Sturm, J.-E. (2014). The swiss mass immigration initiative: The impact of increased policy uncertainty on expected firm behaviour. *KOF Studies*, (53).

Alexopoulos, M. and Cohen, J. (2009). Uncertain times, uncertain measures. *Working Paper*, 352.

Bachmann, R., Elstner, S., and Sims, E. R. (2013). Uncertainty and economic activity: Evidence from business survey data. *American Economic Journal: Macroeconomics*, 5(2):217–249.

Baker, S. R., Bloom, N., and Davis, S. J. (2012). Measuring economic policy uncertainty. In *Labor Markets and the Business Cycle in the Aftermath of the Great Recession*, Federal Reserve Bank of Minneapolis. Available at `https://199.169.201.73/research/conferences/research-events---conferences-and-programs/~/media/files/research/events/2012_11-16/3-BakerBloomDavis.pdf`. Last accessed September 13th 2017.

Baker, S. R., Bloom, N., and Davis, S. J. (2015). Measuring economic policy uncertainty. Technical report, National Bureau of Economic Research.

Baker, S. R., Bloom, N., and Davis, S. J. (2016). Measuring economic policy uncertainty. *The Quarterly Journal of Economics*, 131(4):1593–1636.

Baumgaertner, S. and Engler, J.-O. (2016). Measuring knightian uncertainty. *European Association of Environmental and Resource Economists 22nd Annual Conference, Conference Paper*.

Binding, G. and Dibiasi, A. (2017). Exchange rate uncertainty and firm investment plans evidence from swiss survey data. *Journal of Macroeconomics*, 51:1–27.

Bloom, N. (2009). The impact of uncertainty shocks. *econometrica*, 77(3):623–685.

Bloom, N. (2014). Fluctuations in uncertainty. *The Journal of Economic Perspectives*, 28(2):153–175.

Bloom, N. (2017). Observations on uncertainty. *Australian Economic Review*, 50(1):79–84.

Bloom, N., Bond, S., and Van Reenen, J. (2007). Uncertainty and investment dynamics. *The review of economic studies*, 74(2):391–415.

Boero, G., Smith, J., and Wallis, K. F. (2008). Uncertainty and disagreement in economic prediction: The bank of england survey of external forecasters*. *The Economic Journal*, 118(530):1107–1127.

Bomberger, W. A. (1996). Disagreement as a measure of uncertainty. *Journal of Money, Credit and Banking*, pages 381–392.

Bond, S., Moessner, R., Mumtaz, H., and Syed, M. (2005). Microeconometric evidence on uncertainty and investment.

Chadefaux, T. (2014). Early warning signals for war in the news. *Journal of Peace Research*, 51(1):5–18.

Chang, B. Y. and Feunou, B. (2013). Measuring uncertainty in monetary policy using implied volatility and realized volatility. Technical report, Bank of Canada Working Paper.

Chow, G. C. and Lin, A.-l. (1971). Best linear unbiased interpolation, distribution, and extrapolation of time series by related series. *The review of Economics and Statistics*, pages 372–375.

Cramer, J. and Theil, H. (1954). *On the Utilisation of a New Source of Economic Information: An Econometric Analysis of the Munich Business Test: the 16th European Meeting OF the Econometric Society Uppsala, Sweden, 1954*. Econometric Society Uppsala.

De Bruin, W. B., Fischhoff, B., Millstein, S. G., and Halpern-Felsher, B. L. (2000). Verbal and numerical expressions of probability:"it's a fifty–fifty chance". *Organizational behavior and human decision processes*, 81(1):115–131.

Engelberg, J., Manski, C. F., and Williams, J. (2009). Comparing the point predictions and subjective probability distributions of professional forecasters. *Journal of Business & Economic Statistics*, 27(1):30–41.

European Commission, E. (2013). European business cycle indicators. Technical report, Directorate General for Economic and Financial Affairs (ECFIN), Brussels. Available at `http://ec.europa.eu/economy_finance/publications/cycle_indicators/2013/pdf/3_en.pdf`. Last accessed September 9th 2017.

European Commission, E. (2017). The Joint Harmonised EU Programme of Business and Consumer Surveys. *European Economy-Reports and Studies*.

Ferderer, J. P. (1993). Does uncertainty affect investment spending? *Journal of Post Keynesian Economics*, 16(1):19–35.

Gibbs, J. P. and Poston Jr, D. L. (1975). The division of labor: Conceptualization and related measures. *Social Forces*, 53(3):468–476.

Giordani, P. and Söderlind, P. (2003). Inflation forecast uncertainty. *European Economic Review*, 47(6):1037–1059.

Guiso, L. and Parigi, G. (1999). Investment and demand uncertainty. *Quarterly Journal of Economics*, pages 185–227.

Hisano, R., Sornette, D., Mizuno, T., Ohnishi, T., and Watanabe, T. (2013). High quality topic extraction from business news explains abnormal financial market volatility. *PloS one*, 8(6):e64846.

Iselin, D. and Siliverstovs, B. (2013). The r-word index for switzerland. *Applied Economics Letters*, 20(11):1032–1035.

Jurado, K., Ludvigson, S. C., and Ng, S. (2015). Measuring uncertainty. *American Economic Review*, 105(3):1177–1216.

Keynes, J. M. (1921). Treatise on probability.

Keynes, J. M. (1936). The general theory of employment, interest and money.

Knight, F. H. (1921). Risk, uncertainty and profit. *New York: Hart, Schaffner and Marx.*

Leahy, J. V. and Whited, T. M. (1996). The effect of uncertainty on investment: Some stylized facts. *Journal of Money, Credit and Banking*, pages 64–83.

Levi, M. D. and Makin, J. H. (1980). Inflation uncertainty and the phillips curve: Some empirical evidence. *The American Economic Review*, pages 1022–1027.

Makin, J. H. et al. (1982). Anticipated money, inflation uncertainty and real economic activity. *The Review of Economics and Statistics*, 64(1):126–34.

Mokinski, F., Sheng, X. S., and Yang, J. (2015). Measuring disagreement in qualitative expectations. *Journal of Forecasting*, 34(5):405–426.

Mullineaux, D. J. (1980). Unemployment, industrial production, and inflation uncertainty in the united states. *The Review of Economics and Statistics*, pages 163–169.

Neufeld, A. D. (2015). *Knightian Uncertainty in Mathematical Finance*. PhD thesis, ETH Zurich.

OECD (2003). *Business Tendency Surveys: A Handbook*. Number v. 291 in Business Tendency Surveys: A Handbook. Organisation for Economic Co-operation and Development.

Rich, R. and Tracy, J. (2010). The relationships among expected inflation, disagreement, and uncertainty: evidence from matched point and density forecasts. *The Review of Economics and Statistics*, 92(1):200–207.

Sax, C. and Steiner, P. (2013). Temporal disaggregation of time series. *The R Journal*, 5.

Shiller, R. J. (1981). Do stock prices move too much to be justified by subsequent changes in dividends? *The American Economic Review*, 71(3):421–436.

Theil, H. (1955). Recent experiences with the munich business test: An expository article. *Econometrica: Journal of the Econometric Society*, pages 184–192.

Wei, W. W. S. (1994). *Time series analysis : univariate and multivariate methods*. Redwood City, Calif. : Addison-Wesley Pub., repr. with corrections edition.

Zarnowitz, V. and Lambros, L. A. (1987). Consensus and uncertainty in economic prediction. *The Journal of Political Economy*, pages 591–621.

Appendix

A Uncertainty Indicators for Switzerland

Appendix A provides an overview of all Swiss uncertainty indicators that we examined in course of our study. Besides the indicators that we introduce in the paper, i.e. the Economic Policy Uncertainty Indicator, the implied volatility for the Swiss Market Index(SMI®), the dispersion of professional forecasts, Theil's Disconformity Coefficient and the dispersion of firm forecast errors, we discuss three additional uncertainty indicators for Switzerland. These include Bachmann's variation of Theil's Disconformity Coefficient, the index of qualitative variation and investment realization certainty.

A.1 News Indicator: Economic Policy Uncertainty

We replicate the News Economic Policy Uncertainty (EPU) Indicator introduced by Baker et al. (2015) for Switzerland. The News EPU indicator extracts uncertainty tendency from newspapers. The idea behind its design is to captures uncertainty sentiment in newspapers over time as a reflection of true economic policy uncertainty in an economy. Particularly, the indicator counts newspaper articles that echo policy uncertainty and scales it with all daily published articles. The indicator counts an article as resounding policy uncertainty in case the article contains a combination of keywords. Concerning Switzerland, the EPU indicator comprises two newspapers, "Le Temps" and "Neue Zürcher Zeitung" and is available from January 1st 1900. The advantage of the EPU indicator is its high frequency and long history, i.e. available on a daily basis since the beginning of the 19th century. Possible draw back are that we do not really know what is capture by the indicator and possible cycles in the utilization of words.

The general idea of the indicator is to track sentiment in news. We count all article that include several keywords on a daily basis. In order for an article to be included in the count it has be connected to three dimensions. First, the article has to be economically relevant. Second, the article has to report uncertainty. Finally, the article must address policy. The count includes an article only if it fulfills these three criteria. In order to control for the three dimensions Baker et al. (2015) define three set of keywords. The first set contains economy relevant words, such as economy and economic. The second set includes words such a uncertainty, uncertain and alternations of uncertainty. The third set includes economic policy relevant words such as regulation, spending and national bank. Table 6 defines the sets that we use for the Swiss Economic Policy Indicator.

We collect the daily count of articles contains at least one word of each of the following sets:

Relevance	Keywords
Economic	economic, economy
Uncertainty	uncertainty, uncertain
Policy	tax, economic policy, regulation, spending, national bank, SNB, budget, deficit, budget deficit

Table 6: Key Words News Economic Policy Uncertainty Index.

Notes: The News Economic Policy Uncertainty Index builds on the number of articles that contain at least one word of each set of keywords. The table lists the English keywords for each set. The indicator for Switzerland uses German and French translations of the English keywords. Table 7 lists the exact translations in the Appendix.

We construct the News Economic Policy Uncertainty Index out of two Swiss newspapers. Since March 1st 1998, the EPU indicator comprises two newspapers, "Le Temps" and "Neue Zürcher Zeitung". Thereby, we average both indicators with equal weight. The newspaper "Le Temps" launched on March 1st 1998 as a merger of three newspapers, i.e. "Gazette de Lausanne", "Journal de Geneve" and "Le Nouveau Quotidien". "Le Nouveau Quotidien" itself was founded on September 24th 1991. Before March 1st 1998, we use the arithmetic mean of the three newspapers to proxy the "Le Temps".

We construct, scale and normalize the Swiss EPU Index as in Baker et al. (2015). We carry out the following steps: First, we normalize the scaled EPU frequency of each monthly newspaper series by dividing it through its standard deviation. This produces a monthly series for each newspaper with unit standard deviation. Further, we average the two newspapers over each month and standardize the mean of the resulting series to 100.

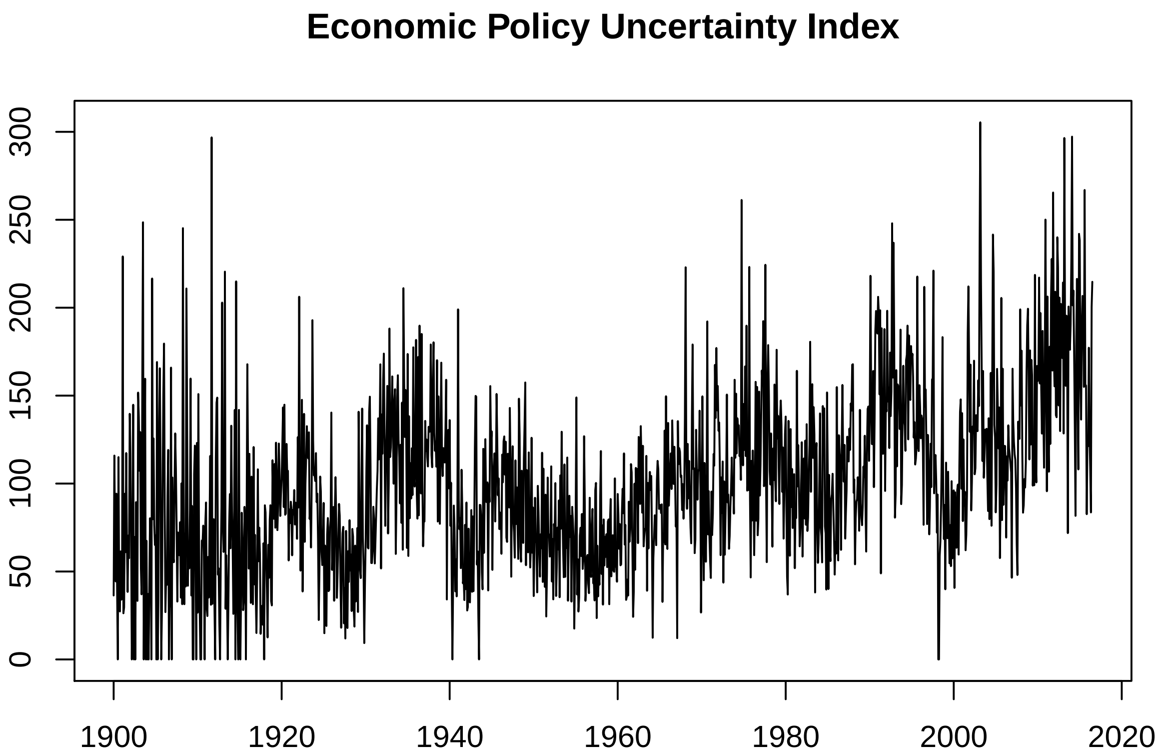

Figure 9: Monthly EPU Index for Switzerland.

Notes: The Figure show the Economic Policy Uncertainty Index for Switzerland from 1900 to 2016. The index is scaled by the set of economy relevant words and normalized to its long term mean of 100.

	German	French
Economic Keywords	wirtschaft, wirtschaftlich	economie, economique, economiques
Uncertainty Keywords	unsicher, Unsicherheit	incertitude, incertain, incertitudes, incertains
Policy Keywords	steuer, wirtschaftspolitik, regulierung, regulierungs, ausgaben, nationalbank, SNB, haushalt, defizit, haushaltsdefizit	taxe, taxes, impot, impots, politique, politiques, regulation, regulations, reglementation, loi, lois reglementations, depense, depenses, deficit, deficits, banque centrale, BNS, banque nationale, budget, budgetaire

Table 7: German and French Keywords for News Economic Policy Uncertainty Index.

Notes: The News Economic Policy Uncertainty Index builds on the number of articles that contain at least one word of each set of keywords. The table lists German and French keywords used by the indicator.

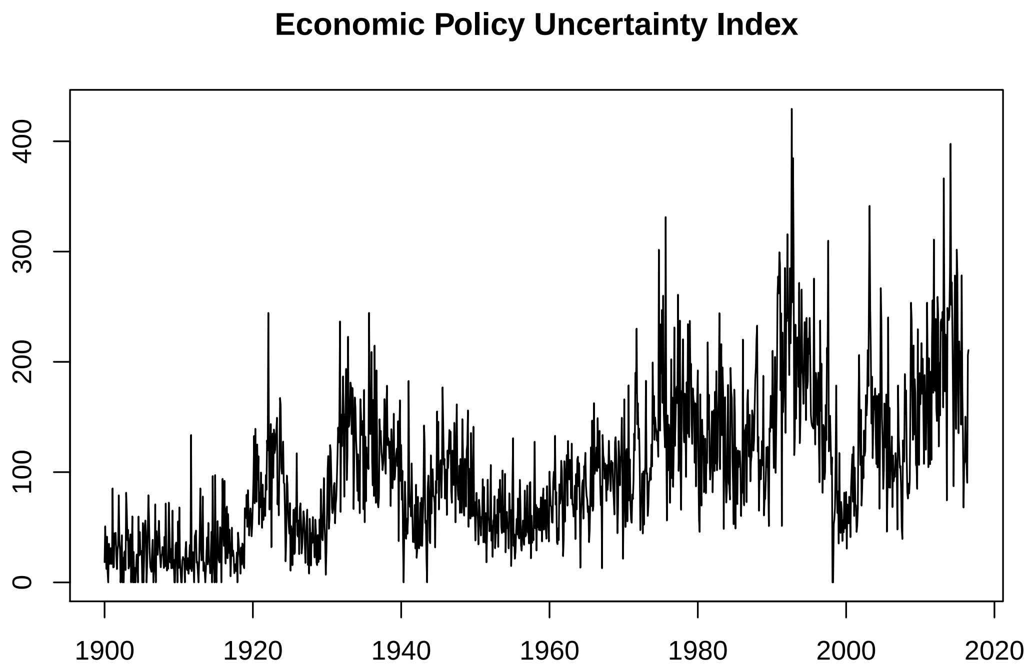

Figure 10: Monthly EPU Index for Switzerland.

Notes: The Figure show the Economic Policy Uncertainty Index for Switzerland from 1900 to 2016. The index is scaled by number of total articles published and normalized to its long term mean of 100.

A.2 VSMI® - Volatility Index on the SMI®

Implied volatility of financial indices is another prominent way to proxy uncertainty. For Switzerland, SIX Swiss Exchange calculates the implied volatility (VSMI®) for the Swiss Market Index (SMI®). The main index is determined on the basis of a fixed residual term of 30 days. However, subindices are calculated for various durations.

The following section shortly summarizes the construction of VSMI® as described in Six (2013) and Six (2014). The model for VSMI creates an index that does not capture the first moment price fluctuations, but only changes in volatility of the Swiss Market Index. Such a measure is not directly achieved through volatility, but rather through variance, i.e. squared volatility. Particularly, the VSMI calculates the implied volatility of a portfolio of SMI options with different exercise prices and a given expiration time. The index weights different options differently.

$$VSMI_i = 100 \times \sqrt{\sigma_i^2} \tag{4}$$

$$\sigma_i^2 = \frac{2}{T} \times \sum_j \frac{\Delta K_{i,j}}{K_{i,j}^2} \times M(K_{i,j}) - \frac{1}{T_i}\left(\frac{F_i}{K_{i,0}} - 1\right)^2, i = 1, 2, ..., 8 \tag{5}$$

where T_i is the time of expiration of the i^{th} option and F_i is the forward price derived from the price of the i^{th} option. $K_{i,j}$ represents the exercise price of the j^{th} out-of-money option of the i^{th}

option's expiration month in ascending order. $\Delta K_{i,j}$ represents interval of the relevant exercise prices, respectively half the interval between the one higher and one lower exercise price.[27] $K_{i,0}$ is the highest exercise price below the forward price F_i. R_i stands for the refinancing factor of the i^{th} option.[28] Finally, $M(K_{i,j})$ stands for the price of the option $K_{i,j}$ with $K_{i,j} \neq K_{i,0}$ and $M(K_{i,0})$ stands for the average of the put and call prices at the exercise price $K_{i,0}$.

The forward price is defined as in Equation 6. Particularly, the model bases on the forward price for which the absolute difference between call and put prices (C and P) is smallest.[29]

$$F_i = K_{min|C-P|} + R_i \times (C_P) \tag{6}$$

The interval between the relevant exercise prises is defined as

$$\Delta K_{i,j} = \frac{K_{i,j+1} - K_{i,j-1}}{2} \tag{7}$$

SIX Swiss Exchange calculates the VSMI for a fixed duration of 30 days.

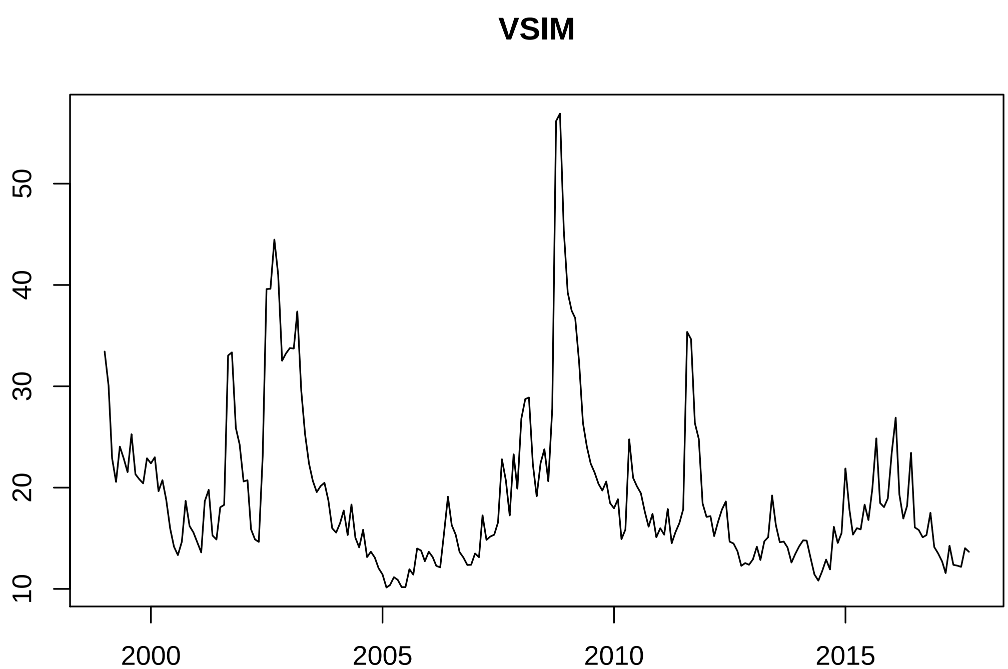

Figure 11: VSMI® - Volatility Index on the SMI®.

Notes: The figure depicts monthly averages of the implied volatility for the Swiss Market Index.

[27]On the boundaries, the model relies on the interval between the highest (lowest) and second highest (lowest) exercise price

[28]The model defines the refinancing factor of the i^{th} option as $R_i = e^{r_i \times T_i}$. r_i stands for the risk-free interest rate to expiration of the i^{th} option.

[29]In case that no clear minimum exists, the calculations consider the average value of the relevant forward price.

A.3 Professional Forecaster Dispersion

An additional way to proxy uncertainty is the dispersion of forecasts of professional forecasters. The indicator bases on the idea that the higher the dispersion of forecast the higher the uncertainty about a certain variable. KOF Swiss Economic Institute collects forecasts for the Swiss economy of various forecasters on a quarterly basis. The participants provide their expectations for several economic variables over different horizons. Table 8 provides an overview of the various variables and horizons. The present indicator relies on a measure of dispersion. One can chose various different measures. In this case, we rely on the standard deviation (sd) and the interquartile range (iqr). Figure 12 to Figure 15 depict the indicators over time.

	Macroeconomic Variables			Financial Variables		
	year t	year t+1	in 5 years	in 3 month	in 12 month	
Real GDP (growth)	X	X	X	X	X	3m interest rate
Prices (CPI) (growth)	X	X	X	X	X	Yield 10y bond
Unemployment	X	X	X	X	X	EUR/CHF
Exports (growth)	X	X		X	X	USD/CHF
Investment (growth)	X	X				

Table 8: KOF Consensus Forecast.

Notes: KOF collects forecasts of Swiss forecasting institutes for various macroeconomic and financial variables over different horizons.

Furthermore, KOF asks survey participants estimates on macroeconomic variables for a specific year, i.e. real GDP growth next year, on four different occasions. That is, March, June, September and December each year. Naturally, forecasters estimates should become more precise throughout the year, i.e. forecasts of real gdp growth for the following year should be more accurate in December than they were in March. Hence, also the dispersion of forecasts might be lower in December than they were in March. In order to account for these potential seasonalities, we seasonally adjust each series using the seasonal adjustment software X-13ARIMA-SEATS provided by US Census Bureau.

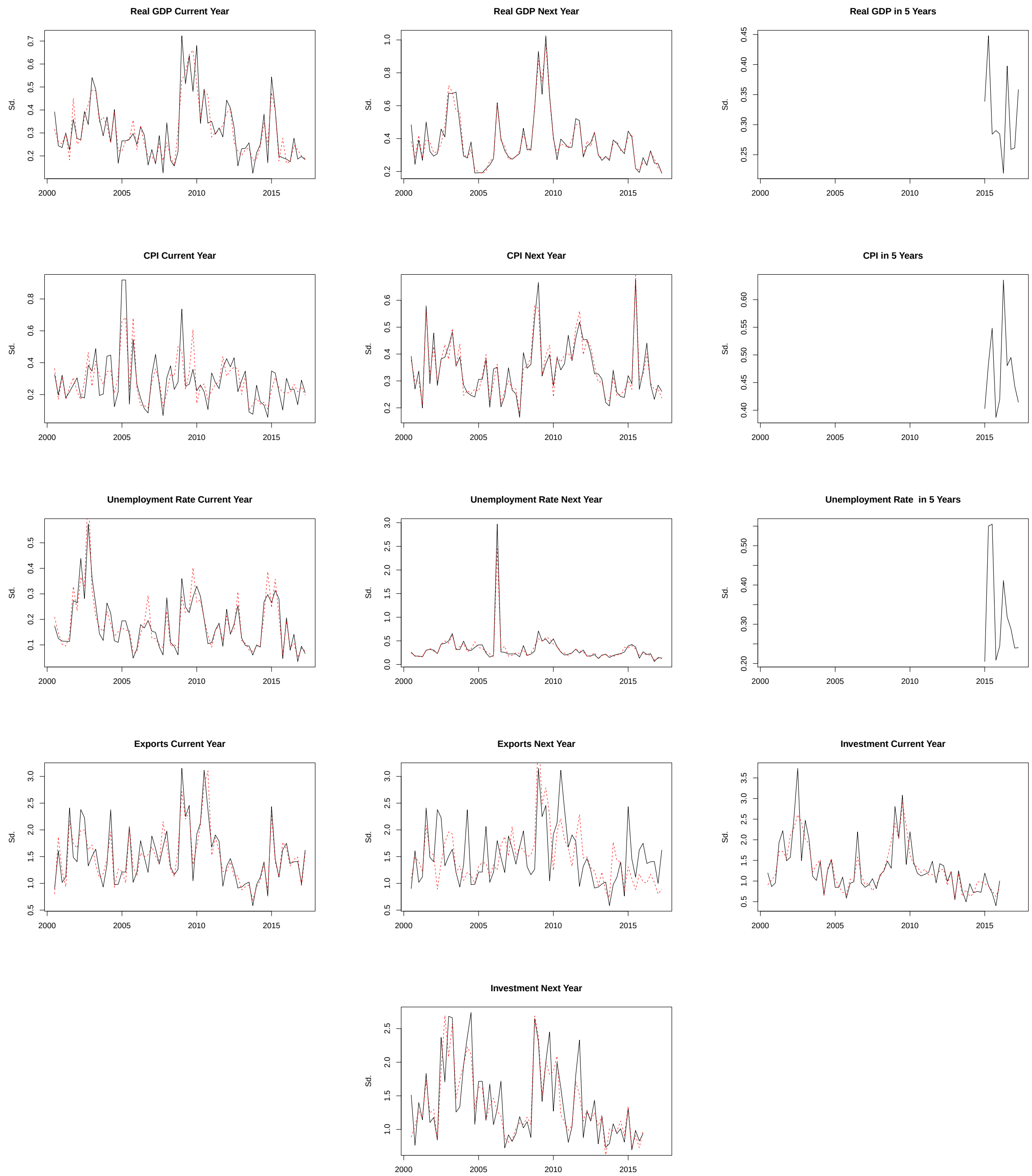

Figure 12: Dispersion of Professional Forecasts - Standard Deviation - Macroeconomic Variables.

Notes: Dispersion of Professional Forecasts - Standard Deviation - Macroeconomic Variables. The black solid line depicts the standard deviation. The red dashed line shows the seasonal adjusted series.

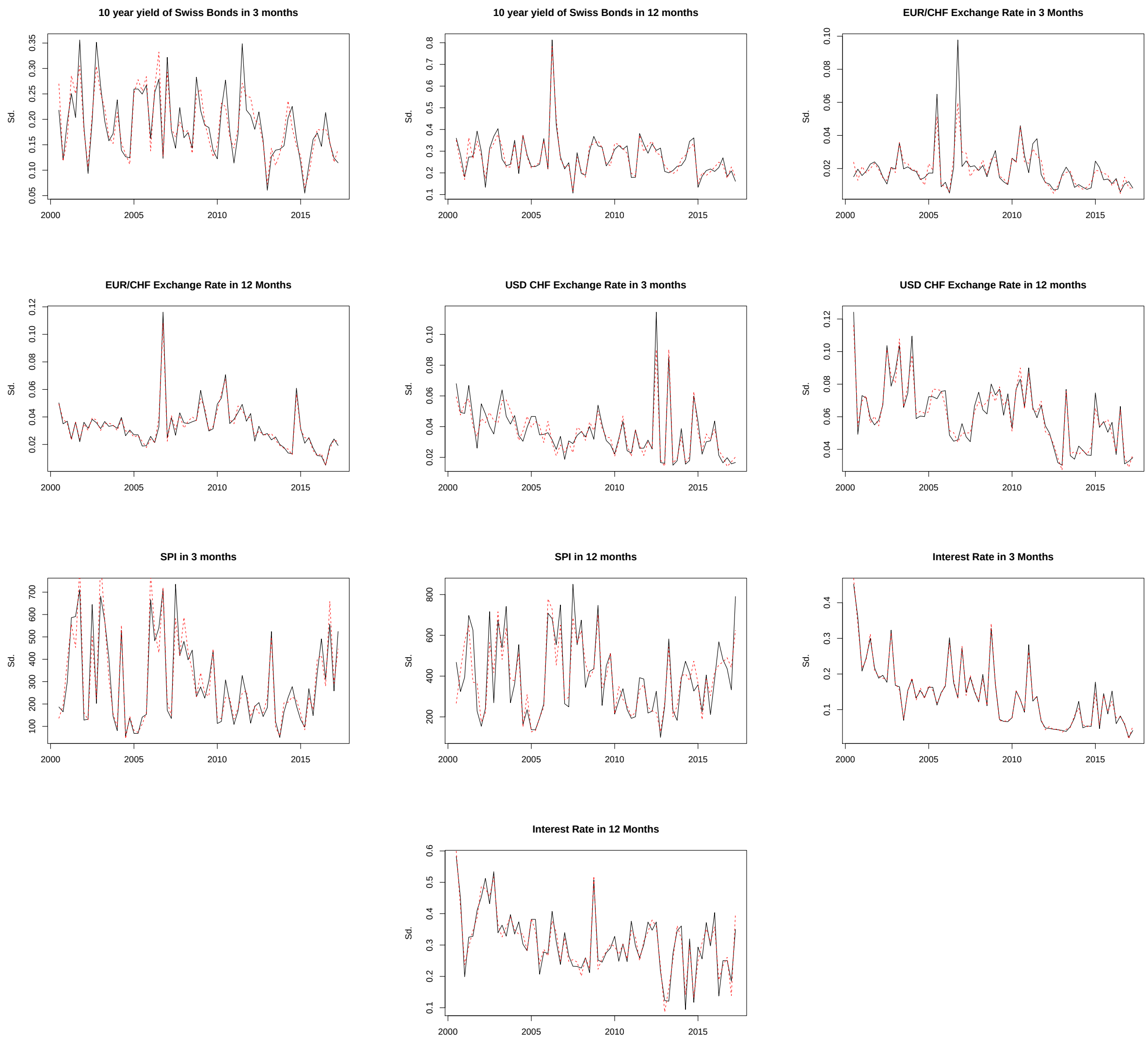

Figure 13: Dispersion of Professional Forecasts - Standard Deviation - Financial Variables.

Notes: Dispersion of Professional Forecasts - Standard Deviation - Financial Variables. The black solid line depicts the standard deviation. The red dashed line shows the seasonal adjusted series.

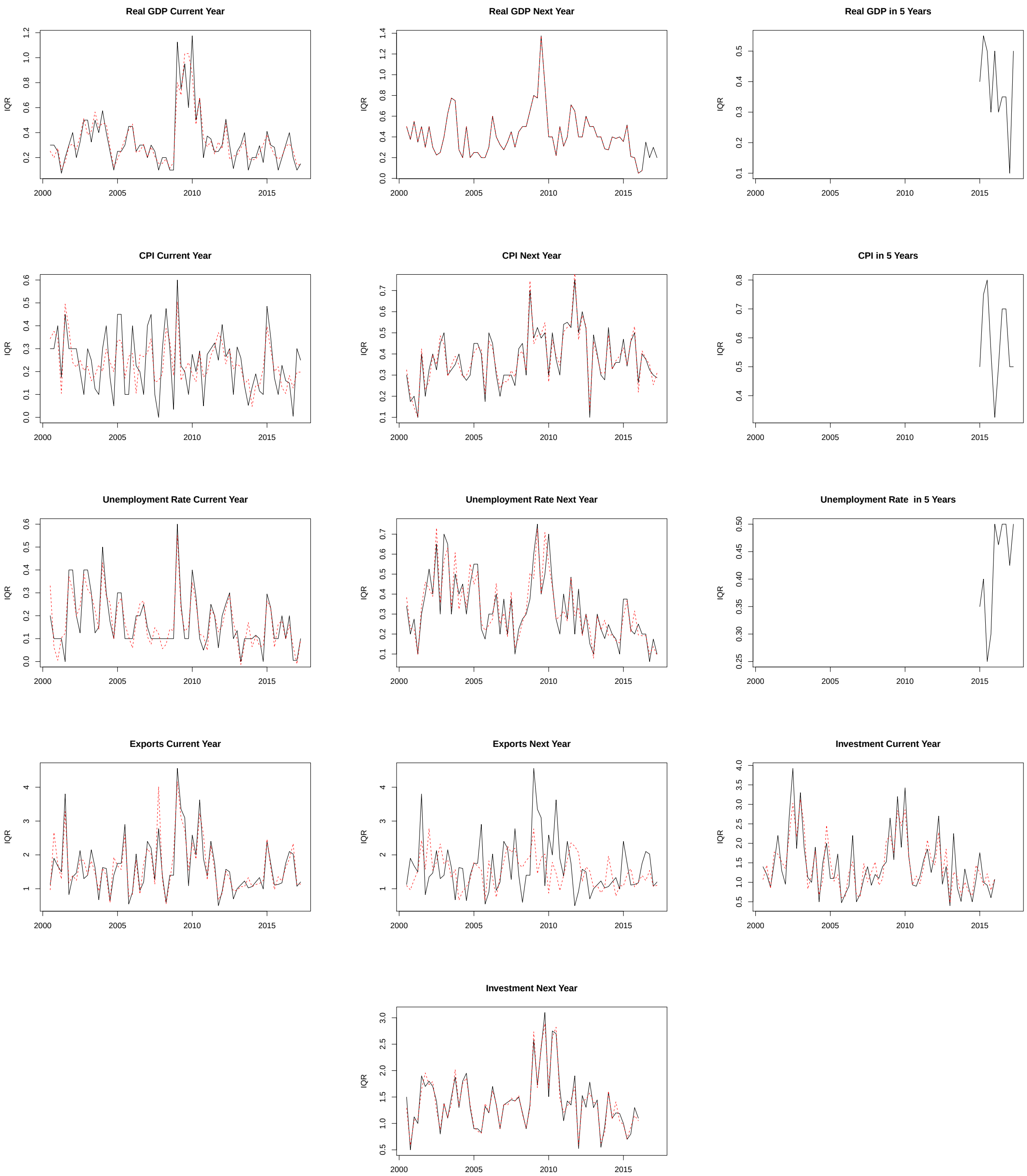

Figure 14: Dispersion of Professional Forecasts - Interquartile Range - Macroeconomic Variables.

Notes: Dispersion of Professional Forecasts - Interquartile Range - Macroeconomic Variables. The black solid line depicts the interquartile range. The red dashed line shows the seasonal adjusted series.

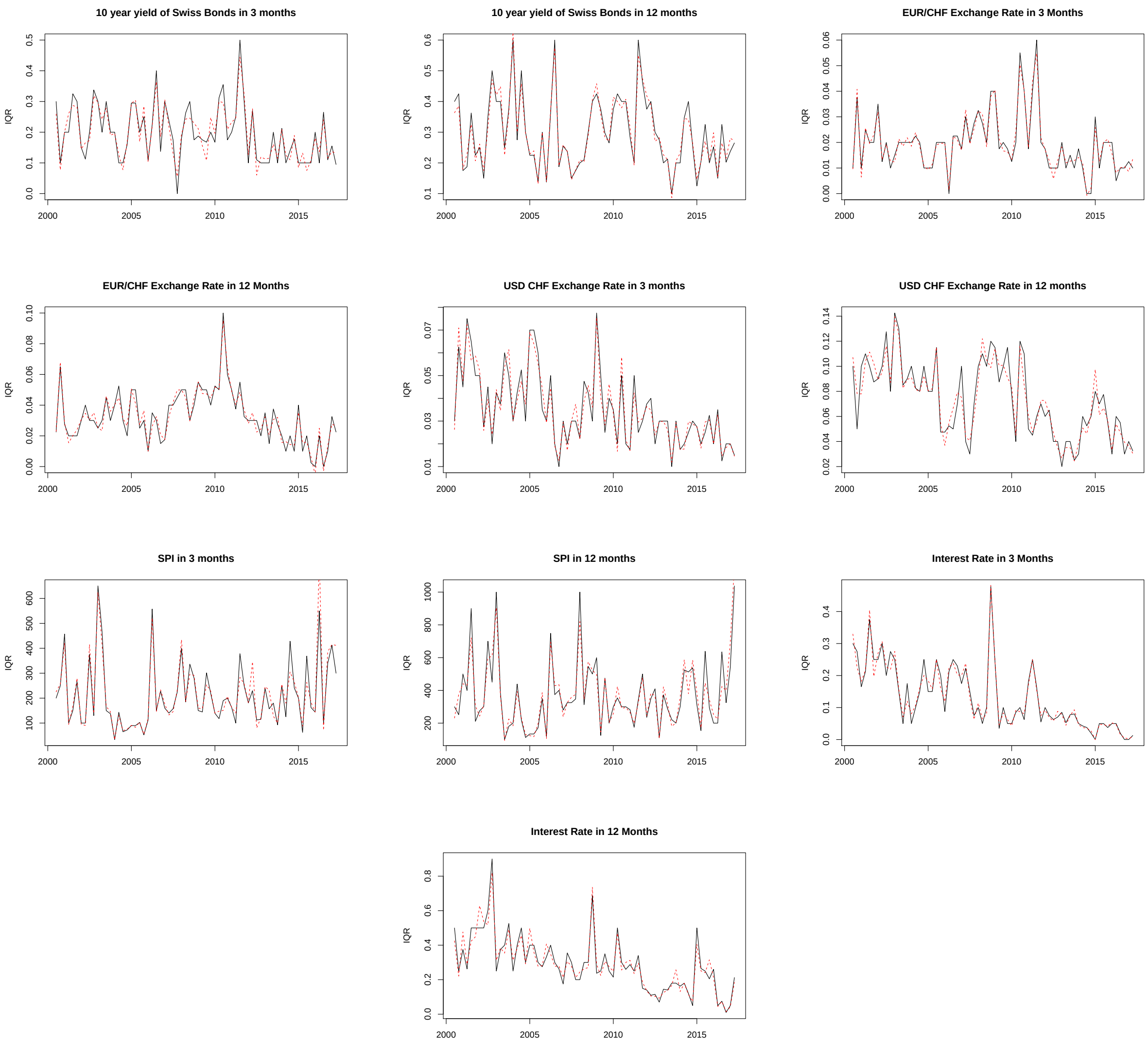

Figure 15: Dispersion of Professional Forecasts - Interquartile Range - Financial Variables.

Notes: Dispersion of Professional Forecasts - Interquartile Range - Financial Variables. The black solid line depicts the interquartile range. The red dashed line shows the seasonal adjusted series.

A.4 Survey Based Uncertainty Measures

A.4.1 Dispersion of Firm Forecast Errors

Another approach to approximate uncertainty relies on the dispersion of forecast errors. In the spirit of Bachmann et al. (2013), we use business tendency survey data to construct firm level forecast error. The KOF business tendency surveys ask firms about their expectations as well as their realisation of various variables of interest. That is, KOF asks firms about a qualitative estimate of how their demand will possibly evolve over the next three months. In additions, firms also report how their demand developed over the last three month. This allows us to construct an forecast error for each single firm with respect to their demand.

While Bachmann et al. (2013) based their uncertainty measure on expected and realized production, we focusing on expected and realized demand. The following two question are taken from the KOF Construction Survey. We use the firm level answers to construct a firm level forecast error.

Over the next 3 months, the demand for our services will

□ increase

□ remained unchanged

□ decrease

Over the last 3 months, the demand for our services has

□ increased

□ remained unchanged

□ decreased

We calculate a firm's forecast error by comparing expected demand measured in period t to realized demand measured in period t+1. Table 9 show all the possible combination of forecast errors.

Forecast Error Business Tendency Survey					
			Realized Demand		
			Up	Same	Down
Expected	Demand	Up	1-1=0	0-1=-1	-1-1=-2
		Same	1-0=1	0-0=0	-1-0=-1
		Down	1-(-1)=2	0-1=-1	(-1)-(-1)=0

Table 9: Forecast Errors Business Tendency Surveys.

Notes: Forecast Errors Business Tendency Surveys. This table depicts possible forecast errors of a single firm.

Following Bachmann et al. (2013), we calculate the dispersion of all forecast errors in every period. Formally,

$$FEDISP_t = stdw(error_{i,t+3}) \tag{8}$$

Figure 16 displays the standard deviation of firms forecast errors over time.

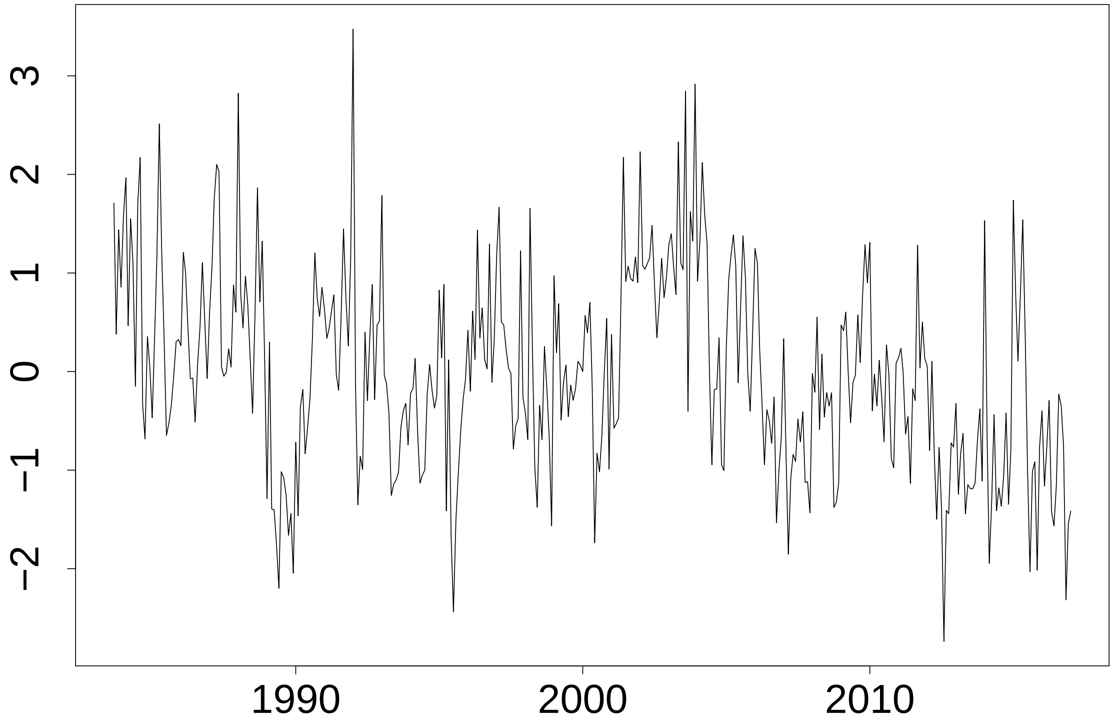

Figure 16: Firm Forecast Error Dispersion

Theil's Disconformity Coefficient

Besides the already mentioned measures of uncertainty, the literature suggests disagreement in qualitative survey data to approximate uncertainty.[30]

One can proxy macroeconomic uncertainty through the variation in demand expectations of economic actors, such as firms. The idea is that a higher dispersion of expectations represents a more uncertain economic environment. This indicator assumes that variance of means is positively correlated with the mean of variances, which represents the ultimate variable of interest.

In the early fifties, Cramer and Theil (1954) termed the disconformity coefficient that represents the variance of qualitative surveys. In 1955, Theil dedicates an essay to the nature of business tendency surveys and concludes that apart from the balance statistic one needs the disconformity coefficient to fully describe the test variates of any variable in any month (Theil (1955)). Bachmann et al. (2013) introduce a slight variation of Theil's disconformity coefficient by taking the square root of the disconformity index. In the following, we will denote Theil's disconformity coefficient with d_t and Bachmann's variation with b_t.

$$d_t = U_t + D_t - (U_t + D_t)^2 \tag{9}$$

[30]Mokinski et al. (2015) provide a recent overview of common approaches to measure disagreement in qualitative survey data.

$$b_t = \sqrt{U_t + D_t - (U_t + D_t)^2} \qquad (10)$$

Figure 17 plots Theil's Disconformity Coefficient index and Bachmann's disagreement measure over the range of possibilities by holding the share of "no change" constant. One would expect that both measures behave similarly. Nevertheless, Figure 17 shows that the measures produce a somewhat different picture. Both measures peak at value one when half of the respondents reported "Up" and half of the respondents reported "Down". Similarly, both measures display zero once all respondents are in the same category. Apart from these three points Theil's Disconformity Index takes always lower values than Bachmann's disagreement measure. These differences result form their mathematical construction. While Theil's Disconformity has a constant second derivative, the second derivative of Bachmann's disagreement is a function that takes the largest values at the extremes (e.g. all respondents select Up or all respondents select Down) and the smallest at the peak of the indicator where respondents are equally distributed across "Up" and "Down" (see Equations 14 to 24 in the Appendix).

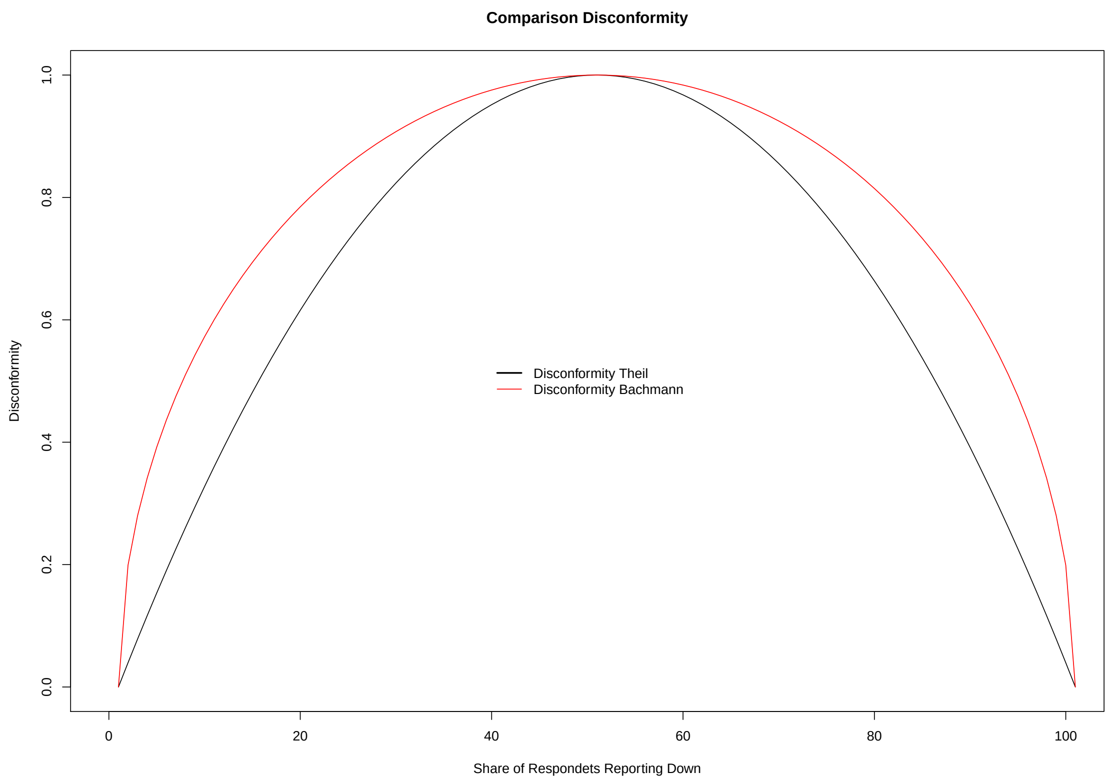

Figure 17: Theil's Disconformity Coefficient vs. Bachmann's Disagreement.

Notes: This Figure plots the Theil's Disconformity Coefficient and Bachmann's Disagreement. Theil's Disconformity Coefficients constantly displays smaller values than Bachmann's Disagreement except for their maximum and minimum, where both measures produce the same value.

Even thought there exists theoretical differences between the two measures, the indicator for expected demand are essentially the same. Figure 18 compares Theil's Disconformity Index to Bachmann's disagreement measure. The correlation between the two series is 0.999.

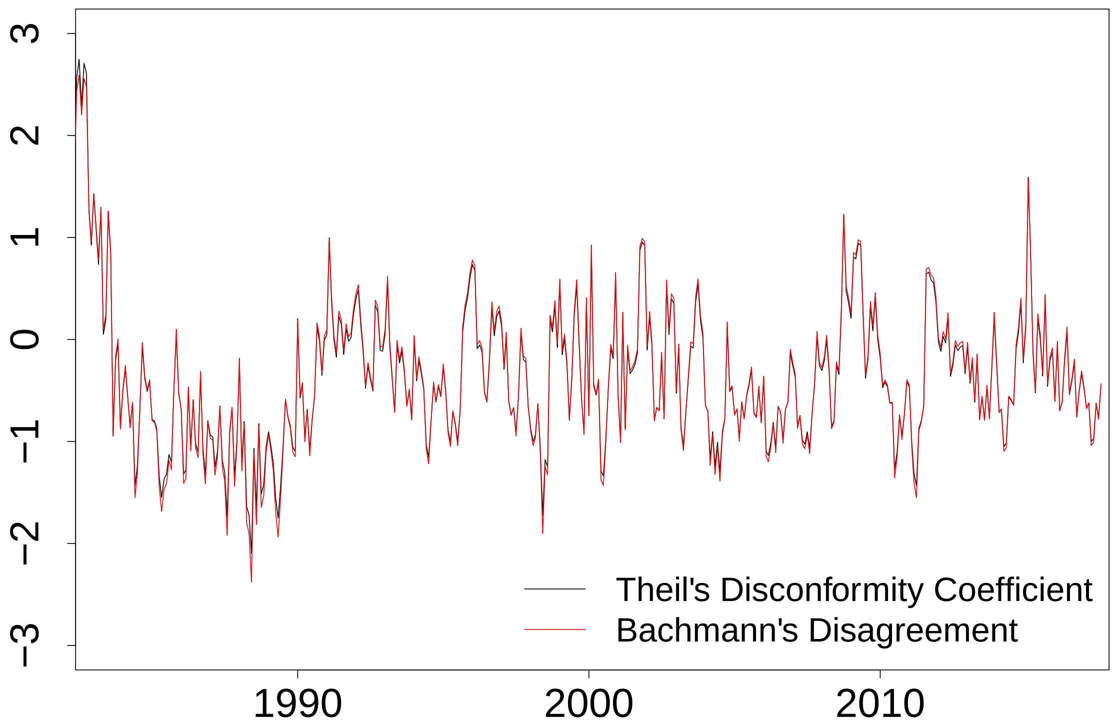

Figure 18: Comparison Theil's Disconformity Coefficient to Bachmann's Disagreement.

Notes: Theil's Disconformity Coefficient and Bachmann's Disagreement of expected demand for Swiss manufacturing firms. Both measures are standardized to zero mean and normalized to unit variance. Although there exists a theoretical difference between the two measures, the correlation exceeds 0.999.

The following equation display the first and second derivative of Theil's Disconformity Index and Bachmann's Disagreement.

$$d = U + D - (U - D)^2 \tag{11}$$
$$d_U = 1 - 2(U - D) \tag{12}$$
$$d_{U,U} = -2 \tag{13}$$

$$b = \sqrt{U + D - (U - D)^2} \tag{14}$$
$$b_U = \frac{1 - 2(U - D)}{2\sqrt{-(U - D)^2 + U + D}} \tag{15}$$
$$b_{U,U} = -\frac{8D + 1}{4\left(-(U - D)^2 + U + D\right)^{\frac{3}{2}}} \tag{16}$$

While the equations above show the first and second derivative of Theil's Disconformity Index and Bachmann's Disagreement for the general case, the following equations show the first and second derivative of Theil's Disconformity Index and Bachmann's Disagreement for the special case in which no respondent chose "no change".

$$d = U + D - (U - D)^2 \tag{17}$$
$$d = U + (1 - U) - (U - (1 - U))^2 \tag{18}$$
$$d_U = 4 - 8U \tag{19}$$
$$d_{U,U} = -8 \tag{20}$$

$$b = \sqrt{U + D - (U - D)^2} \tag{21}$$
$$b = \sqrt{U + (1 - U) - (U - (1 - U))^2} \tag{22}$$
$$b_U = -\frac{4U - 2}{\sqrt{1 - (2U - 1)^2}} \tag{23}$$
$$b_{U,U} = -\frac{4}{\left(1 - (2U - 1)^2\right)^{\frac{3}{2}}} \tag{24}$$

A.4.2 Index of qualitative Variation

Mokinski et al. (2015) compare a variety disagreement measures for qualitative survey data. In addition to Theil's disconformity index, the authors examine the index of qualitative variation (IQV) that was originally suggested by Gibbs and Poston Jr (1975). The IQV represents a disagreement of categorical variables. Thereby, the measures treats each item as nominal. The index of qualitative variation is defined by the following formula:

$$IQV_t = \frac{K}{K - 1}\left(1 - \sum_{i=1}^{K} s_{i,t}^2\right) \tag{25}$$

where K comprises the number of nominal categories in the survey and s_i represents the share of responses in category i. The term $\frac{K}{K-1}$ ensures that the index lies between zero and one. The index reaches one when disagreement is highest, i.e. all responses are uniformly distributed across all items, and zero when there is no disagreement, i.e. all responses are concentrated on one item. Figure 19 depicts the index of qualitative variation for Switzerland.

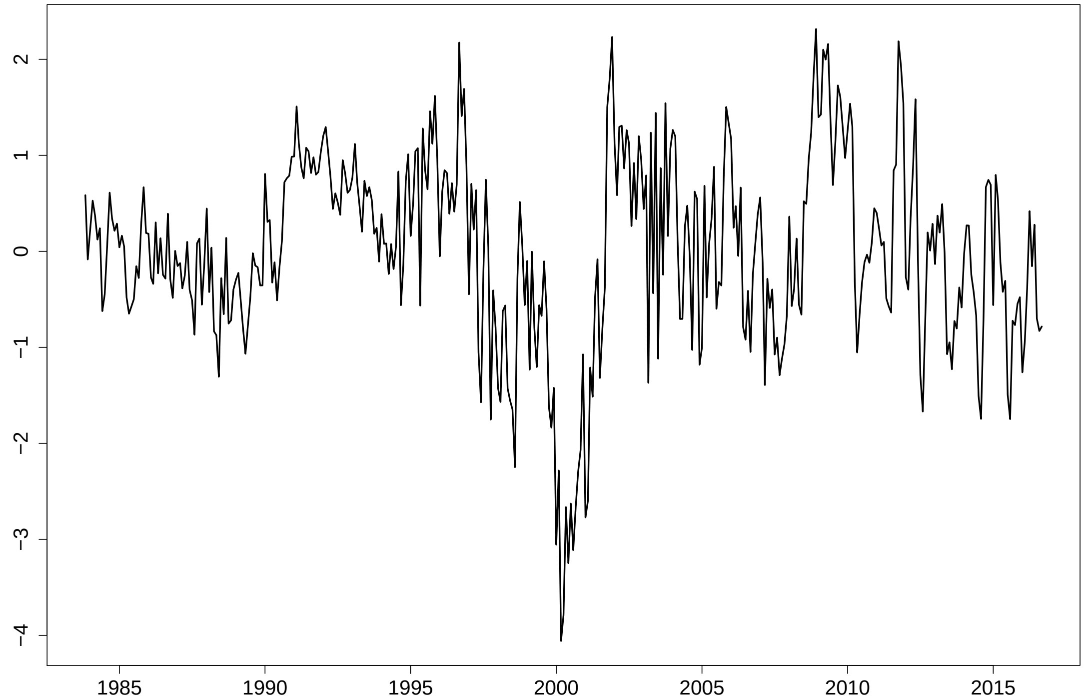

Figure 19: Index of qualitative Variation.

Notes: The figure plot the Index of qualitative Variation for demand expectations of firms. We demean the series and normalize it to unit variance.

A.4.3 Investment Realization Certainty

In addition to the indirect approach, it is also possible to directly ask firms about their perception of uncertainty. However, as far as we know, such a measure has so far never been applied in economic research. Since 1996, participants in the KOF investment surveys have been continuously asked to directly assess their perception of investment certainty. We propose to use this additional measure of uncertainty. Using the direct survey approach in comparison with already established ways of measuring uncertainty promises further understanding of what uncertainty indicators really capture.

Besides its business tendency surveys, KOF Swiss Economic Institute conducts the investment survey amongst a large panel of private firms situated in Switzerland. In 2001 the institute added a new question to the questionnaire. The question asks firms how certain they are about the realisation of the investment plans for next year. The following question presents the exact wording:

We consider the realisation of our investment plans for year t+1 as

- ☐ very certain
- ☐ fairly certain
- ☐ fairly uncertain
- ☐ very uncertain

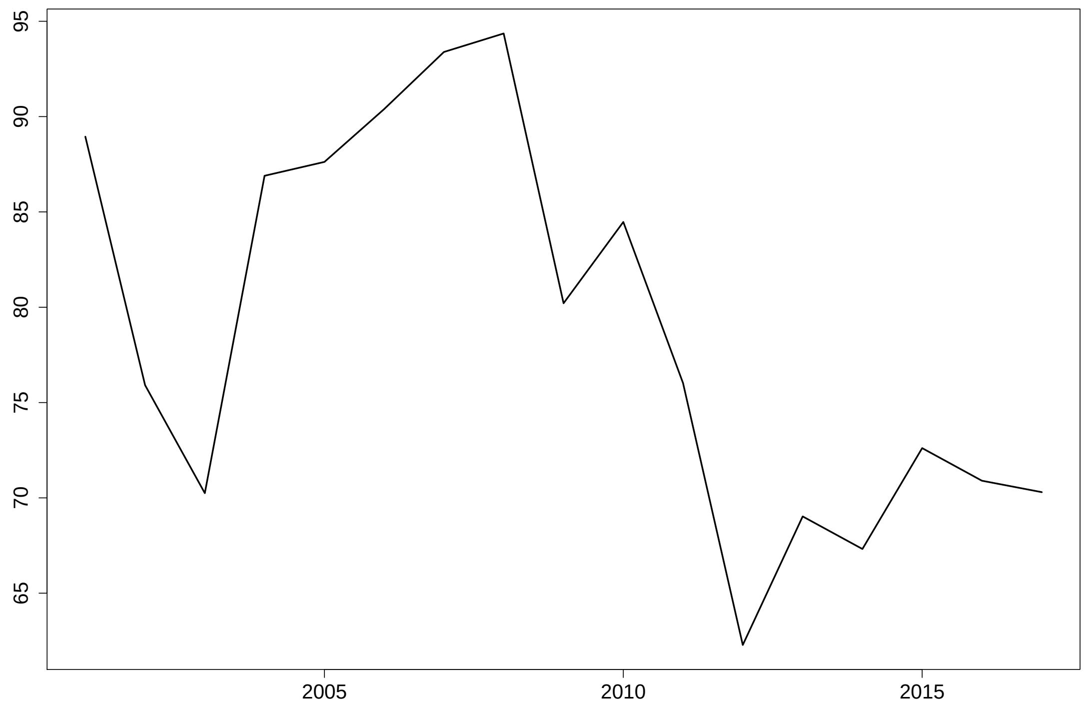

Figure 20: Investment Realization Certainty.

Notes: The figure plot the share of firms that report fairly certain or very certain investment plans.

B Robustness Evaluation & Analysis

B.1 Temporal Disaggregation

In our preferred specification, we construct a monthly Knightian Uncertainty indicator for Switzerland. Thereby, we base the aggregate indicator on eight sectoral indicators of varying frequency (see Table 1). In order to bring all sectoral series to the highest frequency, we rely on temporal disaggregation techniques as described in Section 4. As a robustness check we also compute the Knightian Uncertainty indicator for Switzerland. Figure 21 compares the monthly version of the indicator (red thick line) the its quarterly linearly-interpolated counterpart (black thin line). The quarterly version represents a smooth version of the monthly series. However, during few episodes the temporal disaggregation produces somewhat more pronounced deviation from the linearly-interpolated series. Overall, the two indicators present a very similar picture of uncertainty.

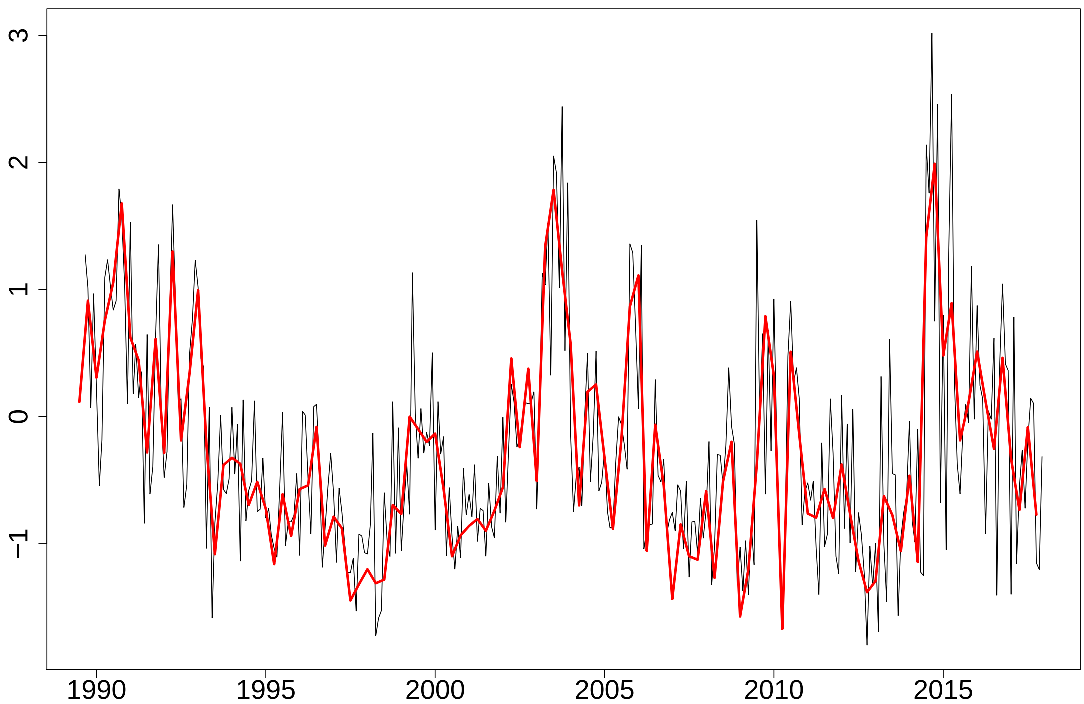

Figure 21: Comparison monthly to quarterly Knightian Uncertainty Indicator (since 1989).

Notes: Comparison monthly to quarterly Knightian Uncertainty Indicator (since 1989). The black thin line depicts the monthly Knightian Uncertainty indicator as described in Section 4. The red thick line presents the quarterly Knightian Uncertainty indicator that does not rely on temporal disaggregation.

B.2 Principal Component Analysis

	1^{st} Component	2^{nd} Component	3^{rd} Component	4^{th} Component
EPU Switzerland	-0.6	0.09	0.29	0.74
DFFE	-0.55	-0.35	0.47	-0.59
Theil Disconformity	-0.53	-0.12	-0.83	-0.09
Knightian Uncertainty	-0.22	0.92	0.04	-0.31
Standard deviation	1.22	1.00	0.90	0.84
Proportion of Variance	0.37	0.25	0.20	0.18
Cumulative Proportion	0.37	0.62	0.82	1.00

Table 10: Principal Component Analysis.

Notes: This table presents the factor loadings and variance analysis of a R-mode Principal Component Analysis. The calculation is done by using eigenvalues on the correlation matrix. EPU represents the News Policy Uncertainty Index, Theil represents Theil's Disconformity Coefficient for expected demand and. DFFE stands for dispersion of firm forecast errors and represents the standard deviation of demand forecast errors by Swiss firms. Knightian Uncertainty represents the Knightian Uncertainty indicator.

References Appendix

Bachmann, R., Elstner, S., and Sims, E. R. (2013). Uncertainty and economic activity: Evidence from business survey data. *American Economic Journal: Macroeconomics*, 5(2):217–249.

Baker, S. R., Bloom, N., and Davis, S. J. (2015). Measuring economic policy uncertainty. Technical report, National Bureau of Economic Research.

Cramer, J. and Theil, H. (1954). *On the Utilisation of a New Source of Economic Information: An Econometric Analysis of the Munich Business Test: the 16th European Meeting OF the Econometric Society Uppsala, Sweden, 1954*. Econometric Society Uppsala.

Mokinski, F., Sheng, X. S., and Yang, J. (2015). Measuring disagreement in qualitative expectations. *Journal of Forecasting*, 34(5):405–426.

Six, I. D. (2013). Volatility index on the smi (vsmi®). Technical report, Six Swiss Exchange Ltd, Selnaustrasse 30, P.O. Box, CH-8021 Zurich. Available at `www.six-swiss-exchange.com/downloads/indexinfo/online/other_indices/vsmi/vsmi_factsheet_en.pdf`. Last accessed July 5th 2016.

Six, I. D. (2014). Guide governing volatility index vsmi®. Technical report, Six Swiss Exchange Ltd, Selnaustrasse 30, P.O. Box, CH-8021 Zurich. Available at `www.six-swiss-exchange.com/downloads/indexinfo/online/other_indices/vsmi/vsmi_rules_en.pdf`. Last accessed July 5th 2016.

Theil, H. (1955). Recent experiences with the munich business test: An expository article. *Econometrica: Journal of the Econometric Society*, pages 184–192.