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Andreas Dibiasi

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No 28 **On the Heterogeneous Effects of Trade and Fiscal Policy**
Katharina Margarete Klara Erhardt

No 29 **Forecasting at the Current Edge – Revisions and Mixed-Frequency Data**
Stefan Gerald Neuwirth

No 30 **Employment Protection and Labor Market Outcomes**
Johanna Mirka Kemper

No 31 **Broader Effects of Migration**
Jan Ruffner

No 32 **The Relationship Between Knowledge Absorption and Innovation Outcomes**
Florian Seliger

No 33 **Four Essays in Wine Economics: An Empirical Approach with Swiss Panel Data**
Alexandre Mondoux

No 34 **The Macroeconomics of Uncertainty**
Andreas Dibiasi

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
kof@kof.ethz.ch
www.kof.ethz.ch
#KOFETH

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The Macroeconomics of Uncertainty

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presented by

ANDREAS DIBIASI

Dipl. oec. in Economics, University of Innsbruck

born on 02.04.1988

citizen of Italy

accepted on the recommendation of

Prof. Dr. Jan-Egbert Sturm, examiner

Dr. Klaus Abberger, co-examiner

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Preface

First and foremost, I would like to thank Professor Jan-Egbert Sturm for his remarks and suggestions on various subjects that were the basis of several revisions. Without his detailed feedback and support alongside the generous flexibility, he provided, I would not have been able to fill this thesis with the substance that it now has. I also want to thank Klaus Abberger. Over the last five years, he has not only been my supervisor but also an excellent mentor. He ensured that I had enough time and resources to conduct my research and provided a great environment. I also would like to thank Professor Marko Köthenburger for his altruism when agreeing to chair my doctoral examination. I also gratefully acknowledge the financial support of the Swiss National Science Foundation.

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Andreas Dibiasi

Contents

List of Figures

List of Tables

Summary of the Thesis

This dissertation studies uncertainty and its consequences on the economy.

Chapter one of this dissertation is devoted to the non-linear effects of uncertainty. Currently, academics brood over the question of why identical uncertainty shocks have more devastating consequences when one occurs during a recession than when one occurs during a boom. Chapter one pursues this question and proposes a theoretical framework that is capable of explaining the non-linear effect of uncertainty. The framework builds on the idea that the negative effects of uncertainty become stronger when the degree of irreversibility increases and illustrates that irreversibility indeed increases during recessions and decreases during booms. The proposed general equilibrium model produces negative effects of uncertainty that are stronger in recessions than in booms.

The second chapter focuses on the measurement of uncertainty. Weak and incomplete measurements of uncertainty are thought to be the main reason for our limited understanding of uncertainty. Chapter two goes back to the early beginnings of uncertainty in economic discussion. It reflects on Frank Knight's early definition of uncertainty and proposes the first direct quantification method of his concept. The new Knightian uncertainty indicator uses firm-level data and is able to trace times of elevated uncertainty and identify uncertainty shocks. Furthermore, this chapter is the first to construct and provide a comprehensive set of uncertainty indicators for Switzerland. Comparing the Knightian uncertainty indicator for Switzerland to alternative measurements of uncertainty reveals that common uncertainty indicators are, against contrary belief, far from identical. In fact, the presented results reveal that most indicators capture a different dimension of uncertainty.

Chapters three and four study two recent events in Switzerland: the unexpected acceptance of the Mass Migration Initiative and the sudden exchange rate appreciation of the Swiss Franc in 2015. These chapters examine the effects of these two events on the investment behaviour of Swiss firms.

As described in Chapter three, the vote put several economically relevant agreements between Switzerland and the European Union (EU) at stake and questioned firms' access to the pool of EU workers. Real option theory predicts that firms that face irreversible investment decisions resort to a wait-and-see behaviour in a situation of temporary increased uncertainty. Firm-level panel data for the 2009-2015 period suggests that the uncertainty shock led to significant downward adjustments in firms' investment. Firms that were exposed to the uncertainty effects of the vote reduced both, investment in equipment and machinery and construction investment in the two years following the vote.

On January 15th, 2015, the Swiss National Bank decided that the fixed exchange rate of the Swiss Franc with the Euro was no longer justified. The subsequent abandonment of the currency peg led to a rapid and strong appreciation of the Swiss Franc against the Euro, by almost 20%. Chapter four exploits this sudden drop in the exchange rate and shows that it led to an increase in uncertainty about the future exchange rate. The study shows that the uncertainty caused by the shock had small negative effects on total investment plans. Although the consequences of the uncertainty shock on total investment were limited, the effects of the shock varied substantially among different investment categories. While the uncertainty shock led to a strong decrease in irreversible investment plans for equipment and machinery, the analysis finds no statistically significant negative effects for planned investment in construction. Finally, estimation results suggest that firms affected by the uncertainty shock intensify their research and development efforts.

Zusammenfassung der Dissertation

Die vorliegende Dissertation beschäftigt sich mit Unsicherheit und ihren volkswirtschaftlichen Auswirkungen. Das erste Kapitel der Dissertation widmet sich dabei der theoretischen Diskussion um mögliche nichtlineare Effekte von Unsicherheit. Mehrere Ökonomen befassen sich aktuell mit der Frage, warum ein Unsicherheitsschock in einer Rezession verheerendere Folgen für eine Volkswirtschaft hat als in einer konjunkturellen Hochphase. Das Kapitel erörtert diese offene Frage und unterbreitet ein theoretisches Modell, welches in der Lage ist, die nichtlinearen Effekte von Unsicherheit abzubilden. Den zentralen Mechanismus des Models bildet die theoretische Überlegung, dass ein höherer Grad an Irreversibilität zu negativeren Auswirkungen von Unsicherheit führt. Im Model erhöht sich der Grad der Irreversibilität in konjunkturellen Tiefphasen und erlaubt dem Model damit Unsicherheitsschocks zu simulieren, welche in einer Rezession deutlich negativere Auswirkungen verursachen als in einer konjunkturellen Hochphase.

Das zweite Kapitel beschäftigt sich mit der Messung von Unsicherheit. Unzureichende Unsicherheitsindikatoren gelten mitunter als Hauptgrund für das aktuell begrenzte Verständnis der Auswirkungen von Unsicherheit. Aus diesem Grund kehrt Kapitel zwei zu den Anfängen der Unsicherheitsdiskussion zurück und befasst sich innig mit dem von Frank Knight im Jahre 1921 vorgeschlagenen Konzept der Unsicherheit. Der zentrale wissenschaftliche Beitrag des Kapitels liegt darin, die erste direkte Quantifizierungsmethode der Knight'schen Unsicherheit zu entwickeln. Der neue Unsicherheitsindikator basiert auf Unternehmensdaten von Konjunkturumfragen und ist in der Lage, Zeiten erhöhter Unsicherheit zu erkennen und einzelne Unsicherheitsschocks zu identifizieren. Im Zuge der Studie wird darüber hinaus eine

umfassende Sammlung von Unsicherheitsindikatoren für die Schweiz erstellt und der Allgemeinheit zur Verfügung gestellt. Ein Vergleich des neuen Unsicherheitsindikators mit alternativen Unsicherheitsmassen zeigt, dass die Unsicherheitsindikatoren, entgegen der gegenteiligen Annahme keineswegs identisch sind. Zudem zeigen die Resultate, dass der neu entwickelte Unsicherheitsindikator eine Dimension von Unsicherheit abgreift, welche die etablierten Indikatoren nicht zu messen vermögen.

Kapitel drei und vier der Dissertation umfassen zwei empirische Studien, welche sich mit zwei aktuellen Schweizer Ereignisse befassen. Die Kapitel analysieren zum einen die Auswirkungen der unerwarteten Annahme der Masseneinwanderungsinitiative und zum anderen die Auswirkungen der Frankenaufwertung vom Jahr 2015.

Kapitel drei untersucht dabei die Auswirkungen der Annahme der Masseneinwanderungsinitiative auf die Investitionen der Schweizer Unternehmen. Die Abstimmung gefährdete mehrere wirtschaftlich relevante Abkommen zwischen der Schweiz und der EU. Gemäss der "Real-Option-Theory" sollte die, von der Abstimmung verursachte Unsicherheit über die zukünftigen rechtlichen Rahmenbedingungen dazu führen, dass Unternehmen irreversible Investitionsentscheidungen aufschieben. Die im Zuge der Studie durchgeführten Paneldatenstudie bestätigt diese These und zeigt, dass der Unsicherheitsschock zu einem erheblichen Rückgang der Unternehmensinvestitionen geführt hat. Unternehmen, die den Unsicherheitseffekten der Abstimmung ausgesetzt waren, reduzierten sowohl ihre Ausrüstungsinvestitionen als auch ihre Bauinvestitionen in den zwei Jahren nach der Abstimmung.

Kapitel vier quantifiziert die Unsicherheitseffekte des SNB Entscheids vom 15. Januar 2015. Am 15. Januar 2015 entschied die Schweizerische Nationalbank, dass ein fester Wechselkurs des Schweizer Frankens gegenüber dem Euro nicht mehr gerechtfertigt sei. Die Aufhebung der Währungsbindung führte zu einer plötzlichen und markanten Aufwertung des Schweizer Frankens gegenüber dem Euro. Kapitel drei nutzt diese plötzlichen Aufwertung und zeigt, dass der SNB Entscheid zu einer Zunahme der Unsicherheit bezüglich des zukünftigen Wechselkurses führte und, dass die von der Unsicherheit betroffene Firmen, ihre Investitionspläne teilweise stark nach unten revidierten.

Introduction

Uncertainty

Uncertainty remains an obscure concept that, to date, literature cannot reconcile into a single definition. In the 1920s, Frank Knight introduced uncertainty into mainstream economic discussion. In his work on Risk, Uncertainty and Profit, Knight drew a fundamental distinction between risk and uncertainty. While risk refers to a state where a person is able to allocate probabilities over future events, uncertainty describes a state in which agents cannot assign probabilities to future events anymore. Today, Knight's concept is often rephrased as a situation in which it is no longer possible to form expectations about the future.

The Cheat with the Ace of Clubs - Georges de La Tour

Source Picture: Commons (1634)

Frank Knight's work shows the ambiguity of the term 'uncertainty'and demonstrates the difficulties in defining it. Down to the present day, the term 'uncertainty'remains polysemous. The multifaceted nature of uncertainty can be illustrated by the painting *The Cheat with the Ace of Clubs* by French Baroque artist Georges de La Tour. First, it depicts a card game, i.e. a game of change with an uncertain outcome. Then, there is the so-called cheat holding his cards behind his back and changing the rules of the game, indicating that the model that the players are using might not quite be the right one. Lastly, there exist two versions of this painting, one in the Louvre and one in Fort Worth, Texas. Rumour has it that only one of them is a real La Tour, showing that we are sometimes not even sure about the actual state of the world.[1]

In economic discussion, economists usually specify, either explicitly or implicitly, their concept of uncertainty. Some refer to uncertainty as the ignorance of future events, while others define it as the second moment of the distribution of future events. Certain economists refer to model uncertainty. Still others consider uncertainty to be about the current state of the economy.

Despite the ambiguity about 'uncertainty'as a term, most economists agree that uncertainty has a real economic effect. The concept of uncertainty introduced in the early 1920s by Frank Knight (1921) has since been established as an essential concept in economics. Although the concept of uncertainty was introduced almost a century ago, until recently, relatively little effort has been made to quantify its effects on the economy. The interest in uncertainty and its consequences has risen since the 80s, and it downright exploded in the aftermath of the Great Recession, the main reason being its assumed influence in significantly shaping the trajectory of the Great Recession (Bloom, 2014). Due to its presumed influence on prolonging recessions, uncertainty is currently a central topic of the economist research agenda. Economic policy uncertainty, i.e. uncertainty that results from political (non-) decisions, is an important source of macroeconomic uncertainty. Compared to alternative sources of uncertainty, such as natural disasters or terrorist attacks, one can, to a varying

[1]All the credit for this comparison goes to Lars Peter Hansen, who, in his 2014 talk on uncertainty, drew my attention to this astonishing analogy (Hansen, 2014a).

degree influence political decision. Hence, the understanding of uncertainty and its consequence is not only relevant from an academic point of view, but also from a policymaker's point of view.

In this thesis, I try to understand uncertainty and study its effects on the economy, thereby trying to increase our understanding of uncertainty along three different dimensions. First, I attempt to increase the theoretical understanding of uncertainty by furthering the knowledge of its non-consequences. Second, I develop an indicator to improve the measurement of uncertainty. Finally, I conduct an empirical analysis to evaluate its effects on firm-level investment. The following three subsections briefly summarize these three dimensions and highlight the contributions of this thesis.

Theoretical Consequences of Uncertainty

A substantial strand of the literature delves into the theoretical consequences of uncertainty. Particularly, the effects of uncertainty on investment are well established. Economists have demonstrated that, in a world without adjustment costs, an increase in uncertainty leads to an increase in investment. Once one introduces adjustment costs, this relationship changes, and an increase in uncertainty leads to a decrease in investment. The central mechanism driving the negative effects of uncertainty and investment is irreversibility. Irreversibility constitutes an adjustment cost that drives a wedge between the buying price and selling price, i.e. one cannot regain the purchase price when reselling an investment.

Currently, academic discussion emphasizes the non-linear effects of uncertainty. Various empirical studies have found that the effect of uncertainty depends on the state of the business cycle. When looking at the data, Caggiano et al. (2014) found that the negative effects of an uncertainty shock are much stronger in a recession than in a boom. However, until now, no theoretical explanation is capable of explaining this observation. In this thesis, I propose a theoretical model that can explain the empirical observation of the non-linear effect of uncertainty. The proposed model builds on the idea that the negative effects of uncertainty become stronger when

the degree of irreversibility increases. Furthermore, I will empirically illustrate that the degree of irreversibility correlates negatively with the business cycle. That is, I will show that irreversibility is higher in an economic downturn, than during an expansionary phase of the business cycle. Finally, the new theoretical model uses the fact of time-varying irreversibility and is thus able to produce the negative effects of the uncertainty shocks that are stronger in recessions than in booms.

Measuring Uncertainty

While its relevance for shaping the trajectory of the Great Recession is certainly the main reason for fuelling academic interest in the effects of uncertainty, the development and construction of various uncertainty indicators has helped to further spur and, in particular, to facilitate research on uncertainty (Bloom, 2014). In order to empirically quantify the effects of uncertainty on the economy, economists rely on a wide range of indicators. These indicators include proxies such as the volatility of financial markets, the disagreement of forecasters, or the number of newspaper articles about uncertainty. Most importantly, the majority of these indicators target the variance of forecasters' predictive distributions by assuming an existing probability distribution over future events. Thus, most indicators approximate the Knightian concept of risk rather than Knightian uncertainty.

This dissertation goes back to the early definition of uncertainty according to Knight and provides a new quantification method for his concept. The method uses business survey data that contains information about firms' expected and realized demand. With this data, we are able to identify the number of firms that are not able to formalize expectations about their future. The proposed indicator is - to my knowledge - the first indicator that directly measures Knightian uncertainty. It turns out that the Knightian uncertainty indicator can trace times of elevated uncertainty and to reasonably identify uncertainty shocks. When comparing this indicator to alternative measurements of uncertainty, we find that various uncertainty indicators are, contrary to what one might think, far from identical. In fact, it appears that every indicator captures a slightly different component of uncertainty. Using

a principal component analysis, we show that the Knightian uncertainty indicator captures a dimension of uncertainty that is orthogonal to all other measurements of uncertainty. That is, the Knightian uncertainty indicator picks up a dimension of uncertainty that alternative uncertainty measurements are not able to capture. We will therefore argue that focusing on one single uncertainty indicator might not be sufficient to properly capture the whole uncertainty of an economy. Finally, we will be the first to construct and openly provide a comprehensive set of uncertainty indicators for Switzerland.

Empirical Evidence of the Effect of Uncertainty

Besides the ambitious task to theoretically explain the consequences of an uncertainty shock on the economy and the art of measuring uncertainty, looking at actual data and estimating the effects of uncertainty on the economy is another challenge. A rich collection of empirical studies has examined the effects of uncertainty on the economy. Although new uncertainty indicators facilitated empirical research, the identification of uncertainty shock remains the central issue of empirical studies. One way to tackle the issue of identification is the use of natural experiments. Here, the exogenous source of uncertainty can be identified. Recently, Jens (2017) and Julio and Yook (2012) used electoral cycles to identify uncertainty, while Baker and Bloom (2013) proposed the use of natural disasters, terrorist events, or policy shocks to identify uncertainty. In this thesis, I will use two events that occurred in Switzerland during the time that I was writing this thesis. I will utilise them as natural experiments and empirically examine the effects of these uncertainty shocks on firm level investment.

The study proceeds as follows. First, I study how the surprising acceptance of a far-reaching popular initiative in Switzerland affected firms' investment plans in the two years following the vote. The vote put several economically relevant agreements between Switzerland and its main trading partner, the EU, at stake, and it questioned firms' access to the pool of EU workers. Similar to the vote on Brexit

and the US presidential elections in 2016, the unanticipated outcome of the referendum created substantial and lasting uncertainty about future economic policy of Switzerland. Real option theory predicts that firms that face irreversible investment decisions resort to wait-and-see behaviour in such a situation of temporary increased uncertainty. Our survey evidence and difference-in-difference-in-differences estimations using firm-level panel data for the 2009-2015 period indeed suggest that this shock led to significant downward adjustments in firms' investment. Firms that were exposed to the uncertainty effects of the vote reduced both their investment in equipment and machinery and their construction investment in the two years following the vote. These negative effects are concentrated among firms that would find it costly to resell their physical capital, which presents difficulties in reversing their investment decisions. The results suggest that the uncertainty created by an unexpected and vaguely formulated amendment in a constitution can immediately reduce firms' investment. However, we also find some evidence that firms facing lower demand or recruiting difficulties, but which are less exposed to the uncertainty effects because of lower investment irreversibility, invested more. This result is corroborated by qualitative survey evidence suggesting that such firms engaged in additional (streamlining) investment.

Besides the unexpected acceptance of the Mass Immigration Initiative, I will use the sudden appreciation of the Swiss Franc in 2015 to quantify the effects of exchange rate uncertainty shock on firm investment plans. On January 15th, 2015, the Swiss National Bank decided that the lower floor of the Swiss Franc vis-à-vis the Euro was no longer justified. The subsequent abandonment of the currency peg led to a rapid and strong appreciation of the Swiss Franc against the Euro by almost 20%. I argue that this sudden appreciation of the exchange rate not only represented a first moment shift in the exchange rate, but also led to an increase in uncertainty surrounding the future exchange rate. Using survey data, we find mixed evidence that exchange rate uncertainty caused by an abrupt change in monetary policy affects firms' investment plans. Uncertainty appears to reduce total investment, but the effect is small and barely significant. We find different effects when we consider disaggregated investment categories. In accordance with real-option

theory, uncertainty strongly decreases irreversible investment in equipment and machinery. However, there are no statistically significant real-option effects for planned investment in construction. Furthermore, estimation results suggest that uncertain firms intensify their research and development efforts, which is in line with previous findings in the literature.

Overall, this thesis consists of four chapters. The first chapter proposes a theoretical framework that explains the non-linear effects of uncertainty. The second chapter suggests a novel indicator capable of measuring Knightian uncertainty. Chapters three and four use natural experiments to empirically evaluate the effects of uncertainty on firm-level investment. Finally, an addendum provides a non-response analysis of business tendency surveys that presents useful insights for the empirical analysis of chapters four and five.

Chapter 1

Non-linear Effects of Uncertainty[1]

1.1 Introduction

The economic literature experienced a surge in studies emphasizing the role of uncertainty in shaping the real economy. The majority of these studies examine the effect of fluctuations in uncertainty on various macroeconomic variables and find that an increase in uncertainty depresses industrial production, investment, consumption and employment.[2] Recently, they started to explore the dependence of the effect of uncertainty shocks on the business cycle. First evidence suggests that the effect of uncertainty might be of non-constant nature and depend on the state of the business cycle. Caggiano et al. (2014) and Nodari (2014) show that financial uncertainty shocks in the U.S. cause much larger effects on unemployment during recessions than during normal times. Caggiano et al. (2017b) show that this result holds true for economic policy uncertainty shocks. Furthermore, Caggiano et al. (2017c) provide empirical evidence that uncertainty spillovers are much stronger in a recession than during a boom. While the literature provides clear empirical evidence that the effect of an uncertainty shock depends on the business cycle, a theoretical explanation is still missing. In this paper I produce a framework that is

[1] This chapter is based on Dibiasi (2018)
[2] For a recent survey of this literature see Castelnuovo et al. (2017).

able to explain the observed dependency of the effect of uncertainty on the business cycle.

While the literature describes alternative channels and mechanisms through which uncertainty affects the real economy, this study focuses on the real option theory and the associated importance of irreversibility. According to real option theory, irreversibility prevents economic agents to take decisions under uncertainty. For instance, an increase in uncertainty delays irreversible business decisions, which in turn depresses investment. This prediction derives from the argument that an economic agent cannot reverse irreversible decisions and has to bear all future costs of its decisions. That is, under full irreversibility a firm cannot resell an investment and has to endure all future costs regardless its success. While full irreversibility might apply for a certain type of investment, i.e. when no second market exists, it is usually the case that firms are able to resell their investment at a discount. Theoretically, the size of the effect of uncertainty on investment depends on the degree of irreversibility.[3] Caballero (1991) provides a framework that demonstrates that an increase in the degree of irreversibility increases the negative effect of uncertainty on investment. Furthermore, Guiso and Parigi (1999), Gulen and Ion (2016), Jens (2016), Abberger et al. (2016) and Binding and Dibiasi (2017) provide empirical evidence that the negative effects of uncertainty are concentrated among irreversible investment.

Economists assume that the degree of irreversibility is constant over time.[4] In this paper I argue that the degree of irreversibility varies with the business cycle by providing evidence that the degree of irreversibility increases in recessionary times and decreases in the expansionary phase of the business cycle. In a first step, I use US

[3]In this study I will model irreversibility as a resale loss, which I defined as one minus the ratio of resale price over buying price. Section 1.2 entails an exhaustive discussion of the concept of irreversibility

[4]Li and Whited (2015) and Lanteri (2016) represent a notable exception. The authors of these studies use endogenous prices for used capital to explain pro-cyclical redistribution of capital.

price indices on new and used cars and trucks to construct a measure of irreversibility. The measure suggests a strong negative relationship between irreversibility and the business cycle. That is, in recessionary times the resale loss appears to be much higher than in expansionary times. In a second step, I present new survey data that supports this evidence. Finally, I use the firm model proposed by Bloom (2009) to jointly estimate labor and capital adjustments cost with time-varying irreversibility. Estimation results show that resale loss is between 5 to 15 percentage points higher during recessionary times than during booms.

After providing empirical evidence for time-varying irreversibility, I enhance the general equilibrium model developed by Bloom et al. (2016) to allow for endogenous irreversibility. In the modified model, the state of the business cycle determines the degree of irreversibility. I use the parameters resulting from the estimated firm model to calibrate the general equilibrium model and show that it produces similar business cycle dependent effects to those observed in by Caggiano et al. (2014), Nodari (2014) and others.

The remainder of this paper is structured as follows. Section 1.2 revisits the relationship between uncertainty, irreversibility and investment. Section 1.3 presents empirical evidence of time-varying irreversibility and demonstrates that irreversibility increases during economic turmoils. Section 1.4 presents the RBC with time-varying irreversibility and Section 1.5 discusses the effects of endogenous irreversibility. Section 1.6 concludes.

1.2 Non-linear Effects of Uncertainty

The negative effects of an uncertainty shock appear to be stronger in recessionary times than in expansionary phases of the business cycle. Caggiano et al. (2014), show that financial uncertainty shocks in the US cause much larger effects on unemployment during recessions than during normal times. The authors present evidence

that there exists a significant difference in the responses of US employment and industrial production to jumps in uncertainty corresponding to particular post-WWII events. The authors further document that monetary policy appears to be less effective in stabilizing the business cycle during downturns than during normal times. Similarly, Caggiano et al. (2017b) show that this result does not only hold for financial uncertainty shocks but is similarly valid for economic policy uncertainty shocks. Nodari (2014) uncovers that the effect of uncertainty shocks resulting from financial regulations on credit spreads, unemployment and industrial production depends on the business cycle. The negative effects tend to be substantially larger during a recession than during a boom. Furthermore, Caggiano et al. (2017c) reveal asymmetries in uncertainty spillovers from the US to other countries. While an uncertainty shock occurring in the US during recessionary times will have negative effects on the Canadian or British economy, uncertainty shocks in US that occur during an expansionary phase of the business cycle are less harmful to other countries.

While the empirical literature appears to agree that the effect of uncertainty depends on the state of the business cycle, a theoretical explanation is still missing. Currently, there exist two approaches that have the potential to explain time-varying effects of uncertainty. First, there exists a string of literature that examines the role of finance-uncertainty multipliers. On the empirical site we have among others, Caggiano et al. (2017a) that estimate a time-varying-parameter VAR with stochastic volatility on US data to show that the magnitude of financial uncertainty shocks on the real economy changes significantly over time. The authors argue that financial uncertainty shocks affect the real economy through financial frictions, which they approximate with excess bond premium à la Gilchrist and Zakrajšek (2012) in their VAR. In a counterfactual exercise Caggiano et al. (2017a) show that once they shut down the financial friction channel, the negative effects of financial uncertainty shocks on the real economy disappear. Gilchrist et al. (2014) and Alfaro et al. (2016) present theoretical frameworks that reveal how financial frictions are able to significantly amplify the negative effects of uncertainty on the real economy. Higher financial friction during a recession could explain why the effect of uncertainty is

stronger during recessions. Second, in a recent attempt to explain the business cycle dependent effects of uncertainty, Castelnuovo and Pellegrino (2017) use a threshold VAR to compute impulse responses of an uncertainty shock in a boom and a bust. The authors use these impulse responses to structurally estimate a new-Keynesian model à la Altig et al. (2011) twice, once fitting the impulse responses by the model to the impulse response of the threshold VAR in the bust and once fitting the impulse responses by the model to the impulse response of the threshold VAR in the boom. Among the parameters they estimate, it is primarily the risk aversion parameter of households that reacts most: In recessionary times households appear to be more risk-averse than in expansionary phases of the business cycle, amplifying the negative effects of uncertainty shocks.

In this paper, I build on a different theoretical argument, i.e. time-varying irreversibility, to explain the observed non-linear effects of uncertainty. Time-varying irreversibility represents one possible mechanism that is able to explain the empirical observation that the negative effect of uncertainty on investment differs depending on the state of the business cycle. Irreversibility represents a type of capital adjustment cost that can be interpreted as a resale loss. It is defined as one minus the expected selling price over buying price.[5]

$$\textbf{Irreversibility} = 1 - \frac{\textbf{E(Selling Price)}}{\textbf{Buying Price}} \tag{1.1}$$

In the literature, we find various types of capital adjustment costs, i.e. convex and non-convex adjustment costs as well as transaction costs, where irreversibility belongs to the latter category. Transaction costs assume that the price of capital is not the same when investing and disinvesting. Instead of one price capital has a buying and a selling price, where the selling price is assumed to be lower than the buying price. This difference in prices is often referred to as irreversibility. The extreme

[5]For a detailed overview of different adjustment costs see Cooper and Haltiwanger (2006) and Bloom (2009).

case of irreversibility assumes a selling price of zero, implying that once capital is acquired it cannot be sold. Irreversibility is a key variable to determine the effect of uncertainty on investment. Pindyck (1988) reveals that the presence of irreversibility influences firm investment behavior. The author assumes full irreversibility and shows that first, irreversibility hampers investment activity during an economic upswing as firms are cautious and anticipate that disinvestment of excessive capacity might not be possible. Second, irreversibility lowers disinvestment in an economic downturn as capacities cannot be sold. Furthermore, Caballero (1991) develops a theoretical framework to demonstrate the negative effects of uncertainty depend on the degree of irreversibility, i.e he shows that a higher degree of irreversibility leads to more negative effects of uncertainty. The literature assumes that the degree of irreversibility is constant over time. However, if irreversibility varies over the business cycle it could explain the non-linear effects of uncertainty. In order for irreversibility to explain the non-linear effects, irreversibility should be low during a booming phase and high during a recessionary face of the business cycle. The rest of this section discusses time-varying irreversibility and provides an intuition why irreversibility might indeed be higher in recessionary times than during expansionary times.

Producers of investment goods sell their merchandise to firms on a primary market. Firms can then resell their investment goods on a second hand market. Thus, investment goods are traded on two separate markets. During an economic downswing firms find themselves in a situation with excessive capacities and try to resell some of their capital in order to avoid overhead costs associated with holding capital. Hence, the supply of investment goods on the second hand market increases driving down resale prices. Additionally, during economic downswings and especially during recessions the number of firms failing and exiting the market increases. This increase leads to a rise of firms trying desperately to resell their investment goods at a discount (fire sales) which in turn further decreases prices on the secondary market. At the same time, prices on the primary market cannot decline to a similar extent as producers need to cover minimal costs. Thus, during an economic downswing prices

decrease more on the secondary market than prices on the primary market, leading to an increase in irreversibility.

Firms are thereby not constrained to purchase their investment on the primary market, but can similarly obtain their investment goods from the secondary market. However, imperfect secondary markets because of adverse selection in which market participants face asymmetric information prevent firms from purchasing second-hand investment goods at the price that is obtained by the selling firms. Additional costs including broker fees to find the adequate investment or inspection costs to ensure quality standards increase the purchasing price on the secondary market. That is, the amount of money that an investing firm pays when buying from the secondary market exceeds the price that is obtained by the disinvesting firm. These additional costs ensure that firms investing from the secondary market will not experience a decrease of irreversibility when switching to the second hand market. Finally, adverse selection is more severe during an economic downturn. Hence, even though selling price on second hand markets fall more in a recession than prices on the first hand market, in a recession investing firms have to pay more to overcome information asymmetries than during a boom.[6]

The degree of irreversibility that a firm faces does not only depend on the state of the business cycle but also on the firm's level of idiosyncratic productivity. A highly productive firm will have less problems to find a adequate buyer that is willing to pay a reasonable price than a low productive firm.

[6]The argument of anti-cyclical adverse selection follows closely the argument made by Li and Whited (2015). Li and Whited (2015) use new and used capital markets as well as anti-cyclical adverse selection to develop a theoretical model that is able to explain pro-cyclical capital reallocation.

1.3 The Empirical Observation of Time-varying Irreversibility

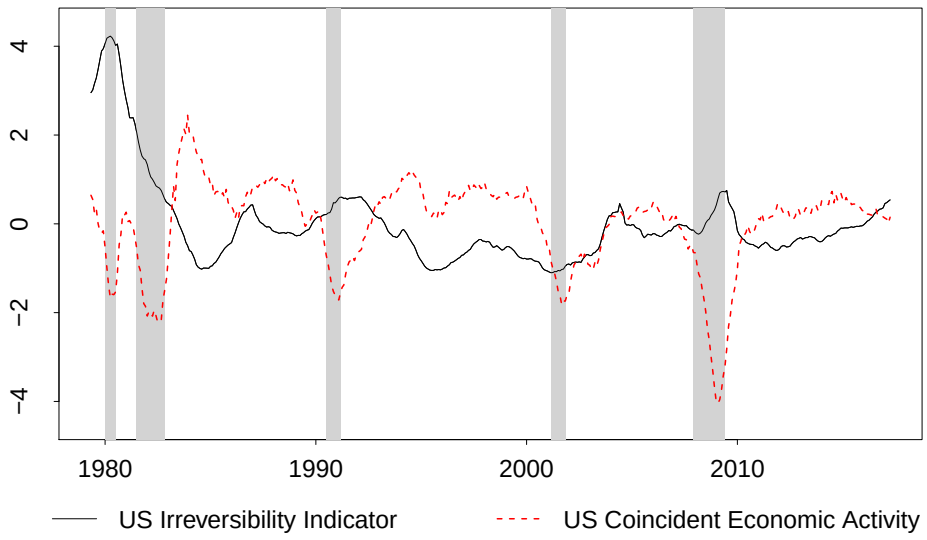
Irreversibility can hardly be observed directly and is hence difficult to measure. Most studies use indirect ways, such as simulated method of moments (SMM), to measure irreversibility. Lanteri (2016) is an exception to it and uses price data of cars, ships, plans and construction machines to show that irreversibility negatively correlates with the business cycle. In this study, I will use three different ways to examine the correlation of irreversibility with the business cycle. First, I rely on price indices of US cars and trucks to approximate irreversibility over time. The measure suggests that irreversibility varies indeed over time and displays countercyclical tendencies. Second, I will use survey data on firms' accessibility to second-hand markets. This approach relies on the idea that limited access to second-hand markets implies a higher degree of irreversibility. The data shows that the access to second hand markets varies over time. Finally, I will estimate the time-varying component of irreversibility with a standard firm model using a simulated method of moments estimator.

Irreversibility is difficult to observe directly. One would need to observe first and second hand prices of the same investment good in order to calculate irreversibility. In addition, to identify a potential time-varying component of irreversibility one would even need to observe these prices over time. In order to obtain at least some direct evidence on irreversibility I use, as in Lanteri (2016), US price indices on new and used cars and trucks to construct an irreversibility indicator as describes in Equation 1.1.[7] While this measure does not tell anything about the absolute value of irreversibility it provides some rough approximation of the time-varying component. Figure 1.1 displays the irreversibility measure over time. The black line

[7]Cars and especially trucks represent a common investment good of firms. According to the Fixed Assets Accounts published by BEA, the asset types *Trucks, buses, and truck trailers* and *Autos* account for 22% of Private Fixed Investment in the US in 2016 (https://www.bea.gov/national/FA2004/TypesEq.pdf).

depicts the irreversibility measure.[8] The red line represents a centered six months moving average of US Coincident Economic Activity Index to approximate the ups and downs in the US business cycle. The index is a composite indicator that includes four US indicators: nonfarm payroll employment, the unemployment rate, average hours worked in manufacturing and wages and salaries. The trend of the index is set to match the trend for gross state product. The correlation coefficient between the series is negative (-0.30) and suggests a negative relationship between the two series.

Figure 1.1: Countercyclical Irreversibility



Notes: This figure relates the indicator of US irreversibility to the US business cycle. The black line represents the irreversibility indicator for the US. The indicator is based on the US consumer price index for used cars and trucks and the US consumer price index for new vehicles. The Federal Reserve Economic Database (FRED) provides the price index on a monthly basis. I seasonal adjust each series and compute an irreversibility measure. The irreversibility indicator has a monthly frequency and starts in December 1953. The red line depicts the "US Coincident Economic Activity". The "US Coincident Economic Activity" represents a composite indicator that includes four statistics: nonfarm payroll employment, the unemployment rate, average hours worked in manufacturing and wages and salaries. The trend of the index is set to match the trend for gross state product. The indicator is available since 1979 on a monthly basis. Both series are demeand and normalized to unit variance.

[8]Appendix A describes the construction of the irreversibility indicator in greater detail and provides various specification of the indicator in order to examine its robustness.

In a descriptive way, Figure 1.1 already indicates that irreversibility varies over time and suggests that it negatively correlates with the US business cycle. Table 1.1 validates this observation within a more statistical context. Table 1.1 shows that the correlation between US irreversibility and three different US business indicators is strongly negative and statistical significant. Model (1) of Table 1.1 regresses the Coincident Economic Activity Index for the United States on irreversibility. Model (2) regresses monthly growth in US industrial production on US irreversibility. Model (3) regresses the growth in monthly nonfarm payroll employment on irreversibility.

Table 1.1: Regression on Irreversibility

	Dependent Variable: Irreversibility		
	(1)	(2)	(3)
US Coincident Economic Activity	-20.322^{***}		
	(2.992)		
US Industrial Production		-6.666^{***}	
		(1.192)	
US Nonfarm Payrolls			-17.728^{***}
			(3.138)
Observations	456	456	456
R^2	0.092	0.064	0.066
Adjusted R^2	0.090	0.062	0.064
Residual Std. Error	0.101	0.102	0.102
F Statistic	46.146^{***}	31.276^{***}	31.914^{***}
Note:			*p<0.1; **p<0.05; ***p<0.01

Notes: This table reports OLS estimation results of three US business indicators on US irreversibility. The dependent variable is the ratio of the US price index of new cars over the US price index of used cars. The variable has monthly frequency and starts in 1979. The variable "US Industrial Production" represents the monthly growth rate of US industrial production. "US Coincident Economic Activity" is a composite indicator that includes four indicators: nonfarm payroll employment, the unemployment rate, average hours worked in manufacturing and wages and salaries. The trend of the index is set to match the trend for gross state product. Finally, the variable "US Nonfarm Payrolls" is a measure of the number of U.S. workers in the economy that excludes proprietors, private household employees, unpaid volunteers, farm employees, and the unincorporated self-employed. This measure accounts for approximately 80 percent of the workers who contribute to Gross Domestic Product (GDP). All estimates include an intercept, but its coefficient are omitted.

Although relying on price indices of new and used cars and trucks provides an interesting experiment, it ultimately represents a very crude way of measuring irreversibility. For various reasons, the indicator might not necessarily reflect the relevant irreversibility for business decisions. First, cars and trucks represent only a fraction of overall investment and second, the first and second hand market of cars and trucks are not confined to firms but are also subject to consumer decisions. Hence, one should take the measure with a large grain of salt.

A completely different approach to measure irreversibility consists in obtaining information on the existence and accessibility of second hand markets for investment goods. The conjecture is that a complete and viable second hand market indicates a lower degree of irreversibility as firms can resell capital rather easily. In 1995 the Bank of Italy included an additional survey question in their Survey of Investment in Manufacturing (SIM) in order to obtain information on the accessibility of second hand markets. The Bank of Italy asked firms whether or not there exists a second hand market for their existing production plants, how long it takes to find a buyer and how high the resale price can be.[9] In Autumn 2014, KOF Swiss Economic Institute added the same question to the standard questionnaire of the KOF Investment Survey.[10] The institute conducts the investment survey for Switzerland on a biannual basis among a large panel of Swiss firms. Up to today, KOF Swiss Economic Institute included this question in four survey waves, i.e. in the autumn 2014 survey (October and November 2014) and in the spring survey from 2015 to 2017, which are conducted in February and March every year. In the spirit of Guiso and Parigi (1999) and other studies exploiting this question[11] I create a binary irreversibility variable that takes value 1 in case a firm states that there exists no second hand market or that there exists a second hand market but it will take a long time to find a buyer and prices can become very low. Formally,

$$\text{Irreversibility}_i = \begin{cases} 1 & \text{if firm i that there exists no second hand market or} \\ & \text{that there exists a second hand market but it will} \\ & \text{take a long time to find a buyer and prices can} \\ & \text{become very low} \\ 0 & \text{otherwise} \end{cases}$$

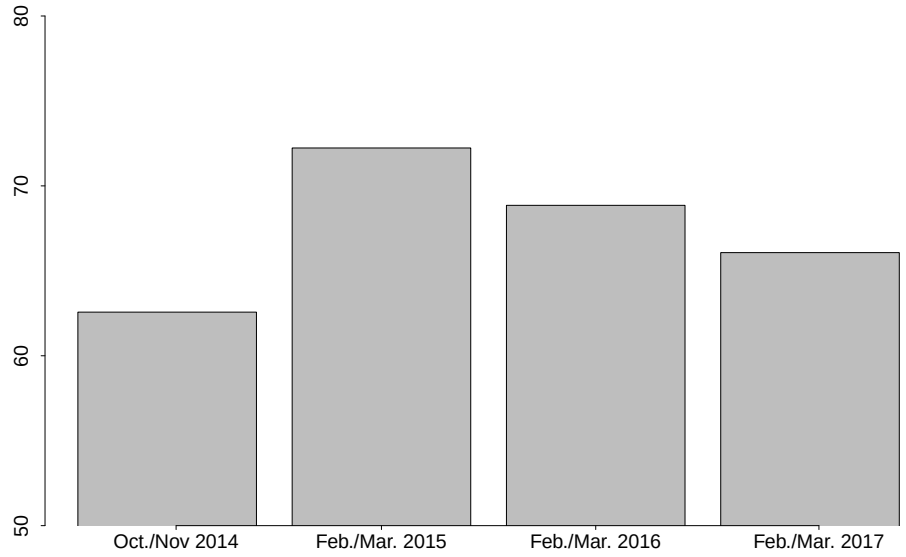
[9] Guiso and Parigi (1999) use this question to demonstrate that the negative effect of uncertainty is stronger among firms with a higher degree of irreversibility.

[10] Appendix A provides the exact wording of the question and additional information on the KOF Investment Survey.

[11] Studies exploiting this question to approximate irreversibility include Abberger et al. (2016) and Binding and Dibiasi (2017).

Figure 1.2 displays the share of firms that report to have irreversible investment according to the equation outlined above. On average 68% of Swiss firms have a limited access to a second hand market. Even though four observations are not enough to conduct a meaningful correlation analysis with other business cycle measures, Figure 1.2 indicates that the share of irreversibility does not necessarily have to be constant over time.

Figure 1.2: Share of Firms with No or Restricted Access to a Second-Hand Market



Notes: This figure presents a survey irreversibility measures in four different points in time, i.e. autumn 2014 (Oct./Nov 2014), spring 2015 (Feb./Mar 2015), spring 2016 (Feb./Mar 2016) and spring 2017 (Feb./Mar 2017). The bars depict the share of firms that state that there exists no second hand market or that there exists a second hand market but it will take a long time to find a buyer and prices can become very low.

In a third step I use a standard firm model to estimate the time-varying component of irreversibility using simulated method of moments (SMM). This part of my study relies heavily on the work of Bloom (2009). In his 2009 paper Bloom proposes a firm model with time-varying second moments to display the effect of uncertainty on the real economy. The model incorporates various kinds of adjustment costs for both labor and capital, including convex, nonconvex and transaction costs, i.e. irreversibility. Bloom (2009) uses this model to jointly estimate labor and capital adjustment costs using an SMM estimation routine. In this paper I modify the model

proposed by Bloom (2009) to allow for time-varying capital irreversibility in order to estimate the time-variation of irreversibility. Using the same SMM estimation routine obtains estimates on the time-varying component of capital irreversibility.

The model proposed by Bloom (2009) represents a firm model in which firms own a fixed number of production plants. Each plant can produce one final good according to a Cobb-Douglas production function which is governed by the level of business conditions as well as by the amount of capital, labor and hours that a firm uses in a given period. In this model, business conditions are a combination of productivity and demand. Bloom (2009) assumes business conditions to follow an augmented geometric random walk with time-varying standard deviation. That is, the standard deviation switches between a large and low standard deviation according to a two-point Markov chain, where a large standard deviation implies a state of high uncertainty and a low standard deviation signifies a state of low uncertainty. Firms react to changes in business conditions by adjusting capital and labor. However, adjusting capital and labor comes at a cost. When adjusting capital and labor, firms face convex, nonconvex and irreversibility costs. Eventually the overall state of the economy is computed by cross-sectional and temporal aggregation. In a simulation exercise various moments are recovered from simulated data (see Table 1.3) and compared to moments observed in real data. In an estimation routine the parameters of the model are chosen in a way that the distance between the moments of the simulated data and the moments observed in the real data is minimized.

The firm model of Bloom (2009) does not model the preference side of the economy. Thus, the model represents a partial equilibrium framework in which prices do not change endogenously. In an ideal world I would use a general equilibrium model that incorporates the household side of the economy to structurally estimate the adjustment costs. However, adding the additional routine of modelling the preference side increases the computation time by the factor of 60 making it too slow for the

SMM routine.[12] The asymmetric nature of the adjustment costs causes jumps in the value function that demand global solution methods. Thus, the model is numerically solved using value function iteration and estimated on firm-level data. Due to lack of space I refrain from reciting the original model. For a detailed description of the model and the exact estimation routine the reader is referred to Bloom (2009). In the rest of this section I will highlight my changes to the original model, present the estimated parameters and conclude by discussing the model fit.

Bloom (2009) models irreversibility as a resale loss. Technically this implies different adjustment costs for positive and negative investment. This means that in case of positive investment a firm faces additional costs equal to the price of capital. However, in the case of disinvestment, i.e. negative investment, the revenue a firm generates by reselling its capital is only a fraction of its value. According to Bloom (2009) the resale loss is approximately one third of the price of capital. Equation 1.2 formally describes capital irreversibility:

$$AC^{irr} = \mathbb{1}(I > 0)I - (1 - C_K^P)\mathbb{1}(I < 0)|I| \tag{1.2}$$

where AC^{irr} covers the part of the overall capital adjustment costs that arises from irreversibility. C_K^P denotes the resale loss as a fraction of the relative purchase price of capital and I denotes the investment of a firm. Bloom (2009) estimates C_K^P to be 33.9%. In order to examine time-varying irreversibility I replace C_K^P with a more flexible version. Particularly, I introduce a fix and a time-varying component of irreversibility. The fix part covers the part of irreversibility that is time invariant C_K^{Pfix}, for instance some sort of physical costs of resale that are independent of the state of the economy. The variable part C_K^{Pvar} covers the part of irreversibility that depends on the state of the economy. Formally:

$$C_{K,t}^P = C_K^{Pfix} + C_K^{Pvar} Y_t \tag{1.3}$$

[12] Solving the partial equilibrium model takes on average five minutes. Solving the general equilibrium model takes on average 5 hours. Currently I do not have the technical resources to estimate time-varying adjustment costs within a DSGE setting.

Plugging in Equation 1.3 in Equation 1.2 gives us irreversible capital adjustment costs with a time-varying component.

$$AC_t^{irr} = \mathbb{1}(I > 0)I - (1 - (C_K^{Pfix} + C_K^{Pvar} Y_t))\mathbb{1}(I < 0)|I| \tag{1.4}$$

In addition to the specification that considers a fix and a time-varying component of irreversibility, I augment the model with a quadratic term. That is, irreversibility has a fix component, a linear and a quadratic time-varying component. Equation 1.5 and Equation 1.6 formally describe this relationship.

$$C_{K,t}^{P} = C_K^{Pfix} + C_K^{Pvar} Y_t + C_K^{Pvar} Y_t^2 \tag{1.5}$$

$$AC_t^{irr^2} = \mathbb{1}(I > 0)I - (1 - (C_K^{Pfix} + C_K^{Pvar} Y_t + C_K^{Pvar} Y_t^2))\mathbb{1}(I < 0)|I| \tag{1.6}$$

I introduce Equation 1.4 into the model and estimate the C_K^{Pfix} and C_K^{Pvar}. Similarly, I estimate a version of the model featuring an additional quadratic term as described in Equation 1.6.[13]

Table 1.2 presents the estimated parameters and compares them with their time-invariant counterparts. The findings support the hypothesis of time-varying irreversibility. First, the constant investment resale loss C_K^{Pfix} amounts to 50.9 and is higher than in the time-invariant version (33.9). The varying component C_K^{Pvar} is negative and estimated to be -20.11. Both coefficients are statistically significant at conventional significance levels.[14] Allowing the level of irreversibility to depend on the state of the business cycle improves the overall fit of the model. The criterion

[13] Description and code of the SMM procedure are still missing, but will follow. I calibrate the model as in Bloom (2009).

[14] I use computational derivations to obtain standard errors for the parameter estimates.

Table 1.2: SMM Parameter Estimation

Estimated Parameters		Constant	Linear	Quadratic
C_K^P:	investment resale loss (%)	**33.9**		
C_K^{Pfix}:	constant investment resale loss (%)		**50.9**	**37.1** (0.1)
C_K^{Pvar}:	varying investment resale loss		**-21.1**	**-58.03** (-0.00)
$(C_K^{Pvar})^2$:	varying investment resale loss			**-160.81** (-0.00)
C_K^F:	investment fixed cost (% annual sales)	1.5	2.0	2.1 (23.02)
C_K^Q:	capital quadratic adjustment cost	0	1.8	1.8 (0.04)
C_L^P:	per capita hiring/firing cost (% wages)	1.8	1.2	1.2 (6.76)
C_L^F:	fixed hiring/firing cost (% sales)	2.1	0.2	0.2 (10.93)
C_L^Q:	labor quadratic adjustment cost	0	0.1	0.1430 (0.01)
σ_L:	baseline level of uncertainty	0.443	0.508	0.508 (0.25)
$\mu_H - \mu_L$:	spread of business conditions growth	0.121	0.0605	0.0558 (1.2168)
$\pi_{H,L}^{\mu}$:	transition business conditions growth	0	0	0 (0.00)
γ:	curvature of hours/wages function	2.093	2.000	2.000 (0.0536)
Criterion of SMM		**404**	**352**	**351**

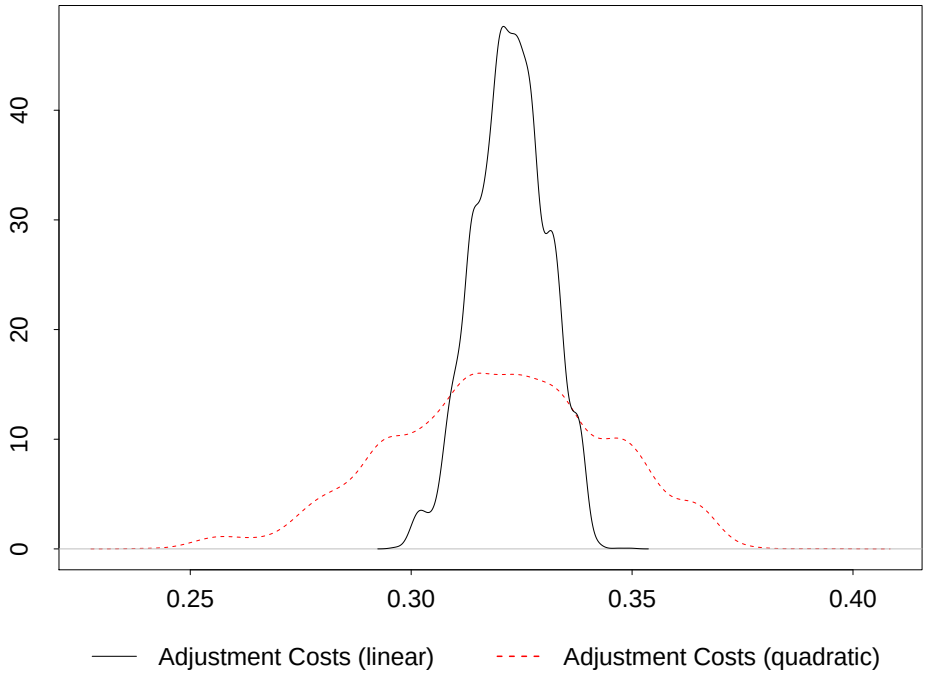
Notes: This table compares SMM parameter estimates of Bloom (2009) to SMM estimates of a more flexible version of Bloom (2009) that allows time-varying irreversibility.

of the SMM estimator, which represents a weighted distance between the simulated moments and the actual moments decreases from 404 to 352 when allowing irreversibility to change with the business cycle. This change is statistically significant.[15] Second, the last column of Table 1.2 reports the parameter estimates of the model that included the quadratic term. Both the coefficients of the linear (C_K^{Pvar}) and the quadratic term ($(C_K^{Pvar})^2$) are negative and statistically significant. This indicates that the relationship of irreversibility and the business cycle might be of a non-linear nature, i.e. in extreme recessions (expansions) the degree of irreversibility might reach extraordinary high (low) levels. However, adding a quadratic term does not lead to a further improvement of the model fit.

The estimation result confirms that the degree of irreversibility varies countercyclically. That is, capital irreversibility C_{Kt}^P is lower in a boom than it is during a bust. Figure 1.3 illustrates how introducing time-variation changes the estimates of irreversibility. In the linear case the resale loss amounts to approximately 30% during a boom and to approximately 35% during a bust. Introducing a quadratic term flattens the distribution of irreversibility such that during a boom the resale loss amounts to 25% percent and during a bust the resale loss increases up to 38%. Note that using the same data set as Bloom (2009) leads to estimates that on average are situated around his estimate of 34%.

[15] The criterion of the SMM estimator follows a χ^2 distribution. The critical value for a 1% significance value and one degree of freedom is 6.64.

Figure 1.3: Time-varying Adjustment Costs



Notes: This figure depicts the distribution of irreversibility. The black solid line displays the distribution of irreversibility in the linear case (see Equation 1.4). The red dashed line displays the distribution of irreversibility in the quadratic case (see Equation 1.6). Technically, the distribution is derived from the output distribution of the model. That is, I recover output from unconditional simulations and derive the level of irreversibility using Equation 1.4 and Equation 1.6. Finally, I estimate a kernel density out of the irreversibility realizations.

Table 1.3 examines the performance of the model, i.e. it compares various characteristics of the data that are generated by the model to characteristics of historical data.[16] Table 1.3 illustrates that introducing time-varying irreversibility increases the model fit significantly from 404 to 351.[17] One would expect that introducing the time-varying irreversibility would especially improve the model fit with respect to the autocorrelation of investment over time. Indeed, Table 1.3 shows that the

[16] Currently, I do not have access to firm data that would allow me to compute the necessary moments. Hence, I need to rely on already existing and published data. In the current version of the paper, I rely on the description of historical data found in Bloom (2009).

[17] The χ^2 value for p-value of 0.95 and 2 degrees of freedom is 5.99.

improved model fit primarily results from an increased ability of the model to produce realistic investment dynamics.

Table 1.3: SMM Moment Comparison

	Data	Constant	Linear	Quadratic
Correlation $(I/K)_{i,t}$ with $(I/K)_{i,t-2}$	0.328	0.060	**-0.0105**	**-0.0090** ↑
Correlation $(I/K)_{i,t}$ with $(I/K)_{i,t-4}$	0.258	0.037	**-0.0330**	**-0.0314** ↑
Correlation $(I/K)_{i,t}$ with $(\Delta L/L)_{i,t-2}$	0.208	0.003	0.0224	0.0236
Correlation $(I/K)_{i,t}$ with $(\Delta L/L)_{i,t-4}$	0.158	â^'0.015	**0.0115**	**0.0126**
Correlation $(I/K)_{i,t}$ with $(\Delta S/S)_{i,t-2}$	0.260	â^'0.023	0.0509	0.0525
Correlation $(I/K)_{i,t}$ with $(\Delta S/S)_{i,t-4}$	0.201	â^'0.010	0.0119	0.0132
Standard deviation $(I/K)_{i,t}$	0.139	â^'0.010	**-0.0035**	**-0.0032** ↑
Coefficient of skewness $(I/K)_{i,t}$	1.789	0.004	0.0046	-0.0070
Correlation $(\Delta L/L)_{i,t}$ with $(I/K)_{i,t-2}$	0.188	â^'0.007	0.0170	0.0179
Correlation $(\Delta L/L)_{i,t}$ with $(I/K)_{i,t-4}$	0.133	â^'0.021	**-0.0000**	**0.0006**
Correlation $(\Delta L/L)_{i,t}$ with $(\Delta L/L)_{i,t-2}$	0.160	0.011	**-0.0053**	**-0.0049** ↑
Correlation $(\Delta L/L)_{i,t}$ with $(\Delta L/L)_{i,t-4}$	0.108	â^'0.013	**-0.0075**	**-0.0071** ↑
Correlation $(\Delta L/L)_{i,t}$ with $(\Delta S/S)_{i,t-2}$	0.193	â^'0.019	0.0258	0.0263
Correlation $(\Delta L/L)_{i,t}$ with $(\Delta S/S)_{i,t-4}$	0.152	0.003	-0.0235	-0.0231 ↑
Standard deviation $(\Delta L/L)_{i,t}$	0.189	â^'0.022	**0.0160**	**0.0161**
Coefficient of skewness $(\Delta L/L)_{i,t}$	0.445	â^'0.136	**0.0206**	**0.0189** ↑
Correlation $(\Delta S/S)_{i,t}$ with $(I/K)_{i,t-2}$	0.203	â^'0.016	0.0261	0.0268
Correlation $(\Delta S/S)_{i,t}$ with $(I/K)_{i,t-4}$	0.142	â^'0.008	**-0.0012**	**-0.0005** ↑
Correlation $(\Delta S/S)_{i,t}$ with $(\Delta L/L)_{i,t-2}$	0.161	â^'0.005	0.0064	0.0069
Correlation $(\Delta S/S)_{i,t}$ with $(\Delta L/L)_{i,t-4}$	0.103	â^'0.015	**0.0021**	**0.0025**
Correlation $(\Delta S/S)_{i,t}$ with $(\Delta S/S)_{i,t-2}$	0.207	â^'0.033	**0.0265**	**0.0270**
Correlation $(\Delta S/S)_{i,t}$ with $(\Delta S/S)_{i,t-4}$	0.156	0.002	-0.0249	-0.0244 ↑
Standard deviation $(\Delta S/S)_{i,t}$	0.165	0.004	-0.0046	-0.0044 ↑
Coefficient of skewness $(\Delta S/S)_{i,t}$	0.342	â^'0.407	**0.3276**	**0.3246** ↑
Criterion of SMM		**404**	**351**	**351**

Notes: This table compares actually observed moments in the data to moments that are recovered from simulated data that are generated by the model. The column "Data" describes the moments observed in the data and are recovered from Bloom (2009). The column "Constant" displays the difference between the moments observed in the data and the moments from model with a constant irreversibility parameter. The column "Linear" displays the difference between the moments observed in the data and the moments resulting from a model with linear time-varying irreversibility (see Equation 1.4). The column "Quadratic" displays the difference between the moments observed in the data and the moments resulting from a model with a linear and a quadratic component of time-varying irreversibility (see Equation 1.6). Bold values emphasize moments where a model with time-varying irreversibility improves with respect to a model with a constant irreversibility parameter. Arrows indicate moments where the model with a linear and a quadratic components improve with respect to a model that considers only a linear component.

The irreversibility index based on price indices, the survey data on the accessibility of second hand markets and the indirect estimation of irreversibility by fitting a model to real data via a minimal distance approach, all point towards the fact that irreversibility is not constant over time but rather varies with the business cycle. A preliminary analysis of the irreversibility index of the US showed that irreversibility appears to vary countercyclically with the business cycle. The SMM estimation confirms this result and suggests that the resale loss might be 5% to 15% higher during recessionary times than during booms.

1.4 Time-varying Irreversibility in a DSGE

In order to study the impact of time-varying irreversibility on the economy in a more structural way I extend a dynamic general equilibrium model such that the degree of irreversibility depends on the state of the business cycle. The model proposed by Bloom et al. (2016) serves as a natural starting point as it already considers a constant degree of irreversibility and allows for changes in uncertainty. The following chapter introduces the model[18] and highlights its extension.

The model considers an economy with a large number of identical households wanting to maximize life-time discounted utility. Each household chooses how much it wants to consume, work and invest in order to maximize its life-time utility. The economy further entails heterogeneous firms that use labor and capital to produce a final good and maximize their life-time discounted value of the firm. Firms are subject to an exogenous process of productivity that has a firm-level and a macroeconomic component. Furthermore, the productivity process varies in the first and second moment over time. Firms react to changes in productivity by adjusting capital and labor. However, adjusting labor and capital comes at a cost, that varies over the business cycle.

[18] The foundation of the model is identical to the model in Bloom et al. (2016). Hence, large parts of this chapter echo chapter three and four of Bloom et al. (2016).

I will begin building the model by introducing the aggregate demand side of the economy. I will then continue with the description of the supply side of the model. In this part I will introduce time-varying irreversibility and show how I endogenize irreversibility so that it depends on the state of the business cycle. I will subsequently discuss the equilibrium conditions of the model and briefly outline its solution. Finally, I will elaborate on the calibration of the model. I conclude with a discussion of the model's ability to replicate US business cycle statistics.

1.4.1 The Aggregate Demand Side

The demand side of the model features a large number of identical households (normalized to 1), which maximize their discounted life-time utility (W). Formally, the maximization problem of the household can be expressed as

$$W(A, \sigma^A, \sigma^Z, \mu) = \max_{C,N,\psi'} \left\{ U(C,N) + \beta E \left[W(A', \sigma^{A'}, \sigma^{Z'}, \mu') \right] \right\} \tag{1.7}$$

subject to the joint distribution of firm-level productivity and firm-level capital stocks and hours worked (μ) and the usual budget constraint (see equation (1.8)) that states that households expenditures on consumption and investment[19] cannot exceed total income, i.e. labor and capital income.

$$\begin{aligned} C + \int q(k', n, z; A, \sigma^A, \sigma^Z, \mu) d\psi'(k', n, z) \\ \leq w(A, \sigma^A, \sigma^Z, \mu) N \int \rho(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu) d\mu(k, n_{-1}, z) \end{aligned} \tag{1.8}$$

Households are assumed to have an instantaneous utility function which is separable across consumption and hours worked. This assumption entails three implications: First, today's household utility arises only from what they consume today. Hence, today's utility is independent from past and future consumption. Second, a household's utility only depends on its own consumption and is independent of the consumption of other households. Third, separability across consumption and

[19] Households can buy shares of firms that they can hold for one-period.

hours worked ensures that the marginal utility of consumption does not depend on the level of hours worked, and vice-versa. Formally, the utility function is defined as

$$U(C_t, N_t) = \frac{C_t^{1-\eta}}{1-\eta} - \theta \frac{N_t^{\chi}}{\chi} \tag{1.9}$$

where η is the intertemporal elasticity of substitution in consumption and χ is the Frish elasticity of labor supply. θ governs how much time households work in the non-stochastic steady state.

1.4.2 The Aggregate Supply Side

The supply side of the model features a large number of heterogeneous firms that use labor and capital to produce a final good and seek to maximize the life-time value of their firm.

Productivity Process

The state of the business cycle is determined by an exogenous productivity processes. Firms face two different productivity processes: one that captures the macroeconomic (A_t) and one that captures the firm-level ($z_{j,t}$) component. Both follow an autoregressive process according to Equations (1.10) and (1.11). The macroeconomic productivity process as well as the firm-level productivity process experience unpredictable first moment innovations through ϵ.

$$log(A_t) = \rho^A log(A_{t-1}) + \sigma_{t-1}^A \epsilon_t \tag{1.10}$$

$$log(z_{j,t}) = \rho^Z log(z_{j,t-1}) + \sigma_{t-1}^Z \epsilon_{j,t} \tag{1.11}$$

Furthermore, the standard deviation of the shock distribution from which ϵ is drawn switches between a high (σ_H) and a low (σ_L) state according to a two-state Markov process.

Technology

All firms are endowed with a Cobb-Douglas production technology featuring decreasing returns to scale. Given the current level of macroeconomic (A_t) and firm-level ($z_{j,t}$) productivity, firms choose the optimal level of capital ($k_{j,t}$) and labor ($n_{j,t}$) to produce a final good ($y_{j,t}$).

$$y_{j,t} = A_t z_{j,t} k_{j,t}^{\alpha} n_{j,t}^{v}, \;\; a + v < 1 \tag{1.12}$$

In addition, firms' capital and labor stocks evolve according to the following laws

$$k_{j,t+1} = (1 - \sigma_k) k_{j,t} + i_{j,t} \tag{1.13}$$

$$n_{j,t+1} = (1 - \sigma_n) n_{j,t} + s_{j,t} \tag{1.14}$$

where σ_k represents the capital depreciation rate and σ_n represents the natural exit rate of employees. $i_{j,t}$ comprises firm j investment in period t. $s_{j,t}$ entails firm j labor adjustment in period t.

Adjustment Costs

Firms adjust capital and labor in order to react to changes in productivity. However, adjusting capital and labor comes at a cost that firms have to take into account when maximizing their firm value. The model considers two types of capital adjustment costs. First, it incorporates fixed costs that arise each time a firm adjusts capital regardless of how much it adjusts its capital stock. The model further considers partial capital irreversibility. The way I model capital irreversibility represents a central innovation of this model in this paper. In contrast to former papers I separate irreversibility into a constant and a variable part. While the constant part does not vary over time, the variable part fluctuates with the business cycle. Equation (1.15) formally describes capital adjustment costs with the first term capturing fixed capital adjustment costs and the second term capturing capital irreversibility.

$$AC^k = \mathbb{1}(|i| > 0)y(z, A, k, n)C_K^F + \frac{\left(C_K^{Pfix} - C_K^{Pvar}y(z, A, k, n)\right)}{A^\iota}|i|\mathbb{1}(i < 0) \quad (1.15)$$

Besides capital adjustment costs, the model includes also two types of labor adjustment costs (AC^n). Firms face fixed and linear costs when adjusting labor. Fixed costs represent a lump sum cost that arises when employees are fired or hired. This cost does not depend on size of the adjustment but on the state of the economy. One can think these costs to result from a deficiency of production that arise, when an experienced employee leaves the company or a new employee enters the company. In contrast to fixed costs, linear costs depend on the size of the labor adjustment. These costs include among others recruiting and training costs for new employees and severance payment when laying off employees. Note that in contrast to capital adjustment costs, labor adjustment costs are symmetric, i.e. firms face the same costs when increasing or decreasing their labor force.

$$AC^n = \mathbb{1}(|s| > 0)y(z, A, k, n)C_L^F + |s|C_L^P w \quad (1.16)$$

The Firm's Value Function

The objective of a firm is to maximize its discounted life-time value. The maximization problem of the firm can be summarized as follows

$$\begin{aligned} V(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu) = \max_{i,n}\{y - w(A, \sigma^A, \sigma^Z, \mu)n - i - \\ AC^K(k, n_{-1}, z, k^{'A}, \sigma^Z, \mu) - AC^n(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu) + \\ E[m(A, \sigma^A, \sigma^Z, \mu; A^{'}, \sigma^{A'}, \sigma^{Z'}, \mu)V(k^{'}, n, z^{'}; A^{'}, \sigma^{A'}, \sigma^{Z'}, \mu^{'})]\} \end{aligned} \quad (1.17)$$

where firms maximize their life-time value under the consideration of the law of motion of the joint distribution of firms idiosyncratic productivity, capital and labor, denoted by μ. m represents the stochastic discount factor.

$$\mu = \Gamma(A, \sigma^A, \sigma^Z, \mu) \quad (1.18)$$

1.4.3 Equilibrium and Solution

The definition of the recursive competitive equilibrium of this model requires the following functions: i) a set of quantity functions $\{C, N^s, \Psi, K, N^d\}$, where C and N^s represent the household consumption and labor supply functions. Ψ determines the policy function and, K and N^d represent the firm's capital and labor demand functions; ii) a set of pricing functions $\{w, q, \rho, m\}$, where the function w determines the wage and q determines the price per share. The function ρ defines the resale value of investment and m represents the stochastic discount factor; iii) value and utility functions $\{V, W\}$, where V represents the firm's lifetime value function and W represents a household's lifetime utility function.
We can use V and $\{K, N^d\}$ to solve the firm's problem described in Equation (1.17) and use W and $\{C, N^s, \Psi\}$ to solve the household's problem described in Equation (1.7). Furthermore, in equilibrium we need asset, goods and labor markets to clear. The asset market clearing condition is given by

$$\mu^{'}(k^{'}, n, z^{'}) = \int \psi^{'}(k^{'}, n, z) f(z^{'}|z) dz, \tag{1.19}$$

which implies that the amount of shares purchased corresponds to the expected state of the economy tomorrow according to the law of motion for the joint distribution of firm-level productivity, capital, and hours. The goods market clearing condition is given by

$$\begin{aligned} C(\psi, A, \sigma^A, \sigma^z, \mu) = \int [Azk^{\alpha} N^d(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu)^{\nu} \\ -(K(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu) - (1-\delta_k)k) - AC^k(k, K(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu)) \\ -AC^n(n_{-1}, N(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu))] d\mu(k, n_{-1}, z), \end{aligned} \tag{1.20}$$

which implies that the amount of goods consumed is equal aggregate output minus investment and adjustment costs. The labor market clearing condition is given by

$$N^s(\psi, A, \sigma^A, \sigma Z, \mu) = \int N^d(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu) d\mu(k, n_{-1}, z), \tag{1.21}$$

which implies that labor demand is equal labor supply. Finally, the joint distribution of firm-level productivity, capital, and hours (Γ) must be consistent. This means that $\Gamma(A, \sigma^A, \sigma^Z, \mu)$ is formed by the factor demand for labor and capital, i.e. $N^d(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu)$ and $K(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu)$, the exogenous stochastic evolution of technology process, i.e. A, z, σ^Z and σ^A, together with the firms optimal choices of capital and hours worked considering the current state variables.

The heterogeneous agent model is solved using the generalized version of the Krusell-Smith algorithm proposed by Khan and Thomas (2008).[20] The Krusell-Smith algorithm - although computationally burdensome - produces a high internal accuracy compared to alternative solution such as the parametrized distribution algorithm by Algan et al. (2008) or the explicit aggregation method by Den Haan and Rendahl (2010).[21] Due to the lack of space, I refrain from a detailed discussion of the solution and refer the reader to Appendix B for an outline of the solution.

1.4.4 Model Calibration and Performance

In order to ensure comparability with Bloom et al. (2016) and the RBC literature in general I do not deviate from a standard calibration of the model except when setting the fix and time-varying component of irreversibility. Table 1.4 presents the parameters that I use to calibrate the model.

[20] Khan and Thomas (2008) expand the method proposed by Krusell and Smith (1998) to models with incomplete markets. The authors also constitute the general equilibrium aspiration of the solution on a bounded rationality approach.

[21] See Terry (2017) for in-depth comparison of solution methods for heterogeneous agent models.

Table 1.4: Model Calibration

Parameter	Description	Value	Meaning
β:	household's discount rate	0.987	$0.95^{0.25} = 0.987$: The household's discount rate matches annual interest rate of 5%
η:	elasticity of inter-temporal substitution	1	
χ:	wage / price relationship	1	
θ:	working time in non-stochastic steady state	2	households work one third of their available time
δ_k:	annual capital depreciation rate	0.026	10% annual capital depreciation rate.
δ_n:	annual exogenous quit rate	0.088	annual exogenous quit rate to 35%.
$\aleph$:	exponent capital production function	0.25	
ν:	exponent capital production function	0.5	
C_K^F:	investment fixed cost (% annual sales)	0	
C_L^F:	fixed hiring/firing costs (% sales)	0.096	
C_L^P:	per capita hiring/firing cost (% wages)	0.072	
C_K^{Pfix}:	constant investment resale loss (%)	0.50	
C_K^{Pvar}:	varying investment resale loss	0.2011	
ι:	irreversibility scaling parameter	2	
ρ^A:	aggregate productivity autocorrelation	0.95	
ρ^Z:	idiosyncratic productivity autocorrelation	0.95	

Notes: This table presents the model calibration and parameter choices. The calibration reflects a quarterly calibration of the model and is based on Bloom et al. (2016).

Besides the parameter presented in Table 1.4, I calibrate the two-state Markov process switching probabilities of the uncertainty process according to estimates

provided by Bloom et al. (2016). The authors estimate that an uncertainty shock occurs on average with a probability of 2.6%. Once an uncertainty shock occurs it persists with a probability of 94.3% (see Table 1.5). Hence, if an uncertainty shock occurs, we will remain in a state with high uncertainty with a probability of 97.4%. Finally, if we find ourselves in a state of low uncertainty, we will remain in that state with a probability of 97.4%.

Table 1.5: Two-State Markov Process Switching Probabilities of Uncertainty

		Period t+1	
		σ_L	σ_H
Period t	σ_L	97.4	2.6
	σ_H	5.7	94.3

Notes: This table contains the estimated transitions probabilities of the two-state Markov process that determines the level of uncertainty. The estimate stems from Bloom et al. (2016).

In order to evaluate the performance of the model I compare the model statistics to US business cycle statistics. Table 1.6 confers moments of US GDP, investment, consumption and hours worked (left panel) to the moments produced by the model (right panel). The first column of each panel display the standard deviation of each series. The second column display the standard deviation of a series relative to the standard deviation of output. Finally, the last column states the contemporaneous correlation of a series with output. The values in parentheses in the right panel show the moments of the model with constant irreversibility. We see that introducing time-varying irreversibility improves the model with respect to the relative volatility of the components to GDP. However, the model with time-varying irreversibility does not necessarily produce better results in terms of the correlation of the simulated series with simulated output. The correlation (ρ) of consumption and especially of hours is much lower in a model constant with irreversibility than in a model with time-varying irreversibility.

Table 1.6: Business Cycle Statistics vs Model Statistics

	Data			Model		
	σ	σ/σ(Output)	ρ	σ	σ/σ(Output)	ρ
Output	3.60	1.00	1.00	2.07 (2.0)	1.00 (1.0)	1.00 (1.0)
Investment	9.46	2.63	0.75	8.82 (11.9)	4.27 (6.0)	0.84 (0.5)
Consumption	3.23	0.90	0.90	1.56 (0.9)	0.75 (0.4)	0.79 (0.9)
Hours	5.33	1.48	0.62	2.96 (2.4)	1.43 (1.2)	0.12 (0.8)

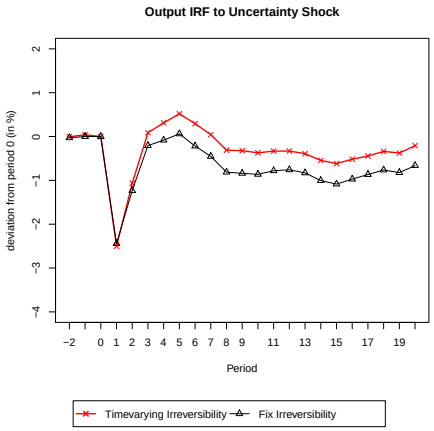
Notes: This table compares actually observed moments in the data to moments that are recovered from simulated data that are generated by the general equilibrium model. The first three columns display business cycle statistics from quarterly U.S. data from 1947Q2 to 2017Q2. The second three columns display moments recovered from simulated data from the model with time-varying irreversibility. The figures in parentheses display the moments from a model with constant irreversibility (see Bloom et al. (2016)). σ denotes the standard deviation. $\sigma/\sigma(Output)$ states the standard deviation relative to the standard deviation from output. ρ states the correlation with output. All series are modified the following way: First, I take the logarithm of each series. Second, I apply an HP-filter with a smoothing parameter of 1600 to recover the trend component of each series. Finally, I take the first difference of each series. All US business cycle data are taken from the FRED database. Following Bloom et al. (2016) I use real gross domestic product (GDPC1), real gross private domestic investment (GPDIC1), real personal consumption expenditures (PCECC96) and hours worked of all persons in the nonfarm business sector (HOANBS).

1.5 Consequences of Time-varying Irreversibility

We can use the model of Section 1.4 as a laboratory and study the consequences of time-varying irreversibility. In a first step, we can compare the effects of a pure uncertainty shock under constant irreversibility to the effects of an uncertainty shock under time-varying irreversibility. Figure 1.4 shows the impulse response of output to an uncertainty shock. The red line with crosses depicts the response of output to an uncertainty shock under time-varying irreversibility. The black line with triangles shows the response of output to an uncertainty shock under fixed irreversibility. The effect of an uncertainty shock on output does not substantially change between the two models because at the point when the shock occurs both models are in the steady state. In the steady state the level of irreversibility is approximately the same in the two models. Figure 1.5 shows the impulse response of investment to an uncertainty shock. The red line with crosses depicts the response of investment to an uncertainty shock under time-varying irreversibility. The black line with triangles shows the response of investment to an uncertainty shock under fixed irreversibility. As in the case of output, the reaction of investment to an uncertainty shock does not vary

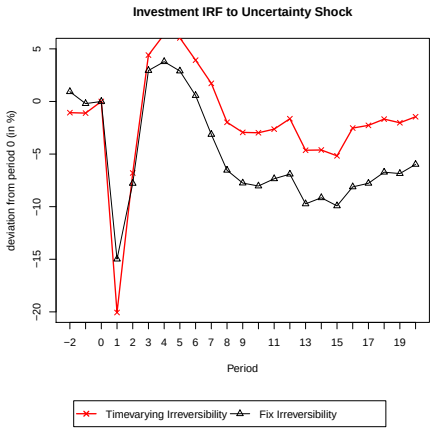
much between fix and time-varying irreversibility. In the case of fixed irreversibility, the case described by Bloom et al. (2016), investment drops by about 15 percentage points in the period after the shock occurs, recovers within the following two quarters and enters into the second decline at quarter six. Time-varying irreversibility slightly amplifies the drop and rebound of investment. We observe a decline of investment by 17% in the first quarter and a slight overshoot in quarter three to five. From quarter six onwards, investment enters the double-dip and declines again.

Figure 1.4: IRF of Output



Notes: The figure compares the response of output to an uncertainty shock under fixed irreversibility to the response of output to an uncertainty shock under varying irreversibility.

Figure 1.5: IRF of Investment



Notes: The figure compares the response of investment to an uncertainty shock under fixed irreversibility to the response of investment to an uncertainty shock under varying irreversibility.

The empirical literature relies on non-linear VARs to compute generalized non-linear impulse response functions (GNIRFs) à la Koop et al. (1996) in order to study the effects of uncertainty. In these non-linear VARs, researcher use an estimated transition function that indicates the probability of an economy being in an expansionary phase of the business cycle. Generalized non-linear impulse response functions are then impulse response functions conditional on the value of the transition function. Similar to the empirical literature, I compute GNIRFs within the DSGE model. While the empirical literature has to estimate the non-observed state of the economy, one can exogenously determine the state of the economy in the theoretical

model.[22] Equation (1.22) defines the generalized impulse response function for this paper. Its value hinge on h, i.e. the number of periods in the future, the level of uncertainty (σ_t) and the state of the business cycle, that in the model is defined through the state of productivity A_t.

$$GIRF(h, \sigma, A_t) = E\left\{X_{t+h}|\sigma_t = \sigma^H, \sigma_{t+h} = \tilde{\sigma}_{t+h}, h > 0, A_t\right\} - E\left\{X_{t+h}|\sigma_t = \sigma^L, \sigma_{t+h} = \tilde{\sigma}_{t+h}, h > 0, A_t\right\} \quad (1.22)$$

The objective of the paper is to provide a theoretical framework that explains the different effects of an uncertainty shock in the boom and in the bust. Hence, I compute impulse responses on two different states. First, I compute impulse response function of an uncertainty shock in the boom and second I calculate impulse response function of an uncertainty shock in a bust.

Figure 1.6 reveals that an uncertainty shock can cause two very different responses of output depending on whether the uncertainty shock occurs in a boom or in a recession. While the initial response of output to an uncertainty shock is more severe in a bust than in a boom, an uncertainty shock in the boom appears more harmful in the medium term than an uncertainty shock in the bust.

The reason for this observation is the following. An uncertainty shock increases the transition probabilities of the productivity process. Hence, the uncertainty shock causes the level of productivity to return quicker to its steady state compared to its counterfactual. This implies that an uncertainty shock in the recession helps the economy to return to its normal state as it decreases the persistence of the technology shock. In a boom, the decrease in persistence causes the economy to exit the

[22] The details of the exact implementation of GNIRF within the DSGE model are included in Appendix B.

booming phase quicker than compared to a situation in which no uncertainty shock occurs.[23]

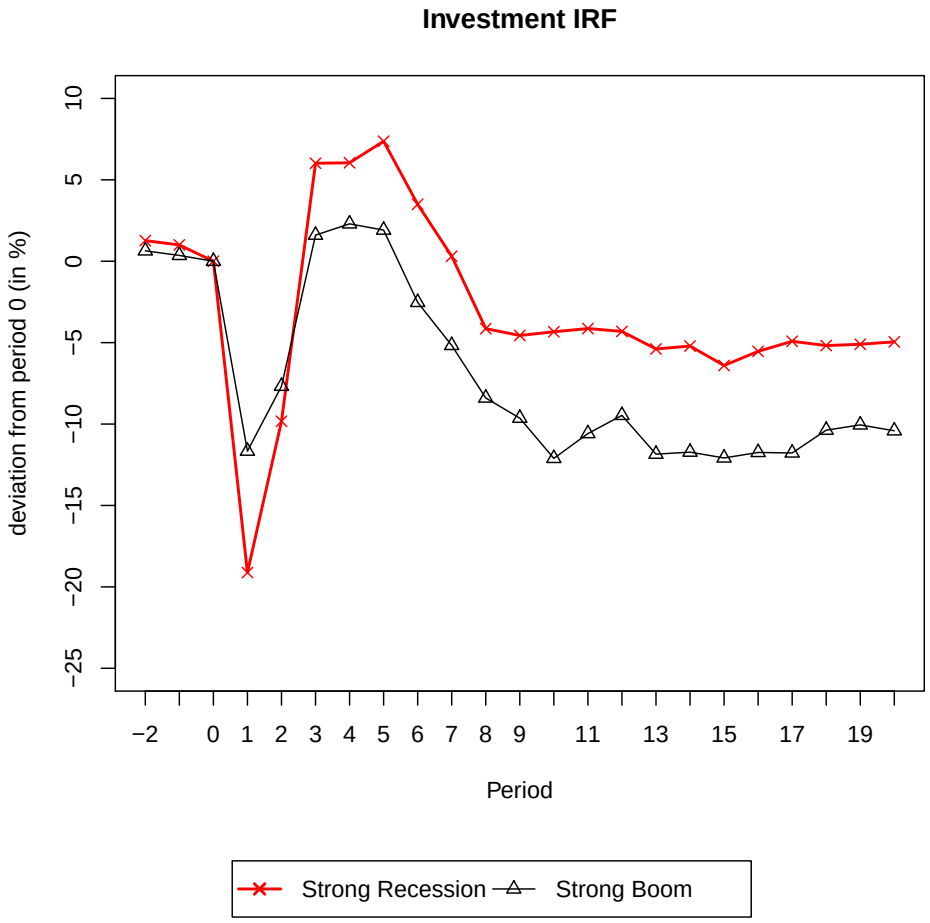
Figure 1.6: GIRF Output

Notes: The figure compares the response of output to an uncertainty shock that occurred during a recession to the response of investment to an uncertainty shock that occurred during a boom.

[23] Appendix B discusses the higher switching probabilities (Table A.2) and displays the difference between the evolution of a first moment shock under high and low uncertainty (Figure A.2).

Figure 1.7 depicts how uncertainty affects investment differently in a boom and bust. Figure 1.7 shows that there exist substantial differences in the response of investment to an uncertainty shock. While an uncertainty shock during a recession leads to an a drop in investment of more than 20%, the same uncertainty shock reduces in a boom reduces investment only little more than 15%.[24]

Figure 1.7: GIRF Investment



Notes: The figure compares the response of investment to an uncertainty shock that occured during a recession to the response of investment to an uncertainty shock that occurred during a boom.

[24]Figure A.3 and Figure A.4 in Appendix B presents the impulse responses of additional variables.

1.6 Conclusion

Recent empirical studies show that the effect of an uncertainty shock are non-linear. The results of this studies suggest that the effect of an uncertainty shock on the economy are weaker during a boom than they are during a recession. While the negative effects of an increase in uncertainty are still present during an expansionary phase of the business cycle, the negative effects are far less severe. In this study I complement these empirical findings by producing a theoretical framework that is consistent with those findings. In a first step, I show that the irreversibility component of capital adjustment cost are not constant over time, but vary with the business cycle. In a second step, I argue that time-varying irreversibility might play a role in explaining the non-linear effects of uncertainty. Finally, I augment a general equilibrium model that accounts for time-varying irreversibility and asymmetric adjustment costs and show that it produces a behavior that is largely in line with recent empirical observations.

Chapter 2

Knightian Uncertainty[1]

2.1 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

[1]This chapter is based on Dibiasi and Iselin (2018)

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 2.2 revisits the most common approaches to measure economic uncertainty. Section 2.3 provides a definition of Knightian Uncertainty. In Section 2.4, we construct the Knightian Uncertainty indicator for Switzerland. In Section 2.5, we compare the common uncertainty indicators with the new Knigthian indicator and examine their impact on the investment. Section 2.6 concludes.

2.2 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.

2.2.1 Disagreement, Disconformity and Discord

One of the most established approaches to measure uncertainty builds upon the use of disagreement in expectations.[2] 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

[2]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.

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.[3] Using data from the Bank of England's Survey of External Forecasters, 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)

[3]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.

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 2.2.4 below).

2.2.2 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.

2.2.3 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.

2.2.4 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. (2014b) 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).

2.2.5 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.[4] 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

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

changes in leverage. Similar concerns have been brought forwards by various studies.[5] 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.[6] 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.

2.3 Measuring Knightian Uncertainty

Knight (1921) is believed to be the creator of the modern concept of uncertainty (Bloom, 2014).[7] 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

[5]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.
[6]See Shiller (1981) for a discussion on "excess volatility".
[7]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.

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.[8]

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,[9] 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.[10]

[8] Baumgaertner and Engler (2016) and Neufeld (2015) suggest that Knightian Uncertainty in mathematical finance can be modelled by considering a set of different probability measures rather than fixing a unique law for a price process, are exceptions.

[9] 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).

[10] 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

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.

$$y(x_{i,t}) = \begin{cases} 1 & \text{if firm i is able to provide information on variable } x \text{ in period t} \\ 0 & \text{otherwise} \end{cases} \tag{2.1}$$

Then Knightian Uncertainty in period t is defined as follow

$$Knight_t = \frac{\sum_i^N \mathbb{1}(y(E(x^{t+1})_{i,t}) = 0) | y(x_{i,t}^{t-1}) = 1)}{\sum_i^N \mathbb{1}(y(x_{i,t}^{t-1}) = 1)} \tag{2.2}$$

where x refers to demand.

2.4 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 2.1 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 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

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.

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.

Table 2.1: Sectors Covered by Uncertainty Indicators in this Study.

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	

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 2.1 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.[11]

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

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.[12]

In a first step, we construct the Knightian Uncertainty indicator for every survey according to Equation 2.2. 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.[13] There exists various ways to interpolate the missing months of the quarterly series. Beside keeping the quarterly

[11] 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.

[12] 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.

[13] In Appendix B.2.1, 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.

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.[14] 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 2.2 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.

Table 2.2: Temporal Disaggregation and Retrapolation

(1) Description	(2) Temporal Disagg. using	(3) Temporal Disagg. from	(4) Retrapolation using	(5) Value added (2015) Mio. CHF	(6) 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%

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

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

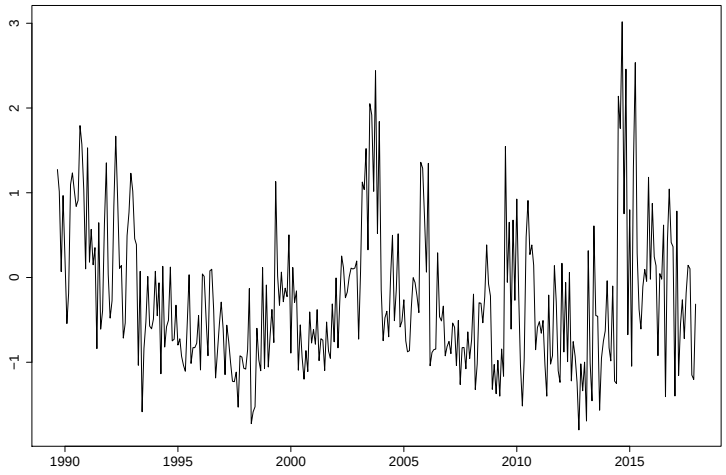
a sectoral indicator. Column (4) of Table 2.2 indicates which indicator was used to retrapolate a series. All series are retrapolated until September 1983, i.e. the start of the earliest indicator.[15]

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 2.2 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.[16]

[15]The aggregate Knightian Uncertainty indicator does change substantially if we transform quarterly to monthly series by keeping the quarterly values constant for each month and retrapolate using the long-term mean of each series.

[16]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.

Figure 2.1: Knightian Uncertainty Indicator (since 1989)



After aggregating, we demean and normalize the indicator to unit-variance. Figure 2.1 presents the Knightian Uncertainty indicator for Switzerland since 1989.[17] 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

[17] 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 2.1.

(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 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.

2.5 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.[18] We will then continue with the comparison by graphically and statistically comparing the Knightian Uncertainty indicator to alternative measures.

[18] 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.

Dispersion of Professional Forecasts

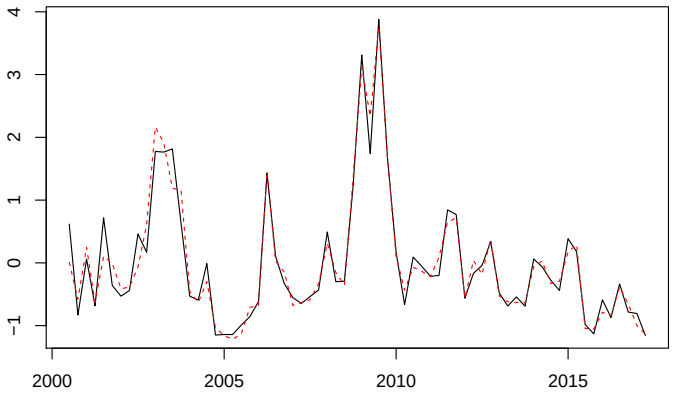
Besides relying on the dispersion of firms' expectations, one can also use the dispersion of point forecasts of professional forecasters. The intuition behind this indicator is the same as the intuition behind Theil's Disconformity Index, i.e. higher uncertainty about the future is associated with higher 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.[19] In our case, we use the question on future real GDP growth. Figure 2.2 plots the standard deviation[20] 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.

[19] Table B.3 in the Appendix provides an overview of the different macroeconomic and financial variables that are included in the survey.

[20] 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 2.2: 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

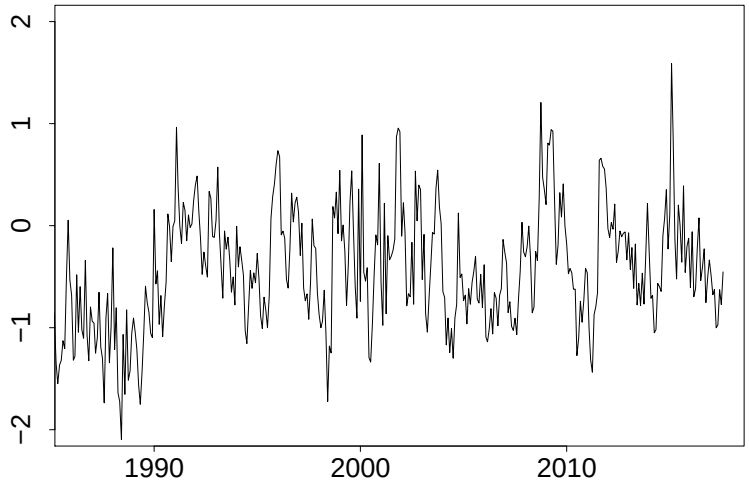
The literature suggests disagreement in expectation of economic agents as an additional approach to approximate uncertainty. The intuition behind this approach is that a higher dispersion of expectations represents a more uncertain economic environment.

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.[21] 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

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

Cramer and Theil (1954) and represents the variance of qualitative surveys. Figure 2.3 depicts the Theil Disconformity Index of expected demand since 1985.

Figure 2.3: Theil Disconformity Index of Expected Demand (since 1985)



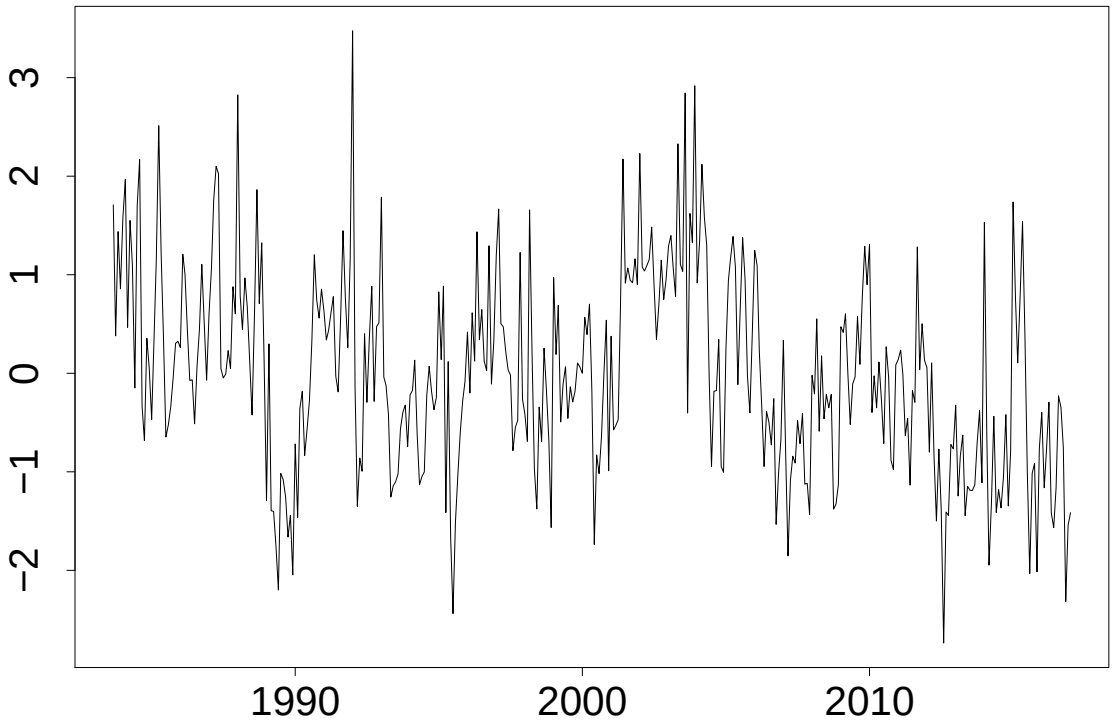
Notes: The indicator is demeaned and normalized to unit variance.

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.[22] 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.[23] Figure 2.4 depicts the aggregate indicator for Switzerland.

Figure 2.4: Firm Forecast Error Dispersion



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

[22] 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.
[23] We include a detailed description of the indicator in Appendix (see B.1.4).

Economic Policy Uncertainty

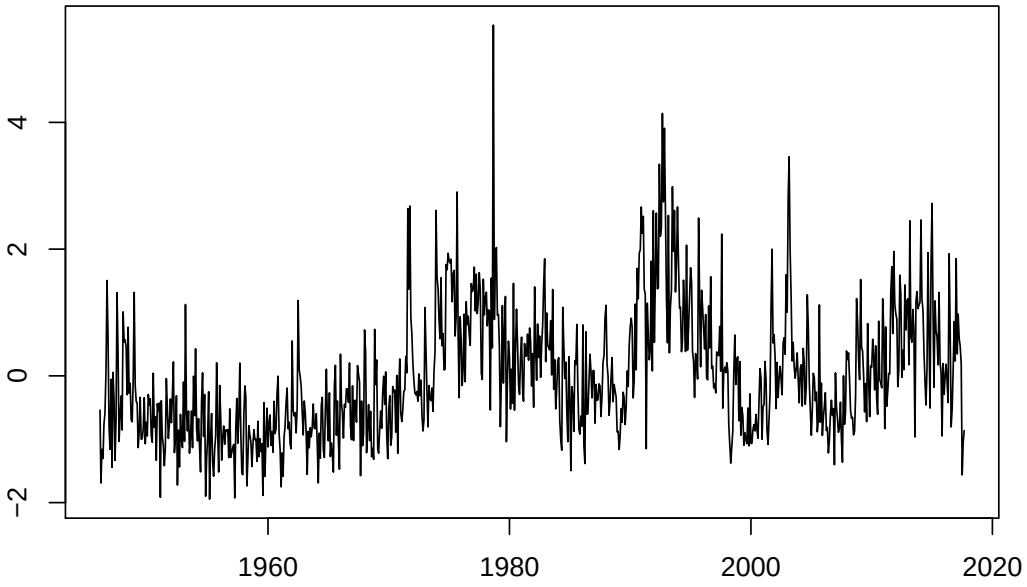
The first indicator we present is the Economic Policy Uncertainty (EPU) based on the method proposed by Baker et al. (2015a). As part of the ongoing digitalization newspaper outlets continue to digitize historical newspaper editions. Baker et al. (2015a) propose to use the digital newspaper archives 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.[24]

We replicate the method proposed by Baker et al. (2015a) 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.[25] 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 2.5 depicts the monthly EPU indicator for Switzerland since WW2.

[24] 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.

[25] Appendix B.1.1 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 2.5: Economic Policy Uncertainty Indicator for Switzerland



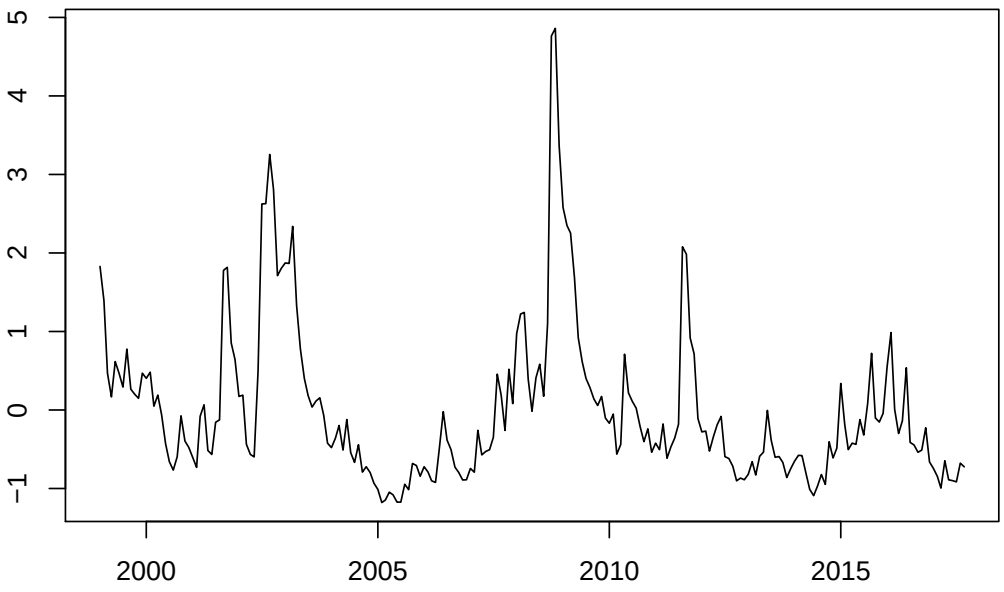
Notes: The figure depicts monthly value of the EPU since January 1946. The indicator is demeaned and normalized to unit variance.

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 2.6 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 2.6: 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 2.3 summarizes the uncertainty indicators used in our analysis.

Table 2.3: Uncertainty Indicators for Switzerland

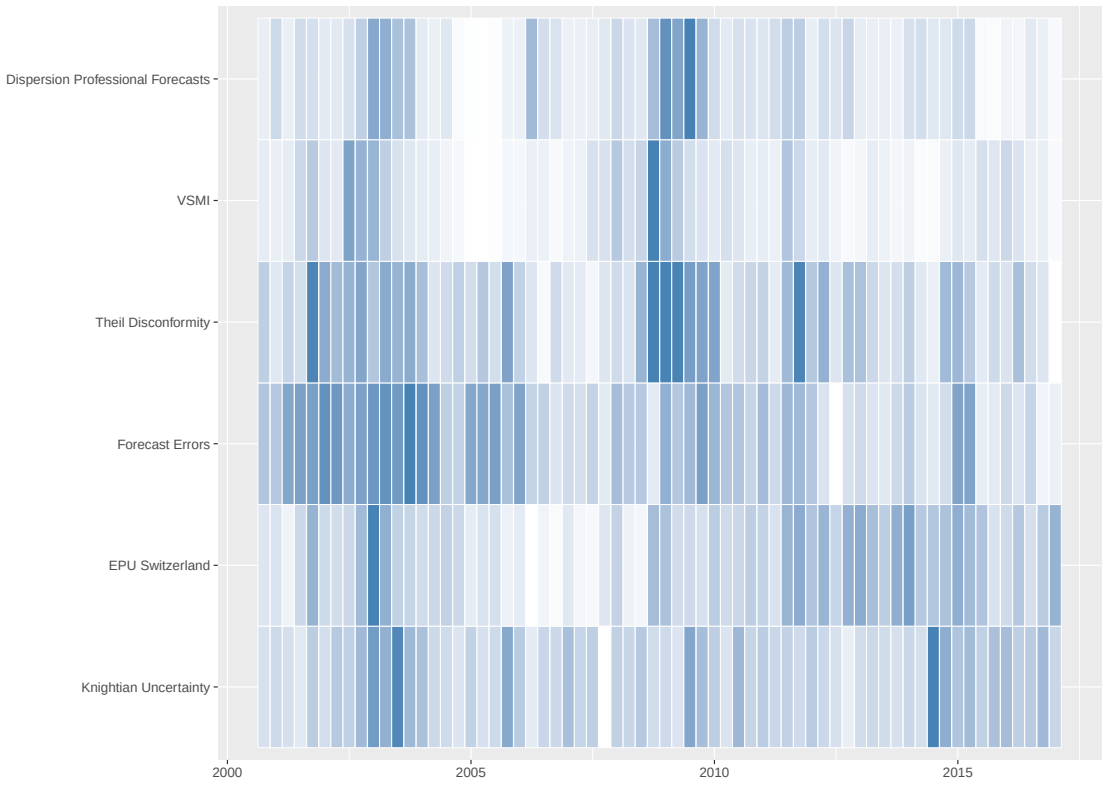
Description	Available Since	Highest Frequency	Available on Sector Level	Provider
EPU Switzerland	01.01.1900	daily	No	KOF
Dispersion Firms Forecast Errors	01.09.1983	monthly	Yes	KOF
Theil Disconformity Index	01.02.1971	monthly	Yes	KOF
Dispersion Professional Forecast Errors	01.07.2001	quarterly	Yes	KOF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

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 2.7 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 2.7 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 2.7: 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 2.7 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 2.4 displays the estimated correlation coefficients. We can learn three lessons from Table 2.4. 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.

Table 2.4: Pearson's Correlation Coefficients

	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

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 2.5 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.[26] 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

[26]The results are robust with respect to the chosen time horizon. In a robustness check that we provide in Table B.5 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.

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.

Table 2.5: Factor Loading of Principal Component Analysis.

	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

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 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.[27] Equation 2.5 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 ($\lambda = 1,600$).

$$(VAR-7) \begin{bmatrix} \log(\text{Investment}) \\ \log(\text{Unemployed}) \\ \log(\text{CPI}) \\ \log(\text{Wage}) \\ \text{3-Month-Libor} \\ \text{uncertainty} \\ \log(\text{SMI}) \end{bmatrix} \tag{2.3}$$

Figure 2.8 presents the Cholesyk orthogonalized impulse responses of investment in machinery and equipment to a one standard deviation shock. Thereby, the black

[27] 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.

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.

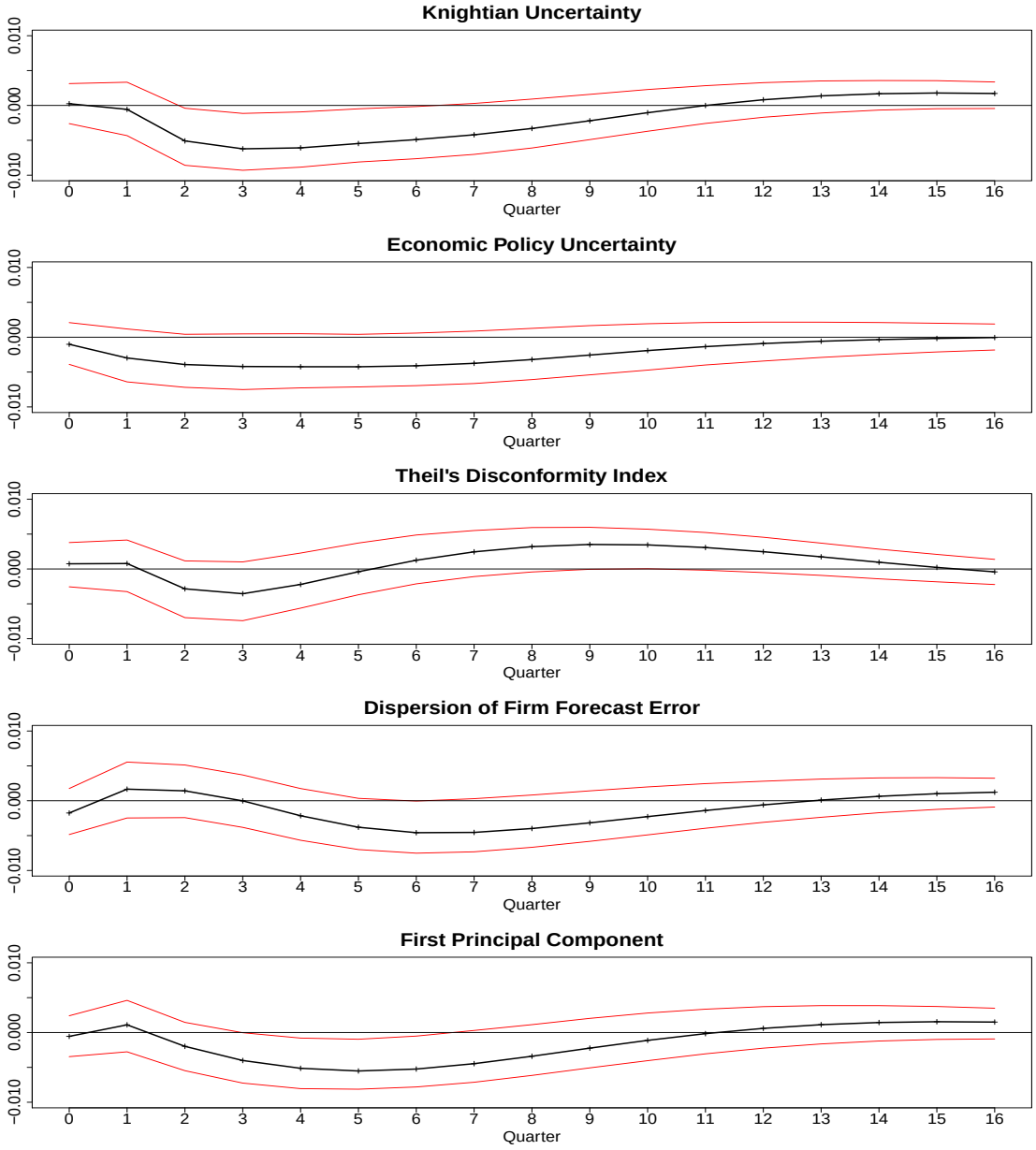
With respect to magnitude, a one standard deviation shock leads to a drop in investment of around 0.6 percentage points. Note that the most extreme uncertainty shocks peak at 2 to 4 standard deviations depending on the indicator. Hence, one needs to scale the impulse responses accordingly in order to 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.

2.6 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.

Figure 2.8: 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.

Chapter 3

The Effect of Policy Uncertainty on Investment: Evidence from the Unexpected Acceptance of a Far-Reaching Referendum in Switzerland[1]

3.1 Introduction

According to many, economic policy uncertainty has increased substantially in recent years. This is confirmed by indicators based on newspaper articles in several countries (Baker et al., 2016). Particularly strong were the jumps in media-reported economic policy uncertainty associated to the "Brexit" decision in June 2016 in the United Kingdom and the US presidential elections in November 2016. It is often argued that a rise in uncertainty can have a major impact on the economy. For instance, the OECD writes in its economic outlook of June 2016 that "[t]he outcome

[1]This chapter is based on Dibiasi et al. (2018a)

of the referendum is a major risk for the economy. A vote for Brexit would heighten uncertainty, raise the cost of finance and hamper investment" (OECD, 2016). Indeed, a substantial theoretical literature suggests that uncertainty affects investment decisions of firms. According to Bernanke (1983) and others, firms may, when facing increased uncertainty, prefer to wait-and-see rather than to engage in partially irreversible investment activities which with hindsight might turn out to have been wrong. These theoretical predictions are examined in a growing empirical literature studying the effects of uncertainty on the real economy.[2] These papers face the challenge that uncertainty is an ambiguous concept and that it remains difficult to uncover the causal relationship between uncertainty and investment. The reason is that most macro variables move together over the business cycle. Does uncertainty cause a fall in investment, does a fall in investment cause uncertainty, or does something else drive both? To identify the causal impact of uncertainty on output and investment, recent papers such as Julio and Yook (2012) and Baker and Bloom (2013) thus study situations in which there is an exogenous shock to uncertainty.

Following these papers, our study examines the effects of an exogenous economic policy uncertainty shock on investment. Policy uncertainty is a particularly interesting source of uncertainty as policy makers often can directly affect it. However, it is rare to observe truly exogenous policy shocks, as outcomes of the political process are often predictable. In this paper, we analyse such a rare event. We study how the surprising acceptance of a far-reaching referendum in Switzerland on 9 February 2014 affected firms' investment.[3] This referendum, the so-called Mass Immigration Initiative (MII), added an amendment to the Swiss constitution, stating that the country has to (re)introduce a system that autonomously manages immigration into

[2]See Bloom (2014) and Castelnuovo et al. (2017) for an overview of recent developments in the uncertainty literature.

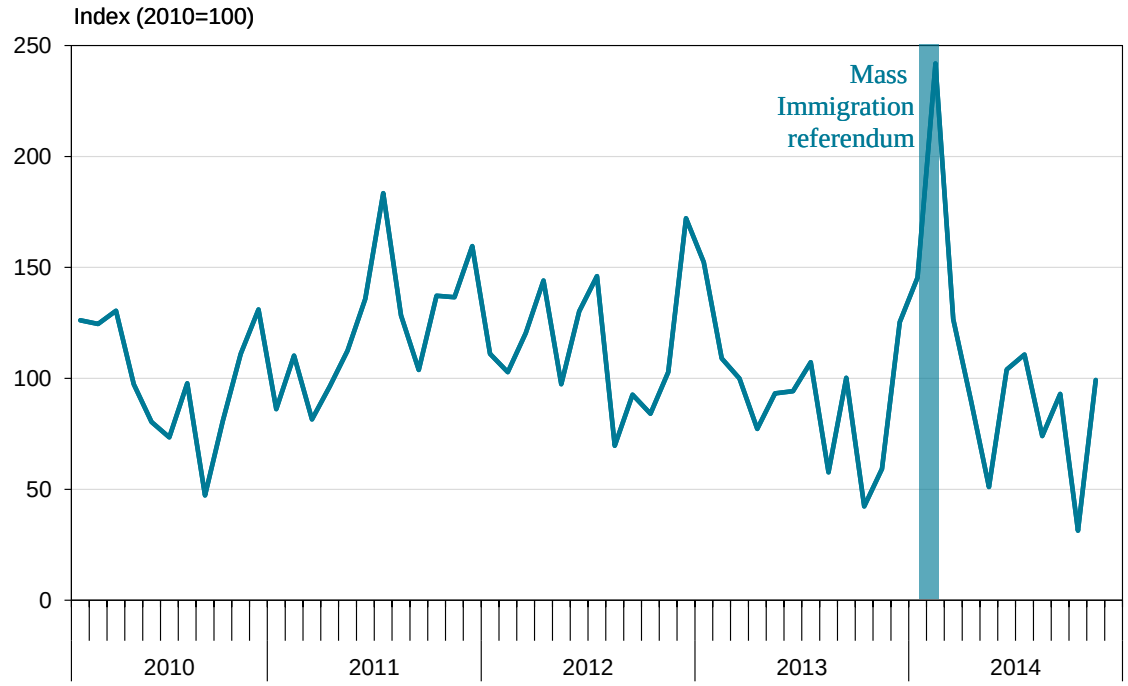
[3]For ease of exposition, we refer to the Mass Immigration Initiative (MII) as a referendum, although technically it was a popular initiative. An "initiative" is a constitutional instrument in Switzerland and represents a cornerstone of the country's direct democracy. It allows individuals and organizations to suggest a law at the federal, cantonal or municipal level. At the national level, citizens must collect signatures of 100,000 voters within 18 months for an initiative to be organized and put to ballot. In what follows, we use referendum and popular initiative interchangeably.

Switzerland. This system should be in place within three years after the vote, i.e. by February 2017.

The outcome of the MII vote came as a big surprise. All prior opinion polls indicated that the referendum would be rejected, and almost all important political players, including the government, had decisively lobbied against it. The outcome of the vote was very close: only a small majority of the population (50.3%) voted in favour of the initiative. The unexpected result of the vote represented a large economic policy uncertainty shock for Switzerland's firms. Figure 3.1 shows an economic policy uncertainty indicator for Switzerland constructed along the lines proposed by Baker et al. (2016).[4] The Swiss uncertainty indicator reached historically high levels around the date of the vote.

[4]This indicator is based on counts of newspaper articles that contain the words "uncertainty" and "economy" along with economic policy terms such as taxes, regulation or budget. The KOF Swiss Economic Institute (KOF) calculates the KOF Economic Policy Uncertainty Index for Switzerland on a daily basis and publishes figures dating back to 1900. The indicator is based on newspaper articles from the "Neue ZÃ¼rcher Zeitung" and "Le Temps", whilst also drawing on articles from "La Gazette de Lausanne", "Le Journal de Geneve" and "Le Nouveau Quotidien" for the pre-1998 period. The indicator is available on the KOF website: https://www.kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-uncertainty-indicator.html (data retrieved 22 December 2016).

Figure 3.1: News Indicator for Economic Policy Uncertainty in Switzerland



Notes: This figure shows a symmetric 5-month rolling average of the Economic Policy Uncertainty index for Switzerland from 2010 to 2014 normalised to equal 100 on average in 2010. The indicator represents the news part of the economic policy uncertainty indicator developed by Baker et al. (2016). The indicator is based on counts of newspaper articles that contain the words uncertainty and economy along with economic policy terms such as taxes, regulation or budget. The shaded area marks February 2014, the month of the vote on the initiative against mass migration. The figure reveals that between 2010 and 2014 economic policy uncertainty in Switzerland was highest around the vote. In fact, in February 2014 the indicator reaches its highest value since 2003.

The reason why the vote led to this substantial policy uncertainty shock is because a reintroduction of quotas conflicts sharply with the principle of "free movement of workers". This principle is the cornerstone of the EU's migration policy and allows its citizens to move freely within the territory of member states for employment purposes. It faced mounting political and public opposition not just in Switzerland, but also in several European countries, which culminated in Great Britain's decision to leave the European Union (EU). Swiss firms had relied heavily on the principle of free movement of workers to recruit EU workers in the years before the vote. Because of a so-called "Guillotine clause", the vote not only put the

free movement of workers at stake, but also six other economically relevant agreements for the country with its main trading partner, the EU. As the referendum is vaguely formulated, it was unclear after the vote how, or if at all, any new regulations would be implemented in 2017 and whether the bilateral agreements would still be in place. An interesting element of our setting is thus that both, the political and economic context and the potential consequences of the vote for firms are quite similar to those of the Brexit vote in the United Kingdom.

Our paper examines whether Swiss firms that were more exposed to the economic policy uncertainty caused by the vote changed their investment differently compared to those less exposed. The data for the analysis stem from two different sources. The first are several waves of the KOF Investment Survey, a biannual business survey on investment activity in Switzerland. The survey collects detailed information on investment activities of firms in the recent past and near future. Using these surveys, we construct a firm-level investment panel data set covering the period 2009-2015. The second data source used in this paper are two special surveys conducted to study the effects of the vote. In these special surveys, we asked firms shortly after the vote whether the referendum affected their investment plans, and whether it affected their demand expectations and their perceived level of investment uncertainty. One of six firms reported an increase in uncertainty regarding their investment plans triggered by the MII vote.

Our paper is most closely related to recent studies that use predetermined elections and close votes to study the effects of shocks to political uncertainty.[5] Exogenous elections and votes help to better isolate causal impacts of political uncertainty and firm investment. Julio and Yook (2012), Kelly et al. (2016), Akey and Lewellen

[5]In a broader sense our paper also speaks to the literature on the effects of economic policy uncertainty and the effects of macroeconomic uncertainty on the economy in general. Works related to this string of literature include, among others, Bachmann et al. (2013), Bianco et al. (2013), Bloom (2009), Bontempi et al. (2010), Caldara et al. (2016), Dixit and Pindyck (1994), Fuss and Vermeulen (2008), Hassett and Metcalf (1999), Jurado et al. (2015), Kang et al. (2014), Lorie and Smith (1970), Meinen and Roehe (2017) and Netšunajev and Glass (2017).

(2016), Riem (2016) and Jens (2017) all rely on electoral cycles to demonstrate the link. These papers have concluded that an increase in policy uncertainty leads to lower investment. Similarly, Baker et al. (2016) show that economic policy uncertainty as measured through newspaper searches has direct negative consequences on firms' investment and employment in policy-sensitive sectors like defence, healthcare and infrastructure construction.

Our paper adds several new elements to this literature on the effects of policy uncertainty on investment. First, to our knowledge, we are the first paper to study how investment at the firm level is affected by an unexpected and far-reaching voting outcome that leads to sudden and substantial uncertainty about the future economic policy of a country. The vote on Brexit and the election of Donald Trump as president of the US, as the most prominent examples, show how relevant a better understanding of the effects of such uncertainty shocks is. Second, our paper combines qualitative and quantitative survey data to study how policy uncertainty shapes firms' investment decisions. Firms' answers to the qualitative survey questions help us understand the results from the quantitative analysis. Our evidence based on survey data corroborates and complements the previous literature that typically relied on elections in combination with quantitative firm data. Third, we propose a way to identify the effects of uncertainty at the firm level. As in previous papers, we compare the evolution of investment in firms that are more and less exposed to changes in expected profits due to the vote. We consider firms to be exposed if they have a high share of foreign workers in total employment and/or if they operate in industries strongly dependent on the bilateral agreements. However, the comparison of exposed and non-exposed firms does not reveal the effect of uncertainty per se, as exposed firms are likely to experience both a change in expected profits (first moment) and a change in the uncertainty around expected profits (second moment) due to the vote. Real option theory predicts that an increase in uncertainty (second moment) will only have negative consequences for investment if these are at least to some extent irreversible Bernanke (1983). On the other hand, the first moment effects of the vote are expected to affect exposed firms

with irreversible and reversible investment similarly. We thus gauge the negative uncertainty effects of the vote through the comparison of exposed firms that differ in the irreversibility of their investment. We implement this idea empirically using Difference-in-Differences-in-Differences (DDD) estimations, measuring a firm's degree of irreversibility of investment using the results of a survey question proposed by Guiso and Parigi (1999).

Our results suggest that the economic policy uncertainty caused by the vote depressed irreversible investment. The preferred DDD estimates indicate that gross fixed capital formation of exposed firms with irreversible investment was, as a consequence of the uncertainty, reduced by as much as a quarter in the first two years after the vote. Our regressions also provide some evidence that exposed firms with reversible investment increased investment in 2014 because of the vote. Hence, while the policy uncertainty effects of the vote clearly depressed investment in the short run, the sum of first and second moment effects of the vote among exposed firms is not statistically significantly negative: the vote appears to have triggered additional investment among firms that were less subjected to the negative effects of uncertainty. The special surveys provide an explanation for this result. When firms are in 2014 asked whether they have already undertaken measures because of the MII or plan to do so until 2016, some firms report that the vote has triggered measures that decrease investment (in particular, led to a postponement thereof)[6], but an equal share of firms reports to undertake measures that increase investment (in particular, streamlining investment). Our interpretation is that the vote induced additional (streamlining) investment among exposed firms, but the uncertainty prevented this reaction among the subset of exposed firms with irreversible investment.

[6]In the context of the KOF Investment Survey, streamlining investment refers to any type of investment that aims at decreasing production costs. Streamlining investment may lead to a decrease in any costs associated to the production costs, i.e. less consumption of materials, energy or manpower (see Konjunkturforschungsstelle et al. (2016)).

The remainder of the paper is organized as follows: Section 2 discusses the Mass Immigration Initiative. In Section 3, we describe our data. Our empirical strategy is explained in Section 4. Section 5 presents the main results. Section 6 concludes.

3.2 The Swiss Mass Migration Initiative

From around 2000 onward, Switzerland experienced a substantial surge in immigration. While the country's foreign-born share had grown little in the 1990s, it increased by 6.4 percentage points between 2000 and 2013, mainly due to immigration of skilled workers from neighbouring EU countries. The largest part of the incoming migrants came for work reasons. This immigration wave to Switzerland raised anti-immigration sentiments in the population (see Siegenthaler et al. (2016), for a discussion).

In 2011, the Swiss People's Party (SVP), a national conservative party, thus started an "initiative" aiming at restricting immigration, the so-called "Stop Mass Immigration Initiative". The initiative demands a reintroduction of an annual cap on total immigration into Switzerland, similar to the system Switzerland had in the 1990s. These limits and quotas should apply to all permits covered by legislation on foreign nationals and must be geared towards Switzerland's overall economic interests. The initiative also demands that businesses must give Swiss residents priority when hiring staff.

Reintroducing quotas on total immigration is incompatible with Switzerland's Free Movement of Persons Treaty (FMP) with the EU/EFTA states. The treaty, gradually introduced between June 2002 and June 2007, lifted all immigration restrictions on EU citizens wishing to work in Switzerland and vice versa. The referendum is at odds with the FMP because it limits the access of foreign workers to the country's labour market and discriminates between resident workers and EU nationals. Furthermore, the FMP is linked to six other bilateral agreements Switzerland has with the EU. These bilateral agreements concern, among others, road and air

traffic, agriculture, and technical trade barriers. Importantly, the agreements are mutually dependent through a so-called Guillotine clause, i.e. if one of them is renounced or not renewed, they all cease to apply–or at least need to be renegotiated. It is widely believed that these agreements contributed to the comparatively strong economic performance of Swiss firms during the last decade.[7]

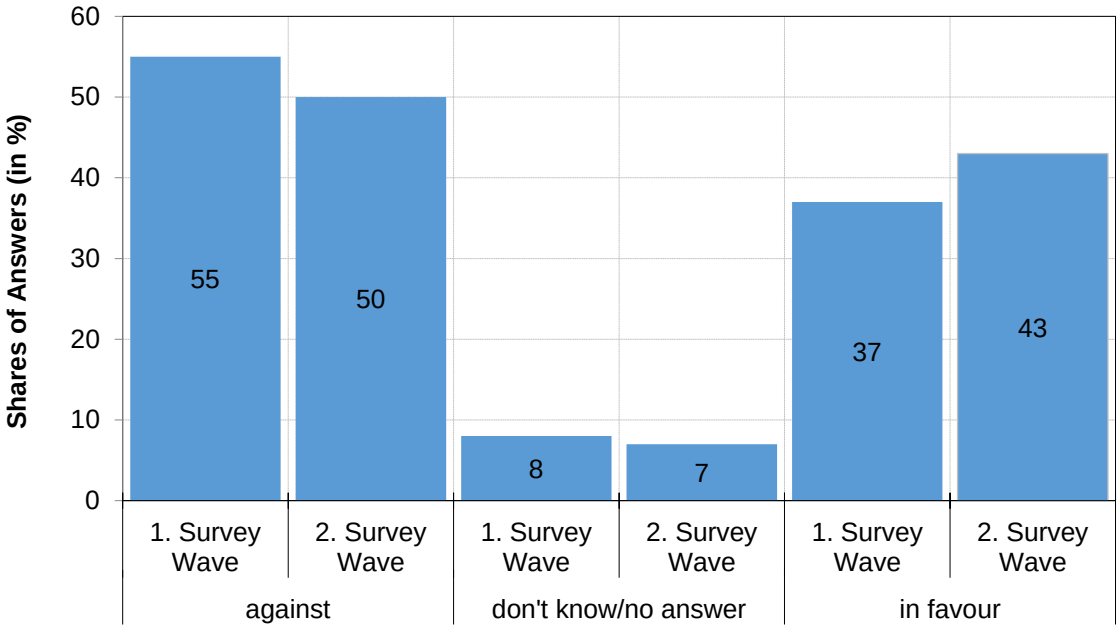
Although the initiative was debated controversially prior to the vote, it was believed the majority of voters would reject it. First, none of the other major political parties, no trade union, no employer organization and only very few media outlets in Switzerland supported the initiative. Second, Switzerland's citizens always voted in favour of the bilateral agreements in several prior votes where the so-called "bilateral way" was put into question. Third, popular initiatives are more often rejected than accepted. Between 1980 and 2015, only 15 out of 125 popular initiatives received the majority of votes. Fourth, popular polls on the initiative indicated that it would not find a majority. The first official poll, financed by the publicly owned television and conducted by GFS between 23 December 2013 and 3 January 2014, saw 55% of the voters against the initiative and only 37% in favour of it, with 8% not yet decided on how to vote (see Figure 3.2). Uncertainty about the outcome of the vote only increased shortly before the vote when the support for the initiative increased in the second official poll, conducted two weeks before the vote (between 20-25 January). The increase in support was unusual. Support for popular initiatives normally declines with the voting day approaching (gfs.bern, 2014). The results from the second opinion poll raised the possibility that the voters could accept the initiative for the first time.[8] By the end of 2013, however, when firms had undertaken their investment for 2013 and conveyed their investment plans for 2014

[7]The FMP has been central for Switzerland's economy in the past decade. It has enabled firms to address labour shortages in the resident workforce by attracting foreign workers (Siegenthaler et al., 2016). This led to a substantial immigration wave that fuelled demand for local products and services and allowed firms to grow to an extent that would not have been possible without the treaty (Ruffner and Siegenthaler (2016)). Abberger et al. (2015) provide a thorough assessment of the importance of these agreements for the Swiss economy.

[8]In fact, the growing support for the referendum contributed to the increase in policy uncertainty before the vote measured by the news-based policy indicator (Figure 3.1).

in KOF's investment survey, an acceptance of the initiative was seen as very unlikely.

Figure 3.2: Official Opinion Polls on the Referendum



Notes: GFS Bern conducted two polls prior to the vote. Both opinion polls indicated that Swiss voter would reject the referendum. The first poll lasted from 23 December 2013 to 3 January 2014. The second survey wave lasted from 20 to 25 January 2014. The bars in the figure presents the share of responses to the question: "If tomorrow was voted about the initiative against mass immigration, would you be..." (Data source: GFS).

The vote itself took place on 9 February 2014. A very close 50.3% of all voters (with a comparatively high voter turnout rate of 56.6%) and the necessary majority of the 26 cantons accepted the constitutional amendment demanded by the initiative. This unexpected result received substantial media interest, both in national and international outlets. An editorial article in the Neue ZÃ$\frac{1}{4}$rcher Zeitung, a renowned newspaper in Switzerland, stated that the result represents a "slap in the face" of the political elite in Switzerland and a "caesura for Switzerland". Many leaders of EU countries expressed their concerns about the outcome. For instance, the German chancellery published a statement saying that it "recognizes and respects the result, but it is nevertheless clear that it creates considerable problems."

The international importance of the vote was also recognized in a retrospective article in the New York Times on 26 February 2014, saying "the referendum [...] sent shock waves across Europe." The unexpected outcome created a substantial amount of policy uncertainty regarding the legal and political environment for Swiss firms. The vote affected the mean and distribution of expected profits of firms mainly in two dimensions.[9] The first relates to firms' labour costs: the referendum questions firms' access to the supply of EU workers. Swiss firms had strongly relied on workers from the EU to fill their open vacancies and to grow in the decade prior to the vote (see Ruffner and Siegenthaler (2016), and Siegenthaler et al. (2016)). The outcome of the vote put this strategy into question but does not give a concrete answer about the alternative as the new constitutional text is vaguely formulated. The referendum neither specifies how high the new quotas will be, nor who should set and allocate them and according to what criteria. More generally, the vote created uncertainty about how Swiss immigration policy might look like in the future.

The second dimension along which the vote affected the expected profits of firms relates to the Guillotine clause, which connects the FMP to the other bilateral agreements. Due to the vote, it became unclear whether or to what extent these other agreements will remain in place. Most importantly, the vote thus affected firms' expectations concerning the preferential access of Swiss firms to the EU single market for goods. Loosing such a preferential access is a substantial risk for Swiss firms, because the EU represents Switzerland's by far most important export market with 54.9% of total exports in 2013.

[9] A third dimension of the policy uncertainty caused by the vote relates to demand uncertainty for domestic firms. In the years before the vote, domestic demand for local goods and services had been fuelled by the substantial inflow of immigrants. With the acceptance of the referendum, this stimulus potentially breaks away. This possible consequence of the referendum is, however, likely to be quantitatively less important and less salient than the two others: many firms may not be able to concretely quantify the importance of immigration and the induced population growth for their demand developments.

3.3 Data

3.3.1 The Regular KOF Investment Surveys

We exploit the unexpected outcome of the popular initiative against mass immigration to investigate hypotheses about the effects of uncertainty on firms' investment decisions. Our empirical analysis is based on data from the investment surveys of the KOF Swiss Economic Institute, ETH Zurich. Since 2012, KOF conducts these surveys bi-annually among a large panel of private firms, in autumn and in spring of a given year. Prior to 2012, the surveys took place only once a year in autumn. The survey is conducted among a large panel of private and semi-private Swiss firms. Currently, the panel contains slightly more than 8,000 unique firms. The average response rate between 2009 and 2015 amounts to 35%. The firms in the sample cover all industries excluding agriculture and account for 34% of total employment (FTE) in Switzerland within the respective sectors. Appendix C.4 describes the survey in greater detail.

Using all KOF investment surveys conducted between autumn 2010 and autumn 2016, we construct a firm-level panel data set providing yearly data on realised investment for the period 2009-2015. The final data set covers roughly 3,000 different firms. We measure the investment consequences of the vote using firms' log gross fixed capital formation as the main outcome.

Another interesting feature of each of the KOF Investment Surveys is that firms are asked about their investment for several years. For instance, in the survey in autumn 2013, firms were asked for quantitative information on investment activity in 2012, 2013 and 2014. Some of the investment data are hence actual (i.e. realised) investment made in the past, and some of the data refer to planned investment in the current and next year. This data structure offers three advantages. First, our panel data set on realised investment 2009-2015 is fairly balanced despite non-response to the individual surveys because a firm is asked to provide realised investment for the

same investment year in three different surveys. Second, we can reduce the measurement error in the investment data for a particular year and firm by using the mean from different surveys for that firm in case it participated in more than one of the surveys that levy information on realised investment for that year. Third, the KOF survey in autumn 2013 asked firms about their investment plans in 2014. This gives rise to a straightforward placebo test, as the effects of the MII should not be observable in the investment plans for 2014 levied 2 to 5 months before the vote.

3.3.2 The Special Surveys in 2014

Our empirical analysis also makes use of additional survey information that was specifically gathered to study the effects of the referendum. These special questions, added to the regular investment surveys in spring 2014 and autumn 2014, directly asked firms about the consequences of the referendum for future investment activities and whether the acceptance of the MII influenced the uncertainty surrounding their investment plans.[10] Among others, we asked survey respondents how the acceptance of the MII affected the growth potential of Switzerland and the expected demand for the products and services sold by the firm. Survey participants could choose one of the following options: "strongly decreased", "decreased", "not changed", "increased", and "strongly increased".[11] In one of the key specifications presented below, we will use the answers to these questions to control for the change in expected demand that the firm faced because of the referendum.

We also collected certain firm characteristics relevant for the empirical analysis in these special surveys. One important variable levied in the surveys is the share of foreign workers in total employment. Another is the degree of irreversibility of a firm's investment. The survey item we added to the specials surveys is based on

[10] The questionnaires of these special questions are shown in Appendix C.4. The reader can find additional information on the special surveys including extensive descriptive statistics in Abberger et al. (2014b).

[11] See the questionnaire in Appendix C.4 for the exact wording.

Guiso and Parigi (1999) and asks firms about the second-hand market conditions for existing production plants and machineries. Firms are given four options: (1) there exists a second-hand market, and it is relatively easy to find a buyer in a short time willing to pay a reasonable price; (2) there exists a second-hand market, but it takes time to find a buyer and selling prices are not very rewarding; (3) even though there exists a second-hand market, it is very difficult to find a buyer and selling prices can be very low; and (4) there does not exist a second-hand market for the existing machinery and production plants. Figure 3.3 displays the distribution of the reported irreversibility by the firms in our sample. The overwhelming majority of firms indicate at least some degree of irreversibility. Only 5% of the firms indicate full reversibility. For simplicity and following Guiso and Parigi (1999) and Binding and Dibiasi (2017), we define a binary variable for irreversibility in the regressions below (see Equation 1). The variable takes a value of 1 in case a firm reports that there does not exist a second-hand market, or it is very difficult to find a buyer and selling prices can be very low at the existing market. According to this measure, approximately 70% of all firms have irreversible investment[12], i.e.

$$Irreversibility_i = \begin{cases} 1 & \text{firm reports high or full irreversibility} \\ 0 & \text{otherwise} x \end{cases} \tag{3.1}$$

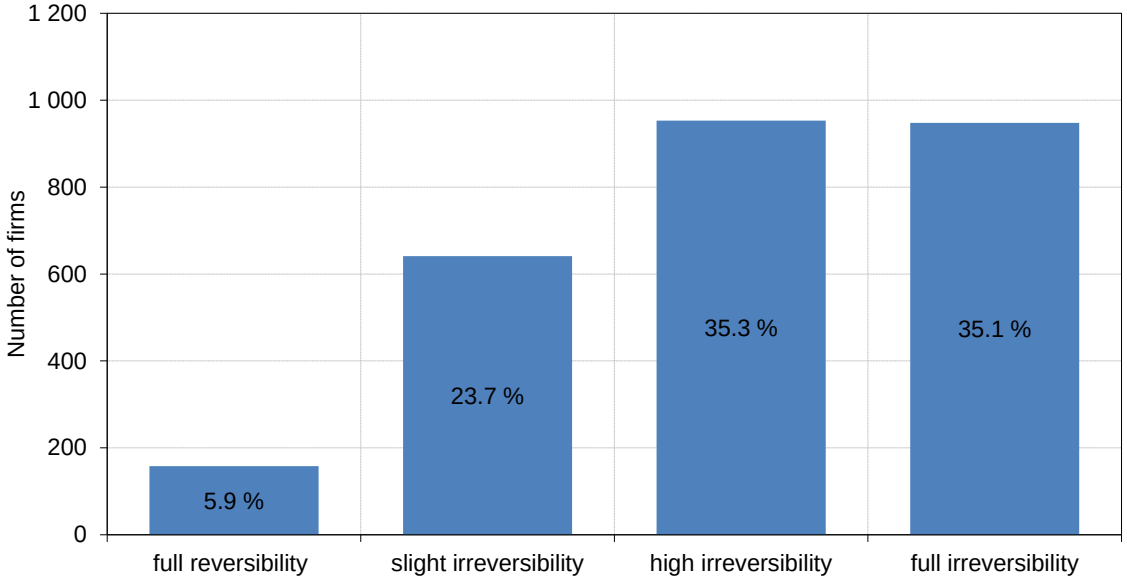
Because the information on firms' foreign employment share and their investment irreversibility are used in our baseline regressions, our regression samples are restricted to firms that participated in either the spring or the autumn survey in 2014. Although these firm characteristics were collected in surveys that took place shortly after the vote, we consider them as "pre-determined" below, as it appears unlikely that the vote had a relevant effect on the foreign employment share and firms' investment irreversibility[13] within the short period between the vote and the

[12] Appendix C.4 provides an extensive discussion of the variable and gives additional information on the irreversibility measure. Strikingly, our evidence suggests that irreversibility represents a firm characteristic that cannot be explained by other firm characteristics.

[13] Conceptually, irreversibility captures characteristics of the resale market for firms' investment goods. Neither this market nor the composition of firms' existing capital stock are likely to be

surveys.[14]

Figure 3.3: Degree of Irreversibility of Investment



Notes: Figure 3.3 shows the distribution of our firm-specific measure of investment irreversibility. Since autumn 2014, KOF asks firms yearly if there exists a second hand market for their existing machinery and production plants and how long it takes to find a suitable buyer. 6% of firms in our sample report that there exists a second market and that it is relatively easy to find a buyer in a short time willing to pay a reasonable price (full reversibility). Roughly one fourth of firms report that there exists a second hand market but it takes time to find a buyer and selling prices are not very rewarding (slight irreversibility). 35% of firms answer that even though there exists a second hand market, it is very difficult to find a buyer and selling prices can become very low (high irreversibility). 35% of participating firms state that there exists no second hand market for their existing machinery and production plants (full irreversibility).

Columns 1-4 of Table 3.1 report the number of observations, the mean, median, and standard deviation of the most important variables used in this paper. The average firm size is 483 FTE workers, of whom 27% are foreigners. About 33% of

affected quantitatively meaningfully by the vote in the period between the vote and the special surveys.

[14]In order to limit concerns that these firm characteristics are affected by the vote further, we always prioritize firms' answers to the spring survey in 2014 in case a firm responded to both, the spring and autumn survey in 2014.

all firms are exporters.[15] The share of firms in the manufacturing sector is 44%. Average investment is 13.1 log points (489,000 CHF) with a standard deviation of 2.2. As usual with investment data, the distribution of log investment is heavily skewed to the right with a small number of firms reporting very large investment figures. To avoid that our results are driven by outliers, we trim the outcome distribution by discarding observations above the 99th percentile. None of our results depends critically on this trimming of the outcome variable, but the estimates tend to be more precise. The main results using an untrimmed outcome and 95% trimming are reported in Appendix C.1.

3.4 Empirical Strategy

3.4.1 Measuring Exposure to the MII

We identify the effects of the vote by comparing firms that differ in their exposure to the effects of the vote using Difference-in-Differences (DD) and Difference-in-Differences-in-Differences (DDD) estimations. Firms' exposure to the referendum is measured based on pre-determined firm characteristics. Our preferred exposure measure incorporates both dimensions along which the referendum affected firms' expected profits simultaneously (see Section 3.2 for details). The first of the two dimensions are the vote's impact on expected revenues (through affecting firms' potential future access to the EU product market). Figure 3.4 illustrates the relevance of this dimension of the vote using firms' answers to the special survey. The dark blue bars of Figure 3.4 show that 12% of all surveyed firms expect that the vote decreased the demand for their goods or services. The second dimension is the

[15] We define exporters as firms that export more than 5% of their production. The reason why we use a dummy variable and why we use this threshold lies in the export information levied in the KOF Investment Survey. Every autumn, KOF asks firms to state the percentage of sales that were exported in the same year. Firms are given a four item response: 0-5%, 6-33%, 34-66% or 67-100%. See the questionnaire in Appendix C.4 for the exact wording of the question. The results are similar if we use another threshold to distinguish between export-oriented and domestic-oriented firms, and if we use a continuous version of the export variable.

Table 3.1: Summary Statistics

Variable Description	(1) Firm-year observation	(2) Mean	(3) Median	(4) St.Dev	(5) 0.01 Quantile	(6) 0.99 Quantile
Investment GFCF (log)	13765	13.08	13.14	2.21	8.29	17.86
Investment Equipment (log)	11411	12.64	12.69	2.11	8.01	17.13
Investment Construction (log)	6818	12.69	12.62	2.24	7.60	17.65
Number of FTE	10287	483	82	20912	2	2774
Large Firm (1 if more than 250 FTE)	10287	0.21	0	0.40	0	1
Irreversiblity (1=Yes, 0=No)	12648	0.70	1	0.46	0	1
Exposed to MII (1=Yes, 0=No)	13765	0.52	1	0.50	0	1
Increased Uncertainty (1=Yes, 0=No)	13700	0.16	0	0.37	0	1
Decrease Demand (1=Yes, 0=No)	10649	0.12	0	0.33	0	1
Decrease Growth Potential (1=Yes, 0=No)	13225	0.52	1	0.50	0	1
Increase Recruitment Costs (1=Yes, 0=No)	13429	0.29	0	0.46	0	1
Exporter (1=Yes, 0=No)	13087	0.33	0	0.47	0	1
Exposed to Bilaterals (1=Yes, 0=No)	13765	0.40	0	0.49	0	1
Foreign Owned (1=Yes, 0=No)	11062	0.17	0	0.37	0	1
Foreign Share (in % of total FTE)	13765	27.06	20	23.63	0	90
Stong Competition (1=Yes, 0=No)	10989	0.69	1	0.46	0	1
Distance to Border (in km)	13747	25.64	22.81	17.85	1.00	70.94
Close to Border (1=Yes, 0=No)	13747	0.23	0	0.42	0	1
Manufacturing Firm	13765	0.44	0	0.50	0	1
Construction Firm	13765	0.07	0	0.26	0	1
Service Firm	13765	0.48	0	0.50	0	1

Notes: This table provides summary statistics for the main variables used in the paper. The table provides averages for firm-year observations for the period 2009–2015. *Investment GFCF*, *Investment Equipment* and *Investment Construction* represent realised nominal investment in logs. The variable *Number of FTE* represents the self-reported number of full-time equivalent workers (FTE). The variable *Large firm* takes value 1 in case a firm has more than 250 FTE and 0 otherwise. The variable *Irreversibility* is a binary variable that takes value 1 in case a firm reports that there does not exist a second-hand market for its existing production plants, or if there exists a second-hand market but it is very difficult to find a buyer and selling prices can be very low at the existing market. The variable *Exposed to MII* shows a firm's exposure to the policy shock (see Section 3.4.1). The variable takes value 1 in case the likelihood of being exposed is above the median and 0 otherwise (see Equation 3.1). The variable *Increased Uncertainty* takes value 1 in case a firm reported a decrease in investment certainty because of MII and 0 otherwise. Similar, the variable *Decrease Demand* takes value 1 in case a firm reported a decrease in demand because of MII and 0 otherwise and the variable *Decrease Growth Potential* takes value 1 in case a firm believes that MII decrease the Swiss growth potential and 0 otherwise. The variable *Exporter* takes value 1 if more than 5% of a firm's sales stem from abroad and 0 otherwise. The variable *Exposed to Bilaterals* takes value one in case a firm operates within a sector that is exposed to Bilateral Agreements according to Buehler et al. (2011). The variable *Foreign Owned* takes value 1 in case a firm is foreign owned and 0 otherwise. *Foreign Share* contains the self-reported share of foreign worker as a percentage of all FTE. The variable *High Competition* takes value 1 in case a firm operates in a highly competitive market. In the special survey in autumn 2014, we asked firms to assess their current level of competitive intensity in their main market. We generate a binary variable that take value 1 in case a firm reports a high or very high competitive intensity. The variable *Close to Border* takes value 1 in case a firm is within 10 km to a border crossing. The variable *Manufacturing Firm* takes value 1 in case that a firm is a manufacturing firm (NACE 10–38) and 0 otherwise. The variable *Construction Firm* takes value 1 in case that a firm is a construction firm (NACE 41–43). The variable *Service Firm* takes value 1 in case that a firm operates within the service sector (NACE 45–96).

vote's impact on expected labour costs (through affecting firms' potential future access to foreign workers). According to Figure 3.4, the share of firms that fear that recruitment costs will rise because of the vote amounts to 29%, highlighting the importance of EU workers in the Swiss labour market. We proxy exposure to the demand dimension using a dummy variable measuring whether a firm is part of a two-digit industry that is affected by the bilateral agreements. This indicator variable is constructed by Buehler et al. (2011), and we term it "Exposed to Bilaterals" below.[16] We capture firms' exposure to the labour cost dimension of the vote using firms' share of foreign employees.

Because working with two different exposure dimensions simultaneously would complicate our regressions substantially, we aggregate the two pre-determined firm characteristics into a one-dimensional exposure measure. Instead of giving the two variables an equal weight in the composite measure, we weight the two variables by the extent to which they correlate with a variable measuring firms' subjective change in investment uncertainty because of the vote. The approach takes advantage of the special surveys conducted in 2014. In these surveys, we asked firms directly whether the certainty of their investment plans had changed due to the acceptance of the referendum. In column 1 of Table 3.2, we present logit regressions in which firms' answers to this question are regressed on firms' foreign employment share and the dummy variable "Exposed to Bilaterals". As expected, the probability of reporting an increase in uncertainty due to the acceptance of the referendum is substantially higher for firms with a high share of foreign employees and for firms that operate in an industry that is directly affected by the bilateral agreements. Because the foreign share correlates more strongly with the self-reported change in investment uncertainty caused by the vote than the bilateral dummy, its weight in our overall exposure measure is higher. We directly construct these weights by

[16] Buehler et al. (2011) study how the trade liberalization caused by the introduction of the bilateral agreements in 2002 affected plant growth in Switzerland. Their measure is built by carefully studying the contents of the bilateral agreements and by assigning each two-digit level key of the NACE industrial classification (rev. 2) to the categories 'non-affected', 'affected', and 'strongly affected' by the agreements. We construct a binary variable that takes value one in case an industry is 'affected' or 'strongly affected' and zero otherwise.

Table 3.2: Constructing Firm-specific Exposure to the Referendum

VARIABLES	(1) Logit Increased uncertainty	(2) Logit Increased uncertainty	(3) Logit at least one measure	(4) Logit at least one measure	(5) Logit Decreased firm demand	(6) Logit Decreased firm demand
Foreign share	0.018***	0.018***	0.002***	0.002***	0.012***	0.015***
	(0.002)	(0.003)	(0.000)	(0.000)	(0.002)	(0.003)
Exposed to Bilaterals	0.287***	0.300*	0.027*	0.038**	0.005	0.248
	(0.100)	(0.166)	(0.015)	(0.019)	(0.131)	(0.187)
Exporter		0.122		0.018		-0.263
		(0.179)		(0.020)		(0.205)
Close to border		-0.227		0.036*		-0.209
		(0.181)		(0.020)		(0.205)
Strong competition		0.307*		0.066***		0.933***
		(0.166)		(0.021)		(0.222)
Large firm		0.343**		0.008		0.535***
		(0.173)		(0.023)		(0.194)
Foreign owned		-0.140		-0.015		0.069
		(0.211)		(0.025)		(0.227)
Subsidiary		-0.089		-0.049**		-0.104
		(0.176)		(0.021)		(0.196)
Observations	3,269	1,599	2,361	1,497	2,423	1,533

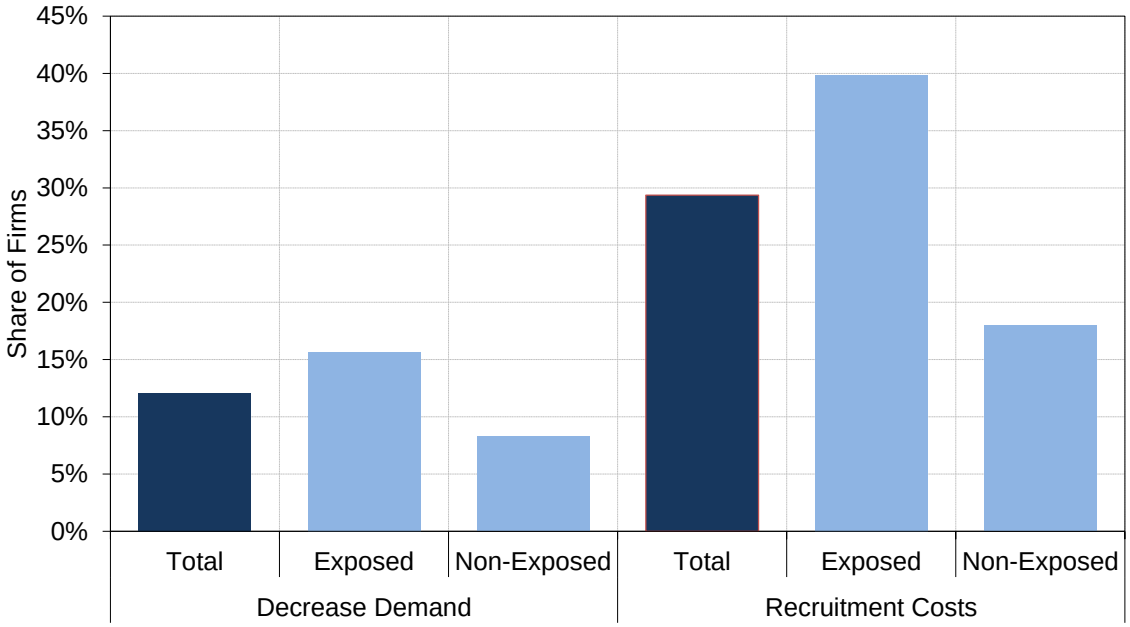
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: This table reports estimation results that are used to create firm level exposure to the MII. The dependent variable in columns 1 and 2 is a dummy equal to 1 if a firm reports an increase in investment uncertainty because of the MII. The dependent variable in columns 3 and 4 is a binary variable that takes value one in case a firm reported to plan at least one of the measures proposed in question 3 in the special survey questionnaire in autumn 2014 (see Appendix IV for the exact wording of the question). The dependent variable in columns 5 and 6 is a dummy equal to one if firm expects reduced demand due to the MII. The variable *Foreign Share* contains the self-reported share of foreign worker as a percentage to all FTE. The variable *Exposed to Bilaterals* takes value one in case a firm operates within a sector that is exposed to Bilateral Agreements according to Buehler et al. (2011). See the notes of Table 3.1 for explanations on the other covariates.

using the predicted probabilities from the logit estimation of column 1 of Table 3.3. Because it is not straightforward and not very transparent to implement DDD estimations with a continuous exposure variable, we then construct a binary variable using the predicted probabilities and consider a firm as exposed if its probability is above the sample median, i.e.

$$Exposed_i = \begin{cases} 1 & p_i(\text{increase uncertainty}) > median \\ 0 & \text{otherwise} x \end{cases} \tag{3.2}$$

Figure 3.4: Expected Change in Demand and Change in Recruitment Costs due to MII, Overall and by Firms' Exposure



Notes: The bars display the share of firms that report an expected decrease in demand because of the vote, and the share of firms that report an expected increase in recruitment costs because of the vote. The dark blue bars depict the overall share. The light blue bars differentiate between firms that are exposed and firms that are not exposed. The data stem from the two special surveys on the effects of the MII in spring and autumn 2014.

Splitting the sample at the median allows us to compare firms that a more exposed to the vote to firms that are less exposed to the vote. As is discussed in greater detail in section 3.5.3 and in the appendix, our results are similar if we use the continuous exposure variable and neither depends on the threshold chosen to label firms as exposed and non-exposed,[17] nor on exactly which dependent or independent variables we use in the logit model to construct exposure, nor on the weighting procedure that we use.

[17] As we show below, a continuous exposure measure yields very similar results. Moreover, if we estimate separate effects for several different levels of exposure, we find that firms with medium levels of exposure react similarly as firms with high levels of exposure. Using a binary exposure, splitting firms at the median level of exposure, thus appears to be a sensible way of summarizing the reaction to the MII (see Appendix C.1).

We illustrate the relevance of our binary exposure measure in Figure 3.4 using two survey items from the special surveys. The figure shows that the probability to expect increased recruitment costs and to report decreased demand expectations because of the vote is about twice as large among exposed compared to non-exposed firms. The exposure dummy thus identifies firms that report to be strongly affected by the vote in the special surveys.

3.4.2 Identifying the Uncertainty Effects of the Vote

Using the binary exposure indicator $Exposed_i$, we study the investment consequences of the vote using a Difference-in-Differences-in-Differences (DDD) regression model. We estimate a DDD instead of the simpler DD model because a DD regression, based on the simple comparison of the change in investment of exposed and non-exposed firms, likely captures both the effects of uncertainty and the first moment shifts in expectations caused by the vote. These first moment effects arise because the vote reduced firms' long-run demand expectations and increased the expected future labour costs. Exposed firms are more likely to be affected by these first moment effects of the vote than less exposed firms.

To isolate the second moment effect of the vote - the effect attributable to policy uncertainty - we exploit that according to real option theory an increase in uncertainty incentivizes firms to postpone investment projects only if they are irreversible. If investment projects can be reversed without costs, it is not rational to postpone investment in the face of a second moment shift of profit expectations Bernanke (1983). In contrast, the degree of irreversibility does not enter a conventional cost benefit analysis of an investment project. Orthodox capital asset pricing models compare future discounted earnings to future discounted costs regardless of the possible resale value. This means that first moment changes in profitability affect investment project decisions independently of their degree of irreversibility. The reasoning suggests that the comparison of exposed firms with more and less reversible investment allows us to isolate the investment effect of uncertainty caused by the vote. To exploit this insight empirically, we estimate variants of the following DDD model:

$$ln(y_{i,t}) = \gamma_i + \delta_{j,t} + \alpha_{1,t}\text{Exposed}_t * T_t + \alpha_{2,t}\text{Irreversible}_i * T_t + \alpha_{3,t}\text{Irreversible}_i * \text{Exposed}_i * \text{MII}_t + \epsilon_{i,t} \quad (3.3)$$

The dependent variable in this model, $ln(y_{i,t})$, is log investment by firm i for year t. Since the log of zero is undefined, about 9.5% of all firms are discarded because they have zero investment. Conditioning the sample to firms with positive investment does not induce a sample selection bias in our application, as we show in Section 3.5.4.

The variable of interest is the triple interaction term $\text{Irreversible}_i * \text{Exposed}_i * MII_t$. The first term, MII_t, simply captures the timing of the referendum. It is a dummy variable equal to 1 in all periods after the acceptance of the initiative early 2014, i.e. MII_t is 1 for $t \geq 2014$. Exposed_i represents the binary, time-invariant exposure dummy, constructed as discussed in the previous section. Irreversible_i reflects firms' self-assessed investment irreversibility. Consequently, α_3 reflects the effect of the referendum vote on exposed firms with irreversible investment. To estimate this parameter, we account for shocks and trends in the outcomes separately for firms with reversible and irreversible investment (due to the inclusion of irreversibility-time fixed effects, $\text{Irreversible}_i * T_t$)[18] and for shocks and trends that differentially affect exposed and non-exposed firms (due to the inclusion of exposed-time fixed effects, $\text{Exposed}_i * T_t$).

To understand how this triple-difference model identifies the effect of policy uncertainty, it is helpful to note that the DDD model compares two different DD: the first is the DD based on the comparison of investment between exposed firms with irreversible investment and non-exposed firms with irreversible investment. The second is the DD of investment between non-exposed and exposed firms with reversible investment. The difference between these DDs is the effect identified in the DDD

[18] T_t represents year dummies.

model, i.e. we compare the relative evolution of investment in exposed versus non-exposed firms with irreversible investment to the relative evolution of investment in exposed versus non-exposed firms with reversible investment. Our DDD reveals the causal effect of the uncertainty caused by MII under the identifying assumption that the two DDs would have displayed common trends absent the MII, conditional on the covariates. This assumption is not directly testable, but its plausibility can be assessed by studying whether the firms had similar investment developments in the period prior to the MII.

To make the assumption more plausible, our model also contains a large set of fixed effects that control for a variety of unobserved factors. First, we include firm fixed effects, γ_i, which account for all time-invariant factors that affect the outcome of firm i, such as firms' initial size and the quality of its initial capital stock. Exposed_i and Irreversible_i and their interaction are also absorbed by the firm fixed effects because these variables are time-invariant. Second, our model also contains a full set of industry-period fixed effects, $\delta_{j,t}$, build on the NACE revision 2 two-digit level.[19] These fixed effects absorb all period-specific factors that affect all firms within the same two-digit industry equally. Their inclusion limits concerns that our results are driven by industry-specific shocks in 2014 or 2015 that affect exposed with irreversible firms differently than other firms in the same industry, such as common demand and productivity shocks.

Despite these fixed effects, the main concern in our regressions is that our estimates are confounded by other simultaneous shocks that affect exposed with irreversible investment differently than other firms. Arguably, the main macroeconomic event in Switzerland in our sample period is the strong real appreciation of the Swiss Franc that followed the decision of the Swiss National Bank (SNB) to in January 2015 lift the exchange rate peg that it previously maintained vis Ã vis the Euro. Following the announcement of the SNB, the Swiss franc appreciated by over 10% against the Euro in real terms. Binding and Dibiasi (2017), Efing et al. (2016), and

[19] There are 75 different industries in our data set.

Kaiser et al. (2017) show that the permanent appreciation of the Swiss franc and the associated increase in uncertainty after the removal of the peg strongly depressed investment in 2015 and 2016 in Swiss firms with large currency exposure. The fact that the removal of the peg falls in our sample period raises concerns that our estimates pick up the effects of the "Franc shock". We provide several pieces of evidence that this is not the case (see Section 3.5.3 and Appendix C.1).

3.5 Main Results

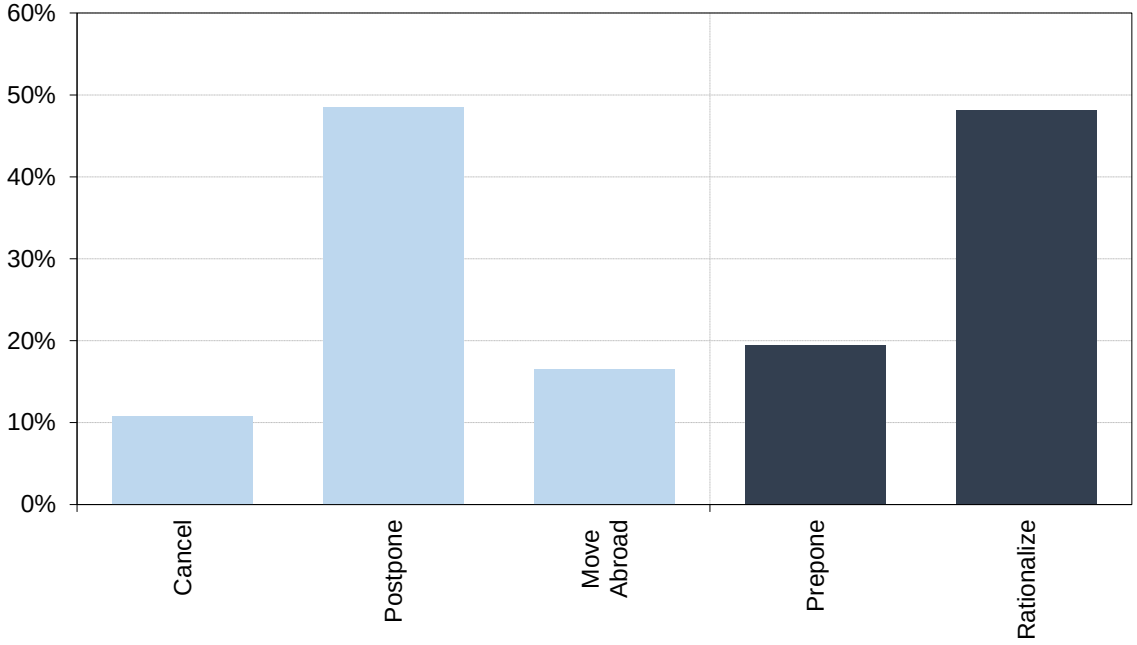
This section presents our main empirical results. A natural starting point for this analysis is the descriptive evidence from the special survey in which we directly asked firms about the consequences of the referendum on their investment behaviour. We then turn to a more formal analysis of the effects of the referendum on realised investment using the DDD model.

3.5.1 Survey Evidence

The special survey asked firms whether the acceptance of the referendum induced them to change their investment plans. Firms were given six different options, with the possibility to choose more than one. The options were: no measure, cancel investment, postpone investment, move investment activities abroad, prepone investment, and implement investment to streamline production. Overall, 85% of all participating firms reported that they will not and did not yet undertake any specific measure because of the policy shock. Figure 3.5 displays the share of firms reporting each measure conditional on those that report at least one measure. About half of these firms report to postpone investment. An almost equal share reports to engage in investment that streamline production. From a conceptual point of view, postponing investment is more likely to result from the uncertainty caused by the vote, while implementing investment to streamline production is rather caused by changes in the actually expected conditions, like future revenues, labour costs and profits. The figure suggests that the vote may, overall, not have led to a short-run decrease in investment: measures that decrease investment (cancel, postpone and move abroad)

might be balanced out by those that increase investment (prepone and streamlining).

Figure 3.5: Firms Reaction to the Acceptance of the MII



Notes: In autumn 2014, approximately 15% of all firms report that they have undertaken investment measures due to the acceptance of the MII. This figure displays which measures were taken and reports the share of firms that report a particular measure (conditional on firms reporting a least one measure). We weight firm answers with their number of FTE.

In the special surveys in spring and autumn 2014, we also asked survey participants how the acceptance of the referendum changed the certainty of their investment plans.[20] Firms could answer on a 5-item Likert-scale. Table 3.1 presents firms' answers to this question. It reveals that in both surveys approximately 16% of the participating firms reported that the referendum decreased their investment certainty.

[20] See the questionnaire in Appendix C.4 for the exact wording. Abberger et al. (2014) and Abberger et al. (2015) provide additional information on the special surveys in spring and autumn 2014.

3.5.2 Effects on Investment

The survey evidence suggests that the vote influenced firms' uncertainty surrounding their investment activity and that it had an impact on the investment plans of a sizeable subset of firms. In this section, we analyse how the MII affected firms' investment in the two years following the vote using the empirical strategy presented in Section 3.4.

In Table 3.3, we use the triple-difference model with firm fixed effects presented in Section 3.4.2 to identify the uncertainty effects of the vote on investment. Here and throughout the paper, standard errors are clustered on the level of the individual firm. The estimation sample covers the years 2009-2015. The estimated coefficient on the triple interaction term $\text{Irreversible}_i * \text{Exposed}_i * MII_t$ in column 1 of Table 3.3 is negative and statistically significant. Exposed firms with irreversible investment clearly lower investment expenditures in 2014 and 2015 relative to other firms. According to our theoretical argument, the estimate reflects the extent to which the uncertainty created by the vote depressed investment, as irreversibility mediates the uncertainty effects of the vote but should not matter regarding the first moment effects. Column 2 of Table 3.3 substantiates this presumption by flexibly controlling for the perceived first order effects of the referendum on the individual firms, as we collected them in the special surveys. These variables are the binary, self-reported effects of the MII on expected demand, Switzerland's growth potential, and firms' expected recruitment costs, each variable interacted with the exposed dummy. The point estimate of the triple interaction term $\text{Irreversible}_i * \text{Exposed}_i * MII_t$ remains almost unchanged if we do this, signalling that our approach is indeed able to pick up the effect attributable to uncertainty.

As was mentioned above, the DDD estimate in the first column of Table 3.3 is based on the difference of two DDs. It is instructive to look at these two DDs separately. The first DD is the DD comparing investment between exposed firms with irreversible investment and non-exposed firms with irreversible investment. The investment development of these two groups is plotted in the left part of Figure 3.6. In

order to illustrate the variation that we exploit in the firm fixed effects regressions in Table 3.3, we plot averages of firm-demeaned data (i.e. we subtract the time-average in investment from each observation and plot averages of deviations from within-firm means). We observe a strikingly similar trend of investment in both groups between 2009 and 2013. In 2014 and 2015, investment declines for exposed firms with irreversible investment, while it remains more or less constant for non-exposed firms with irreversible investment. The figure suggests that the vote had a negative impact on investment of exposed firms with irreversible investment. If we cast the plotted data into a simple DD model with firm- and industry-period fixed effects, we see that the difference in the evolution of investment between the two groups is statistically significant (column 4 of Table 3.3).

The second DD of interest in the DDD model compares investment of non-exposed and exposed firms with reversible investment. The right part of Figure 3.6 plots investment developments in these two groups. It suggests that the vote led to an increase in investment in exposed firms relative to non-exposed firms in 2014. Estimating a DD model with firm- and industry-period fixed effects confirms that the DD between the two groups in 2014 and 2015 is statistically significant (column 5 of Table 3.3). Note that there are some discernible differences in investment growth between exposed firms and non-exposed firms with reversible investment before the vote (see Figure 3.6). These differences in pre-trends are not statistically significant, however, and in fact become smaller once we account for industry-period fixed effects, as is done in our regression models.

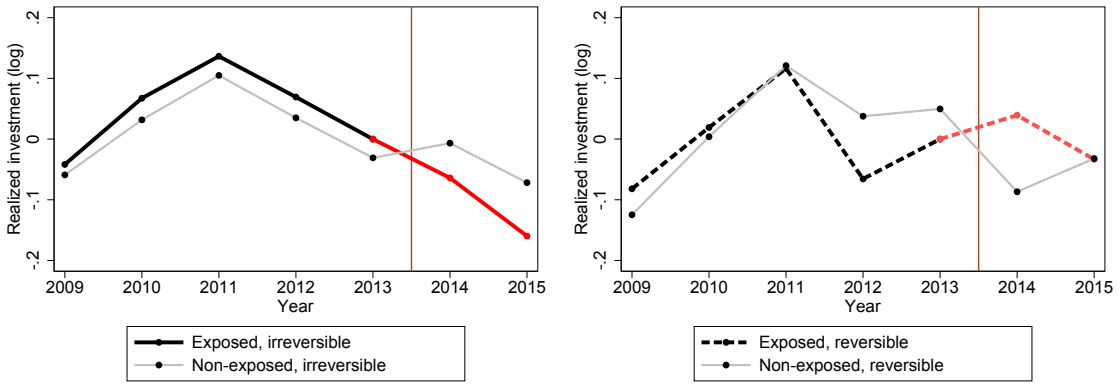
Table 3.3: DD and DDD Estimates of Effect of the MII Policy Shock on Investment

VARIABLES	(1) FE DDD	(2) FE DDD	(3) FE DDD continuous exposure	(4) FE DD only irreversible	(5) FE DD only reversible	(6) FE DD
MII x Exposed x Irreversible	-0.287***	-0.311***				
	(0.100)	(0.110)				
MII x Exposure x Irreversible			-0.759***			
			(0.293)			
MII x Exposed				-0.131**	0.180*	-0.040
				(0.066)	(0.100)	(0.053)
MII x Decreased exp. demand		0.055				
		(0.127)				
MII x Exposed x Decreased exp. demand		0.106				
		(0.163)				
MII x Decreased growth potential		0.026				
		(0.080)				
MII x Exposed x Decreased growth potential		-0.131				
		(0.107)				
MII x Exposed x Increase exp. recruitment costs		0.226*				
		(0.119)				
MII x Increase exp. recruitment costs		-0.021				
		(0.094)				
MII x Exposure			0.274			
			(0.482)			
Observations	12,648	10,340	12,648	8,850	3,798	13,765
R-squared	0.061	0.076	0.059	0.082	0.110	0.055
Number of firms	2,700	2,196	2,700	1,901	799	3,071
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Exposed-time FE	Yes	Yes	No	No	No	No
Irreversibility-time FE	Yes	Yes	No	No	No	No

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable in columns 1 to 6 is firm-level GFCF (in log). The variable *MII* captures the effect of the MII on investment plans and takes value one for the years 2014 and 2015 and takes value 0 for the years 2009–2013. The variable *Exposed* takes value 1 in case the likelihood of being exposed is above the median and 0 otherwise. *Exposure* is the corresponding continuous variable. The variable *Decreased exp. demand* takes value 1 in case a firm reported that the acceptance of the MII negatively affects its demand and 0 otherwise. The variable *Decreased growth potential* takes value 1 in case a firm expects negative effects of the MII on Swiss growth potential and 0 otherwise. The variable *Increase exp. recruitment costs* is one if a firm reports to expect increased recruitment costs because of the vote. The variable *irreversible* takes value 1 in case a firm has irreversible investment and zero otherwise. Model (1) to Model (3) examine the effect of policy uncertainty on firm investment using a DDD approach. Model (4) to Model (6) investigate the overall effect of the vote on investment in a DD setting. Model (4) limits the sample to firms that have irreversible investment. Model (5) limits the sample to firms that have reversible investment. Model (6) uses the entire sample.

Figure 3.6: Comparison of Evolution of Log Investment between Exposed and Non-Exposed Firms, by Investment Irreversibility



Notes: The figure visualises our DDD approach. In the subfigure on the left, we confine our sample to firms with irreversible investment and compare average realised Gross Fixed Capital Formation (GFCF) (in log) of exposed to non-exposed firms. In the subfigure on the right, we confine our sample to firms with reversible investment. In both figures, we demean investment data at the firm level in order to replicate the variation exploited in the firm fixed effects regressions. The red line separates years that are affected by the MII, i.e. 2014 and 2015, from years that are prior to the MII (2009–2013).

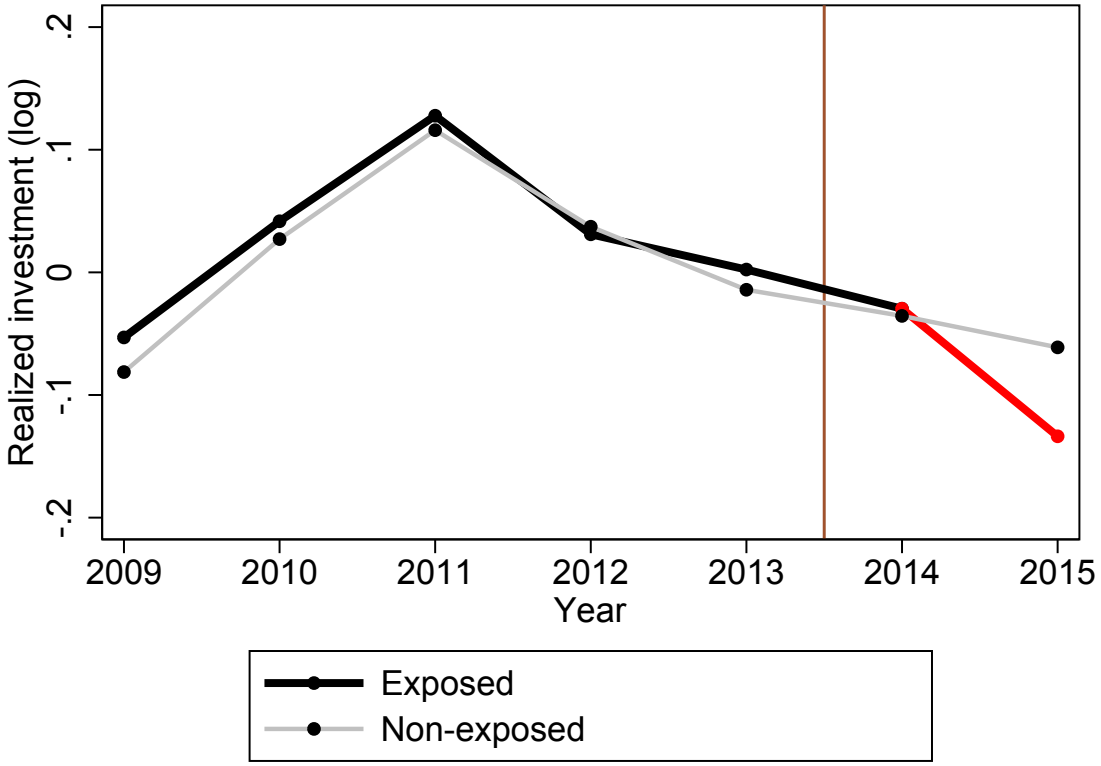
As becomes evident from the two DD in columns 4 and 5 of Table 3.3, the impact of the vote may combine real option and Oi-Hartman-Abel effects.[21] The negative uncertainty effect of the vote on investment arises, on the one hand, because exposed firms with irreversible investment reduce investment relative to non-exposed firms with irreversible investment, consistent with real option effects. On the other hand, it arises because exposed firms with reversible investment invest more, consistent with Oi-Hartman-Abel effects. Given the survey evidence presented in Section 3.5.1, this may reflect that the referendum led to the postponement of investment in some exposed firms but triggered investment–investment to streamline production in particular–in other exposed firms. Consistent with this explanation, column 2 of Table 3.3 shows that exposed firms that expect increased recruitment costs because of the vote invest more in 2014 and 2015 (i.e. the triple interaction term

[21] The Oi (1961), Hartman (1972), Abel (1983) effect states that in the absence of irreversibility (and other adjustment costs) an increase in uncertainty about future business condition leads to an increase of investment as optimal capital choices are convex in business conditions.

Increase exp.recruitment costs$_i$ $*$ Exposed$_i$ $* MII_t$ is positive and statistically significant). The uncertainty caused by the vote may have prevented the latter reaction in exposed firms with irreversible investment.

These results indicate that, as a whole, exposed firms did not invest less than non-exposed firms in 2014 and 2015, as the positive effect on investment of one group of exposed firms compensates the negative effect on the other group. Figure 3.7 illustrates this by plotting firm-demeaned yearly log investment separately for all exposed and non-exposed firms. The figure shows that realised investment developed very similarly in the two groups during the entire 2009-2014. There is some evidence that investment declines in exposed firms relative to non-exposed firms in 2015, but the difference is in fact not statistically significant. If we cast the plotted data into the simple panel DD model, it is confirmed that there are no statistically significant differences in gross fixed capital formation between exposed and non-exposed firms in 2014 and 2015 (cf. the last column of Table 3.3). Overall, our results suggest that the total investment effect of the vote, i.e. the sum of first and second moment effects, was close to zero. However, exposed firms with reversible investment invested more and exposed firms with irreversible investment invested less because of the vote. We interpret this heterogeneity among exposed firms as evidence for negative uncertainty effects of the vote.

Figure 3.7: Differences in Firm-Demeaned Gross Fixed Capital Formation between Exposed and Non-Exposed Firms



Notes: The figure compares average realised GFCF (in log) of exposed and non-exposed firms. We demean investment data at the firm level in order to replicate the variation exploited in the firm fixed effects regressions. The red line separates years that are affected by the MII, i.e. 2014 and 2015, from years that are prior to the MII (2009–2013).

This uncertainty effect is quite homogeneous across exposed firms with irreversible investment. There are no statistically significant differences in the uncertainty effects of the MII between exporters and non-exporters, between foreign-owned and domestic firms, and between firms with differing competition intensities.[22] The only groups of firms that are not statistically significantly affected by the uncertainty caused by the vote are large firms (firms with more than 250 FTE

[22]See Appendix C.3 and Table C.5 for details.

workers) and firms in the construction sector.[23] We also investigated whether it is the uncertainty about future recruitment costs or the uncertainty about expected demand and the access to the European market that drives the negative uncertainty effect of the vote. Our analysis suggests that both, the recruitment cost and the demand dimension play a role. However, the recruitment cost channel is empirically more robust and thus potentially more relevant (see Table C.4 and Appendix C.3 for details).

The estimates in columns 1 and 2 of Table 3.3 suggest that the economic policy uncertainty induced by the vote reduced irreversible investment by as much as 25-30% in 2014 and 2015 in exposed firms, suggesting that irreversible investment is very sensitive to policy uncertainty. How do the uncertainty effects found in this paper relate to estimates from previous papers? This question is not straightforward to answer because of the heterogeneity in size, significance, and in the measurement of the uncertainty shocks studied in the literature. However, assuming that the vote roughly doubled the economic policy uncertainty in Switzerland, as shown by the respective index in Figure 3.1, the estimated uncertainty effects are remarkably similar in magnitude to those in Gulen and Ion (2016). These authors find that a doubling of the Economic Policy Uncertainty index decreases irreversible investment by roughly 25% in the US. Jens (2017) shows that gubernatorial elections in the US depress investment by 5% on average. As in our study, this effect is significantly larger for investment that display a certain degree of irreversibility. Similarly,

[23] A potential reason for the smaller effects of uncertainty on large firms is that large firms display on average a lower degree of risk aversion. In spring 2017, Dibiasi et al. (2018b) conducted a survey experiment among the participants of the KOF Investment Survey to study the relative importance of capital irreversibility in the uncertainty-investment relationship. As part of the survey experiment, the authors levied information on the degree of firms' risk aversion. The results show that large firms display on average a lower degree of risk aversion than small firms. An explanation for the lower effect on investment in construction is that Swiss voters also decided on a second referendum on February 14 which is likely to have decreased policy uncertainty among some firms in this sector. In particular, the electorate accepted the introduction of the FABI rail infrastructure financing fund. This fund ensures the long-term funding of the rail infrastructure. Since FABI came into force in 2016, more funds are available for the maintenance and expansion of the railway network.

Riem (2016) finds that state elections in Germany decrease investment substantially. Overall, investment declines by 10% during years with state elections. Capacity expanding investment is reduced by 19%. The author attributes this to the larger adjustment costs for expansion investment. Despite the similarities with other studies, our findings also differ in one important dimension: our results suggest that the vote as a whole did not significantly affect firms' short-run investment expenditures on average because those exposed firms with more reversible investment invest more.

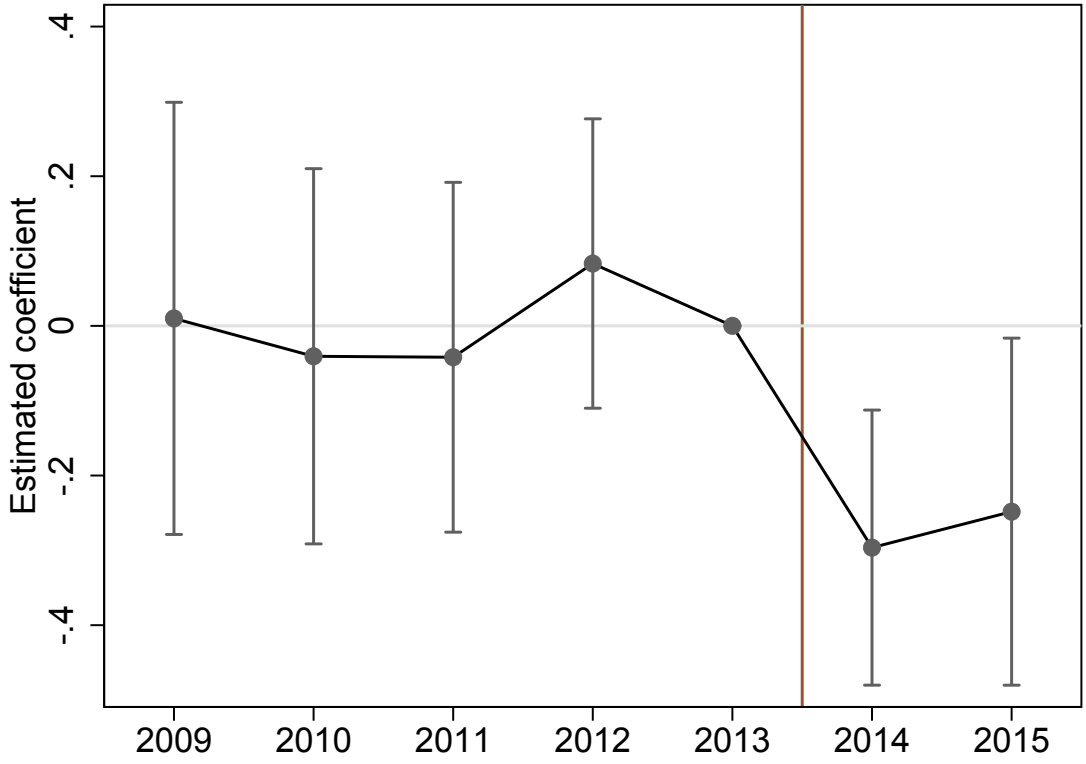
3.5.3 Placebo and Main Sensitivity Checks

Our DDD estimates rely on the assumption of a common trend in the two relevant DD absent the referendum. To examine whether this assumption is plausible, we study whether our DDD estimation identifies a spurious effect of the MII vote before the referendum took place. To this end, we generalize the DDD model to the following event study DDD model:

$$\begin{aligned} ln(y_{i,t}) = \gamma_i + \delta_{j,t} + \alpha_{1,t}\text{Exposed}_t * T_t + \alpha_{2,t}\text{Irreversible}_i * T_t \\ + \sum_{\substack{k=2009,\ldots,2005 \\ k\neq 2013}} \alpha_{3,t}\text{Irreversible}_i * \text{Exposed}_i * \text{MII}_t + \epsilon_{i,t} \end{aligned} \tag{3.4}$$

The event study model estimates the triple interaction term, capturing the uncertainty effect of the referendum, for every period before and after the vote. Because we omit the triple interaction term for 2013 from the regression, the treatment effects for each year are estimated relative to 2013, the year before the vote. The estimated series of coefficients on the variable of interest, $\alpha_{3,k}$, and their 90% confidence intervals, are plotted in Figure 3.8. The figure illustrates the substantial negative uncertainty effect of the vote identified by the DDD model in the period between 2013 and 2014. Investment remains depressed in 2015. On the other hand, we do not observe a significant effect of the referendum in the years leading up to the MII vote. This gives support to the validity of the central identifying assumption that the groups of firms would have displayed a common trend in the outcome absent the referendum.

Figure 3.8: Event Study Coefficients of the DDD Model



Notes: The figure depicts the series of event study coefficients (Equation 3.4) and the associated 90% confidence intervals. The event study model estimates the triple interaction term, capturing the uncertainty effect of the referendum, for every period before and after the vote. Because we omit the triple interaction term for 2013 from the regression, the treatment effects for each year are estimated relative to 2013, the year before the vote. The estimation sample covers the 2009–2015 period. The figure illustrates the substantial negative uncertainty effect of the vote identified by the DDD model in the period between 2013 and 2014.

Our unique data structure allows us to conduct another placebo test. In particular, we observe firms' investment plans for 2014 as collected in the survey in autumn 2013. This survey took place before the MII was accepted. Obviously, we should not be able to identify a significant effect of the MII on these plans. We thus re-estimate our panel DDD model (Equation 3.3) using the investment plans as collected in previous years' autumn surveys as outcome for each year. In this

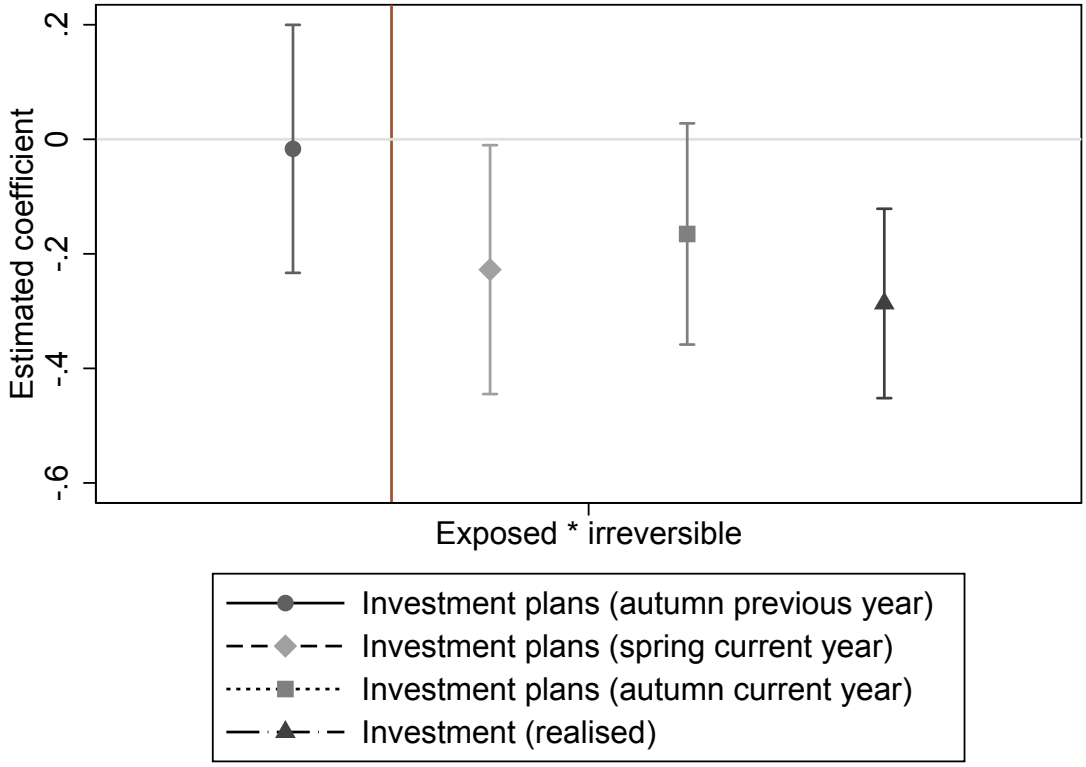
analysis, the sample is limited to the 2011-2014 period.[24] The resulting coefficient on the triple interaction $\text{Irreversible}_i * \text{Exposed}_i * \text{MII}_t$ is the first coefficient shown in Figure 3.9. Reassuringly, the point estimate in this placebo estimation is close to and statistically indistinguishable from 0.

The point estimate becomes negative if the outcome variable used in the regression is replaced by the partly planned and partly realised investment as collected in the spring surveys of the respective investment years. Using these spring figures for the running year as outcomes leads to the negative second coefficient in Figure 3.9. Note that these plans are potentially affected by the vote as the spring survey in 2014 was conducted a few weeks after the unexpected acceptance of the referendum. The difference between the first and the second coefficient in the figure shows that firms revised their investment plans for 2014 downward between autumn 2013 and spring 2014.[25] The third and fourth coefficient in the figure reveal that the downward revision persisted. We find a negative effect of uncertainty caused by the MII using the investment plans levied in the autumn survey of 2014 (coefficient 3) and in the realised investment figures (coefficient 4).

[24] The years 2009 and 2010 are dropped because we lack data on the outcome for these years. (The autumn survey in 2010, the earliest survey used in this study, provides planned investment for 2011.) We drop 2015 from the sample as the investment plans for 2015 levied in autumn 2014 are affected by the MII.

[25] In Appendix C.2, we examine formally how the referendum affected the revision in investment plans between the autumn 2013 and spring 2014 survey. The results are in line with our baseline estimates.

Figure 3.9: Uncertainty Effects of the MII, by Wave of the KOF Investment Survey



Notes: The figure shows the triple interaction term capturing the uncertainty effect of the MII, and associated 90% confidence intervals, estimated in four separate panel regressions of the baseline DDD model. The outcome is log nominal investment in all regressions, constructed using only the investment data from the respective survey indicated in the legend. For instance, the first whisker illustrates the point estimate and standard errors of the triple interaction term in our DDD model if the dependent variable is investment as levied in the autumn surveys previous to the investment year. The red line separates survey periods that are affected by the MII from survey periods that are not affected by the MII. The estimation sample covers the 2009–2014 period in all cases.

Apart from these placebo checks, we conducted a variety of sensitivity and robustness checks of which only the most important ones are shortly discussed here.[26] First, we show that the results do not depend on the specific way we constructed firms' exposure to the referendum. For instance, our results are very similar if we use the foreign share or the bilateral dummy directly as measures of exposure, rather than combing them into one composite exposure measure. The same holds if we use

[26] We refer to Appendix I for an extensive discussion of the robustness tests that we conducted.

another survey question to weight the foreign employment share and the "Exposed to Bilaterals" dummy.[27] Our results also do not change if we use the regression model in column 2 of Table 3.2 to construct firms' exposure to the referendum. In this logit regression, we include additional variables which likely affect firms' exposure to the MII, such as firms' export status or some variable measuring firms' perceptions about the intensity of price competition in their main selling market.[28] We prefer the more parsimonious specification as our baseline specification because using more pre-determined firm characteristics to construct exposure leads to a reduction in the number of observations available for estimation. Finally, the third column of Table 3.3 shows that we get similar results concerning the uncertainty effects of the vote if we use a continuous rather than a binary exposure measure. This also shows that our results are not driven by the threshold chosen to assign firms into exposed and non-exposed.

Second, we address the concern that the estimated effects are driven by unobserved confounding factors that affect exposed firms with irreversible investment but not the other groups of firms in 2014 or 2015. Our main results continue to hold if we control for a variety of fixed effects that absorb, among others, unobserved shocks that potentially affected exporters and non-exporters differentially (e.g., changes in trade policies) and unobserved regional shocks (e.g., changes in cantonal taxes), and if we control for group-specific linear time trends that account for separate time trends in the outcome for exposed and non-exposed firms with and without irreversible investment.

[27] This can be seen by comparing columns 1 and 2 with columns 3 and 4 of Table 3.2. In columns 3 and 4, we use a dummy equal to one if a firm reports in the special surveys that it has changed its investment plans because of the MII. The weights assigned to the foreign employment share and the bilateral dummy resulting from these regressions are very similar as the weights from columns 1 and 2 of Table 3.2.

[28] We present a specification that uses the full specification from column 2 of Table 3.2 in the robustness section in Appendix I.

We also studied in detail whether our results partly pick up the effects of the strong real appreciation of the Swiss Franc in 2015. As mentioned above, the appreciation was the consequence of the decision of the Swiss National Bank in January 2015 to lift the ceiling of the Franc vis-Ã -vis the Euro. There are several pieces of evidence that the "Franc shock" does not drive our results. First, our results are robust to including exporter-industry-period effects, which likely control for the disproportionate effects of the Franc shock on exporters. Second, firms that are more exposed to the MII shock are not firms that are particularly exposed to currency movements.[29] Third and most importantly, our results are virtually unchanged if we drop the year 2015 from the sample or, even more restrictively, if we restrict the sample to the 2012-2014 period (see columns 7 and 8 of Table C.1). Because of the ceiling entertained by the SNB, the trade-weighted real exchange rate of Switzerland was virtually constant during this period.

Finally, we provide evidence that the results and the size of the estimated effect are remarkably similar if we apply two complementary approaches to estimate the uncertainty effects of the vote. The first alternative compares the reaction of firms to the MII that were 'fairly uncertain' or 'very uncertain' about the realisation of their investment in 2014 to the reaction of firms that were 'fairly certain' or 'very certain' about their investment when asked about this in autumn 2013. We find that firms that considered their investment plans for 2014 uncertain before the vote display a stronger negative reaction to the outcome of the vote. The second alternative approach exploits that we asked firms directly whether the vote affected the uncertainty surrounding future investment activities in the special surveys. Using

[29] Kaiser et al. (2017) analyze the effects of the "Franc shock" on firms' investment. Their analysis is based on the KOF investment data set as well. They follow previous papers on the effects of exchange rates on firm investment and consider a firm to be exposed to currency movements if it has a high share of exports in sales and a low share of imported intermediate inputs in costs (see, e.g., Ekholm et al. (2012), for a discussion). They find strong negative effects of the Franc shock on investment in exposed firms. Importantly, however, the correlation between their net exposure measure (i.e. firms export share in sales minus firms imported inputs share in costs) and the continuous version of the exposure measure used in this paper is only 0.14. This suggests that the Franc shock affected a different set of firms than the MII shock.

firms' answers to this question, we study whether firms that report to be affected by increased investment uncertainty because of the MII change their investment plans differently than firms that did not report increased investment uncertainty. The regressions use firms' revisions in investment plans between autumn 2013 and spring 2014 as outcome. The results show a statistically significant negative uncertainty effect on firms' revisions in their investment plans. As in our baseline approach, these effects are concentrated among firms with irreversible investment.

3.5.4 Effects on Equipment and Construction Investment

How did the uncertainty caused by the vote affect firms' investment in machinery and equipment and construction investment? The response to an uncertainty shock might differ between these two types of investment. On the one hand, the two investment types differ in their degree of irreversibility. Commercial buildings can often be used for different purposes, while equipment and machinery are less likely to be of use to another firm, implying that investment in construction display on average a lower degree of irreversibility than investment in machinery and equipment (Ronen and Sorter, 1972; Berger et al., 1996). However, the average depreciation rate of construction investment is usually lower than the depreciation rate of equipment. Hence, construction investment may be more forward-looking than investment in machinery and equipment. In cases where uncertainty does not immediately resolve, construction investment might thus be more sensitive to policy uncertainty than investment in equipment.[30]

To study the question how uncertainty affects different types of investment, we first compare investment between all exposed and non-exposed firms. The results are presented in the first column of Table 3.4. The estimation sample covers the period between 2010 and 2015.[31] We find no evidence for a systematic effect of the

[30] We thank an anonymous reviewer for pointing this out to us.

[31] KOF started levying data on different investment categories only in spring 2012. Hence, there are no investment data available for 2009. The sample period of these regressions is thus 2010-2015.

vote on equipment investment and construction investment. The second column reports the results of our baseline DDD model that identifies the effects of the uncertainty caused by the vote. We find evidence that the uncertainty depressed firms' investment in machinery and equipment (column 2, Panel A) and firms' construction investment (column 2, Panel B) in 2014 and 2015. The estimated effects are of similar size for both investment categories.

One concern with these estimates for equipment and construction investment is that observations with zeros are discarded from the estimation sample because we use a log-transformed outcome. This is a particular worry for construction investment because many firms actually do have zero expenditure on construction investment in many years. Two pieces of evidence suggest that the results from our baseline model do not depend on the exclusion of the zeros, however. First, the MII does not appear to influence the probability to have nonzero investment. This holds for equipment and construction investment and, consequently, also for investment in total (see column 3 of Table 3.4).[32] In these regressions, we use a dummy variable equal to 1 if the respective investment is positive and 0 if it is truly zero as outcome of our baseline DDD model.

Second, the results are similar if we use investment in levels rather than logs as the outcome variable. These regressions retain the true zeros in the estimation sample. In order to reduce the efficiency loss due to over-dispersion in the dependent variable, we normalize the outcome variable with the initial size (in terms of FTE employment) in these regressions. We estimate the DDD on the investment per FTE worker using a FE regression model in column 5 of Table 3.4 and using a FE Poisson model with heteroscedasticity-robust standard errors in column 6. The FE Poisson estimator has interesting robustness properties as it is consistent even if the data are not actually Poisson distributed provided the conditional mean is correctly

[32] The fourth column of the table shows that the conclusion is unchanged if we replace truly missing observations with 0 and re-estimate the model including missings as zeros.

specified.[33] These alternative models confirm our baseline estimates. Reassuringly, the same regression models also confirm our baseline results for total investment (see Panel C of Table 3.4). They tend to be less precisely estimated, however, probably due to the large over-dispersion in the dependent variable.

Table 3.4: DD and DDD Estimates of Effect of the MII Policy Shock on Investment

VARIABLES	(1) DD OLS Baseline	(2) DDD OLS Baseline	(3) DDD LPM 0/1	(4) DDD LPM 0/1 incl. missing	(5) DDD OLS Investment rate (level)	(6) DDD FE Poisson Investment rate (level)
Panel A: Equipment investment						
MII x Exposed	-0.060					
	(0.051)					
MII x Exposed x Irreversible		-0.204**	-0.000	-0.031	-2,246**	-0.251**
		(0.098)	(0.019)	(0.033)	(1,048)	(0.122)
Observations	11,445	10,561	11,562	14,873	11,438	11,006
Panel B: Construction investment						
MII x Exposed	-0.028					
	(0.100)					
MII x Exposed x Irreversible		-0.373**	-0.010	-0.041	-3,882	-0.468*
		(0.183)	(0.035)	(0.034)	(2,383)	(0.241)
Observations	6,845	6,359	9,710	14,873	9,622	7,652
Panel C: Total investment						
MII x Exposed	-0.028					
	(0.053)					
MII x Exposed x Irreversible		-0.286***	0.007	-0.026	-6,626**	-0.394***
		(0.101)	(0.017)	(0.031)	(2,608)	(0.143)
Observations	12,505	11,496	12,451	14,873	12,334	11,970

Notes: The table reports estimations using the specification of the outcome mentioned in the column header. The estimation sample covers the years 2010–2015. The dependent variables are investment in equipment (Panel A), investment in construction (Panel B), and gross fixed capital formation (GFCF, Panel C). Column (1) reports the results from a DD model, comparing exposed with non-exposed firms. The remaining columns present the results from our baseline DDD model. Column (2) reports OLS fixed effect panel estimations and uses investment figures (in log) as dependent variable. Column (3) reports coefficients of a linear probability model on a binary variable that takes value 1 in case a firm invested in a given year and zero otherwise. Column (4) also uses the binary outcome but includes missing values as zeros. Column (5) reports OLS fixed effect panel estimations. The dependent variable is investment divided by the number of FTE in the first year a firm is observed in the panel data set. Column (6) reports coefficients of a fixed effect Poisson model using the same outcome variable as in column (5).

[33] This is an important reason why this estimator has become standard in the analysis of trade flows (see Silva and Tenreyro (2006)).

3.6 Conclusion

We study how the surprising acceptance of a far-reaching popular initiative in Switzerland affected firms' investment plans in the two years following the vote. The vote put several economically relevant agreements between Switzerland and its main trading partner, the EU, at stake, and questioned firms' access to the pool of EU workers. In the years prior to the vote, firms heavily recruited from EU countries. Similar to the vote on the Brexit and the US presidential elections in 2016, the unanticipated acceptance of the referendum created substantial and lasting uncertainty about future economic policy of Switzerland. Real option theory predicts that firms that face irreversible investment decisions resort to a wait-and-see behaviour in such a situation of temporary increased uncertainty.

Our survey evidence and Difference-in-Differences-in-Differences (DDD) estimations using firm-level panel data for the 2009-2015 period indeed suggest that the policy uncertainty shock led to significant downward adjustments in firms' investment. Firms that were exposed to the uncertainty effects of the vote reduced both, investment in equipment and machinery and construction investment in the two years following the vote. These negative effects are concentrated among firms that would find it costly to resell their physical capital and have therefore difficulties reversing their investment decisions. The results suggest that the uncertainty created by an unexpected and vaguely formulated amendment of the constitution can immediately reduce firms' investment. However, we also find some evidence that firms facing lower demand or recruiting difficulties but less exposed to the uncertainty effects because of lower investment irreversibility, invested more. This result is corroborated by qualitative survey evidence suggesting that such firms engaged in additional (streamlining) investment.

Chapter 4

Exchange Rate Uncertainty and Firm Investment Plans Evidence from Swiss Survey Data[1]

4.1 Introduction

On January 15th, 2015 the Swiss National Bank (SNB) removed a lower exchange rate floor of the Swiss Franc vis-a-vis the Euro and introduced a floating exchange rate regime immediately. This change of exchange rate regime came as a surprise. The Swiss Franc appreciated by around 15 percent against the Euro in the immediate aftermath of the announcement. We argue that this sudden appreciation did not only represent a first moment shift of the CHF/EUR exchange rate, but that it also increased uncertainty about the future exchange rate. Aggregate uncertainty indicators reacted strongly as a consequence of this policy change, which supports our claim.

The economic literature has discussed the importance of uncertainty for economic activities extensively in the past forty years. Arguments have been made for various channels of influence between uncertainty and economic indicators. We will limit

[1]This chapter is based on Binding and Dibiasi (2017)

our analysis to the effect of uncertainty on investment and focus on the theoretical channels known as real-option and growth-option effects. While real-option theory argues that uncertainty should lower irreversible investment temporarily if markets are not perfectly competitive, growth-option effects imply an increase in investment in uncertain times. This counterintuitive prediction deduces from the idea that the potential losses of an investment project are confined at a project's initial costs while possible revenues from the same project are unbounded.

We study the monetary policy shock in Switzerland and its effect on investment plans of Swiss firms. We assume that the policy shock introduced exchange rate uncertainty that is equivalent to uncertainty about foreign market prices. This should directly affect firms' decisions. We exploit the exogenous nature of the exchange rate shock and estimate its effect on firm-level investment. The firm-level data stem from the KOF investment survey. The biannual survey provides data on firms' investment plans for the year 2015 at two time points, once in Autumn 2014 and once in Spring 2015. Therefore, we obtain firm-level investment projections for 2015 at a time when the lower bound was still effective (in Autumn 2014) and at a time when the lower bound had been abandoned (in Spring 2015). We can measure the change in firms' investment plans for 2015 between the two survey waves, so that we can estimate whether a firm increased or decreased its investment plans for 2015 between Autumn 2014 and Spring 2015. Finally, we connect these investment plan changes to the exchange rate shock.

Within the data, we can distinguish between the areas where each firm chose to invest: investment plans in equipment and machinery, in construction, and in research and development. Additionally, the dataset allows the identification of the subjective first and second moment impacts of the sudden appreciation of the Swiss Franc on exchange rate expectations. Furthermore, the dataset contains information on further firm-specific characteristics, such as the sector in which a firm operates, a firm's number of employees, different degrees of irreversibility of investment, or a firm's export share. We will use this set of variables to explain firms' investment plan revisions for 2015 across the different types of investment categories distinguished above.

Our firm-level proxy for uncertainty can explain firm investment plan revisions to a certain extent. We find a negative effect of uncertainty on investment plans in equipment and machinery and find that the effect of uncertainty is stronger for irreversible investment than reversible investment. The difference in investment plans for equipment between firms indicating uncertainty and irreversible investment and other firms is a decrease of almost 10 percentage points. This finding is in line with real-option theory. Furthermore, we find a positive effect of uncertainty on expenditures in research and development through growth-option effects, indicating that firms experiencing uncertainty planned to increase their investments in research and development after the shock. Here, the difference between firms indicating uncertainty and other firms is roughly 13 percentage points.

This paper adds to the ongoing debate on wait-and-see business cycles. While Bloom (2009) and Baker and Bloom (2013) provide evidence that macroeconomic uncertainty shocks are strong enough to lead to wait-and-see fluctuations in aggregate investment, Bachmann and Bayer (2013) find that macroeconomic uncertainty shocks can only explain a small percentage of the variation in aggregate investment. These contradictory results are a consequence of the samples of firms used in these articles, as Bachmann and Bayer (2013) demonstrate that limiting analysis to publicly listed firms overemphasizes the effect of uncertainty.

We provide evidence that the effect of uncertainty increases with firm size and add another dimension to the discussion. When studying the effect of uncertainty on aggregate investment, researchers usually focus on gross fixed capital formation (GFCF) which represents an aggregate of various investment categories, such as investment in machinery and equipment, investment in construction or investment in research and development. Yet the effect of uncertainty on investment in these distinct categories is not coordinate. We show that focusing on gross fixed capital formation masks the effects of uncertainty, as the effects within the distinct investment categories are of opposite signs.

Furthermore, this paper uses the combination of an exogenous event and firm-level uncertainty measures to circumvent identification issues. Generally, identification appears to be a constant struggle when studying uncertainty shocks. We solve

this problem by exploiting an exogenous policy shock. The removal of the currency peg allows us to determine the source of uncertainty and study its effects on firm investment plans. To fully identify the effects of uncertainty, we need to separate how much of the investment plan revisions are due to first moment changes and how much of the revisions are due to second moment changes. We observe first moment changes and can derive changes in firm-level uncertainty from a survey question designed to measure perceived uncertainty.

The remainder of the paper is structured as follows. First, we reflect on the theoretical relationship of uncertainty and investment and elaborate on recent developments in measuring uncertainty. Then, we focus on the change in exchange rate regimes and the appreciation of the Swiss Franc before describing our hypotheses. Section 4.3 presents our dataset and and the variables used in estimation. We present our identification strategy of uncertainty as well as our empirical model in Section 4.4, before Section 4.5 concludes. We provide robustness analysis and diagnostics in the Appendix.

4.2 Uncertainty and Investment

Recently, studies on uncertainty have received increased attention. Several factors have led to this surge in the literature. According to Bloom (2014), the sudden increase in economic uncertainty with the beginning of the Great Recession in 2008 and uncertainty's role in the recession's trajectory led to heightened academic interest. Additionally, technical progress such as increased computing power and the digitalization of news allowed for novel methods of measurement and of estimation of uncertainty (Bloom, 2014).

In this section, we summarize findings in theoretical and empirical literature on investment under uncertainty. We continue with a discussion of uncertainty measurement and provide arguments why the sudden exchange rate appreciation on January 15th, 2015 lead to an increase in uncertainty about the future exchange rate. We conclude this section by defining our hypothesis.

4.2.1 Theoretical Aspects of Uncertainty

Investment theory has long recognized that investment decisions are influenced by uncertainty.[2] In this study, we shall focus on two theories, real-option and growth-option theory, which propose different theoretical channels through which uncertainty may influence investment. Additionally, we will consider the renewed debate concerning the relevance of aggregate uncertainty shocks for business cycles.

Real-option theory argues that uncertainty can reduce investment when irreversibility of investment is given (Bernanke (1983); Pindyck (1988); Caballero (1991)). Several studies have provided empirical evidence in favour of real-option theory. Guiso and Parigi (1999) proxy uncertainty using the variance of a firm's self-reported probability distribution of future demand. They find that uncertainty decreases investment among Italian firms. Additionally, they find that the negative effect of uncertainty on investment is stronger for firms with higher market power and more irreversible investment. Similarly, Bontempi et al. (2010) exploit the panel structure of Italian firm-level data to show that a reduction in demand uncertainty leads to an increase in investment activity. Using Belgium investment survey data, Fuss and Vermeulen (2008) show that uncertainty does not influence the revisions of investment plans of Belgian firms, while realized investment is influenced by uncertainty. The authors conclude that uncertainty might affect investment decisions only after a certain delay. Kang et al. (2014) exploit the interaction of aggregate policy uncertainty shocks with firm-level uncertainty to show that different aggregate uncertainty shocks can hamper firm-level investment.

[2]Uncertainty is an ambiguous concept. The term uncertainty is referred to in various applications of probability theory with perceptions differing fundamentally. The relevant conception for uncertainty in investment decisions is uncertainty as described in Knight (1921). Knightian uncertainty represents a type of uncertainty which comprises a fundamental lack of knowledge about the future. Knightian uncertainty is the kind of uncertainty necessary to trigger a wait-and-see behaviour according to Bernanke (1983) and is probably best known from the "Ellsberg paradox" (Ellsberg, 1961). Hansen (2014b) offers a depiction of the concept's relevance in modern economic literature.

Contrary to real-option theory, growth-option theory describes a mechanism by which uncertainty can increase investment. For example, when investment is reversible, when firms operate in perfectly competitive markets, or when investment projects have a long time span, uncertainty may enhance investment activity. This notion is based on the idea that the potential losses of investment projects are bounded at their initiation costs, while potential revenue is unbounded. A mean-preserving increase of uncertainty in the expected price development increases expected profit (Bar-Ilan and Strange (1996)). Empirical support for this theory has often be found in connection with expenditure in research and development. Kraft et al. (2013) and Stein and Stone (2013) find positive effects of uncertainty on research and development intensive firms. However, Czarnitzki and Toole (2011) find that research and development investment falls in response to higher levels of uncertainty.

Several papers have considered the question whether uncertainty shocks can influence business cycles. Bloom (2009) provides evidence that uncertainty shocks trigger wait-and-see behavior of aggregate variables, i.e. the variables experience a sharp drop and subsequently a rapid rebound that overshoots their initial state. In a large cross sectional study, Baker and Bloom (2013) use natural experiments to study the effect of uncertainty and find similar patterns. However, Bachmann and Bayer (2013) present evidence that points towards a more moderate effect of uncertainty on aggregate fluctuations. The authors present evidence that macroeconomic uncertainty explains only a small percentage of the variation in aggregate investment. A factor that can explain these contradictory conclusions is the sample of firms used in estimation. For example, Bachmann and Bayer (2013) use USTAN data, a German dataset that has a broader coverage of more diverse firms than most comparable datasets. The authors show that the effect of uncertainty is higher when focusing on larger firms but abates when all firms are includes in the analysis. Recently, Morikawa (2016) examined the effect of business uncertainty on investment plans of Japanese firms. The author finds mixed evidence in this matter. While uncertainty over firms' business situation appears to have a more negative influence

on larger firms' investment plans, appears uncertainty over production capacity to have a more negative effect on investment plans of small firms.

Finally, while there is a large amount of literature concerning the relationship of uncertainty and investment in general, studies that focus on the relationship between exchange rate uncertainty and investment are rather rare. Building on theoretical work laid out by Dixit and Pindyck (1994), Darby et al. (1999) examine the impact of exchange rate uncertainty on investment within a theoretical framework. The authors show that an increase in exchange rate volatility can lead to a decrease in investment. However, the theoretical relationship is clear-cut and leads to contradictory predictions. The direction of the effect of exchange rate uncertainty on investment appears to be more stable in empirical studies. Using a large sample of developing countries, Servén (2003) finds a negative impact of exchange rate uncertainty on private investment.

4.2.2 Measuring Uncertainty

The measurement of uncertainty is an often discussed topic. In recent years, a branch of literature has started to focus more intensely on different sources of uncertainty and on new methods of measurement. The most prominent ways of measuring uncertainty include capturing sentiment in newspapers[3], the dispersion of point estimates of professional forecasters[4], the dispersion of firm assessments in survey data[5], and volatility measures in equity and bond markets[6].

Although certain indicators have become more prominent in this field (such as the uncertainty indicator by Baker et al. (2015b) which incorporates and aggregates different types and sources of information), it is still often unclear what kind of uncertainty is being captured by various indicators. The variety of ways uncertainty is measured makes it difficult to derive clear policy decisions from existing literature.

[3]Baker et al. (2015b), Iselin and Siliverstovs (2013)
[4]Bomberger (1996), Boero et al. (2008), Baker et al. (2015b)
[5]Pattillo (1998), Guiso and Parigi (1999), Temple et al. (2001), Driver et al. (2004), Bachmann et al. (2013), Bianco et al. (2013)Abberger et al. (2014b), Abberger et al. (2015)
[6]Bloom et al. (2007),Bekaert et al. (2010), Stein and Stone (2013)

One way to tackle this deficit can be the use of natural experiments. Here, the exogenous source of uncertainty can be identified, while other methods of measurement tend to have difficulties in identifying the origin of changes in their uncertainty measure. Recently, Julio and Yook (2012) used exogenous electoral cycles to identify uncertainty, while Baker and Bloom (2013) proposed the use of natural disasters, terrorist events, or policy shocks to identify uncertainty.

Finally, a clean identification of uncertainty requires a differentiation between first and second moment effects.[7] We address both issues in this paper to fully identify uncertainty. First, we exploit the unexpected switch in exchange rate regimes on January 15th, 2015 as an exogenous policy event. We argue that removing the lower bound led to a negative first moment shift in the CHF/EUR exchange rate and to an increase in uncertainty about the future exchange rate.[8] Second, we use survey data to determine the first and second moment effects of this shock on firms' subjective exchange rate expectations.

4.2.3 Exchange Rate Uncertainty in Switzerland

An exchange rate floor of the Swiss Franc versus the Euro was originally introduced in September 2011 after the Franc had appreciated in value. The Swiss National Bank justified the implementation of such a regime with the explicit goal of limiting risks for the Swiss economy and of minimizing the possibility of deflation (Rathke and Sturm, 2015). Therefore, a minimal exchange rate of 1.20 CHF per Euro was defended with all means available to the central bank. In this section, we focus on

[7] First moment changes in price expectations affect investment. Changes in the first moment can be systematically related to changes in the second moment. If they are systematically related, not controlling for the first moment change would lead to a misspecified model and introduce an omitted variable bias.

[8] Note that the exchange rate determines the foreign market price, which is part of the cost-benefit analysis of investment projects. This means that uncertainty about the future exchange rate directly influences firms investment decisions. Also, note that Switzerland is a small open economy and that the European market is the most important export market for Swiss firms (more than 50% of Swiss exports have a destination within the EU-28, Bundesamt für Statistik (2015)).

explaining why the removal of the lower floor by the SNB caused uncertainty and provide aggregate measures which support our claim.

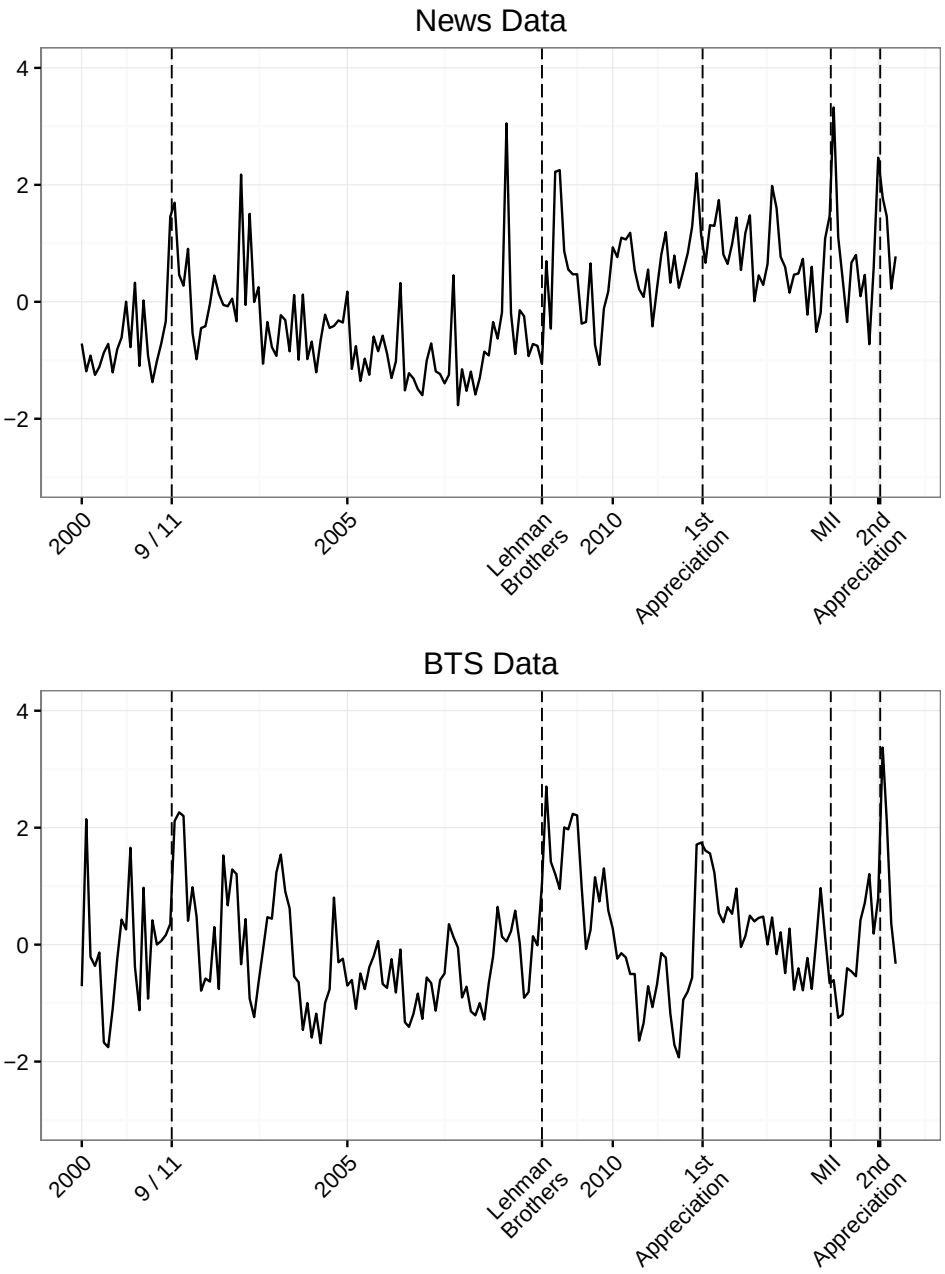
In the three years after the original announcement, the National Bank defended the lower bound. In the days and weeks leading up to the announcement of a flexible exchange rate versus the Euro, executive members of the National Bank had continued to repeat that a floored exchange rate was necessary. There were no indications for regime-change prior to the announcement of the Swiss National Bank that this regime would come to an end (Rathke and Sturm, 2015; Fuster, 2014). Articles in the influential Swiss newspaper “Neue Zürcher Zeitung" support this point of view, stating that not even the national executive council (the “Bundesrat") had been informed before the announcement by the central bank (Flückiger, 2015). The arguments presented by the Swiss National Bank as to why they decided to leave this path were twofold. First, a divergence of currencies was observed. While the US Dollar was appreciating in value, the Euro (and along with it the CHF) was depreciating. As the European Central Bank had announced that they would loosen their monetary policy even further, this tendency was bound to continue in the coming months. Second, the president of the Swiss National Bank, Thomas Jordan, indicated that Swiss firms had been able to use the period of relative certainty to adapt to the new situation. The introduction of a floored exchange rate had never been communicated as a permanent regime, its temporary nature was clear from the beginning (Fuster, 2015).

Even so, the actions of the National Bank leading up to January 15th, 2015 made its announcement unforeseeable. It had been expected that the Swiss National Bank would not exit this strategy abruptly, but that they would adapt step by step. Additionally, it had been assumed that this change would be announced (or at least suggested) publicly prior to any actual action (Fuster, 2015). Beside the modalities of communication and action of the Swiss National Bank, the timing of this decision was a surprise for all observers. It had been expected that the exchange rate floor would be defended as long as inflation in Switzerland remained low and the economic crisis in Europe continued (Rathke and Sturm, 2015). The general economic situation in Switzerland and elsewhere had not changed, which

made the abrupt change in policy all the more surprising. As such, we will consider the unexpected decision of the Swiss National Bank to allow the Swiss Franc to float versus the Euro as an exogenous shock, leading to exchange rate uncertainty for Swiss firms.

Admittedly, this assessment of the situation could be based on hearsay or anecdotal evidence. To support our claim, we present two quantitative indicators which reproduce the shock at an aggregate level. One of them measures coverage of uncertainty in the media, the other one measures the dispersion of demand expectations of industrial firms. First, the uncertainty indicator described in Iselin (2015) is an uncertainty measure similar to the media indicator documented in Baker et al. (2015b). Here, a daily measure of the keywords "Switzerland+uncertainty" in Swiss newspapers is generated. The development of this indicator can then be understood as a reproduction of concern for uncertainty in the media. This is displayed in Figure 4.1 in the top panel. The daily data is aggregated to its monthly sum and subsequently standardized. Evidently, two periods of heightened newspaper coverage of uncertainty can be identified. The first period is after the acceptance of the initiative on immigration in February 9th, 2014 (MII), the second is between January and March 2015. The indicator mirrors uncertainty transmitted through newspapers and peaks in January 15th 2015.

Figure 4.1: Uncertainty Indicators for Switzerland



Notes: The upper panel shows the News Uncertainty Indicator for Switzerland that stems from Iselin (2015). Based on the idea of Baker et al. (2015b), Iselin (2015) counts Swiss newspaper articles that contain "Switzerland" and "uncertainty". We aggregate the daily indicator to a monthly frequency. The indicator mirrors uncertainty transmitted through newspapers and peaks in January 15th 2015. The lower panel shows Theil's disconformity index for firms' demand expectations. The indicator depicts the monthly disagreement of demand expectations of firms participating in the KOF manufacturing business tendency survey. All indicators are standardized to mean zero and normalized to unit variance. Figure D.1 in the Appendix shows that Reardon (2009) measure of ordinal variation produces a similar picture.

A second indicator measuring the dispersion of demand expectations which supports the claim that floating the Franc came as a shock is shown in the bottom panel in Figure 4.1. This indicator is created by measuring the dispersion of short term demand expectations of industrial firms, identical to Theil's disconformity index for qualitative surveys (Theil, 1955). Firms are asked whether they expect demand to increase, stay unchanged, or decrease in the months to come in a KOF Business Tendency Survey (BTS). The measure is then obtained by the sum of the percentage of firms indicating an increase and that of those indicating a decrease, minus the squared difference of the two shares. The variance of expectations can be thus seen as a measure of aggregate demand uncertainty. The months after January 15th indicate the highest uncertainty by far.[9] It is important to understand that the two indicators measure uncertainty differently, so that there are similarities, but also differences in their developments.

To summarize, these two quantitative indicators support our claim that the actions of the Swiss National Bank were a shock for both economic and political actors in Switzerland. This supports our anecdotal evidence presented above. We would also like to refer to other papers which studied economic phenomena in the light of this event and considered the actions of the Swiss National Bank as a shock. Efing et al. (2015) study the response of investors to the currency shock. The study provides evidence that publicly listed firms with a large currency exposure experienced large negative announcement returns. Bonadio et al. (2016) use the shock to analyze the speed of exchange rate pass-through in the light of a rapid appreciation and find that the speed of adjustment is surprisingly fast. Interestingly, nominal rigidities appear to play a less prominent role. Amador et al. (2016) use the unexpected event to develop a model for "reverse speculative attacks". That is, to develop a theoretical framework to study the case in which a central bank seeks to maintain a currency peg under appreciation pressure. The model predicts dynamics that resemble those observed in Switzerland fairly well.

[9] A similar picture results when a measure for ordinal variation is calculated, see Figure D.1 in the Appendix (Reardon, 2009)

4.2.4 Theoretical Hypotheses and Empirical Specification

Section 4.2.3 argued that the exchange rate shock can be considered an exogenous shock. The sudden appreciation was not only a first moment shock of the CHF/EUR exchange rate, but also lead to a substantial increase in uncertainty about the future exchange rate. As the exchange rate determines prices in foreign markets, firms' investment decisions should be affected directly by these first and second moment changes. Consequently, the policy shock should provide ideal circumstances to investigate how uncertainty affects firm investment plans. As discussed in Section 4.2.1, uncertainty can affect the investment of firms through different mechanisms. We focus on mechanisms described in growth-option and real-option theory. Ideally, we would like to observe firm investment plans both before and after the shock to test the influence of the uncertainty induced by the exchange rate shock on investment plans. This would allow us to quantify revisions of investment plans and tie them to the exchange rate shock. Furthermore, we would like to observe how the shock changed the first and second moment of firms' subjective exchange rate expectations. Finally, we would like to have information on the degree of irreversibility of planned investment. Observing these variables and characteristics, we would be able to test the influence of the exchange rate shock on firm's investment plan revisions via the following model:

$$\Delta I_{i,t=2015} = a_1 \Delta \textit{expected exchange rate}_i + a_2 \Delta \textit{uncertainty}_i + a_3 \textit{irreversibility}_i + a_4 \Delta \textit{uncertainty}_i \times \textit{irreversibility}_i + \mathbf{aX}_i \quad (4.1)$$

where $\Delta I_{i,t=2015}$ represents the change of firm i's planned investment for the year 2015 due to the exchange rate shock (the notation used in this paper is explained in Chapter 4.3.2 in more detail). $\Delta \textit{expected exchange rate}_i$ represents the subjective first moment shift in the expected exchange rate of firm i. $\Delta \textit{uncertainty}_i$ represents the change of the second moment of the expected exchange rate of firm i. The variable $\textit{irreversibility}_i$ controls for the degree of irreversibility of firm i's investment

plans. The interaction term $uncertainty_i \times irreversibility_i$ captures potential real-option effects. And $\mathbf{X}_i$ controls for additional firm characteristics.[10]

As the sign of $\Delta expected\ exchange\ rate_i$ depends on the combination of a firms' export and import share, it is difficult to formalize expectations on the sign of the coefficient. It is much easier to formalize expectations on the signs of the remaining coefficients. In accordance with growth-option theory, we expect the coefficient of $\Delta uncertainty_i$ to be positive as an increase in uncertainty should lead to an increase in reversible investment. However, real-option effects should prevail when $irreversibility_i$ is controlled for and interacted with $\Delta uncertainty_i$. In sum, we would then expect a negative effect of uncertainty on investment plans.

4.3 Data and the Problem of Measuring Relevant Variables

4.3.1 KOF Investment Survey

We use data from the biannual KOF investment survey to empirically test the influence of uncertainty on investment plans.[11] The survey is conducted among a panel of private firms in Switzerland. In this paper, we will use data from the

[10] The vector X_i contains several other firm characteristics including $\Delta I_{i,t=2014}$ which represents the investment revision of firm i for year 2014 between the two surveys (see Chapter 4.3.2). "exchange rate", which covers the CHF/EUR exchange rate on the day the questionnaire in Spring 2015 was completed by the firm. "comp" takes value one if the firm operates in a highly competitive market and zero otherwise. "foreign owned" indicates if a firm is owned by a foreign company and zero otherwise. "export" is one if a firm's exports are higher than 5% and zero otherwise. "distance border" indicates a firm's distance to the closest national border. "share foreign employees" indicates the share of foreign employees. "days snb" counts the days passed between the decision of the SNB on January 15th, 2015 and the day a firm filled out the questionnaire. "certainty s2014" is one if a firm is very or fairly certain of their investment plans in Autumn 2014 and zero otherwise. Additionally, we control for number of employees, NACE 2-digit sector, and geographic NUTS 2 region of a firm. Table D.1 in the Appendix provides a detailed overview of these variables.

[11] Schenker (2007) examined the KOF investment survey regarding its quality, consistency, and information content. Recent studies using KOF investment survey data include Abberger et al. (2014b), Bannert et al. (2015a) and Bannert et al. (2015b)

survey waves in Autumn 2014 and Spring 2015. Firms were asked for quantitative information on their investment activities in the years 2013, 2014, and 2015 in both survey waves. Because of the timing of the two waves, the information on investment activities refers to (practically) realized investment for the financial years 2013 and 2014 and to investment plans for 2015. The survey distinguishes between investment in construction, in machinery and equipment, and in research and development. The questionnaires from both waves are included in the Appendix.

The investment survey in Autumn 2014 was sent to the sample of firms on October 8th, 2014. Answers were accepted until December 31st, 2014. From 8052 contacted firms, 3072 valid questionnaires were received, corresponding to a response rate of approximately 38%. In the final dataset of the survey of Autumn 2014, approximately 40% are firms active in manufacturing, 7% are active in construction and the remaining 53% firms are based in the services sector. In Spring 2015, questionnaires were sent to the same sample of firms on February 18th, 2015.[12] Answers were accepted until May 31th, 2015. From the 8072 firms that were contacted, 3395 valid questionnaires were received, corresponding to a response rate of approximately 42%. Firms in the manufacturing, construction, and services sectors account for 40%, 7%, and 52% of the final sample of this survey wave, respectively. The response rate was similar within sectors, with a slightly lower rate for construction firms. Table 4.1 summarizes the information regarding the sample of firms. The columns 1 and 2 show the number of contacted firms by sector and survey wave, columns 3 and 4 show the response rates across sectors and survey waves, and the final columns 5 and 6 presents the numbers of firms by sector which reported full investment figures in both waves.

Our final dataset contains 1025 observations. The reason for this relatively small overlap is that we only kept firms which reported investment figures for both 2014 and 2015 in both waves. Additionally, we need a full set of controls for each firm. From the 1025 firms in the merged and reduced dataset, 948 firms reported complete figures for investment in equipment twice and 414 firms reported complete figures

[12] There are small changes in the panel across different survey waves, as some firms drop out of the sample and others are added.

Table 4.1: Sample Survey Participants

	Contacted Firms		Response Rate		Joint samples with complete answers	
	Autumn 2014	Spring 2015	Autumn 2014	Spring 2015	Number of firms	Share
Manufacturing	3177	3133	40%	44%	498	49%
Construction	710	707	30%	36%	62	6%
Service	4160	4212	38%	43%	463	45%
Overall	8048	8072	38%	42%	1025	100%

Notes: This table presents some general information on the sample of firms that were invited to the investment surveys in Autumn 2014 and Spring 2015. Further, the table shows the sectoral distribution of the final dataset. Specifically, columns 1 and 2 present the absolute amount of firms contacted in each wave. Columns 3 and 4 show the response rate. Columns 5 and 6 contain firms which reported full investment figures in both waves.

for investment in construction in both waves. 314 firms reported their investment in research and development in both Autumn 2014 and Spring 2015.

The merged dataset displays a slight over-representation of firms in manufacturing (see Table 4.1, columns 5 and 6) with respect to the distribution among the firms originally contacted. While only approximately 39% of all contacted firms were active in manufacturing, they account for approximately 49% of all firms in the final dataset. The over-representation of manufacturing firms is exclusively at the expense of firms of the service sector. While more than half of the firms contacted (approx. 53%) belong to the service sector, only 45% of the remaining observations stem from this sector. The differences in response rates could indicate a potential bias. Firms that are more affected by the appreciation of the Swiss Franc may be more likely to participate in the survey than firms less affected. To address this issue, we first employ a method proposed by Wallace and Mellor (1988). The main idea of this method is that late responders to the survey are similar to non-responders, so that comparing the profiles of early and late responders should allow us to assess whether these sub-groups differ in their characteristics. We find no statistically significant differences between the two groups (see Table D.11 in the Appendix). Furthermore, we estimate the underlying non-response process so as to be able to control for a possible bias. We estimate a firms response probability according to firm, respondent, and survey design characteristics and subsequently re-estimate

our main specification using inverse probability weighting. The results show that non-response does not influence our results in a significant way (see Table D.12 and Table D.13 in the Appendix).

4.3.2 Measuring Firm-specific Investment Plan Revisions

In each biannual survey wave of the KOF investment survey, firms are asked about their investment plans for three years. In autumn firms report their investment for the past, the current and the following year. In spring current year and the past two years are reported. Observed investment plans can therefore vary in three dimensions: they vary by firm (i), by year (t), and by survey wave (s). We indicate each dimension of an investment plan in the subscripts, i.e $I_{i,t,s}$. For instance, the investment plan of firm A for the year 2015 indicated in the survey wave of Autumn 2014 is $I_{A,2015,\text{Autumn 2014}}$, while the investment plan of the same firm for the same year but indicated in the subsequent survey wave is $I_{A,2015,\text{Spring 2015}}$.

The biannual nature and repetition of the same indicators across survey waves therefore allow us to calculate the investment plan revisions of firms after the exchange rate shock. We observe a firm's expected investment for the year 2015 both before the exchange rate shock and after the shock ($I_{i,t=2015,s=\text{Spring 2015}}$ and $I_{i,t=2015,s=\text{Autumn 2014}}$). We can then quantify firms' investment plan revisions as shown in Equation 4.2.

$$\Delta I_{i,t} = log(I_{i,t,s=\text{Spring 2015}}) - log(I_{i,t,s=\text{Autumn 2014}}) \tag{4.2}$$

The survey asks firms to state their investment separately for investment in equipment and machinery, investment in construction, and investment in research and development. Hence, we are able to compute revisions in overall investment plans (gross fixed capital formation - GFCF) as well as for the categories mentioned. The revisions of total investment plans and of different investment categories will serve as our dependent variables in the regressions.

Furthermore, the data contains information on firm investment for the year 2014. Although investment for 2014 was not affected by the exchange rate shock, we calculate firm investment revision regarding 2014 ($\Delta I_{i,t=2014}$). We use this information as an explanatory variable in the regressions. This variable allows us to control for inter-temporal shifts in investment and heterogeneous investment cycles.

4.3.3 Measuring Firm-specific Exchange Rate Expectations

In order to ensure a clean identification of the effect of uncertainty on investment plans, it is necessary to control for the first moment change in exchange rate expectations. After all, revisions in investment plans may well be due to expected shifts in the mean expected future exchange rate as elaborated in Section 4.2.3. In the survey wave in Spring 2015, the questionnaire asks for the expected exchange rate of the Swiss Franc vis-Ã -vis the Euro. Firms are asked to report the expected rate in 6, 12, 18, and 24 months[13]. We include the firm-specific exchange rate expectation in 24 months as we consider it to be the most relevant time period of those available for the evaluation of investment projects. Summary statistics provided in Table 4.3 show that firms expect an exchange rate of 1.084 CHF/EUR on average, with a median of 1.10. However, variation in expectation is large, with a standard deviation of 0.059. This variable measuring the mean expected exchange rate will enter our regression as an explanatory variable. Note that we do not observe the change in the expected exchange rate. However, given the stability of the exchange rate in the previous three years, we assume that a priori firms expected the exchange rate to remain at 1.20.

4.3.4 Measuring Firm-specific Uncertainty

Ideally, we would use an indicator measuring the change in uncertainty around the expected exchange rate of firm i to measure the second moment shifts due to the

[13]The exact wording is presented in the questionnaire included in the Appendix.

policy shock (see Section 4.2.4). Unfortunately, this information is not provided in the survey data so we propose an alternative strategy.

We identify uncertainty by using the responses given to a question concerning the realization certainty of firms' reported investment plans which was asked in both waves of the KOF investment survey. Firms were asked how certain they are that their future investment plans would be realized.[14] Survey participants could classify their reported investment plans for 2015 as "very certain", "fairly certain", "fairly uncertain" or "very uncertain". Based on this question, firms can be identified which indicated a change in certainty between Autumn 2014 and Spring 2015. Table 4.2 provides an overview of how realization certainty changed between the two waves. For most firms, investment certainty did not change between the two survey waves. However, 188 firms indicated an increase in investment certainty (the sum of firms below the diagonal in Table 4.2). A slightly larger number of 191 firms indicated that they were less certain about the realization of their planned investment for 2015 in Spring than they were in Autumn (the sum of firms above the diagonal in Table 4.2). The comparison of values given across both survey waves allows the identification of firms experiencing increased uncertainty.

Table 4.2: Contingency Table

		Spring 2015			
		Very Certain	Fairly Certain	Fairly Uncertain	Very Uncertain
Autumn 2014	Very Certain	92	70	12	0
	Fairly Certain	106	488	97	5
	Fairly Uncertain	13	60	50	7
	Very Uncertain	0	4	5	2

Notes: This contingency table shows changes in firm specific investment uncertainty.

[14] The exact wording is presented in the questionnaires included in the Appendix.

We argue that not all firms were affected by the appreciation of the Swiss Franc to the same extent. For some, exchange rate uncertainty may be of no importance in planning investment. We identify firms reporting increased uncertainty and consider the change in investment plan realization certainty as driven by exchange rate uncertainty. We will come back to this claim in Section 4.4 and verify the validity of this assumption.

We construct a proxy for uncertainty based on the responses to this survey question. A binary variable is created that takes value 1 if a firm's self-reported investment certainty decreased between the two survey waves in Autumn 2014 and Spring 2015. Technically, the variable *uncertainty* behaves the following way:

$$\Delta uncertainty_i = \begin{cases} 1 & \text{if } certainty_{i,s=\text{Spring 2015}} < certainty_{i,s=\text{Autumn 2014}} \\ 0 & otherwise \end{cases} \tag{4.3}$$

where $certainty_{i,s=\text{Spring 2015}}$ is the self-reported realization certainty of investment plans for 2015 of firm i reported in the investment survey in Spring 2015 and $certainty_{i,s=\text{Autumn 2014}}$ is the self-reported investment certainty of firm i stemming from the survey wave in Autumn 2014. The variable $\Delta uncertainty_i$ indicates if a firm experienced an increase in uncertainty.

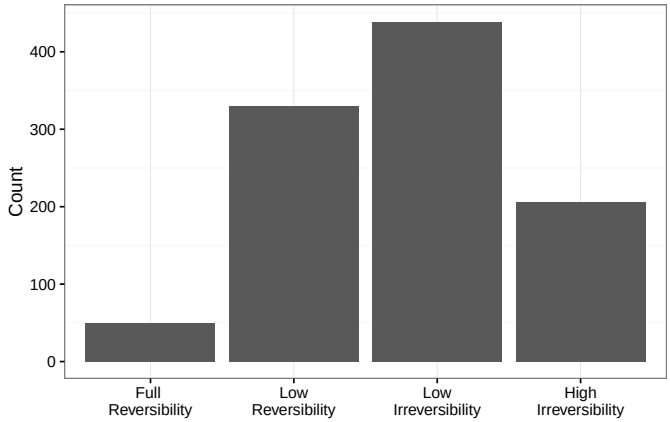
4.3.5 Measuring Firm-specific Irreversibility

Real-option theory requires investment to be irreversible for uncertainty to affect investment (Bernanke, 1983; Pindyck, 1988; Caballero, 1991). If investment is perfectly reversible, changes in uncertainty should have little to no effect on investment. Fortunately, the investment survey of Spring 2015 contains a question on this topic, which we use to infer the degree of irreversibility of firm investment.[15] The source of the wording of this question is the Italian Survey of Investment in Manufacturing (SIM). In line with Guiso and Parigi (1999), we use firms' answers to this question to

[15]The exact wording is presented in the questionnaire included in the Appendix.

proxy irreversibility. The question asks firms whether a second hand market exists for their current machinery and / or equipment.

Figure 4.2: Distribution of irreversibility in the data



Notes: The investment survey of Spring 2015 contains a question that allows to infer the degree of irreversibility of firm investment. The histogram depicts the distribution of answers to this question.

The question provides four options, each indicating a separate level of reversibility of equipment and / or machinery within the company. The 4 item Likert scale goes from full reversibility to full irreversibility. The two categories in between the extremes are differentiated according to time required, difficulty, and expected prices when re-selling equipment and / or machinery. The overwhelming majority of firms indicate at least a certain degree of irreversibility. Similar to Guiso and Parigi (1999), the firms are designated as having high or low irreversibility according to the category they chose. As such, firms indicating that it is easy or only takes some time to sell their equipment and / or machinery are attributed low irreversibility, while those indicating that it is very difficult or that there is no market for their equipment and / or machinery are attributed high irreversibility. Technically, we define the variable *irreversibility* the following way:

$$irreversibility_i = \begin{cases} 1 & \text{if firm i reported high or full irreversibility} \\ 0 & \text{otherwise} \end{cases} \tag{4.4}$$

The distribution of responses to this question for the firms in estimation is displayed in Figure 4.2. The majority (436) of all firms indicated that re-selling equipment and / or machinery is very difficult but not impossible, while 324 firms indicated that re-selling is possible within a short period. 201 firms indicated that there is no market for their equipment and / or machinery, with only 50 out of 1011 firms indicating full reversibility.

4.3.6 Summary Statistics

All in all, the final sample contains 1025 firms. Approximately 19% of all firms indicated an increase of uncertainty between the survey waves of Autumn 2014 and the wave of Spring 2015. The majority of firms questioned indicated either no change in investment plan certainty or higher certainty. As described in Section 4.3.5, we can distinguish between firms indicating high irreversibility of investment and those indicating a low degree of irreversibility. The mean of the binary variable of irreversibility of 0.63 reflects the fact that the majority of firms indicated a high or very high degree of irreversibility. The mean expected exchange rate of the CHF versus the Euro in 24 months is 1.084 CHF/EUR. The variables $\Delta I_{i,t}$ represent the average investment plan revisions of firms. We can distinguish investment plans for gross fixed capital formation, equipment, construction, and research and development. On average, the revisions are not very large. The higher standard deviations for investment revisions of 2015 are intuitive and speak for the validity of the data.

For a better understanding of the data, we split the dataset into those firms indicating more uncertainty and those not indicating more uncertainty. Table 4.3 provides summary statistics for the data in estimation and when split into both subgroups. Specifically, N shows the number of observations available for a variable. Mean and St. Dev. refer to all available observations in the sample. Mean (Certain) and Mean (Uncertain) refer to the mean for the subgroup of uncertain and not uncertain firm. P-Value shows the two tail p-value resulting from a comparison of Mean (Certain) and Mean (Uncertain) with a two-sample t-test assuming unequal variance.

Table 4.3: Summary Statistics

Statistic	N	Mean	St. Dev.	Mean (Certain)	Mean (Uncertain)	p-Value
$\Delta I_{i,t=2014}$ (GFCF)	1,025	−0.003	0.178	−0.007	0.016	0.17
$\Delta I_{i,t=2015}$ (GFCF)	1,025	0.013	0.236	0.023	−0.025	0.01**
$\Delta I_{i,t=2014}$ (construction)	414	−0.002	0.274	−0.008	0.027	0.31
$\Delta I_{i,t=2015}$ (construction)	414	0.004	0.340	0.007	−0.005	0.80
$\Delta I_{i,t=2014}$ (equipment)	948	−0.007	0.194	−0.014	0.022	0.06*
$\Delta I_{i,t=2015}$ (equipment)	948	0.024	0.250	0.039	−0.037	0.00***
$\Delta I_{i,t=2014}$ (R&D)	314	0.026	0.578	0.052	−0.084	0.16
$\Delta I_{i,t=2015}$ (R&D)	314	−0.040	0.552	−0.071	0.089	0.02**
Δuncertainty$_i$	1,025	0.189	0.392	0.000	1.000	n.a.
irreversibility$_i$	1,025	0.629	0.483	0.614	0.696	0.03**
expected exchange rate$_i$	1,025	1.084	0.059	1.084	1.084	0.97
employees$_i$ (fte)	1,025	274	1,245	284	229	0.33

Notes: This table provides summary statistics for the dataset used in estimations. Specifically, N shows the number of observations available for a variable. Mean and St. Dev. refer to all available observations in the sample. Mean (Certain) and Mean (Uncertain) refers to the mean for the subgroup of uncertain and not uncertain firm. P-Value shows the two tail p-value resulting from a comparison of Mean (Certain) and Mean (Uncertain) with a two-sample t-test assuming unequal variance. The stars indicate if the means are significantly different at conventional level: ***p $<$ 0.01, **p $<$ 0.05, *p $<$ 0.1.

The mean of the expected exchange rate in 24 month is virtually identical between the two groups. Firms indicating higher uncertainty after the exchange rate shock have a higher degree of irreversibility than the other firms on average. Finally, more uncertain firms are smaller than other firms when the mean number of employees per subgroup is considered, but the difference is not significant.

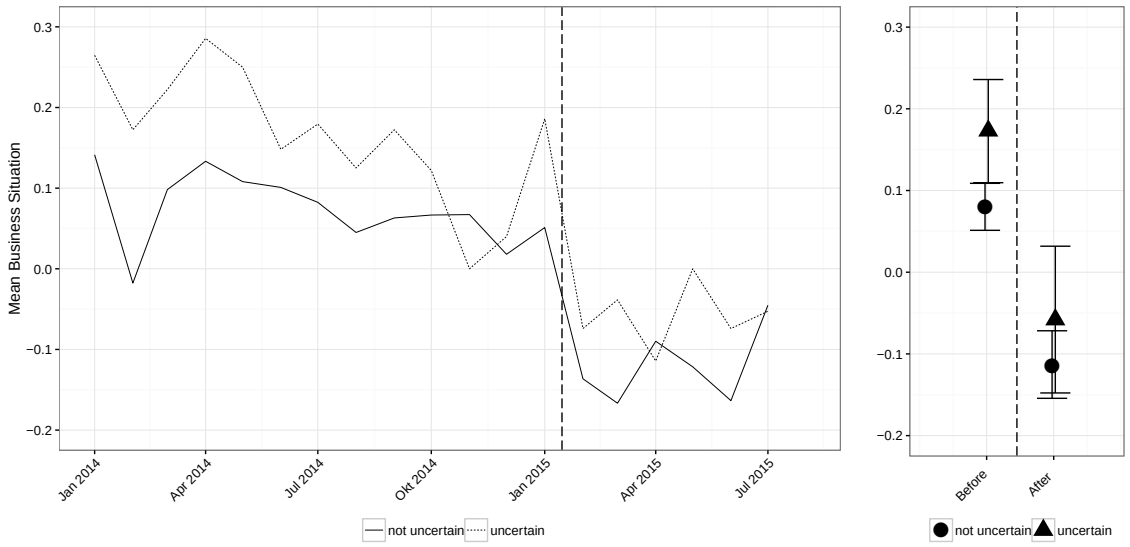
4.4 Identification

The following section elucidates the identification of firm-specific uncertainty. Two issues must be addressed concerning the identification of uncertainty. One concerns causality and one concerns the exclusion restriction. Even if the causal source of uncertainty can be identified via an exogenous shock, it is still necessary to disentangle first and second moment effects to address the issue of exclusion restriction. In our case, identification is provided as long as we know what caused uncertainty. Additionally, we are able to control for the first moment shift caused by the shock

as we control for firms' exchange rate expectations. This allows us to disentangle first moment effects from second moment effects.

The method of identification of uncertain firms can be criticized. A reduction in self-reported realization certainty of planned investment between Autumn 2014 and Spring 2015 may be due to other factors than the exchange rate shock. For example, the firms reporting higher uncertainty may depend on a common economic trend which lead to an increase in uncertainty for other reasons than the decision of the Swiss National Bank. In this case, the increase in uncertainty may be due another factor and have nothing to do with changes in monetary policy. To address this potential criticism and support our claim that the increase in uncertainty was caused by the exchange rate shock, we display the results of the Business Tendency Survey (BTS) of the KOF Swiss Economic Institute to track the economic performance of the firms in the final sample prior and post the SNB decision.

Figure 4.3: Impact on Firms Business Situation



Notes: The panel on the left depicts the monthly mean of the business situation over time for firms indicating higher uncertainty and not indicating higher uncertainty. Monthly Business Tendency Surveys invite Swiss firms to assess their current business situation. The question is of qualitative nature and firms may judge their current business situation as "good", "satisfactory", or "poor". We code "good" as 1, "satisfactory" as zero and "poor" as -1. Business situation is a collective term which captures the most important business variables such as a firm's profit and cost situation, turnover, and liquidity (Abberger et al. (2009, 2014a)). We conduct a Chow test that confirms that a structural break occurred in January 2015. This hold true for the certain as well as for the uncertain firms. The panel on the right depicts the average business situation before and after the exchange rate shock. The whiskers around the mean indicate a 95% confidence interval. While uncertain firms had a significant higher business situation before the shock, no statistical significant difference exists after the shock.

BTS monitors important business variables over time. Although BTS covers all sectors represented in the investment survey, not all sectors are surveyed on a monthly basis (some sectors are contacted on a monthly, some only on a quarterly basis). To isolate the effect of the exchange rate shock as precisely as possible, we limit our analysis to monthly surveys.[16] In addition to this limitation, the BTS and the investment survey are not conducted with the same set of firms. The overlap of firms participating in both surveys is 172 firms. 33 firms of these 172 indicated higher uncertainty according to the definition provided above.[17]

All firms participating in the BTS are asked to report their current business situation.[18] The question is qualitative and firms judge their current business situation as "good", "satisfactory", or "poor". In the left panel of Figure 4.3 the monthly mean business situation[19] over time for firms indicating higher uncertainty (32 firms of Table D.2) and not indicating higher uncertainty (137 firms of Table D.3) is shown. In the right panel of Figure 4.3, the mean business situation of uncertain and not uncertain firms for the total periods before and after the exchange rate shock are shown. The whiskers indicate 95% confidence intervals around the mean. While uncertain firms had a significantly more positive business situation assessment than not uncertain firms before the shock, there is no significant difference in firms' assessments after the shock. Additionally, a formal Chow test for structural breaks confirmed a break in the business situation assessments of both subgroups of firms

[16] NACE 2 Digit covered by monthly BTS include 10-33, 41-43, 47, 64-66, 71

[17] As focusing on the overlap between the two surveys could induce a bias, we recalculated the summary statistics provided in Section 4.3.6 for firms in both surveys. The summary statistics are provided in the Appendix in Tables D.2 and D.3. Comparing the properties of firms in the sample after the merger of the two datasets with the properties of those firms included in our underlying sample (see Table 4.3), shows that they are similar to some extent, yet notable differences exist as well. One distinctive characteristic is that firms participating in the investment survey as well as in the business tendency survey tend to have a higher number of employees on average. Further, we limit our empirical analysis of Section 4.5 to the 172 firms and show that our estimations produce similar results for the sub-sample. The findings are reported in Table D.14 in the Appendix.

[18] Abberger et al. (2009, 2014a) show that business situation is a collective term which captures the most important business variables such as a firm's profit and cost situation, turnover, and liquidity.

[19] We coded "good" as 1, "satisfactory" as zero and "poor" as -1.

in January 2015. The dashed vertical line in both panels indicates January 15th, 2015.

Figure 4.3 confirms two points. First, although the series of uncertain firms appears more volatile than the series of the other firms, both sets display a slightly downward-sloped movement throughout 2014. Second, the dismissal of the lower exchange rate floor has had a strong influence on firms' business situations. This holds true for both groups of firms. However, uncertain firms were hit harder. This is visible by the distance between the overall mean of the two sub-samples before and after the monetary policy shock.[20]

We consider Figure 4.3 as supporting evidence that the identification of uncertainty via the self-reported investment certainty variable is not driven by a third factor in a systematic way and reflects the sudden exchange rate shock and subsequent uncertainty.

4.5 Results and Discussion

This section details the effect of uncertainty on firms' investment plans. We can quantify investment plan revisions that took place after the exchange rate shock as we observe firm-specific investment plans for 2015 twice, once in Autumn 2014 and once in Spring 2015. Additionally, we can identify firms exposed to uncertainty caused by the switch in exchange rate regimes. Uncertain firms are identified using a self-reported uncertainty measure as explained in Section 4.3.4. In line with real-option theory presented in Section 4.2.1, our results support the claim that uncertainty induced by a monetary policy shock leads to downward revisions of investment plans in equipment.

[20] Efing et al. (2015) examine the effect of the appreciation of the Swiss Franc after January 15, 2015 on stock returns of Swiss Firms. The authors show that firms with a higher exposure to the exchange rate experienced a more pronounced decline in stock prices than firms with a low exposure to the exchange rate. Note that Figure 4.3 resembles Figure 3 of Efing et al. (2015). In Figure 3 the authors show that the cumulative stock market returns of firms with a low and high exchange rate exposure move largely in parallel before the SNB decision. However, the cumulative returns diverge strongly at the day of the announcement and do not converge for months after the announcement.

On the other hand, increased uncertainty leads to higher planned expenditures in research and development. This finding is in line with previous studies. Kraft et al. (2013) as well as Stein and Stone (2013) find similar results for research and development expenditure and attribute this effect to growth-option theory which is better suited for explaining the effect of uncertainty on research and development expenditure. Both studies find that uncertainty enhances investment in research and development.

Table 4.4: Average Firm Investment 2015 (in logs).

	GFCF			Construction		
	Autumn 2014	Spring 2015	Spring - Autumn	Autumn 2014	Spring 2015	Spring - Autumn
Certain	15.98	16.02	0.04	15.41	15.44	0.03
	(0.02)	(0.02)	(0)	(0.03)	(0.03)	(0)
Uncertain	15.95	15.93	-0.02	15.3	15.26	-0.04
	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.06)
Δ	0.03	0.09	0.06	0.11	0.18	0.07
	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.06)
	Equipment			R&D		
	Autumn 2014	Spring 2015	Spring - Autumn	Autumn 2014	Spring 2015	Spring - Autumn
Certain	15.72	15.76	0.04	12.05	12.08	0.03
	(0.02)	(0.02)	(0)	(0.09)	(0.09)	(0)
Uncertain	15.7	15.68	-0.02	11.74	11.82	0.08
	(0.03)	(0.03)	(0.04)	(0.18)	(0.19)	(0.26)
Δ	0.02	0.08	0.06	0.31	0.26	-0.05
	(0.03)	(0.03)	(0.04)	(0.18)	(0.19)	(0.26)

Notes: Average Firm Investment 2015 (in logs). One might read this table as a Difference-in-Difference table. For instance, we report firms' average gross fixed capital formation for 2015 in the first panel (top left). We distinguish between certain and uncertain firms as well as the survey waves when average investment plans were reported - Autumn 2014 and Spring 2015. Formally, the first figure in the top left panel is calculated as $\frac{1}{N}\sum_i^N log(I_{I,t=2015,s=\text{Autumn 2014}})$ for all certain firms and amounts to 15.98. We report standard errors in parentheses.

Table 4.4 presents average investment plans for 2015 across the two survey waves for certain and uncertain firms. Total investment (gross fixed capital formation - GFCF), investment in equipment, construction, and research and development are displayed in separate panels. The last row of each panel displays the difference of average investment between certain and uncertain firms. The last column of each

panel shows the difference in average investment plans reported before and after the policy shock. The value in the last cell of the last row of each panel shows the difference between the two differences. Ignoring any kind of firm-specific characteristics, we find that uncertainty reduces total investment plans by 6 percent (shown in the top left panel). Separating total investment into its subcategories reveals that firms that are exposed to uncertainty reduced their investment in equipment and construction more compared to firms that are not exposed (minus 7 and minus 6 percent, respectively) across the two survey waves. The opposite case must be made for investment in research and development. Uncertain firms planned to increase their investment in research and development by 5 percent more in 2015 compared to firms not indicating uncertainty. The directions of the effects are intuitive and in line with those expected under real-option and growth-option theory. However, while the magnitude of the effects appear to be economically significant, they are not statistically significant in all of the four panels. In order to evaluate the results shown in Table 4.4, Equation 4.1 is estimated using OLS regression. Table 4.5 presents selected estimation results. These are separated according to investment category and according to the inclusion of the interaction term between irreversibility and uncertainty.[21]

Table 4.5 confirms the tendencies revealed by Table 4.4. Note that Table 4.4 shows the unconditional differences in average firm-level investment plans while the dependent variable in Table 4.5 is the difference in firm-level investment plans. A delicate distinction necessary for a proper understanding of both tables. Model 1 of Table 4.5 shows that firms reporting uncertainty reduce their total investment plans (GFCF) by 4 percentage points relative to firms that did not experience an increase in uncertainty. The effect is statistically significant. However, once we control for irreversibility we find no significant effect of uncertainty (Model 2). This finding appears to be at odds with standard real-option theory and merits further investigation. Therefore, Models 3 to 8 estimate the effect of uncertainty on different investment categories and may deliver explanations for the non-existence of real-option effects of uncertainty on total investment.

[21] We provide full estimation results in Table D.4 in the Appendix.

When we distinguish according to distinct investment categories, interesting insights are uncovered. We find a negative and strongly significant effect of uncertainty on investment in equipment (Model 3). Additionally, we find robust real-option effects for investment plans in equipment (Model 4). The coefficient of the interaction term between $uncertainty_i$ and $irreversibility_i$ is negative and statistically significant at a 5 percent level. More precisely, firms indicating increased uncertainty decrease irreversible investment by 9 percentage points more or increase irreversible investment by nine percentage points less than firms not indicating increased uncertainty. We consider the magnitude of this effect to be substantial and economically relevant. Furthermore, the effect is of similar magnitude as those found in Abberger et al. (2016). The authors show that uncertainty caused by an unexpected outcome of a vote in February 2014 in Switzerland decreased investment plans of Swiss firms exposed to policy uncertainty by 13 percentage points.

We find no effect of uncertainty on investment plans in construction. While the coefficient of the interaction term between $uncertainty_i$ and $irreversibility_i$ is negative for investment plans in construction, the coefficient is not statistically significant (Model 6). Meanwhile, the effect of uncertainty on research and development is positive and significant at a p-value of 0.1 (Model 7). This means that firms indicating uncertainty appear to increase their investment plans in research and development by a magnitude of 13 percentage points more when compared to other firms. However, controlling for $irreversibility_i$ renders the effect of uncertainty on research and development expenditure insignificant (Model 8).

The results displayed in Models 3 to 8 in Table 4.5 show the importance of distinguishing between investment plans in different categories instead of only considering effects on total investment plans. On the one hand, different theoretical channels seem to be more adequate than others when attempting to model the effect of uncertainty on investment plans in distinct categories. While we find results that point towards real-option effects for investment plans in equipment, growth-option effects appear to be more adequate when attempting to explain the change of investment plans in research and development. At the same time, we find no evidence for either of the two theories when examining investment plans in construction.

On the other hand, this also means that both the magnitude and direction of the effects vary across different investment categories. While the interaction of $uncertainty_i$ and $irreversibility_i$ decreases investment plans in equipment by 9 percentage points, $uncertainty_i$ increases investment in research and development by 13 percentage points. These findings are important when considering the effects of uncertainty and irreversibility on total investment plans, as these dynamics within investment categories are masked when only examined at an aggregate level.

Table 4.5: Main Specification

	Dependent variable:							
	Δ GFCF		Δ Equipment Investment		Δ Construction Investment		Δ RnD Investment	
	OLS		*OLS*		*OLS*		*OLS*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
uncertainty	-0.042^{**}	-0.003	-0.070^{***}	-0.004	0.0004	0.074	0.132^{**}	0.211^{*}
	(0.018)	(0.031)	(0.025)	(0.028)	(0.040)	(0.079)	(0.061)	(0.119)
irreversibility		0.014		0.018		0.050		-0.093^{*}
		(0.019)		(0.020)		(0.051)		(0.052)
irreversibility × uncertainty		-0.056		-0.094^{**}		-0.111		-0.099
		(0.038)		(0.039)		(0.100)		(0.141)
ΔI_{2014}	-0.174^{*}	-0.173^{*}	-0.225^{*}	-0.224^{*}	-0.322^{***}	-0.316^{***}	-0.426^{***}	-0.429^{***}
	(0.100)	(0.100)	(0.122)	(0.124)	(0.100)	(0.098)	(0.104)	(0.101)
expected exchange rate	0.175	0.172	0.147	0.140	-0.022	-0.010	-0.074	-0.059
	(0.128)	(0.128)	(0.144)	(0.145)	(0.229)	(0.220)	(0.392)	(0.368)
Constant	-1.849	-1.855	-3.776^{**}	-3.822^{**}	1.726	1.866	-0.965	-1.286
	(1.628)	(1.653)	(1.871)	(1.878)	(3.571)	(3.603)	(5.846)	(5.875)
Observations	1,025	1,025	948	948	414	414	314	314
R^2	0.076	0.078	0.105	0.109	0.179	0.184	0.370	0.378

*p<0.1; **p<0.05; ***p<0.01
Additional controls are included but coefficients not reported. Standard Errors are clustered at industry (NACE 2) levels.

We find statistically significant effects of revisions of lagged investment in all models estimated. This finding mirrors the rather mechanical effect of inter-temporal shifts of investment. If a firm plans to realize an investment project within the year, then it will report the full amount for the current year in the survey wave of Autumn. But if an investment project is not fully realized within the year, the reported values for this year decrease while those for the next year increase in the next survey wave. This leads to an upward revision of next year's investment plans. The large coefficient values can be deceiving. A reduction of one percentage point in lagged investment plan revisions of firm i for the year 2014 leads to a 1.74 percentage point higher revision of 2015 investment plan revisions.

Additionally, we find no significant influence of the mean expected exchange rate on investment revisions. This finding might be surprising at first, but two reasons could explain this finding. First, the effects of the expected exchange rate might

cancel out on an aggregate level. Firms losing from a negative first moment shift of the exchange rate (appreciation of the Swiss Franc) balance firms gaining from this shift. In other words, export-oriented firms which obtain their input factors from the domestic market cancel out firms which sell on the domestic market while obtaining input factors from foreign markets. Additionally, we control for the actual exchange rate on the date the survey was completed. This means that the effect of the expected exchange rate is conditional on the actual exchange rate at the time of survey completion.

In an additional step, we would like to consider what the effect of the uncertainty shock was on aggregate investment. As there is no way to observe the counter-factual, we cannot answer this question precisely. However, assuming equal investment among firms and assuming that affected firms would have revised their investment in a similar manner as firms that were not affected, we can deliver a ballpark estimation.[22] Considering that 19% of all firms were exposed to the uncertainty shock, aggregate gross fixed capital formation would have been 0.8 percentage points higher had the shock not happened. If we consider separate investment categories, it can be shown that aggregate investment in equipment would have been roughly 1.3 percentage points higher. Expenditure in research and development would have been 2.5 percentage points lower. Finally, aggregate construction investment would have remained unaffected. As we have mentioned, these are rough estimates, but they can still give an indication as to how strong the effect of this shock was on the Swiss economy.

Furthermore, we examine the impact of firm size on the effect of uncertainty. Bachmann and Bayer (2013) show that focusing on large firms tends to overemphasize the effect of uncertainty. Similarly, using Japanese firm-level data Morikawa (2016) shows that the effect of uncertainty on investment differs in firm size. Our dataset allows us to determine if the effect of uncertainty on investment changes with the number of employees. Table 4.6 presents the coefficients of $uncertainty_i$

[22] We compute aggregate estimates using the coefficients in 4.6. Particularly, we assume identical investment revision in an hypothetical scenario with no increase in uncertainty for affected and not affected firms.

Table 4.6: Effect of Firm Size

Dependent Variable	>0%	>25%	>50%	>75%
		$uncertainty_i$		
$\Delta I_{i,t=2015}$ (GFCF)	-0.003	-0.005	0.004	-0.130
$\Delta I_{i,t=2015}$ (equipment)	-0.004	-0.008	-0.020	-0.092
$\Delta I_{i,t=2015}$ (construction)	0.074	0.065	0.121	-0.080
$\Delta I_{i,t=2015}$ (R&D)	0.211	0.250	0.208	0.791
	$uncertainty_i \times irreversibility_i$			
$\Delta I_{i,t=2015}$ (GFCF)	-0.056	-0.062	-0.081	0.009
$\Delta I_{i,t=2015}$ (equipment)	-0.094	-0.102	-0.126	-0.132
$\Delta I_{i,t=2015}$ (construction)	-0.111	-0.100	-0.171	-0.049
$\Delta I_{i,t=2015}$ (R&D)	-0.099	-0.193	-0.164	-0.585

Notes: This table examines the effect of firm size on the magnitude of the effect of uncertainty on investment plans. The table presents the coefficients of $uncertainty_i$ and $uncertainty_i \times irreversibility_i$ for different firm sizes. The coefficients displayed under > 0% stem from a regression that includes all firms,> 25% neglects the 25% of the smallest firms and > 50% neglects the 50% of the smallest firms. > 75% reduces the sample to the largest 25%. We include the regressions in the Appendix (Table D.16).

and $uncertainty_i \times irreversibility_i$ for different firm sizes. The coefficients displayed under > 0% stem from a regression that includes all firms,> 25% neglects the 25% of the smallest firms and > 50% neglects the 50% of the smallest firms. > 75% reduces the sample to the largest 25%. We include the regressions in the Appendix (Table D.16). Generally, the coefficient of uncertainty seems on average to turn stronger when focusing on larger firms. Interacting uncertainty with the number of employees confirms this tendency. Although the coefficients of all interaction effects are negative only the coefficient for investment in equipment is statistically significant to conventional significance levels.

Finally, we conduct common robustness tests and diagnostics and present their results in the Appendix. Among others, we conduct a Placebo test (Table D.7), use an alternative method to proxy firm-level uncertainty (Table D.8), and present different specifications of Equation 4.1. We neglect all additional control variables (Table D.9) in one specification and in another we omit past investment plan revisions (Table D.10). All robustness checks confirm the main results of the empirical analysis.

4.6 Conclusion

In this paper we exploit an unexpected policy event to investigate the effect of exchange rate uncertainty on investment plans. On January 15th, 2015 the Swiss National Bank decided that the lower floor of the Swiss Franc vis-Ã -vis the Euro was no longer justified. The subsequent abandonment of the currency peg led to a rapid and strong appreciation of the Swiss Franc against the Euro by 20%. We argue that this sudden drop in the exchange rate did not only represent a first moment shift in the exchange rate, but also led to an increase in uncertainty surrounding the mean future exchange rate.

Using survey data, we identify changes in the first and second moments of firm exchange rate expectations that occurred because of the policy shock. This allows us to disentangled first and second moment effects. We estimate the revisions of firms' investment plans because of changes in the first moment and the revisions of firms' investment plans because of changes in the second moment. Firm-level data provide information concerning realized and planned investment for the years 2014 and 2015. These values are observed twice, once before the shock in Autumn 2014, once after the shock in Spring 2015. We quantify the revisions in investment plans at firm-level and connect them to first and second moment changes in expectations. Furthermore, the dataset distinguishes between total investment and investment in equipment and machinery, construction, and research and development, and data on on the degree of investment irreversibility at firm-level. Therefore, we can test theoretical channels suggested by real-option theory and growth-option theory across different investment categories. To our knowledge, this is a novel contribution to the literature on the effects of uncertainty on investment.

We find mixed evidence that exchange rate uncertainty caused by an abrupt change in monetary policy affects firms' investment plans. Uncertainty appears to reduce total investment, but the effect is small and barely significant. We find different effects when we consider disaggregated investment categories. In accordance with real-option theory, uncertainty strongly decreases irreversible investment in equipment and machinery. However, there are no statistically significant real-option

effects for planned investment in construction. Furthermore, estimation results suggest that uncertain firms intensify their research and development efforts, which is in line with previous findings in the literature.

Because we observe the varying effects across different investment categories, we can also provide a rough estimate of the effect of the uncertainty shock on aggregate investment in Switzerland if we assume homogeneous firms. Aggregate investment in equipment would have been roughly 1.3 percentage points higher and expenditure in research and development would have been 2.5 percentage points lower. Finally, aggregate construction investment would have remained unaffected.

This paper also adds to the ongoing debate on Wait-and-See business cycles. Bachmann and Bayer (2013) challenge the opinion that macroeconomic uncertainty shocks cause significant aggregate fluctuations. The authors show that focusing on larger firms overemphasises the effect of uncertainty. In this study we make a similar observation. When our sample is reduced to larger firms, the coefficients of the effect of uncertainty increase.

To summarize, we provide evidence that the effect of uncertainty varies across different investment categories. While real-option effects seems to be the dominant channel for investment in machinery and equipment, uncertainty appears to influence research and development via growth-option effects. We do not find any significant effect of uncertainty on investment in construction. A long planning phase and high adjustment costs once constructions are initiated could mask potential effects in our temporally limited set-up. Nevertheless, showing that uncertainty influences different investment categories through different mechanisms suggests that it is not sufficient to focus on aggregated investment such as fixed gross capital investment when investigating the effects uncertainty.

Addendum I

Unveiling Participant Level Determinants of Unit Non-Response in Business Tendency Surveys[1]

I.1 Introduction

In many countries researchers and policy makers alike rely on indicators built based on Business Tendency Survey (BTS) data.[2] Thus it is important for conductors of BTS to monitor the quality of their data closely and adapt their methodology to changes in participant behavior, as well as to new technical developments in information and communication technology. Within this context, survey researchers courting the attention of their increasingly distracted participants have to worry about non-response (Seiler, 2012). Researchers need to account for vast changes in participant behavior such as the degree of commitment towards requests in general. Strinkingly, despite the idiosyncratic nature of BTS (Dillman, 2000), which hampers careless inference of results from other fields of survey based research – contributions of economic survey researchers to the methodological literature are rather scarce.

[1] This chapter is based on Bannert and Dibiasi (2014)

[2] E.g. the *ifo Geschäftsklimaindex* (Germany), the *KOF Barometer* (Switzerland) or the Business Climate Indicator for the Euro area provided by the European Commission / DG ECFIN.

In this paper, we intend to contribute to the research on unit non-response by studying characteristics and attitudes of long-term BTS participants. We believe that the longitudinal structure and comparatively large samples of BTS contribute to methodological research beyond mere economic reasoning. While many studies on data quality use metrics at the survey-wave level, we are explicitly looking at the respondent-level. In other words, we are studying the relevance of participant characteristics to explain non-response as opposed to survey wave level effects. We pay particular attention to company characteristics such as company size, because, if these characteristics were unbalanced due to non-response, then economic inference from survey data would be influenced. We use a rich BTS dataset from the KOF Swiss Economic Institute and match it with data from an exclusive meta survey also conducted by the KOF. The matched dataset extends our set of firm characteristics with invidual assessment and characteristics such as valuation of BTS, perceived response burden or participant gender.

The remainder of the paper is structured as follows: section I.2 will give an overview of related studies in the field. In section I.3 we describe our dataset and its different sources including a description of the meta survey. A detailed description of our empirical strategy follows in section I.4. This methodology section consists of two major parts: First we explain how we account for selectivity issues caused by merging data from different surveys. Second, we discuss a hurdle model to model unit non-response count. Section I.5 presents our estimation results. Finally section I.6 summarizes our most robust results and provides an outlook for further research.

I.2 Literature

Despite the fact that Dillman (2000) points out the idiosyncrasies of surveying organizations: "people are asked to report information for an entity that is distinct from them personally"(Dillman, 2000, p. 324), and therefore justifies business survey-specific research, business survey specific contributions to survey methodology are comparatively scarce. As one of the few, Seiler (2013) studies non-response behavior based on German data from the ifo Institute's manufacturing survey. Furthermore

we have common ground with the work of Abberger et al. (2009) and Abberger et al. (2014a) who gathered additional meta information by conducting surveys about surveys. Section I.2.2 discusses meta information in BTS in greater detail. In addition to the BTS-specific literature this paper has been influenced by the work of Little and Rubin (2002) and Groves et al. (2002) on handling non-response and missing data in general. The ensuing subsection gives a brief introduction to non-response and missing data.

I.2.1 Non-response and Missing Data

The concept of non-response is usually defined as the rejection of an individual to participate in a survey (Groves et al., 2002). In order for non-response to occur some sort of contact between participant and survey conductor is assumed, e.g., in form of an email invitation. In this sense, individuals not included in the set of contacted individuals are not accounted for in the concept of non-response. However, in our paper the set of potential non-respondents is defined as a slightly larger group: Companies who were contacted but could not be reached are also counted as non-respondents. Due to limitations in the dataset, we cannot distinguish these companies from those who were reached but explicitly refused to answer. However, this classification seems justifiable when we consider that the long-term customer relationship management of the KOF Swiss Economic Institute has filtered out letterbox companies and other irrelevant addresses over the years.

The literature distinguishes between item non-response and unit non-response. Item non-response describes a situation in which single questions are not answered whereas unit non-response means that a participant does not answer at all in a particular survey wave. In the latter case, the survey conductor does not gather any information on the company, which hinders sample adjustment within the post-processing of the dataset. In turn non-response potentially leads to several problems such as bias of the estimator's projection or inflation of its variance (Groves et al., 2002). This paper focuses on unit response and individual-level determinants of unit non-response in particular.

Several statistical methods deal with missing data caused by non-response. The ultimate success of these methods depends heavily on the systematics of non-response. Little and Rubin (2002) provide a useful classification of missing data: Data can be missing completely at random (MCAR), missing at random (MAR) or not be missing at random (NMAR). Data are called MCAR if the missing data mechanism depends on neither observed nor unobserved data. This is a very strict assumption in practice at times, which is why the weaker concept of MAR is widely used in applied research. MAR refers to a process in which the missing data mechanism depends only on observables. Data are said not to be missing at random (NMAR) if missingness depends on unobserved data.

In order to understand what causes non-response, a list of possible factors which have to be controlled for has to be found. Willimack et al. (2002) developed a conceptual framework for participation in business surveys.[3] Taken from an earlier version of Groves and Couper (1998), Willimack et al. (2002) maintain the dichotomy of factors, which are under the control of the researcher, and factors that the researcher has no influence on. The factors which are under control of the researcher are factors related to survey design, including sample design, instruments offered to answer the survey, time schedule and offered confidentiality. Factors, that are out of the researcher's control are divided into three subgroups, namely external environment, factors related to the business and factors related to the respondent. External factors include economic conditions and the legal and regulatory requirements. Among business related factors we find firm characteristics, such as size, industry, organizational structure as well as a company's philosophy and availability of resources. Finally we have a group containing factors of the respondent itself, such as sex, age, authority, capacity and motivation. Although the concept does not claim completeness, it offers a comprehensive list of factors which should be addressed when studying non-response.

[3]The graphical depiction of the conceptual framework taken from Willimack et al. (2002) can be found in the appendix at the end of this thesis.

I.2.2 Meta-information on BTS

The KOF BTS are conducted as multi-mode surveys where participants can take part either online or on paper. This opens up a plethora opportunities to gather meta information. Scholars of online research methods highlight the potential of non-reactive online research which analyzes subtly collected data (Reips, 2009) without the participant consciously answering questions. Such non-reactive research methods can also be combined with online surveys (Reips, 2009) resulting in so called paradata (data about the data generating process itself) and meta data (e.g. type of web browser or screen resolution) when data is collected through a web browser.

Though paradata promises insightful information about participant behavior that might eventually lead to non-response (Stieger and Reips, 2010), paradata in this strict sense cannot be used in our study. First, even for online participants paradata is not always available in desired quality for technical reasons, thus reliable paradata has not been collected for the entire sample of online participants. Using paradata would limit our research to sub-samples which would likely introduce selection problems. Yet we advocate the use of paradata and the introduction of tools to collect such information in BTS for future research. Second, a substantial part of our participants continues to answer on paper. Hence, web paradata-based information would not be comparable across all participants.

Nevertheless, meta information on participants and the survey process itself is crucial to our work. Hence, we collected meta information using a multi-mode meta survey that allowed us to gather the same comparable information from participants of both modes: online and paper. Besides the methodological work of the scholars mentioned above, the pioneering work of Abberger et al. (2009), who conducted a survey about surveys, was inspirational to our work. While the study by Abberger et al. (2009) was limited to German trade firms we base our study on Abberger et al. (2014a), which collected background information on firms from the Swiss service sector. The survey itself was conducted in the summer of 2013 and collected feedback data from all firms of BTS sample of Swiss service sector.

I.3 Data

All data used in this paper stem from surveys conducted by the KOF Swiss Economic Institute. KOF has implemented BTS in eight sectors, namely manufacturing, construction, retail trade, wholesale trade, service sector, hotels and restaurants, project engineering and financial and insurance activities. Today, KOF surveys include more than 11'000 companies. In addition to the regular BTS surveys, we conducted a feedback survey among the same set of participants as the KOF service sector survey. The following subsections introduce both datasets, the BTS data and the feedback data, used in this paper.

I.3.1 KOF BTS in the Service Sector

We chose to focus on the KOF BTS in the service sector because of its comparatively young age and decent share of online participants. Established only in 2006, paper based as well as online participation was possible from the first wave of the survey. Thus, participants were not potentially influenced by the introduction of an additional survey mode.

This paper uses a sample containing a total of 51'241 observations that were generated between the fourth quarter of 2006 and the fourth quarter of 2013. On average, close to 1'800 companies responded per wave during that timespan.

The available sample covers the following set of sectors according to the NACE 2-digit sector classification: 49-53, 58-63, 68-70,712, 72-75, 77-82, 86-88, 90-93, 95, 96. The sample does not contain firms of the accommodation and food service activities (NACE 55-56) sector, nor does it contain any firms of the financial and insurance sector (NACE 64-66). The survey in the service sector is conducted on a quarterly basis and the questionnaire consists of ten qualitative questions and one question with several non-mutually exclusive items.

I.3.2 A Survey About Surveys

In order to gather additional participant characteristics besides standard firm properties, we conducted a meta survey in summer 2013. We gain information on three major aspects:

- companies' understanding of the concept of the general business situation
- companies' valuation of the BTS
- measuring capacity utilization in the service sector

In advance of the survey we conducted interviewer pre-test to check the validity of our questions and items as well as the relevance of our set of questions to regular participants. We adjusted our questionnaire accordingly which left us with 10 questions covering the areas listed above.[4]

I.3.3 Merged Sample

We merge the regular BTS sample and the sample of the feedback survey. Because the feedback survey was only conducted once we need to assume that the information gathered in this survey is time-invariant. This is a highly plausible assumption for a short period around the date of the feedback survey. The gathered information on company policies and structures is hardly volatile within a one year timespan. Hence, we decided to limit our non-response analysis to two quarters before and two quarters after the feedback survey. We devide our data into two subsets: data that was generated in the year of the feedback survey, namely 2013, and data that was gathered before.

We use the entire 2013 sample to analyze unit response in that year using standard firm characteristics and the additional firm data generated from the feedback survey. Any company that took part in the feedback survey conducted in the second quarter of 2013 and was invited to all waves of the regular BTS in 2013 is part of the sample. The 2013 subset contains 1136 companies. The data before 2013 is used to

[4]The full questionnaire can be found in appendix to this chapter at the end of the dissertation.

compute variables such as a company's survey track record, which is used to proxy a company's motivation to participate in 2013. Figure I.1 shows the distribution of unit non-response count in 2013: in the left facet we see the distribution of unit non-response count for all companies that have been invited to take part in the regular BTS. The right facet shows the unit non-response count of the regular BTS in 2013 for those who also took part in the feedback survey. Section I.4.1 describes how BTS data before 2013 is used to predict participation in the feedback sample in order to account for selectivity.

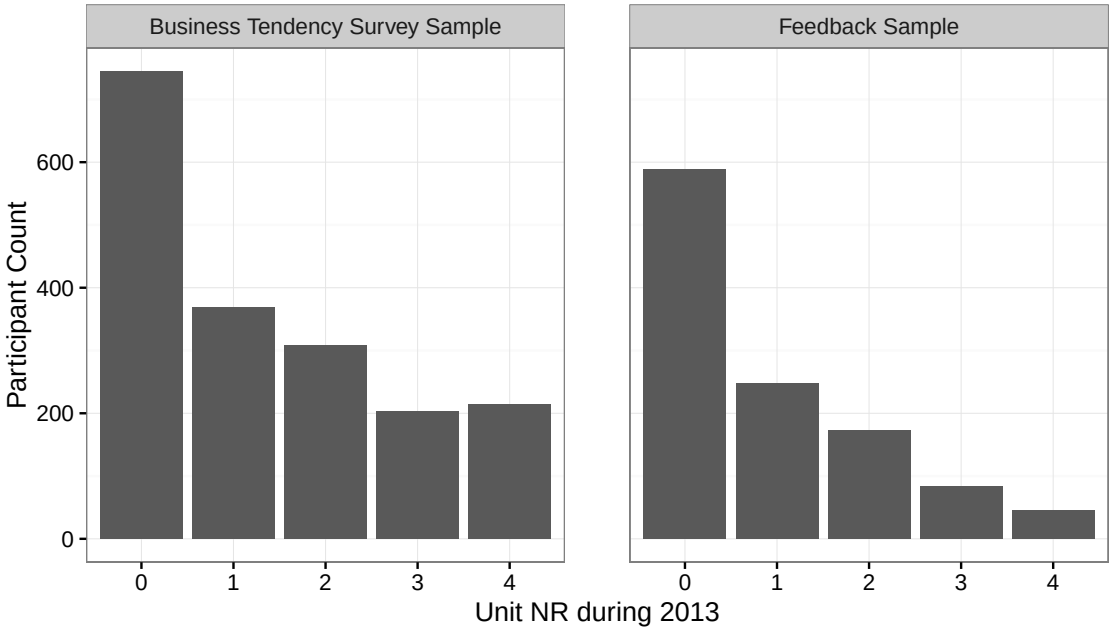


Figure I.1: Unit Non-Response Count by Samples

I.3.4 Variables

This section presents all variables that are used in our analysis described in section I.4. Table I.1 classifies the displayed variables according to the conceptual framework (Willimack et al., 2002) discussed in section I.2.

The first variable, *unit_nr_count*, is the number of quarters in which a firm did not respond over the course of 2013, i.e. the year of the feedback survey. The

Variable	Type	Dataset	Description
Company			
unit_nr_count	count	BTS	Number of unit non-response quarters during the year 2013 with zero if the company never missed a survey and four if the company did not participate at all.
unit_nr_ratio	continous	BTS	Record of past participation ratio: 0 = individual always participated before 2013, 1 = individual never participated before 2013.
avg_run	metric	BTS	Average of measured reaction time categories: 0 = fast, 1 = medium, 2 = slow.
valuation	metric	feedback	Importance of BTS: 1 = not important, 5 = important (5 items).
timeliness	categorical	feedback	Describes when a firm usually responds to a questionnaire. Answering straight away is the reference. time = whenever the person has time, deadline = answer right before the deadline, reminder = only when a reminder is received.
employees	log	company information	Size of a company: log number of employees.
region	categorical	company information	Espace, Lake Geneva Region, Northwestern Switzerland, Eastern Switzerland, Central Switzerland, Ticino and Zurich.
sector_class	categorical	company information	Part of the service sector, DL1 contains NACE 2 digit groups: 49-53, 58-63, DL2 contains 68-70, 72-75, 712, 77-82, and DL3 contains 86-88, 90-93, 95, 96.
capacity_utilization	continous	feedback	Capacity Utilization in percent, used to proxy business tendency at the firm level.
staff_shortage	binary	feedback	Indicate whether a company has problem hiring suitable staff.
Respondent			
gender	categorical	respondent information	Male, female, unknown (i.e no specific contact person).
language	categorical	respondent information	Italian, French, German.
position	categorical	feedback	Position of the person that answers the questionnaire: ownership or management, head of department, administration, someone else, no answer.
response_burden	binary	feedback	Perceived response burden high = 1, else 0.
surveys	count	feedback	Amount of surveys the respondents answer on average in one year.
Survey Design			
participation_mode	categorical	BTS	Paper, Online, Mixed.

Table I.1: Variable Description

variable *unit_nr_count* is our variable of interest. All other variables will be used to explain the variation in *unit_nr_count*. The second row contains *unit_nr_ratio*, which captures the ratio of quarters in which a firm did not respond to the number of quarters since the firm's first invitation. The variable *unit_nr_ratio* can be regarded as a proxy for a firm's history of long-run motivation to take part in the survey before 2013. The variable in the third row, *avg_run*, is the average of a categorical timeliness indicator. A low average means that a company usually returns questionnaires immediately.

The variable *valuation* stems from the feedback survey and asks companies to evaluate the use of business tendency surveys in general. The variable *timeliness* captures a company's reported common reaction and thus proxies company's policy towards surveys. Companies were asked for their standards in processing regular BTS with respect to reaction time using the following items: answer right away, answer when time permits, answer before deadline or only answer after being reminded. It is difficult to form expectations on company policy, but we expect routines other than answering right away, to cause higher non-response. This is, because consistently rapid answers are more likely when a firm has incorporated the survey into their workflow routine. The variables *employees*, *region* and *sector_class* control for firm specific size, region and sector effects. In our view no clear expectations exist on the impact of different regions or sectors. The variables *capacity_utilization* and *staff_shortage* measure a company's availability of resources. Both variables are taken from the feedback survey. The variable *capacity_utilization* enters the model with indicated capacity utilization in percentage points and *staff_shortage* as a binary variable. We use both variables as an indicator for a firm's individual business situation. In the sense of Willimack et al. (2002), the variables presented above are company properties. In turn the variables described below relate to the respondent.

Ex-ante both variables, *gender* and *language*, are not expected to influence non-response in any direction. Besides male and female the gender variable has a third category labelled *unknown* which depicts cases in which companies did not provide a specific contact person. The work by Dillman (2000) shows that addressing a specific

person within a company decreases non-response. The downside of addressing a specific person is the particular employee leaving the company. Several invitation letters were returned unopened with a remark that the addressed person has left the company. Both effects work in opposite directions and could cancel out in the aggregate. We expect the net effect to be negative, because fluctuation of employees within the sample is relatively small compared to the commitment effect of addressing a person directly. Therefore, addressing persons within a company directly is expected to decrease non-response. However, our dataset contains only 20 *unknown* observations. Thus our investigation focuses on gender aspects as opposed to contact person vs. no-contact person set-ups.

The variable *position* indicates the position of the respondent within the firm. Both Abberger et al. (2009) and Abberger et al. (2014a) show that business tendency surveys in Germany and Switzerland are mostly completed by persons in management positions. Tomaskovic-Devey et al. (1994) already pointed out that the position of the respondent can predict non-response. If the questionnaire is filled out by a person of a lower hierachy level we expect non-response to increase for different reasons: Management level executives are likely to be more concerned with the company's reputation and are thus influenced by the commercial equivalent of social desirability. Furthermore, management level executives are more likely to be data savvy and might cherish additional information gained from business tendency surveys. Therefore we believe that management decisions to take part in surveys are more systematic than at lower hierarchy levels.

The fourth variable related to the respondent is a binary indicator on perceived response burden: If the perceived time to complete is longer than 10 minutes, it is labelled as burdensome. We expect the perception of burden to increase non-response. While the variable *response_burden* covers the burden caused by the KOF BTS in the service sector, the variable *surveys* counts the number of surveys from any survey conductor. Again both variables stem from the feedback survey.

The categorical variable *participation_mode* indicates the medium through which a company has chosen to participate. Participants can either take part on paper or online. Because we aggregate over one year the binary choice is extended by a

mixed category indicating that not all quarters of 2013 were answered using the same participation mode. Ideally participation mode has no influence on non-response. Nevertheless, we expect an increase in non-response for online participants, as well as for those who switched the medium within 2013. Our expectations are based on the fact that companies who intend to drop out are sometimes convinced by KOF's costumer relationship management that they can reduce the effort by answering online.

I.4 Methodology

Our dependent variable *unit_ nr_ count* can be suitably fitted using a Poisson distribution with excess zeros. We employ a two part hurdle model (Zeileis et al., 2008) to explain unit non-response count at the firm level. First, to measure firm-level unit non-response itself we count how many times a firm refused to answer the standard quarterly BTS during the course of 2013. Our estimations focus on the year 2013 because the feedback survey was only conducted once in summer 2013.

Unit non-response count $unit\_ nr\_ count \in \{0, 1, 2, 3, 4\}$ is the dependent variable in our model and we assume that the explanatory variables, which we obtained from the feedback survey, are time invariant over the course of one year. This assumption is highly plausible because variables such as the number of surveys answered per year or the responsible department are not likely to change over the course of one year unless company policy or the attitude of the management changes.[5] The next section describes briefly how we account for selectivity issues. Subsection I.4.2 describes how different count data models can be modelled in a GLM framework and subsection I.4.3 continues to describe our main model.

[5]Please find the documentation of the questionnaire used in the feedback survey in the appendix at the end of the thesis.

I.4.1 Accounting for Selectivity

As described in section I.3.3 we make use of a merged sample, which contains data from the regular business tendency survey as well as from the feedback survey. Thus the sample used in our regressions contains only firms that are part of both datasets. This may lead to self-selection bias, as long-term, reliable participants of the regular surveys may be more likely to provide feedback than firms that frequently drop out from the regular surveys. In turn, we do not expect selection into our merged sample to occur completely at random. Thus we follow an approach similar to Little and Rubin (2002), who have shown how to account for selectivity when data is not missing completely at random. Figure I.1 compares the distribution of our main variable of interest, namely unit non-response count across samples: especially the tails indicate that the merged sample and the original BTS sample do not follow the same distribution.

We make use of inverse probability weighting to weigh (Horvitz and Thompson, 1952) our observations given their conditional propensity to end up in the merged sample as shown in equations 1 and 2. We use a standard probit model to estimate the probability $\hat{p}_i$ of being in the merged sample – i.e. to be invited to the BTS and to have taken part in the feedback survey – given a set of firm characteristics.

$$w_i = \frac{1 - \hat{p}}{\hat{p}} \tag{I.1}$$

$$w_{norm,i} = \frac{w_i}{\frac{1}{n}\sum_{i=1}^{n} w_i} \tag{I.2}$$

These inverse probability weights $w_{norm,i}$ put more emphasis on observations that have a lower propensity to be in the merged sample given their characteristics. These observations would be under-represented without weighting. Remarkably, we were able to collect feedback data for several firms that did not take part in the regular survey all year. This information is very valuable since one usually does not have any information on mid- and long-term non-respondents.

I.4.2 Estimation of Unit Non-response in a GLM Framework

Our analysis focuses on a hurdle model which is described in greater detail in section I.4.3. The hurdle model is a two part model which consists of a Binomial and a Poisson component, both of which can be estimated in a GLM framework. Additionally, we estimate a standard Poisson model in section I.5.2 to check the robustness of our results. All our regression models used to estimate non-response employ the same set of covariates X to explain the dependent variable $Y \in \{0, 1, 2, 3, 4\}$. Following Cox and Smith (1989), the hurdle model components and the models presented in the robustness section can be described as generalized linear models that consist of three components:

1. A *random component*
2. A *systematic component* η which is defined as: $\eta = \sum_1^k x_j \beta_i$ where k is the number of covariates
3. a link between the random and the systematic component which is defined as $\eta = g(\mu)$

Accordingly, $g(\cdot)$ is called the link function. Obviously, the discrete dependent variable $Y_i \in \{0, 1, 2, 3, 4\}$ is not represented well by the OLS model, i.e. the random component of Y was $N(\mu, \sigma^2)$ distributed and the *identity* function was used for the link. Thus, we configure the GLM framework presented above to describe a Poisson model, which provides a suitable benchmark for further computations and is also useful in our mixture model. Poisson models are among the most common models for count data and can also be specified within the GLM framework (Cameron and Trivedi, 2013). In the case of a Poisson model, the random component of Y is $P(\mu)$ distributed and the link function is $g(\cdot) = log$. Cox and Smith (1989) and Cameron and Trivedi (2013) show that the Poisson model can also be estimated using iteratively weighted least squares (IWLS). Thus, our selectivity weights $w_{i,norm}$ from the previous section can be used in a straight forward manner. The Binomial part of the hurdle model is covered by the GLM framework in similar fashion as the Poisson model except that the random component is assumed to follow a Binomial distribution.

I.4.3 Estimation of Unit Non-response in a Two Part Model

Figure I.1 clearly shows that a unit non-response count of zero is the most prevalent among the sample firms in 2013. Though this is encouraging in the first place, an excess number of zeros does not comfortably suit a Poisson distribution. Hence, we estimate a two part model in order to account for these excess zeros. The binomial part models the decision whether to always answer the survey or drop out at least once. The Poisson part models the non-response behavior of firms which dropped out at least once. Further, Zeileis et al. (2008) suggest that the hurdle model might be slightly preferable over the related zero-inflation model, which is discussed in their same paper, because its interpretation is more intuitive. The distribution of our dependent variable suggests that non-response is ultimately determined by multiple processes. In a first step, firms might decide whether to incorporate regular BTS into their workflow and thus answer by default or not. Firms that do not employ such a policy make the decision whether to take part in a survey wave upon receiving the questionnaire.

We specify a hurdle model which consists of two parts: First, a binomial part models the decision to participate in general as opposed to not participating. Second, a count part models how often non-response occurs $Y_i \in \{1, 2, 3, 4\}$ among those firms which dropped out at least once. Note that we use the same regressors $x_i = z_i$ to keep our models as comparable as possible though it is not required to use the same set of regressors. Formally:

$$f_{hurdle}(y; x, z, \beta, \gamma) = \begin{cases} f_{zero}(0; z, \gamma) & \text{if } y = 0 \\ (1 - f_{zero}(0; z, \gamma)) \cdot f_{count}(y; x, \beta)/(1 - f_{count}(0; x, \beta)) & \text{if } y > 0 \end{cases} \tag{I.3}$$

I.5 Discussion of Estimation Results

This section is divided into two subsections: First, we discuss the estimation results of our main two part hurdle model. Second, we present a robustness check which

contains a weighted Poisson model as a benchmark, as well as models based on automatic variable selection procedures, such LASSO (Least Absolute Shrinkage and Selection Operator) and stepwise AIC.

I.5.1 Two Part Model Estimation Results

Table I.2 shows the estimation results of our mixture model estimations. The left column lists the estimation results of the count data part and the right column shows the results for the binomial part of the hurdle model.

The non-response history of a company *unit_ nr_ ratio* is a significant indicator for future unit non-response in both parts of the model. The companies' reported common reaction time *timeliness* is a significant predictor of unit non-response. Every other behavior category increases unit non-response compared to answering right away. Albeit it is noteworthy that companies which report to answer right before the deadline do not have a significantly lower propensity to not take part the entire year.

Though any significant influence of the business situation is clearly undesired, we find that firms which indicate higher *capacity_ utilization* are more likely to employ a policy to generally return all waves of the KOF service sector survey. At first glance this finding seems to contradict Seiler (2013) and Harris-Kojetin and Tucker (1999), who find higher non-response during economically satisfactory times. However, their statement refers to inter-temporal comparison with the business cycle in mind, while we compare longterm participants with each other at the same point in the business cycle. We believe our results are plausible inasmuch that business success and responsible corporate citizenship, which includes participation in surveys, are both correlated with being well-organized and well-led. An upward bias, induced by the self-selection of well-managed companies into the sample, would be as undesired as any other bias. Identifying well led companies and adjusting the sample or post processing the results accordingly is a potential path to improve data quality. Clearly, more research, such as the regular analysis of different sectors and countries, is needed to monitor the influence of the business situation on non-response and to keep potential biases at bay.

	Count model	Zero model
(Intercept)	−1.18 (0.43)*	0.11 (0.79)
unit_nr_ratio	0.97 (0.24)	2.65 (0.60)***
timeliness_time	0.65 (0.20)***	1.28 (0.22)***
timeliness_deadline	0.58 (0.24)**	0.73 (0.48)
timeliness_reminder	0.99 (0.23)***	2.74 (0.86)***
cu	−0.00 (0.00)	−0.03 (0.01)***
position_department	0.21 (0.10)*	−0.05 (0.32)
position_admin	−0.34 (0.25)	−0.01 (0.67)
position_other	0.01 (0.22)	1.10 (0.51)**
position_no_answer	0.69 (0.19)***	−1.76 (0.83)**
response_burden_D	0.29 (0.10)***	0.46 (0.21)**
gender_female	0.04 (0.11)	0.47 (0.24)*
gender_unknown	0.06 (0.10)	0.94 (0.58)**
participation_mode_online	0.67 (0.19)***	1.53 (0.25)***
participation_mode_mixed	0.60 (0.30)**	1.86 (0.91)**
avg_run	−0.08 (0.12)	2.61 (0.49)***
valuation	−0.03 (0.03)	0.05 (0.07)
surveys	−0.01 (0.01)	−0.04 (0.02)
staff_shortage	0.05 (0.10)	−0.33 (0.22)
employees	−0.02 (0.04)	0.06 (0.09)
region_Espace	0.03 (0.17)	−0.45 (0.36)
region_LakeGeneva	−0.15 (0.29)	−0.64 (0.55)
region_Northwestern	−0.33 (0.23)	−0.25 (0.36)
region_Easern	−0.48 (0.28)*	0.36 (0.55)
region_Ticino	1.07 (1.23)*	−4.46 (1.67)***
region_Central	−0.39 (0.17)**	0.53 (0.54)
sector_class_DL2	0.18 (0.11)	0.07 (0.28)
sector_class_DL3	0.07 (0.11)	−0.16 (0.25)
language_F	0.38 (0.26)	0.15 (0.53)
language_I	−0.97 (0.62)	4.02 (1.52)***
AIC	2122.67	2122.67
Log Likelihood	-1001.34	-1001.34
Num. obs.	865	865

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table I.2: Hurdle model

When we account for excess zeros we see the effect of the position a respondent has within their company. We find that when surveys are answered outside of the

management, administration and department heads and thus the ultimate decision whether to take part in general is made outside those parts of the company, companies are less likely to take part the entire year.[6] The *position_other* category is not significant in the count part though. Whereas when the ultimate decision to take part is made by a department head instead of the management level, companies tend to not respond more often over the course of the year.

Perceived *response_burden* is a highly significant predictor of unit non-response. Accounting for excess zeros in fact emphasizes the effect of *response_burden* slightly. In particular, the effect on participation for a full year is stronger. Strinkingly, we can see an effect of *gender*: females are significantly less likely to take part the entire year, though gender does not have a significant influence on the number of non-participation. This may be an indication that the *gender* of the participant, which is most likely at the management level, is actually correlated with a different kind of company culture, policy or age of the company. Yet, a gender effect is not expected and cannot be further explained by our data.

The results for *participation_mode* are in line with our expectations. Yet the effect of choosing not to answer the paper-based survey is emphasized in the binomial part and dampened in the count part. The true average reaction time *avg_run* is significant in the binomial part. Companies that return questionnaires later are on average less likely to have taken part in all waves of 2013. But there is no evidence that returning questionnaires later increases non-response count when we only consider firms that dropped out from the regular survey at least once during 2013.

Aside from capturing companies' general assessment of the value of BTS, *valuation* does not have a significant influence on non-response. This finding might be surprising at first but it is in line with findings for other types of surveys made in previous studies. Couper, M.P., Singer, E., Conrad, F.G., and Groves, R.M (2008) show that altruistic reasons are one of the most prominent motivations to take part in a survey. More than 30 percent of their participants indicated that they take

[6]Only six companies chose to select *no_answer* in the position question of the feedback survey. Hence, we abstain from discussing possible reasons of the counterintuitive sign of this coefficient.

part in surveys due to altruistic motives. Porst and von Biel (1995) report similar results for a study in the German-speaking area. Spitzmüller et al. (2007) also find that altruism is a driving force of response in organizational surveys. The number of *surveys* a company takes part in, *staff_ shortage* and the size of the company (*employees*) do not play a significant role in either part of the hurdle model. Further, we cannot observe significant sectoral effects (*sector_ class*).[7]

I.5.2 Variation and Robustness of Results

This section discusses other model variations in order to check the robustness of our results. While the discussion in the first subsection focused on specifications to find the distribution that suits our data best, this section compares our theoretical variable selection with two automatic variable selection procedures. Table I.3 re-estimates our main model from table I.2 using a weighted Poisson for benchmarking purposes. Column 2 compares the benchmark model to a stepwise AIC based variable selection (Venables and Ripley, 2002).[8] Further, we check the robustness of our results using a shrinkage-based LASSO selection procedure, based on the *glmnet* implementation (Friedman et al., 2010). Note that we do not report shrunk coefficients and only use LASSO to suggest variables, which we include in a re-computed, weighted Poisson model.

Our main results, namely the effects of a firm's response history *unit_ nr_ ratio*, the reported common reaction time *timeliness* and *participation_ mode* remain significant for all selection methods. The LASSO-based selection drops the *response_ burden* dummy. We can thus consider the result less robust, but should not overvalue this selection because it is not backed up by a theoretical basis. Also, *gender* is not selected based on the LASSO method which fuels previously stated thoughts that claiming a true gender effect is rather questionable and requires further research. Also, the undesired effect of *capacity_ utilization* is left out in the selection mechanism presented in the third column. Although the fact that a variable, which is

[7]Regional and language effects are difficult to interpret. Overall, we find that non-response count is not significantly influenced by region or language.
[8]The *R* procedure we used runs both directions when running stepwise AIC-based selection.

	Theoretical Selection	AIC	LASSO
(Intercept)	−0.99 (0.30)**	−1.05 (0.20)***	−1.70 (0.14)***
unit_nr_ratio	1.33 (0.19)***	1.23 (0.14)***	1.39 (0.21)
timeliness_time	0.85 (0.13)***	0.83 (0.13)***	0.89 (0.13)***
timeliness_deadline	0.63 (0.20)**	0.64 (0.19)***	0.74 (0.19)***
timeliness_reminder	1.21 (0.17)***	1.24 (0.19)***	1.33 (0.18)
cu	−0.01 (0.00)***	−0.01 (0.00)**	
position_department	0.16 (0.10)*	0.17 (0.10)*	
position_admin	−0.20 (0.19)	−0.17 (0.18)	
position_other	0.19 (0.16)	0.22 (0.14)	
position_no_answer	−0.17 (0.61)	−0.13 (0.69)	
response_burden_D	0.25 (0.08)***	0.19 (0.08)**	
gender_female	0.15 (0.09)*	0.23 (0.08)***	
gender_unknown	0.32 (0.19)*	0.27 (0.18)	
participation_mode_online	0.85 (0.13)***	0.81 (0.13)***	0.78 (0.13)***
participation_mode_mixed	0.74 (0.25)***	0.81 (0.27)***	0.71 (0.25)***
avg_run	−0.08 (0.12)	2.61 (0.49)***	
valuation	−0.01 (0.03)		
surveys	−0.01 (0.01)	−0.01 (0.01)	
staff_shortage	0.05 (0.10)	−0.33 (0.22)	
employees	0.02 (0.03)		
region_Espace	−0.08 (0.16)		
region_LakeGeneva	−0.35 (0.28)		
region_Northwestern	−0.23 (0.15)		
region_Easern	−0.24 (0.14)*		
region_Ticino	−1.07 (0.28)***		
region_Central	−0.05 (0.12)		
sector_class_DL2	0.15 (0.10)		
sector_class_DL3	0.06 (0.09)		
language_F	0.38 (0.26)	0.15 (0.53)	0.11 (0.79)
language_I	−0.97 (0.62)	4.02 (1.52)***	0.11 (0.79)
AIC	2139.67	2131.26	2150.31
BIC	2282.56	2216.99	2197.94
Deviance Inform. Criterion	775.50	791.09	826.13
Log Likelihood	-1039.84	-1047.63	-1065.15
Num. obs.	865	865	865

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table I.3: Automatically Selected Variables vs. Initial Model

correlated with the business situation, is not selected comes in handy for the economic researcher, we should abstain from bold claims about the absence of a business situation-induced selection bias.

I.6 Conclusion and Outlook

The process that determines non-response in BTS is fairly complex and cannot be modelled fully. Further complexity is introduced by the fact that participants are answering on behalf of companies instead of representing themselves. Nevertheless, our regressions are able to model a substantial part of the process described in the conceptional framework of Willimack et al. (2002). In our paper, we are able to identify important drivers of unit non-response and show meta information, which has so far largely been neglected, explains a substantial amount of unit non-response. We found that a company's response history, the reported common reaction time and the participation mode to be important predictors of unit non-response in all of our model set-ups. We believe that our mode effect is not necessarily a true mode effect, as presenting questions online does not affect the result or the likelihood to respond. Companies which are less committed and answer more ad hoc are rather induced to answer given the ease of an online survey. Also, companies which drop out of the paper-based survey are encouraged to reduce the burden by participating online. Thus, our results are not based on a pure medium effect. In addition, we consider perceived response burden to be among the strongest indicators of unit non-response. Hence, we advise conductors of BTS to put emphasis on the optimization of usability in order to reduce the perceived response burden.

By measuring non-response as the cumulative non-response count of a company in 2013, we are able to model this unit non-response count via a Poisson distribution with excess zeros. This suggests that unit response in regular BTS cannot be explained with one single data generating process, but is rather a mixture of processes. The first decision that a company makes with respect to surveys might be whether to include regular survey participation into their usual workflow. If a company does not have a policy of participation, the decision to participate is made during every

wave of the survey. It is plausible that these two different decisions are driven by different factors.

Fortunately, we do not find an effect of company size and sector affiliation on the propensity to not respond. This is a desirable result from an economic point of view, as there is no evidence of self-selection of larger firms or particular sectors. Further, we find no evidence of an effect of valuation of BTS or the number of surveys a company answers on the propensity not to respond. This is only mildly surprising as it is in line with previous findings in the literature, which state that altruism is a main driver for survey participation (Couper, M.P., Singer, E., Conrad, F.G., and Groves, R.M, 2008).

However, we find that high capacity utilization – reported through the one time feedback survey – reduces unit response. On the one hand this finding may indicate that our sector controls are not sufficient to account for firm-level heterogeneity, on the other hand, this finding may well be driven by the undeniable correlation between capacity utilization and the business situation. This latter implication is concerning from an economic standpoint: companies in a better business situation – proxied by capacity utilization – tend to answer more regularly.

Female participants seem to be less likely to respond regularly. Though this an intriguing finding, we abstain from claiming a true gender effect. We find gender to be significant only in the binomial part of our two part model, suggesting that female participants were less likely to answer all waves in 2013, which might be driven by company characteristics that are correlated with the prevalence of women in executive positions. Company characteristics that are correlated with not including surveys in the regular workflow and employing female executives may rather drive this finding.

We showed that meta information such as the response burden or gender improve modelling unit non-response in BTS. Furthermore, our results show that two groups of firms with different non-response behavior exist. Further feedback data from other sectors is needed to generalize our findings. We suggest implementing regular feedback surveys that alternate through sectors in different periods to gather meta information from each sector every couple of years. This would help monitoring

changes in the data generating process more closely and help improving methodology in economic surveys and to adapting surveys and panel management. Our work also emphasizes the importance of participant relationship management. If participants do not drop out at random they need to be replaced carefully. Also our results with respect to company policies and overall participation patterns emphasize the importance of recruiting new companies explicitly to a panel survey, as opposed to recruiting firms to a single wave.

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Appendix A

Appendix Chapter 1

A.1 Price Data US Cars and Trucks

The Federal Reserve Economic Data (FRED) published a consumer price index for new and used cars and trucks on a monthly basis. The price indices are not published for the US as a whole but for the four census regions, i.e. North East, Midwest, South and West. I seasonal adjust each series and compute a irreversibility measure for each region. I than use the arithmetic mean to compute one US price index from the four census regions

Figure A.1: Countercyclical Irreversbility

Notes: This figure relates the indicator of US irreversibility to the US business cycle. The black line represents the irreversibility indicator for the US. The indicators is constructed from the US consumer price index for new and used cars and trucks. The Federal Reserve Economic Database (FRED) provides the price index for the four census regions (North East, Midwest, South and West) on a monthly basis. I seasonal adjust each series and compute an irreversibility measure for each region according to Equation 1.1. I than use the arithmetic mean to compute one US price index from the four census regions. The irreversibility indicator has a monthly frequency and starts in December 1997. The red line depicts the "US Coincident Economic Activity". The "US Coincident Economic Activity" represents a composite indicator that includes four statistics: nonfarm payroll employment, the unemployment rate, average hours worked in manufacturing and wages and salaries. The trend of the index is set to match the trend for gross state product. Both series are demeand and normalized to unit variance.

Table A.1: Regression on Irreversibility

	Dependent Variable: Irreversibility		
	(1)	(2)	(3)
US Coincident Economic Activity	-10.297^{***}		
	(2.618)		
US Industrial Production		-2.734^{***}	
		(1.042)	
US Nonfarm Payrolls			-8.809^{***}
			(2.513)
Constant	-0.522^{***}	-0.539^{***}	-0.534^{***}
	(0.006)	(0.004)	(0.005)
Observations	229	223	229
R^2	0.064	0.030	0.051
Adjusted R^2	0.060	0.026	0.047
Residual Std. Error	0.063	0.064	0.064
F Statistic	15.470^{***}	6.891^{***}	12.286^{***}
Note:			*p<0.1; **p<0.05; ***p<0.01

Notes: This table reports ols estimation results of three US business indicators on US irreversibility. The dependent variable is the ratio of the US price index of new cars over the US price index of used cars. The variable has monthly frequency and start starts in December 1997. The variable "US Industrial Production" represents the monthly growth rate of US industrial production. "US Coincident Economic Activity" is a composite indicator that includes four indicators: nonfarm payroll employment, the unemployment rate, average hours worked in manufacturing and wages and salaries. The trend of the index is set to match the trend for gross state product. Finally, the variable "US Nonfarm Payrolls" is a measure of the number of U.S. workers in the economy that excludes proprietors, private household employees, unpaid volunteers, farm employees, and the unincorporated self-employed. This measure accounts for approximately 80 percent of the workers who contribute to Gross Domestic Product (GDP).

A.2 Irreversibility Survey Question

The KOF Investment Survey is a business survey in Switzerland that is conducted by KOF Swiss Economic Institute at ETH Zurich. Until 2011 the investment survey

was conducted in autumn every year. Since 2012 the survey is conducted bi-annually, once in spring and once in autumn. In Spring, KOF Swiss Economic Institute send invitations to participants at the end of February and accepts answers until the beginning of May. In autumn, participants are invited mid-October and allowed to answers until the end of the year. The survey is conducted among a large panel of private and semi-private Swiss firms. Currently, the panel contains slightly more than 8.000 unique Swiss firms. The survey is based on the same sample as the KOF innovation survey, which is the Swiss counterpart of the Community Innovation Survey (CIS) conducted in most member states of Eurostat. The participation in this international program requires high standards in the representativeness of the sample. We are thus confident that the firm sample mirrors the Swiss firm distribution (in terms of employees) on a 2-digit-industry level. The average response rate between 2009 and 2015 amounts to 35%. The response rate varies slightly for the different survey waves between 33% and 39%. The firms in the sample cover all industries excluding agriculture (NACE 10 to 96) and account for 34% of total employment (FTE) in Switzerland within the respective sectors. 34% of firms belong to the manufacturing sector (NACE 10-33) and 2% to Energy, Water supply and waste management industries (NACE 35-38). 9% of the firms in the sample are in construction (NACE 41-43) and 55% belong to the service sector (NACE 45-96). In terms of size, 10% of all firms are large firms (more than 250 FTE), 27% are medium size firms (between 50 and 249 FTE) and 63% of all firms in the sample have less than 50 employees.

The question on irreversibility first appeared in an Italian business tendency survey in 1995. In their 1999 QJE Paper, Guiso and Pargi used this question to approximate the degree of firm-level irreversibility and to show that irreversibility matters for the negative effects of uncertainty. KOF Swiss Economic Institute at ETH Zurich introduced the identical question first in their extra survey on the consequences of the Mass Immigration Initiative in autumn 2014. Since spring 2015 the question is part of the regular KOF Investment Survey in spring.

As in Guiso and Parigi (1999), Binding and Dibiasi (2017) and Abberger et al. (2016), we take the answer to this question and construct a binary variable that approximates firm-level irreversibility. This binary variable takes value 1 in case a firm states that there exists no second hand market to sell their existing machinery and equipment or if a firm states that there exists such a second hand market but it is difficult to find a buyer and selling prices can become very low.

Interestingly, Abberger et al. (2016) find that irreversibility represents an idiosyncratic firm characteristic that cannot be explained by other firm characteristics. The authors reveal that firm-specific irreversibility does not correlate with other firm characteristics in an informative way. The only firm characteristic that contains some information on the average level of irreversibility is disaggregated sector information.

Bearing in mind the type of equipment / machinery used in making your main product / services, we would like to know whether a secondhand market exists where in case of need it could be sold.

- ☐ Yes, and it is relatively easy to find a buyer in a short time willing to pay a reasonable price.
- ☐ Yes, but it takes time to find a buyer and selling prices are not very rewarding.
- ☐ Yes, but it is very difficult to find a buyer and selling prices can become very low.
- ☐ No, there is no such market.

Outline of the solution

The following section of Appendix B provides an outline of the solution of the model in order to provide a general understanding of the solution. However, for further information on the solution I refer the reader to Appendix B of Bloom et al. (2016)

which entails a thorough description of solution algorithm as well as useful comments on the practical numerical choices.

The model represents a heterogeneous agent model with aggregate uncertainty, labor and capital adjustment costs and a cross-sectional distribution of idiosyncratic productivity and capital. Especially aggregate uncertainty and the intractable cross-sectional distribution complicate the model with compare to standard representative agent model. Fortunately, there exists different ways to handle such heterogeneous agent models. In this particular case, the model is solved using non-linear techniques based on the generalized version of the Krusell and Smith (1998) method by Khan and Thomas (2008).

We start by combining the firm and household problem into one dynamic optimization problem. In order to do so we first focus on the household side. In a first step, we obtain the standard optimality condition of labor supply (Equation A.1) and the stochastic discount factor (Equation A.2) from the household problem.

$$w = -\frac{U_N(C,N)}{U_C(C,N)} \tag{A.1}$$

$$m = \beta \frac{U_N(C',N')}{U_C(C,N)} \tag{A.2}$$

We then use the standard optimality condition of labor supply (Equation (A.1)) and the utility function (Equation (1.9)) to obtain the wage rate:

$$w_t = \theta N_t^{\chi-1} C_t^{\eta} \tag{A.3}$$

Define the intertemporal price of consumption goods as $p(A, \sigma^Z, \sigma^A, \mu) \equiv U_C(C,N)$. This allows us to state the firm problem in terms of marginal utility and we can

derive a marginal-utility transformed Bellman equation that is given by

$$\tilde{V} \equiv pV \tag{A.4}$$

$$\begin{aligned}\tilde{V}(k, n_{-1}, z; A, \sigma^A, \sigma^Z, \mu) = \max_{i,n}\{p(A, \sigma^Z, \sigma^A, \mu)(y - w(A, \sigma^A, \sigma^Z, \mu)n - i \\ -AC^K(k, k') - AC^n(n_{-1}, n)) + \beta E\left[\tilde{V}(k', n, z'; A', \sigma^{A'}, \sigma^{Z'}, \mu')\right]\}\end{aligned} \tag{A.5}$$

Equation (A.5) features a constant discount factor β. In addition, it allows the conversion of dividends to a marginal utility price p. This implies that firm value maximization is equal to the maximizing dividends weighted by the marginal price of utility p. From Equation (A.5) we can infer further that the aggregate state is defined by the four state variables $A, \sigma^A, \sigma^Z, \mu$, i.e. aggregate productivity, aggregate and idiosyncratic uncertainty and the cross sectional distribution of idiosyncratic capital and productivity.

We know that in equilibrium markets clear and prices are equal marginal utility of consumption. Hence in optimum the following two relationships hold:

$$p(A, \sigma^A, \sigma^Z, \mu) = \frac{1}{C(A, \sigma^A, \sigma^Z, \mu)^\eta} \tag{A.6}$$

$$w(A, \sigma^A, \sigma^Z, \mu) = \theta N(A, \sigma^A, \sigma^Z, \mu)^{\chi-1} C(A, \sigma^A, \sigma^Z, \mu)^\eta \tag{A.7}$$

Assuming log consumption utility, i.e. $\eta = 1$ and an infinite Frisch elasticity of substitution, i.e. $\chi = 1$, further simplifies the problem and we end up with

$$p(A, \sigma^A, \sigma^Z, \mu) = \frac{1}{C(A, \sigma^A, \sigma^Z, \mu)} \tag{A.8}$$

$$w(A, \sigma^A, \sigma^Z, \mu) = \frac{\theta}{p(A, \sigma^A, \sigma^Z, \mu)} \tag{A.9}$$

Hence, with log consumption utility, i.e. $\eta = 1$, an infinite Frisch elasticity of substitution, i.e. $\chi = 1$, and a linear disutility from labor (θ), the wage rate is function of the marginal utility price.

Finally, in order to fully specify the recursive equilibrium we need the mapping that specifies the evolution of the cross-sectional distribution of idiosyncratic productivity, capital and hours and the mapping that specifies the evolution of the marginal utility price.

$$\Gamma_\mu(A, \sigma^A, \sigma^Z, \mu) \tag{A.10}$$

$$\Gamma_p(A, \sigma^A, \sigma^Z, \mu) \tag{A.11}$$

These two mappings are sufficient to fully specify the aggregate state of the economy.

For further information on the solution I refer the reader to Appendix B of Bloom et al. (2016) which entails a thorough description of solution algorithm as well as useful comments on the practical numerical choices.

Discretization of continuous AR1 process

The continuous AR1 process with time-varying variance is approximated by a discrete Markov-process with 5 gird points. I use the method proposed by Tauchen (1986) to approximate the continuous process. Table A.2 display the switching probabilities for the state of low and high uncertainty. An uncertainty shock increases the switching probabilities of the transition matrix, i.e. it is less likely to remain in a same state. This implies that an uncertainty shock increases the speed with which the technological process will return to its long-term equilibrium. Figure A.2 shows the difference in the evolution of technology after a shock under low and high uncertainty.

Table A.2: Markov Switching Probabilities Aggregate Productivity

		Low Uncertainty							High Uncertainty				
		Productivity in t+1							Productivity in t+1				
		5	4	3	2	1			5	4	3	2	1
Productivity in t	5	89.99	10.01	0.00	0.00	0.00	Productivity in t	5	78.75	20.99	0.26	0.00	0.00
	4	3.92	88.61	7.48	0.00	0.00		4	13.63	67.9	18.28	0.19	0.00
	3	0.00	5.47	89.07	5.47	0.00		3	0.14	15.79	68.14	15.79	12.17
	2	0.00	0.00	7.48	88.61	3.91		2	0.00	0.19	18.28	67.90	13.63
	1	0.00	0.00	0.00	10.01	89.99		1	0.00	0.00	0.26	20.99	78.75

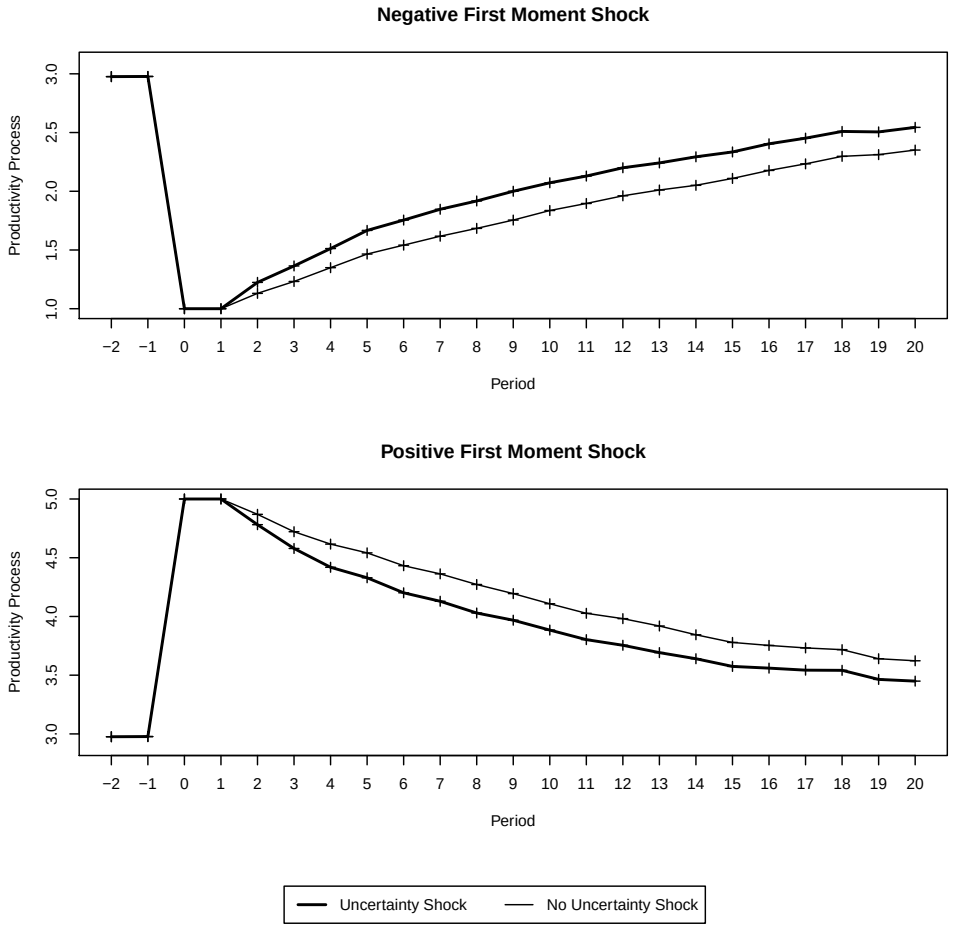
Notes: The table displays the switching probabilities between the states of aggregate productivity for low and high uncertainty.

Table A.3: Markov Switching Probabilities Idiosyncratic Productivity

		Low Uncertainty							High Uncertainty				
		Productivity in t+1							Productivity in t+1				
		5	4	3	2	1			5	4	3	2	1
Productivity in t	5	89.99	10.01	0.00	0.00	0.00	Productivity in t	5	62.22	23.98	10.71	2.69	0.41
	4	3.92	88.61	7.48	0.00	0.00		4	33.44	30.25	23.35	10.13	2.83
	3	0.00	5.47	89.07	5.47	0.00		3	12.16	22.70	30.27	22.70	12.17
	2	0.00	0.00	7.48	88.61	3.91		2	2.83	10.13	23.35	30.25	33.44
	1	0.00	0.00	0.00	10.01	89.99		1	0.41	2.69	10.71	23.98	62.22

Notes: The table displays the switching probabilities between the states of idiosyncratic productivity for low and high uncertainty.

Figure A.2: Evolution of a Positive and Negative Aggregate Productivity Shock



Notes: The figure compares the response of aggregate productivity to a first moment productivity shock that coincides with an uncertainty to first moment productivity shock that does not coincide with an uncertainty shock.

Calculations of the impulse responses

In the model, the calculation of generalized nonlinear impulse responses /'a la Koop et al. (1996) relies on a pair of simulations. The first simulation is thereby conducted without a shock and the second simulation includes a shock. More specifically, both simulations are run under an identical evolution of exogenous shock process until a

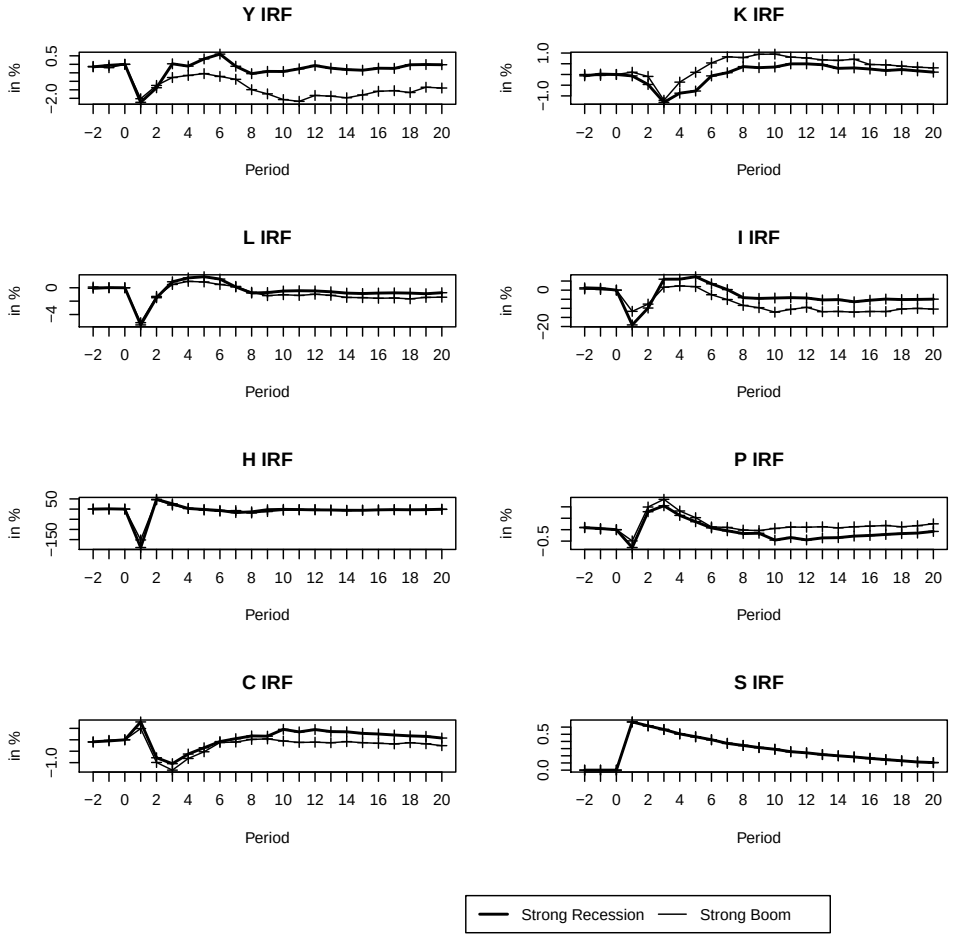
specific period in which the shock occurs in one simulation, but not in the second. After the shock, the exogenous shock process of both pairs is allowed to evolve according to the underlying process. According to Terry (2017) provides the difference of a series between the shock and no shock simulation an adequate approximation of the average response of this series to the imposed shock.

In this paper I am not only interested in the average response of a series, but additionally concerned about the state of the economy when the shock occurs, i.e. I am interested in the consequences of an uncertainty shock in the boom and an uncertainty shock in a bust. Hence, in the boom setting the exogenous productivity process is set to the highest possible grid value, for both simulations, two periods before the uncertainty shock. Similarly, two compute impulse response function in a bust I exogenously set the aggregate state of productivity to the lowest possible grid value, for both simulations, two periods before the uncertainty shock occurs.

Impulse Responses

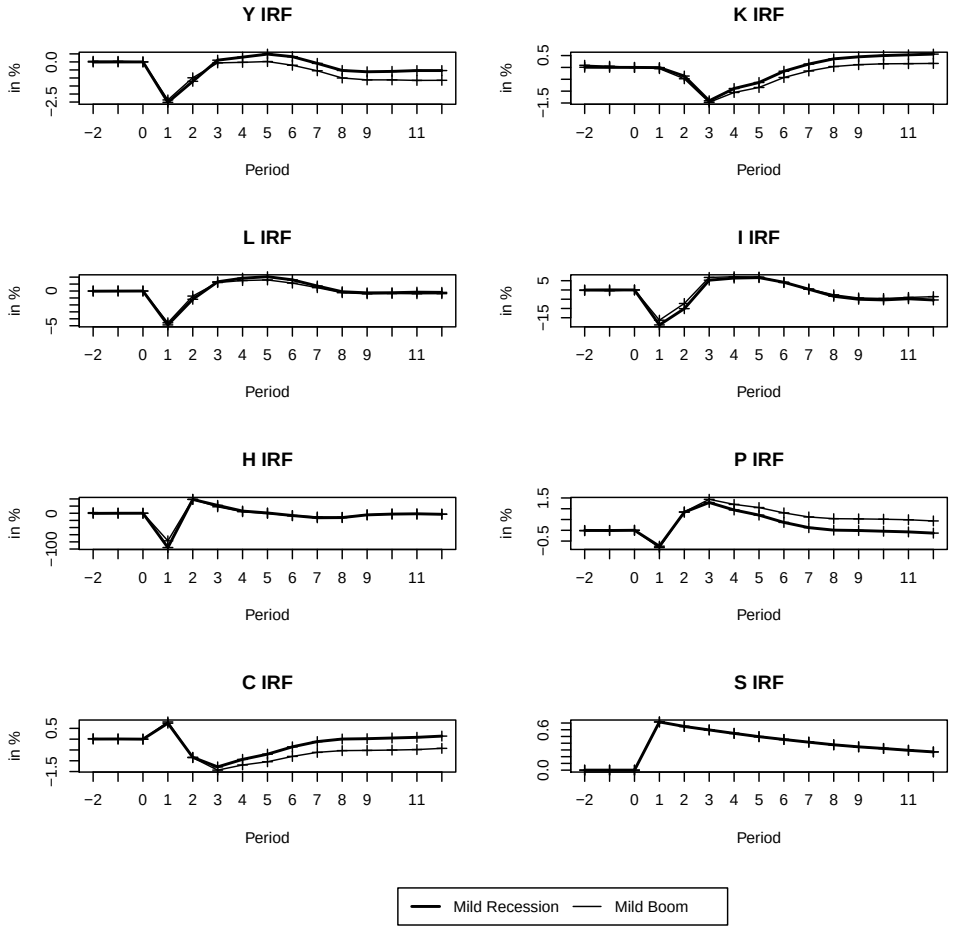
Figure A.3 displays the reaction of various variables to an uncertainty shock in the boom and to an uncertainty shock in the bust. Figure A.4 shows the impulse responses of various variables to an uncertainty shock that occurs in a mild boom and to an uncertainty shock in a mild bust. Technically, while in Figure A.3 the aggregate productivity process jumps to the highest respectively lowest possible grid point, in Figure A.4 the aggregate productivity process jumps to the grid point that lies in between the highest and middle grid point respectively jumps to the grid point that lies in between the lowest and middle grid point.

Figure A.3: Uncertainty Shocks in Strong Booms and Busts



Notes: The figure compares the response of various variables to an uncertainty shock that occured during a strong recession to the response of investment to an uncertainty shock that occured during a strong boom.

Figure A.4: Uncertainty Shocks in Mild Booms and Busts



Notes: The figure compares the response of various variables to an uncertainty shock that occured during a mild recession to the response of investment to an uncertainty shock that occured during a mild boom.

Appendix B

Appendix Chapter 2

B.1 Uncertainty Indicators for Switzerland

Appendix B.1 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.

B.1.1 News Indicator: Economic Policy Uncertainty

We replicate the News Economic Policy Uncertainty (EPU) Indicator introduced by Baker et al. (2015a) 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. (2015a)

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 B.1 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:

Table B.1: Key Words News Economic Policy Uncertainty Index

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

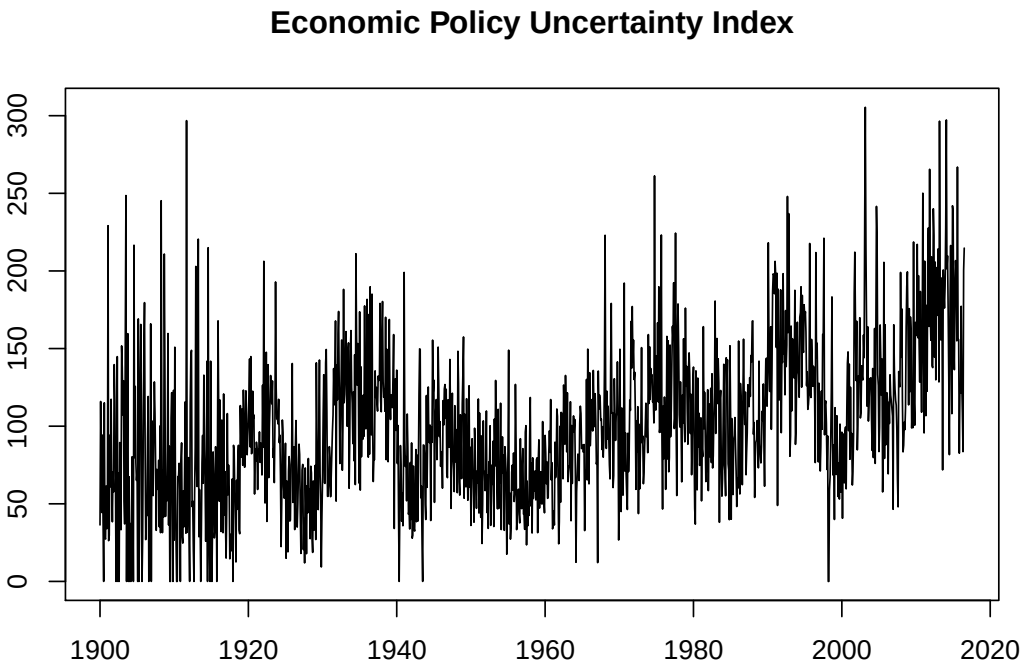
Notes: The News Economic Policy Uncertainty Index builds on the number of articles that contain at least one word of each set of keywords. The table lists the English keywords for each set. The indicator for Switzerland uses German and French translations of the English keywords. Table B.2 lists the 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. (2015a). 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 B.1: Monthly EPU Index for Switzerland



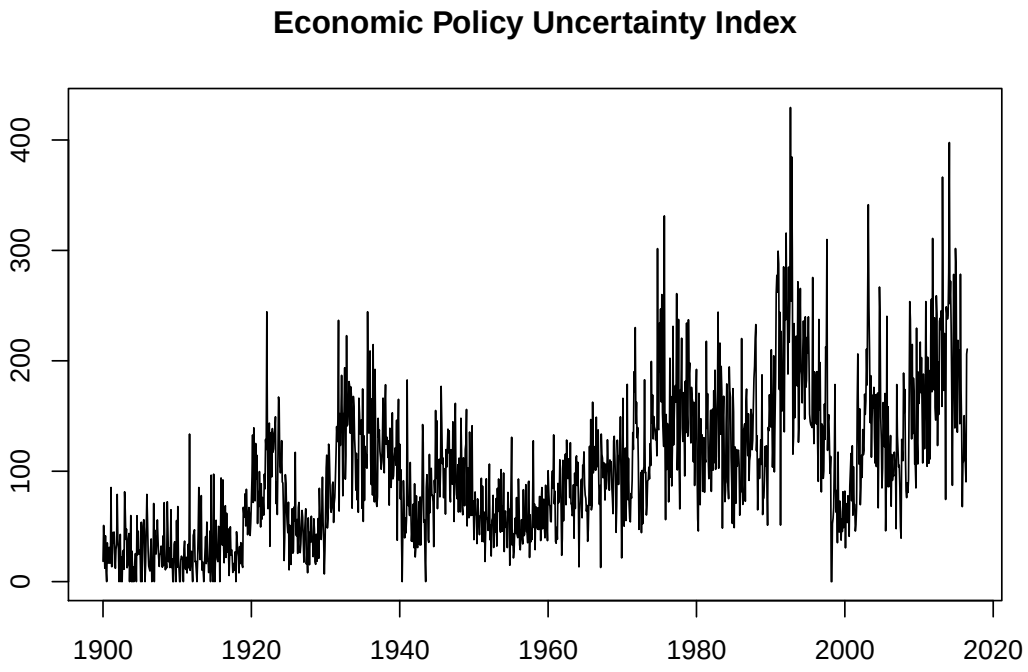
Notes: The Figure show the Economic Policy Uncertainty Index for Switzerland from 1900 to 2016. The index is scaled by the set of economy relevant words and normalized to its long term mean of 100.

Table B.2: German and French Keywords for Economic Policy Uncertainty Index

	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

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 B.2: 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.

B.1.2 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.

$$VSMI_i = 100 \times \sqrt{\sigma_i^2} \tag{B.1}$$

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

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.[1] $K_{i,0}$ is the highest exercise price below the forward price F_i. R_i stands for the refinancing factor of the i^{th} option.[2] 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 B.3. Particularly, the model bases on the forward price for which the absolute difference between call and put prices (C and P) is smallest.[3]

$$F_i = K_{min|C-P|} + R_i \times (C_P) \tag{B.3}$$

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

[2] 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.

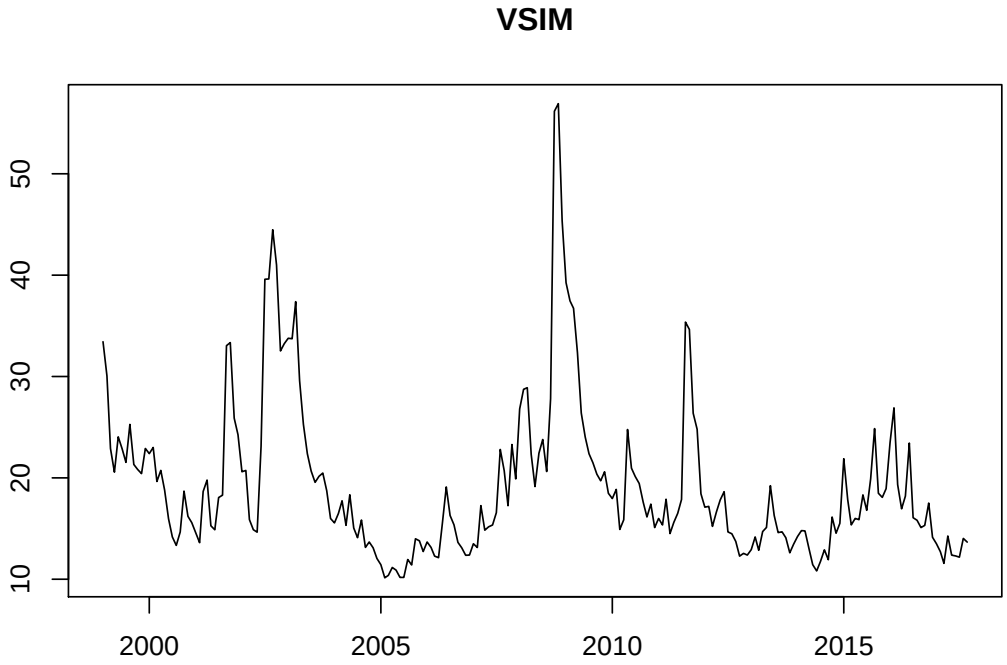
[3] In case that no clear minimum exists, the calculations consider the average value of the relevant forward price.

The interval between the relevant exercise prises is defined as

$$\Delta K_{i,j} = \frac{K_{i,j+1} - K_{i,j-1}}{2} \tag{B.4}$$

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

Figure B.3: VSMI® - Volatility Index on the SMI®



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

B.1.3 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 B.3 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 B.4 to Figure B.7 depict the indicators over time.

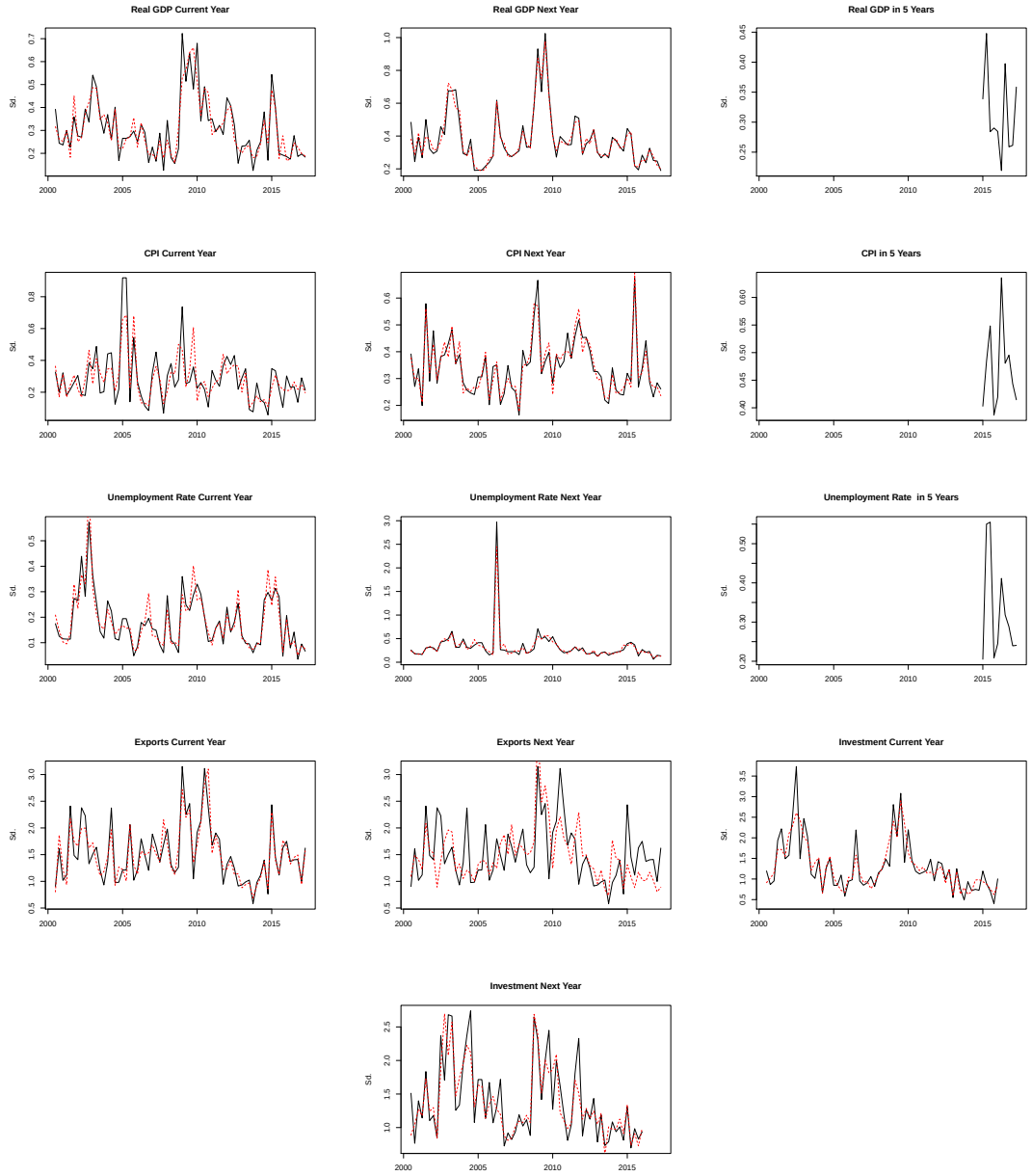
Table B.3: KOF Consensus Forecast.

	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				

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

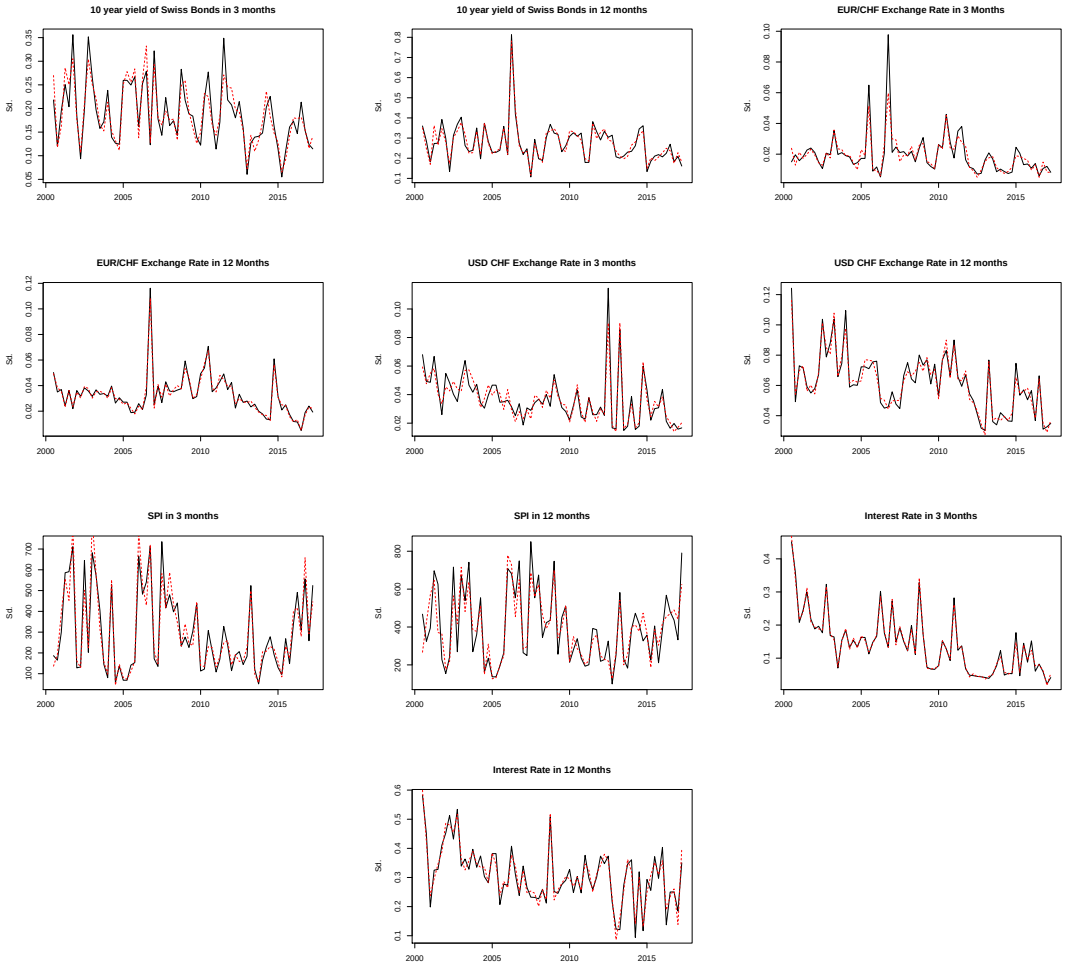
Furthermore, KOF asks survey participants estimates on macroeconomic variables for a specific year, i.e. real GDP growth next year, on four different occasions. That is, March, June, September and December each year. Naturally, forecasters estimates should become more precise throughout the year, i.e. 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 B.4: Dispersion of Professional Forecasts - Standard Deviation - Macroeconomic Variables



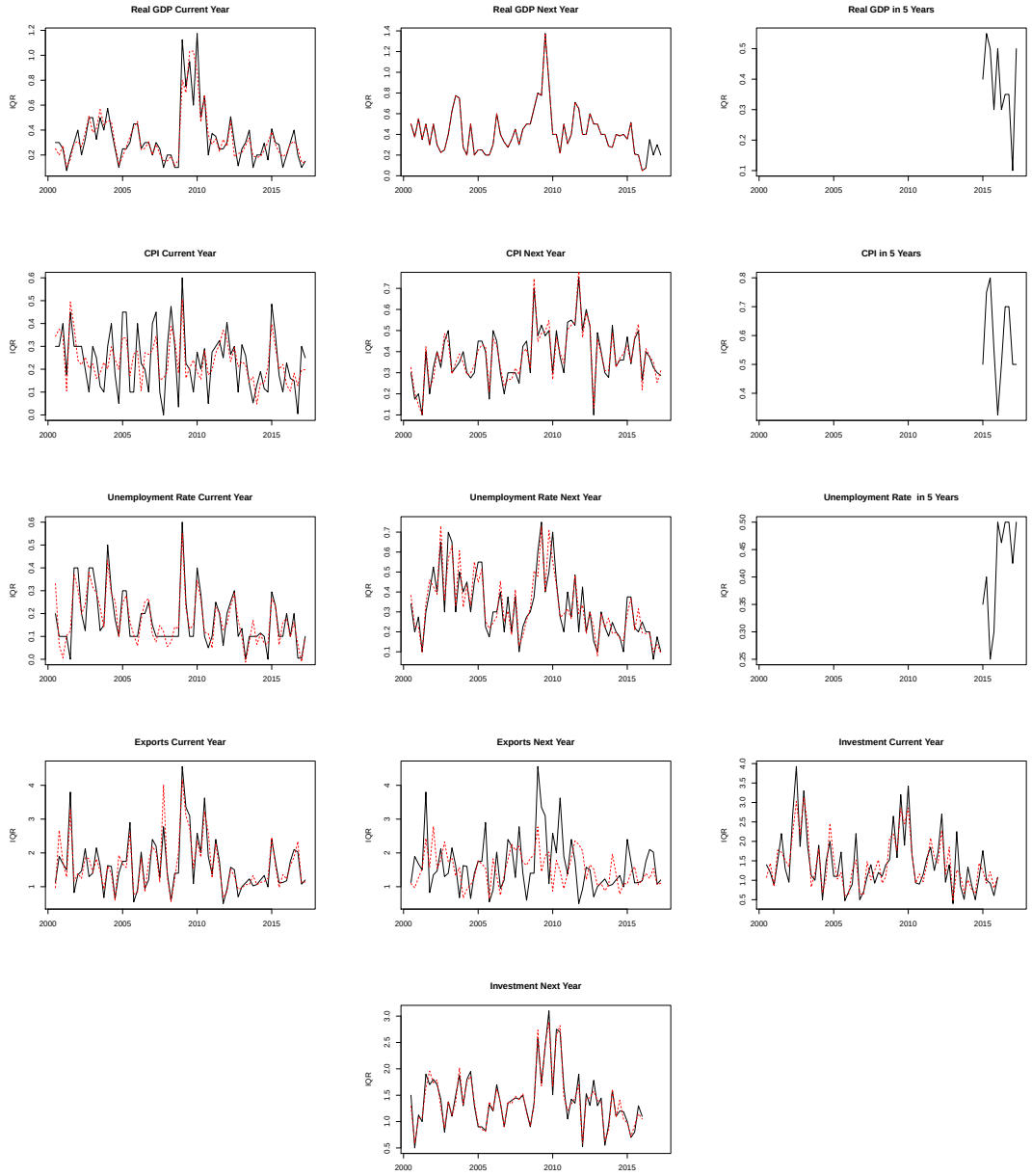
Notes: Dispersion of Professional Forecasts - Standard Deviation - Macroeconomic Variables. The black solid line depicts the standard deviation. The red dashed line shows the seasonal adjusted series.

Figure B.5: Dispersion of Professional Forecasts - Standard Deviation - Financial Variables



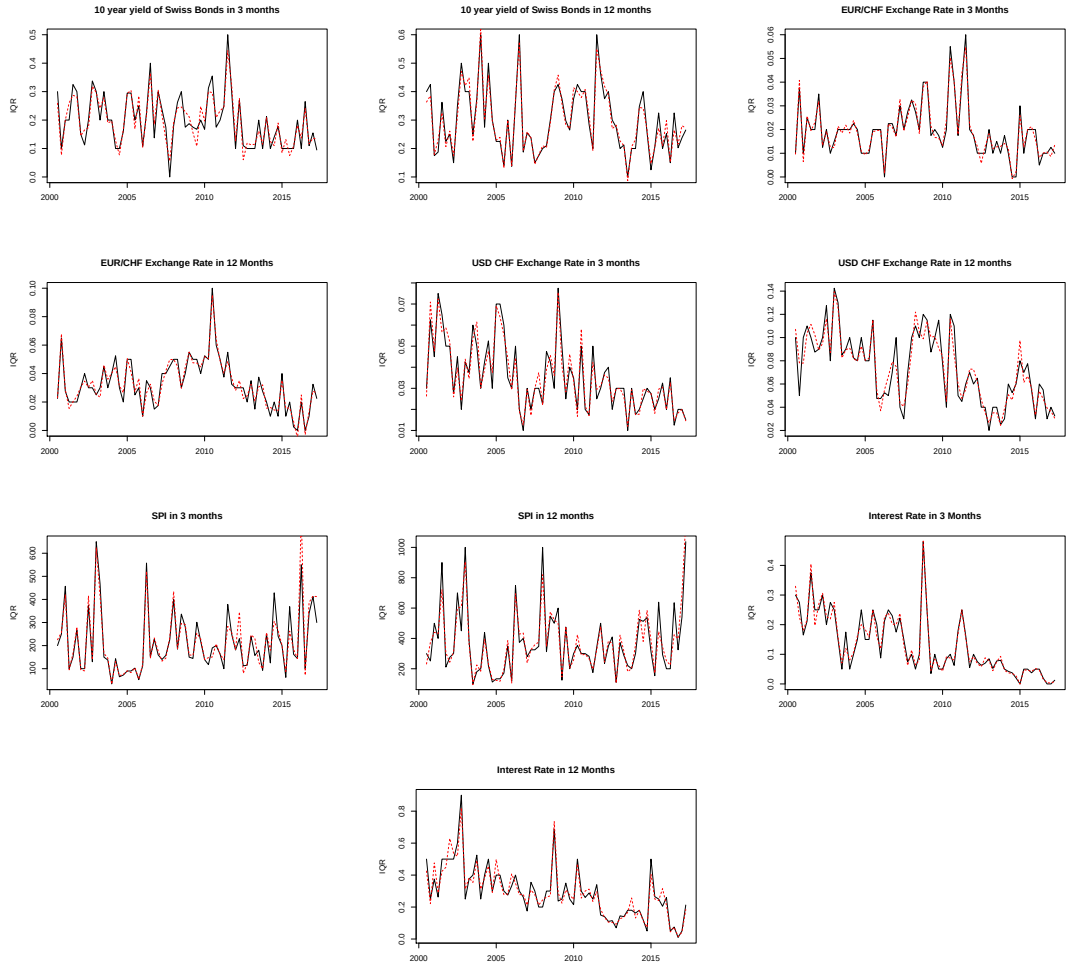
Notes: Dispersion of Professional Forecasts - Standard Deviation - Financial Variables. The black solid line depicts the standard deviation. The red dashed line shows the seasonal adjusted series.

Figure B.6: 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 B.7: 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.

B.1.4 Survey Based Uncertainty Measures

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 B.4 show all the possible combination of forecast errors.

Table B.4: Forecast Errors Business Tendency Surveys

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

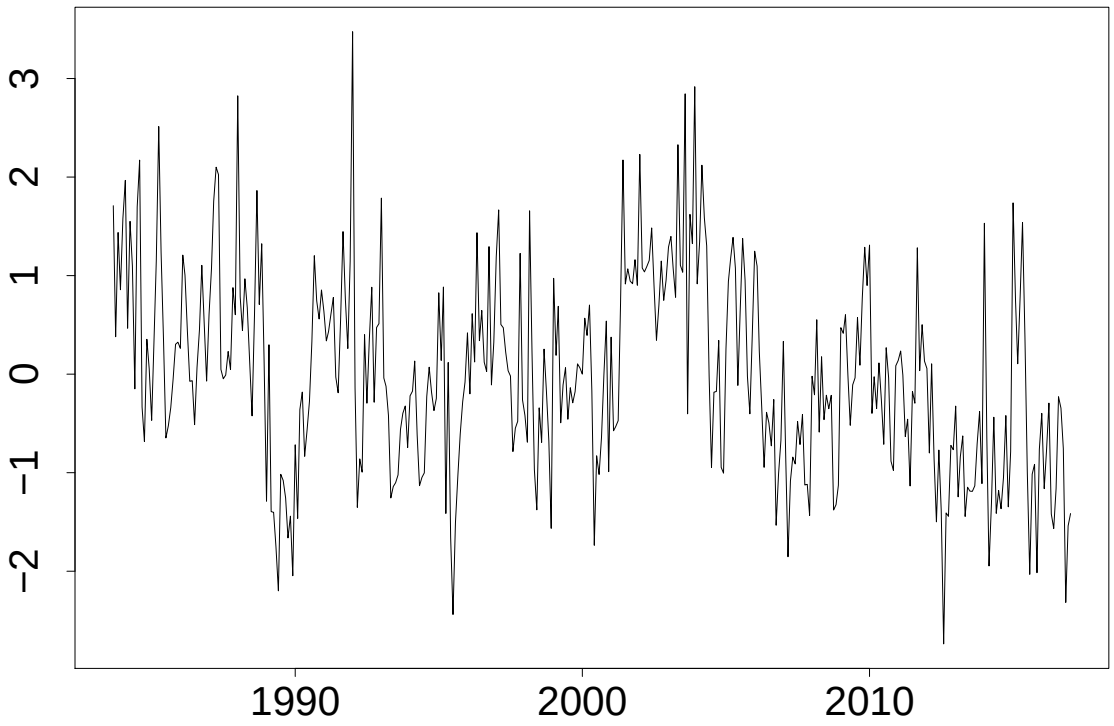
Notes: Forecast Errors Business Tendency Surveys. This table depicts possible forecast errors of a single firm.

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

$$FEDISP_t = stdw(error_{i,t+3}) \tag{B.5}$$

Figure B.8 displays the standard deviation of firms forecast errors over time.

Figure B.8: 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.[4]

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.

$$d_t = U_t + D_t - (U_t + D_t)^2 \tag{B.6}$$

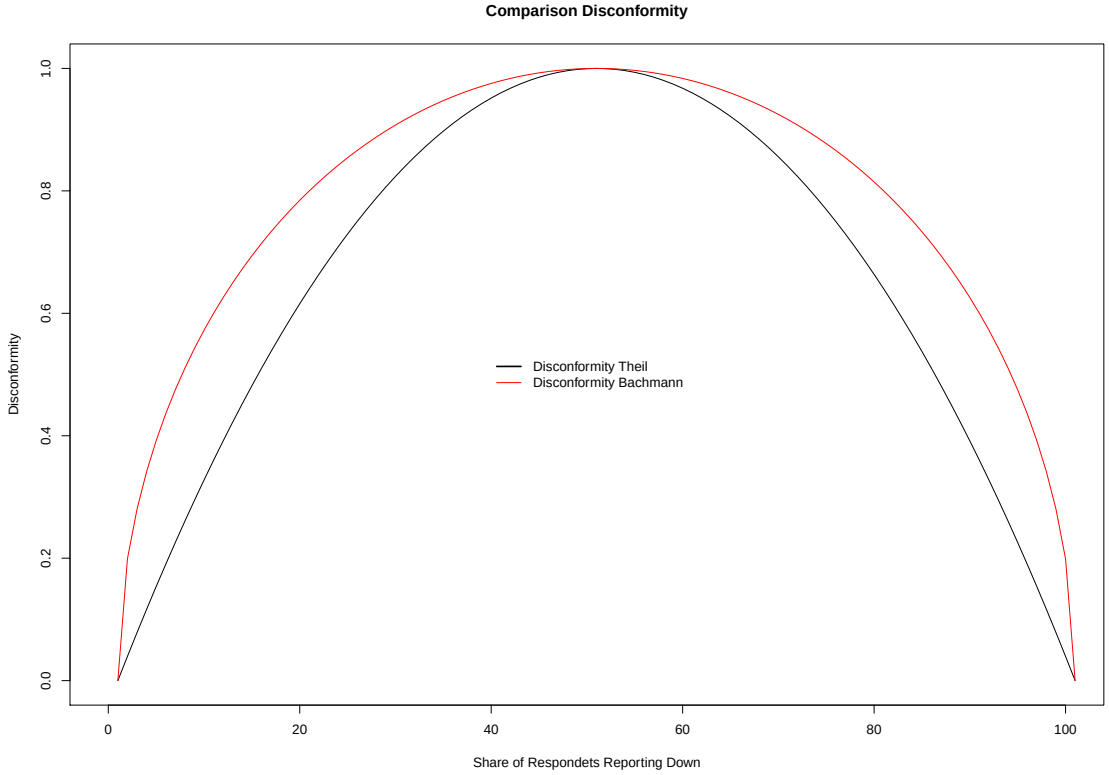
$$b_t = \sqrt{U_t + D_t - (U_t + D_t)^2} \tag{B.7}$$

Figure B.9 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 B.9 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.

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

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 B.11 to B.21 in the Appendix).

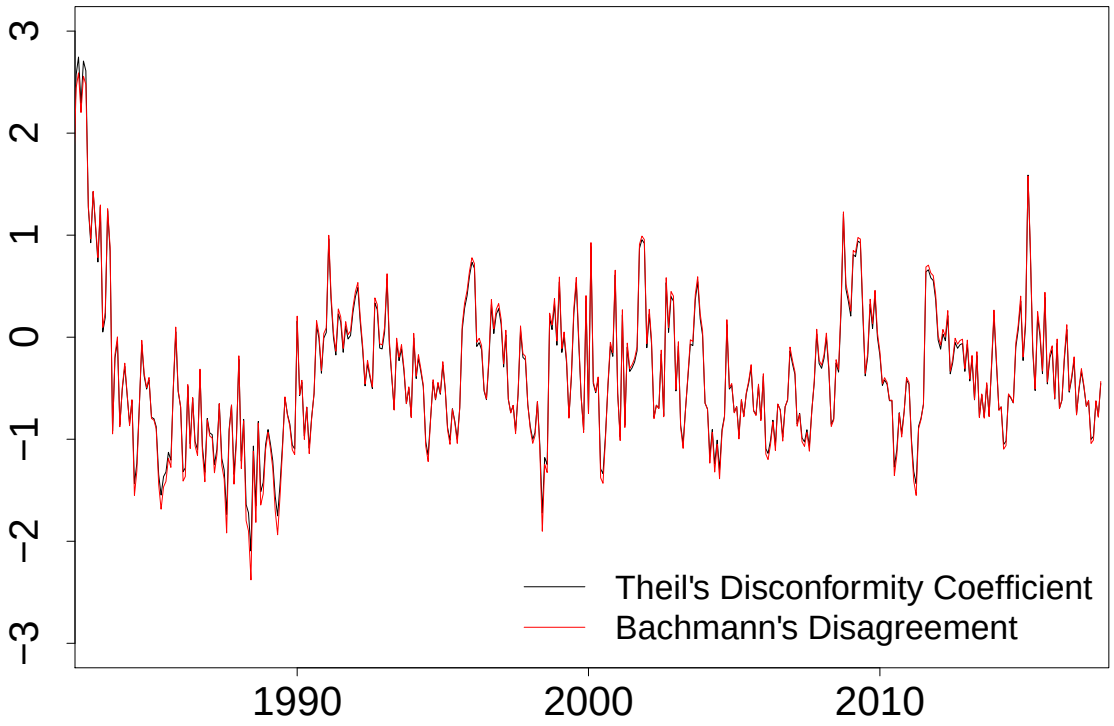
Figure B.9: Theil's Disconformity Coefficient vs. Bachmann's Disagreement



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 B.10 compares Theil's Disconformity Index to Bachmann's disagreement measure. The correlation between the two series is 0.999.

Figure B.10: 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.

$$d = U + D - (U - D)^2 \tag{B.8}$$

$$d_U = 1 - 2\,(U - D) \tag{B.9}$$

$$d_{U,U} = -2 \tag{B.10}$$

$$b = \sqrt{U + D - (U - D)^2} \tag{B.11}$$

$$b_U = \frac{1 - 2\,(U - D)}{2\sqrt{-\,(U - D)^2 + U + D}} \tag{B.12}$$

$$b_{U,U} = -\frac{8D + 1}{4\left(-\,(U - D)^2 + U + D\right)^{\frac{3}{2}}} \tag{B.13}$$

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".

$$d = U + D - (U - D)^2 \tag{B.14}$$

$$d = U + (1 - U) - (U - (1 - U))^2 \tag{B.15}$$

$$d_U = 4 - 8U \tag{B.16}$$

$$d_{U,U} = -8 \tag{B.17}$$

$$b = \sqrt{U + D - (U - D)^2} \tag{B.18}$$

$$b = \sqrt{U + (1 - U) - (U - (1 - U))^2} \tag{B.19}$$

$$b_U = -\frac{4U - 2}{\sqrt{1 - (2U - 1)^2}} \tag{B.20}$$

$$b_{U,U} = -\frac{4}{\left(1 - (2U - 1)^2\right)^{\frac{3}{2}}} \tag{B.21}$$

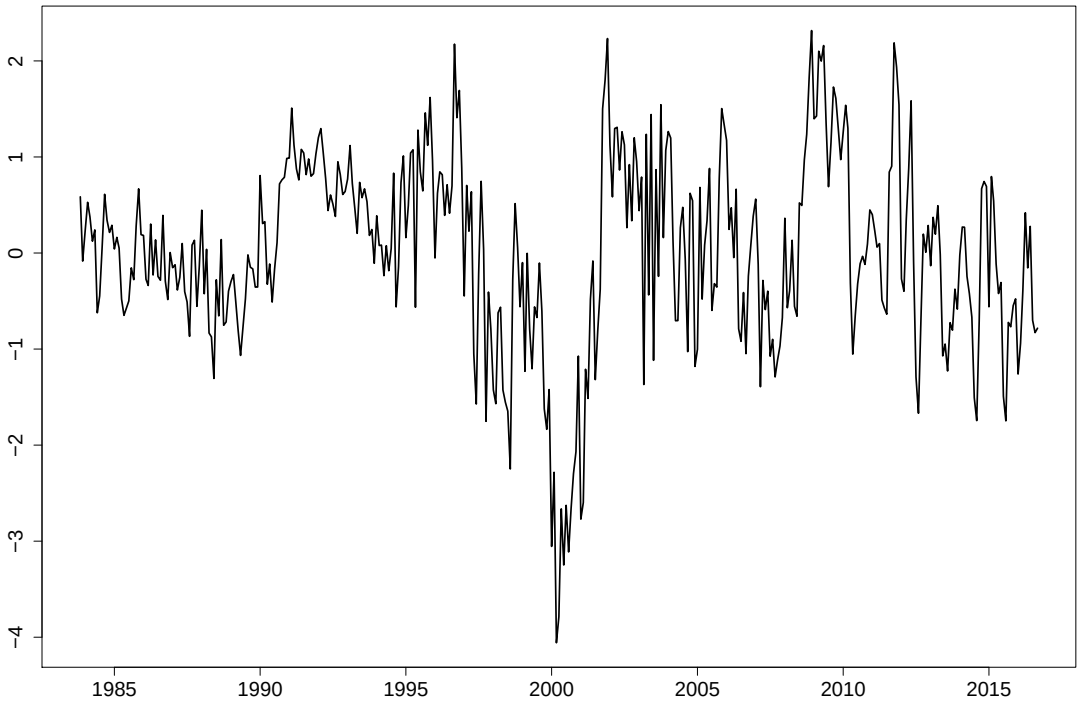
Index of Qualitative Variation

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:

$$IQV_t = \frac{K}{K-1}\left(1 - \sum_{i=1}^{K} s_{i,t}^2\right) \tag{B.22}$$

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 B.11 depicts the index of qualitative variation for Switzerland.

Figure B.11: 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.

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

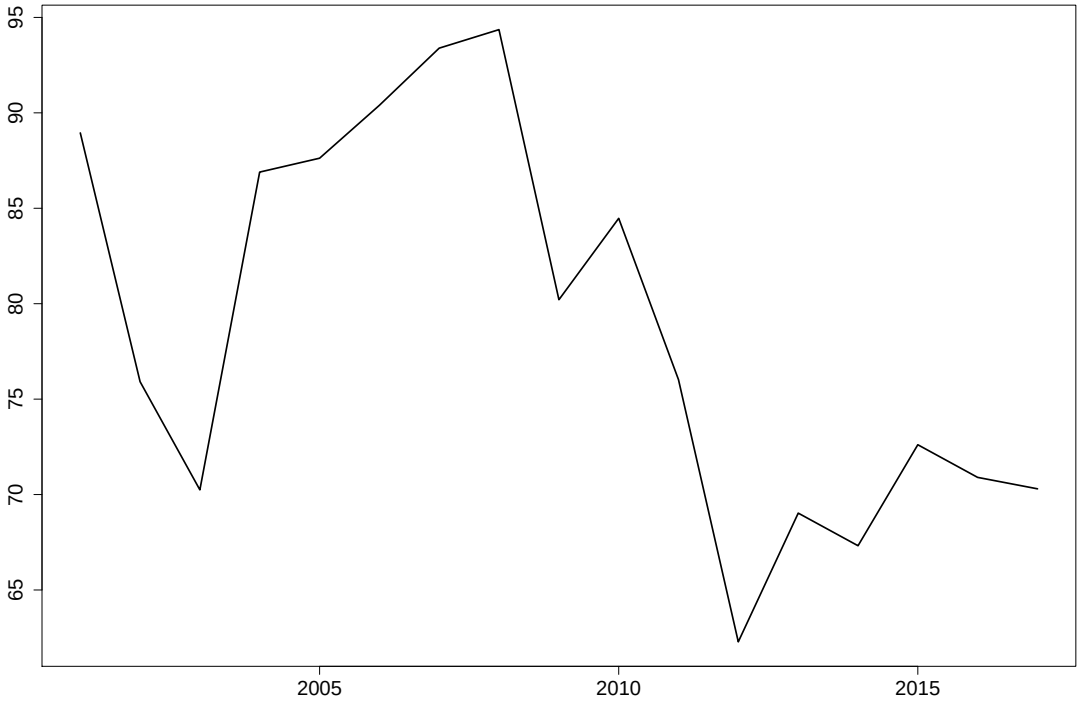
☐ very certain

☐ fairly certain

☐ fairly uncertain

☐ very uncertain

Figure B.12: Investment Realization Certainty



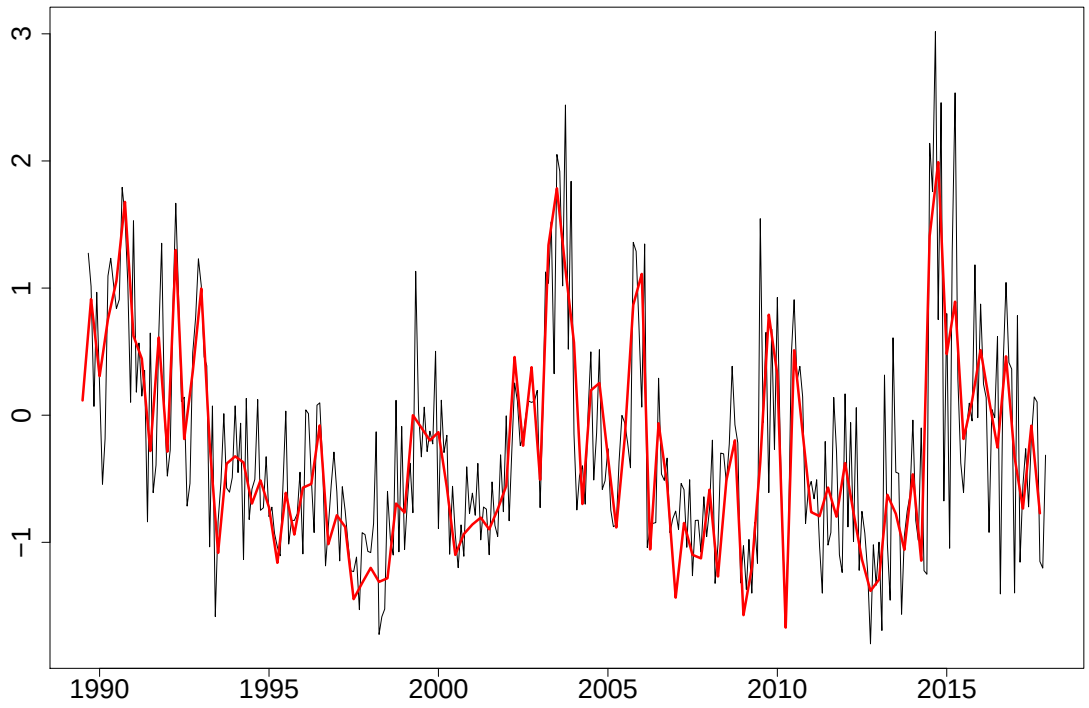
Notes: The figure plot the share of firms that report fairly certain or very certain investment plans.

B.2 Robustness Evaluation & Analysis

B.2.1 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 2.1). In order to bring all sectoral series to the highest frequency, we rely on temporal disaggregation techniques as described in Section 2.4. As a robustness check we also compute the Knightian Uncertainty indicator for Switzerland. Figure B.13 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 B.13: 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 2.4. The red thick line presents the quarterly Knightian Uncertainty indicator that does not rely on temporal disaggregation.

B.2.2 Principal Component Analysis

Table B.5: 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

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.

Appendix C

Appendix Chapter 3

C.1 Sensitivity Analysis

This section presents several sensitivity checks of our main results. One potential concern with our DDD regressions is that the estimated effects are driven by an unobserved confounding factor that affects exposed firms with irreversible investment but not the other groups of firms in 2014 or 2015. We study the relevance of this concern in Table C.1. The second column shows that our central result does not depend on the full set of industry-time effects that are contained in our baseline model (column 1 of the table). The industry-period effects, however, tend to increase the precision of our estimates. The remaining columns show that our results are similar if we account for exporter-industry-period FE, which absorb all industry-specific shocks that affected exporters and non-exporters differentially such as changes in trade policies (column 3). They also hold if we control for canton-period fixed effects, which absorb unobserved regional shocks, changes in cantonal policies and changes in taxes (column 4), and if we control for group-specific linear time trends which account for a separate time trend in the outcome for exposed and non-exposed with and without irreversible investment (column 5). The latter result suggests that our results do not capture an underlying trend in investment in the four groups of firms that we compare in our DDD. Column 6 of Table C.1 shows that the main result is robust to controlling for these trends and fixed effects simultaneously.

Another potentially relevant concern in our estimations – only partially addressed by including industry-time and exporter-industry-time FE – is that our results partly pick up the effects of the strong appreciation of the Swiss Franc in 2015. The appreciation was the consequence of the decision of the Swiss National Bank in January 2015 to lift the ceiling of the Franc vis-à-vis the Euro. The strong appreciation had a sizeable negative impact on investment in affected firms in Switzerland (Binding and Dibiasi (2017); Efing et al. (2016); Kaiser et al. (2017)). To rule out that this exchange rate shock biases our estimates, we drop 2015 from the sample (column 7 of Table C.1), and, even more restrictively, restrict the sample to the 2012–2014 period (column 8 of Table C.1). Because of the ceiling, the trade-weighted real exchange rate of Switzerland was virtually constant during this period. Reassuringly,

Table C.1: Robustness of Baseline DDD to Unobserved Regional and Industrial Shocks and Trends

VARIABLES	(1) FE Baseline DDD	(2) FE DDD	(3) FE DDD	(4) FE DDD	(5) FE DDD	(6) FE DDD	(7) FE DDD 2009-2014	(8) FE DDD 2012-2014
MII x Exposed x Irreversible	-0.287***	-0.226**	-0.264**	-0.281***	-0.323**	-0.304**	-0.307***	-0.319***
	(0.100)	(0.097)	(0.103)	(0.101)	(0.134)	(0.139)	(0.111)	(0.113)
Observations	12,648	12,648	12,294	12,648	12,648	12,294	10,949	6,860
R-squared	0.061	0.008	0.098	0.079	0.061	0.117	0.061	0.034
Number of firms	2,700	2,700	2,593	2,700	2,700	2,593	2,684	2,637
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-time FE	Yes	No	No	Yes	Yes	No	Yes	Yes
Exposed-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Irreversibility-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-industry-time FE	No	No	Yes	No	No	Yes	No	No
Canton-time FE	No	No	No	Yes	No	Yes	No	No
Group trends	No	No	No	No	Yes	Yes	No	No

Cluster-robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The table presents results of our baseline DDD model, excluding or including various fixed effects. *Industry-time FE* control for time fixed effects for each two-digit industry. *Canton-time FE* control for canton times period fixed effects. *Exporter-industry-time FE* indicate a full set of export status times two-digit industry times period fixed effects. *Group trends* controls for linear group time trends (i.e. we add a time trend for each exposed-irreversibility combination). Model (7) confines the sample period to the year 2009 to 2014. Model (8) confines the sample period to the years 2012 to 2014.

our results are very similar in these cases.

Table C.2 presents the results of a variety of further sensitivity checks. First, we show that the results are similar if we do not trim the dependent variable (column 2) and if we trim it at the 95th percentile (instead of the 99th percentile) of its distribution (column 3). The effects tend to become smaller in the latter estimation, however, which suggests that part of our effects stem from a small set of firms that substantially reduce investment. Second, column 4 shows that our results are similar if we use a balanced panel. This suggests that our results are not driven by non-random firm exit or panel non-response.[1]

[1]Biases due to do non-random firm entry are accounted for through the inclusion of firm fixed effects in our main specifications. Arguably, factors affecting the entry of firms are fixed at the time of entry and are hence absorbed by these fixed effects.

Table C.2: Various Robustness Checks

VARIABLES	(1) DDD Baseline	(2) DDD not trimmed	(3) DDD trimmed 95%	(4) DDD balanced panel	(5) DDD Alternative exposure	(6) DDD Alternative irreversibility	(7) DDD Inv. uncertainty aut. 2013
MII x Exposed x Irreversible	-0.287***	-0.239**	-0.167*	-0.235*			
	(0.100)	(0.105)	(0.097)	(0.127)			
MII x Exposed_2 x Irreversible					-0.270**		
					(0.124)		
MII x Exposed x Irreversible (proxy)						-0.143	
						(0.149)	
MII x High inv. uncertainty aut. 2013							-0.176**
							(0.069)
Observations	12,648	12,840	11,724	7,826	6,410	6,475	11,788
R-squared	0.061	0.055	0.062	0.087	0.088	0.102	0.077
Number of firms	2,700	2,725	2,610	1,322	1,518	1,213	2,584
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exposed-time FE	Yes	Yes	Yes	Yes	Yes	Yes	No
Irreversibility-time FE	Yes	Yes	Yes	Yes	Yes	Yes	No

Cluster-robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The table presents various specifications checks for our baseline DDD model. Model (1) presents our baseline specification. Estimation results without trimming the outcome distribution are presented in Model (2). In Model (3), we trim the outcome at the 95th percentile of the outcome distribution. Model (4) is based on a balanced firm panel. The estimation is restricted to 2014. Model (5) measures firms' exposure to the vote using the predicted values of Model (2) of Table 2. Model (6) exploits that the autumn survey 2013 contains information on the structure (equipment vs. construction) of planned investment to proxy firm-specific irreversibility. The dummy variable *Irreversible (proxy)* is 1 if a firm only plans equipment investment in 2014. Model (7) examines the effect of a priori investment uncertainty. This approach exploits that we know how certain firms were about their investment plans of 2014 prior to the vote. In the regular investment survey in autumn 2013, KOF asked firms how certain firms were about the realisation of their investment plans for 2014. Model (7) compares the reaction of firms to the MII that were 'fairly uncertain' or 'very uncertain' about the realisation of their investment, to the reaction of firms that were 'fairly certain' or 'very certain' about their investment.

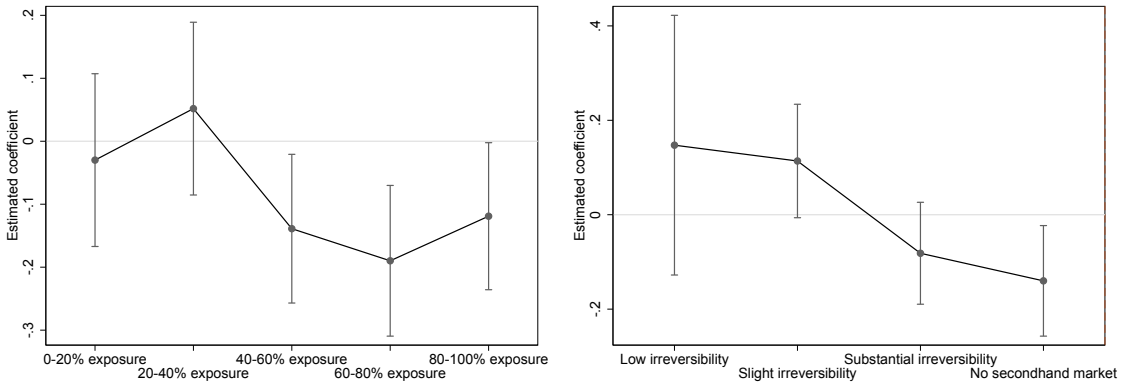
A fourth sensitivity check is provided in column 5, which alters the way we measure firms' exposure to the vote. In particular, instead of using predicted values of model (1) of Table 3.2, we employ the more elaborate regression model (column 2 of Table 3.2) to construct the binary exposure variable. Even though the sample size shrinks substantially using this exposure measure, the estimated uncertainty effect of the vote is of similar magnitude as our baseline estimate and statistically significant.

Figure C.1a illustrates that our results do not depend on the threshold we chose to assign firms into exposed and non-exposed firms. The figure presents separate effects of the vote for firms with five different levels of predicted exposure.[2] These are estimated using a version of our baseline model that contains five interactions between $\text{Irreversible}_i * \text{MII}_i$ and indicators for the different levels of exposure. As expected, firms with low levels of predicted exposure do not react to the uncertainty created by the MII. The effect kicks in with firms that have about 40% exposure. The figure also suggests that the negative effect of the MII is nonlinear in the predicted level of exposure, with firms with medium levels of exposure reacting similarly as firms with high levels of exposure. Using a binary exposure, splitting firms at the median level of exposure, thus appears to be a sensible way of summarizing the uncertainty effects of the MII depending on firms' predicted exposure.

Similar comments apply concerning irreversibility as shown in Figure C.1b. The figure is based on an estimation that yields separate MII effects for firms with the four different levels of irreversibility that can be constructed from our survey question (see Figure 3.3). While firms with low or slight investment irreversibility do not react to the MII, or even tend to increase investment, firms with the two higher levels of irreversibility reduce investment as a reaction the vote.

[2]In order to construct five different levels of exposure, we use the predicted values of the specification presented in Table 3.2 to rank firms according to their probability to be exposed. Finally, we create five equal bins, i.e. each 20% are attributed to one level of exposure.

Figure C.1: Effect by Detailed Intensity of Exposure and Irreversibility



Notes: The figure shows the estimated uncertainty effect of the MII on total investment, depending on detailed exposure (left) and detailed irreversibility (right). The effects are estimated by regressing the outcome on a triple interaction with indicators for the respective category of irreversibility and exposure. The estimation period is 2009–2015..

Finally, in column 6 of Table C.2, we use the share of equipment investment in total investment as an alternative measure to proxy firm-specific irreversibility. This measure is based on the idea that commercial buildings can be used for different purposes while equipment and machinery are less likely to be of use to another firm. Following Ronen and Sorter (1972), various papers have used this measure to proxy for irreversibility (Berger et al. (1996); Jens (2017)). Exploiting that the autumn survey 2013 contains information on the structure (equipment vs. construction) of planned investment in 2014, we set the irreversibility proxy constructed this way to 1 if, prior to the vote, a firm planned to invest only in equipment and not in construction investment in 2014. Replacing Irreversible_i with this irreversibility proxy leads to results that are statistically insignificant but also not statistically different from our baseline estimates.

C.2 Alternative Identification of Uncertainty Effects

Our main analysis is based on the presumption that the irreversibility of investment can be used to gauge the negative effects of uncertainty. In this subsection, we outline two complementary approaches to estimate the uncertainty effects of the policy shock.

The first alternative approach uses firms' self-reported certainty regarding the realisation of their investment plans. This approach exploits that we know how certain firms were about their investment plans of 2014 prior to the vote. In the regular investment survey in autumn 2013, KOF asked firms how certain they were about the realisation of their investment plans for 2014. One can interpret the answer to this question as a verbal expression of the variance around a firm's quantitative point estimate. Using this survey question, we compare the reaction of firms to the MII that were 'fairly uncertain' or 'very uncertain' about the realisation of their investment in 2014, to the reaction of firms that were 'fairly certain' or 'very certain' about their investment. The idea here is that firms that were more uncertain about their investment in 2014 some months prior to the policy shock are more likely to adjust their investment because of the vote. The regression, shown in the last column of Table C.2, provides evidence supporting this argument: firms that considered their investment plans for 2014 uncertain before the vote display a stronger negative reaction to the outcome of the vote. Moreover, the estimated negative effect is very similar in size as the estimated effect in our baseline specification.

The second alternative to estimate the uncertainty effects of the vote exploits that we asked firms directly whether the vote changed the uncertainty surrounding future investment activities. Since this question arguably pinpoints firms that were affected by the uncertainty caused by the vote, we study whether firms that reported to be affected by increased uncertainty because of the policy shock change their investment plans differently than firms that did not report increased investment uncertainty. In this analysis, we concentrate on firms' revisions in their investment plans for 2014 between the survey conducted in autumn 2013 and the survey in

spring 2014. Such a regression accounts for firms' investment plans for 2014 as they held them in late 2013. It also exploits that the by far most important event affecting investment uncertainty in Switzerland in the short period between end of 2013 and spring 2014 was the acceptance of the MII (see Figure 3.1), making it more likely that the regression identifies the effects of the MII rather than some other shock that affected firms' investment uncertainty. Finally, we directly control for the impact of the vote that is triggered by changes in the mean of the expected demand by including two self-reported variables revealing whether firms think that their demand development was affected by the vote.

Putting these elements together, we estimate the following regression model:

$$\begin{aligned} ln(y_{i,p=Spr14,t=2014}) - ln(y_{i,p=Aut13,t=2014}) = \alpha_0 + \alpha_1 \Delta\text{exp. demand}_i \\ + \alpha_2 \Delta\text{growth potential}_i + \alpha_3 \Delta\text{uncertainty}_i + \alpha_x X_i + \epsilon_i \end{aligned} \tag{C.1}$$

where $y_{i,p,t}$ stands for the investment for year $t = 2014$ as observed in survey $p \in (Autumn2013, Spring2014)$ by firm i. The variable Δexp. demand$_i$, takes the value one if a firm states that a firm perceives a decline in expected demand due to the policy shock and zero otherwise. Δgrowth potential$_i$ is one if the firm reported a decline in Switzerland's growth potential because of the vote. These two variables control for the first moment effects of the vote. The variable Δuncertainty$_i$, measures an increase in the second moment of their expected demand due to the vote. It equals one in case a firm experiences an increase in uncertainty due to the MII and zero otherwise. The vector of covariates $X_i$contains a set of dummy variables controlling for the impact of firms' export status, two-digit industry affiliation, and size on investment revisions.

Table C.3 reports the results from these regressions, separately for equipment (columns 1 and 2) and construction investment (columns 3 and 4). The table identifies a statistically significant negative effect of self-reported investment uncertainty

Table C.3: Uncertainty Effect of the MII on Investment Plan Revisions of Firms

VARIABLES	(1) OLS equipment revisions 2014	(2) OLS equipment revisions 2014	(3) OLS construction revisions 2014	(4) OLS construction revisions 2014
Decreased exp. demand	-0.327***	-0.332***	0.089	0.090
	(0.115)	(0.115)	(0.160)	(0.160)
Decreased growth potential	0.039	0.043	0.013	0.014
	(0.072)	(0.073)	(0.109)	(0.109)
Increased uncertainty	-0.197*	-0.090	-0.260*	-0.181
	(0.107)	(0.190)	(0.157)	(0.272)
Irreversible		0.045		0.098
		(0.079)		(0.117)
Increased uncertainty x Irreversible		-0.159		-0.108
		(0.216)		(0.311)
Observations	949	947	525	524
R-squared	0.069	0.071	0.109	0.110
Industry FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Uncertainty x Irreversible		-0.249**		-0.289

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The table presents examines the effect of the vote on investment plan revisions. The dependent variable of this table represent firm-level investment plan revisions for 2014 between autumn 2013 and spring 2014 (see Equation C.1). Model (1) and Model (2) focuses on revisions in planned investment in equipment. Model (3) and Model (4) focuses on revisions in planned constructions. In the last row of columns 2 and 4, we report the investment effect on firms that have irreversible investment and that perceive increased investment uncertainty.

on the investment plan revisions in spring 2014 beyond the first moment effects of the vote. Columns 2 and 4 extend the model slightly by interacting the coefficient of interest with the irreversibility dummy. Column 2 suggests that the uncertainty effects on equipment investment are concentrated among firms with irreversible investment. It is noteworthy that the point estimates in these regressions are close to the estimate of the effect of uncertainty on investment that we get in in our baseline model using an entirely different identification strategy.

C.3 Heterogeneous Effects and Channels

In this section, we first study which of the dimensions of the vote was central for firms' reaction to vote. Is it the uncertainty concerning future recruitment costs or concerning expected demand and the access to the European market? We study this question using regressions where we replace the multi-dimensional exposure variable in our baseline model with several variables reflecting firms' exposure along the different dimensions of the uncertainty created by the vote. The set of variables used for this exercise is the same set that we used in Table 3.2 in order to predict firms' exposure to the vote. These variables are then interacted with the indicator for the MII (MII_t) as well as the indicator for irreversibility (Irreversible_t). The goal is to find out which of the aspects of the uncertainty shock drives the negative impact of the vote in irreversible firms.

The evidence emerging from the regressions in Table C.4 is that all dimensions are relevant for the uncertainty effect identified in our main specification. Almost all triple interaction terms presented in the table are negative and most of them are also statistically significant. The factor, however, that most strongly drives the negative triple interaction term is the foreign employment share of a firm (column 1). This evidence, which is consistent with the high share of firms expecting an increase in recruitment costs due to vote (see Figure 3.4), suggests that the recruitment cost aspect of the vote was a central element of the uncertainty created by the vote.

The analysis presented in the main text focuses on the average uncertainty effects of the vote. Here we also study whether the uncertainty effects are concentrated among a particular group of firms. In order to answer this question, we interact the triple interaction term of interest, identifying the uncertainty effect of the vote, with indicator variables for various subgroups of firms. Table C.5 presents the estimation results. Columns 1 and 2 examine if the effects differ across industries. We do not find a statistical significant effect between industries. Specification 3 investigates if uncertainty affects large firms (more than 250 FTE) differently from the small and medium size firms. Indeed, estimation results suggest that the negative effects

Table C.4: Channels

VARIABLES	(1) FE DDD	(2) FE DDD	(3) FE DDD	(4) FE DDD	(5) FE DDD	(6) FE DDD	(7) FE DDD	(8) FE DDD
MII x Foreign share	0.002							
	(0.002)							
MII x Foreign share x Irreversible	-0.004***							
	(0.001)							
MII x Exposed to Bilaterals		-0.061						
		(0.456)						
MII x Exposed to Bilaterals x Irreversible		-0.115						
		(0.071)						
MII x Exporter			0.080					
			(0.079)					
MII x Exporter x Irreversible			-0.126*					
			(0.074)					
MII x Close to border				0.125				
				(0.091)				
MII x Close to border x Irreversible				-0.183*				
				(0.103)				
MII x Strong competition					0.124*			
					(0.070)			
MII x Strong competition x Irreversible					-0.146**			
					(0.063)			
MII x Large firm						0.182**		
						(0.071)		
MII x Large firm x Irreversible						-0.091		
						(0.081)		
MII x Foreign owned							0.035	
							(0.094)	
MII x Foreign owned x Irreversible							-0.150	
							(0.117)	
MII x Subsidiary								-0.113
								(0.089)
MII x Subsidiary x Irreversible								0.046
								(0.097)
Observations	12,648	15,812	14,847	15,790	11,438	11,596	11,505	10,316
R-squared	0.059	0.053	0.055	0.053	0.071	0.063	0.069	0.072
Number of firms	2,700	3,665	3,295	3,660	2,439	3,460	2,465	2,019
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Cluster-robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The table presents examines the effect of the vote on investment plan revisions. The dependent variable of this table represent firm-level investment plan revisions for 2014 between autumn 2013 and spring 2014 (see Equation C.1). Model (1) and Model (2) focuses on revisions in planned investment in equipment. Model (3) and Model (4) focuses on revisions in planned constructions. In the last row of columns 2 and 4, we report the investment effect on firms that have irreversible investment and that perceive increased investment uncertainty.

Table C.5: Analysis of Effect Heterogeneity

VARIABLES	(1) FE DDD	(2) FE DDD	(3) FE DDD	(4) FE DDD	(5) FE DDD	(6) FE DDD	(7) FE DDD
MII x Exposed x Irreversible	-0.325***	-0.301***	-0.365***	-0.284***	-0.231**	-0.273**	-0.294***
	(0.121)	(0.101)	(0.107)	(0.110)	(0.108)	(0.124)	(0.104)
MII x Exposed x Irreversible x I(Manufacturing=1)	0.066						
	(0.101)						
MII x Exposed x Irreversible x I(Construction=1)		0.230					
		(0.179)					
MII x Exposed x Irreversible x Large			0.162**				
			(0.073)				
MII x Exposed x Irreversible x Exporter				0.035			
				(0.079)			
MII x Exposed x Irreversible x Foreign owned					-0.093		
					(0.101)		
MII x Exposed x Irreversible x High competition						-0.004	
						(0.084)	
MII x Exposed x Irreversible x Close to border							0.033
							(0.079)
Observations	12,648	12,648	9,618	12,294	10,964	10,897	12,630
R-squared	0.061	0.061	0.072	0.063	0.071	0.072	0.061
Number of firms	2,700	2,700	2,581	2,593	2,336	2,311	2,697
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exposed-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Irreversibility-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Effect on subcategory	-0.259**	-0.070	-0.203*	-0.249**	-0.324**	-0.276**	-0.260**

Cluster-robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The table investigate the heterogeneity in the effect of uncertainty on investment. The dependent variable is log investment (GFCF). The variable *MII* captures the effect of the MII on investment plans and takes value one for the years 2014 and 2015 and takes value 0 for the years 2009–2013. The variable *Exposed* shows a firm's exposure to the policy shock (see Section 3.4.1). The variable takes value 1 in case the likelihood of being exposed is above the median and 0 otherwise (see Equation 3.2). See the notes of Table 3.1 for explanations on the other covariates.

appear to be less severe for large firms. Specifically, small and medium size firms that are exposed and have irreversible investment reduce their investment roughly twice as much as otherwise similar large firms. We cannot document any difference in the effect for exporting and non-exporting firms (column 4). Furthermore, we find no statistically significant effect when looking at foreign-owned firms or firms that operate in highly competitive markets (specifications 5 and 6). Finally, the negative effects of uncertainty do not depend on the location of a firm. That is, the effect does not vary with distance to border (column 7). Overall, the negative effects of uncertainty appear to be evenly distributed among Swiss firms with the exception of one group: large firms appear to be significantly less negatively affected by the vote.

C.4 KOF Investment Surveys

The KOF Investment Survey is a business survey in Switzerland that is conducted by the KOF Swiss Economic Institute at the ETH Zurich. Until 2011 the investment survey was conducted in autumn every year. Since 2012 the survey is conducted bi-annually, once in spring and once in autumn. In Spring, KOF sends invitations to participants at the end of February and accepts answers until the beginning of May. In autumn, participants are invited mid-October and allowed to answers until the end of the year. The survey is conducted among a large panel of private and semi-private Swiss firms. Currently, the panel contains slightly more than 8.000 unique Swiss firms. The survey is based on the same sample as the KOF innovation survey, which is the Swiss counterpart of the Community Innovation Survey (CIS) conducted in most EU member states. The participation in this international program requires high standards regarding the representativeness of the sample. We are thus confident that the firm sample mirrors the Swiss firm distribution (in terms of employees) on a 2-digit-industry level. The average response rate between 2009 and 2015 amounts to 35%. The response rate varies slightly for the different survey waves between 33% and 39%. The firms in the sample cover all industries excluding agriculture (NACE 10 to 96) and account for 34% of total employment (FTE) in Switzerland within the respective sectors. 34% of firms belong to the manufacturing sector (NACE 10-33) and 2% to Energy, Water supply and waste management industries (NACE 35-38). 9% of the firms in the sample are in construction (NACE 41-43) and 55% belong to the service sector (NACE 45-96). In terms of size, 10% of all firms are large firms (more than 250 FTE), 27% are medium size firms (between 50 and 249 FTE) and 63% of all firms in the sample have less than 50 employees.
The question on irreversibility first appeared in an Italian business tendency survey in 1995. In their 1999 QJE Paper, Guiso and Parigi used this question to approximate the degree of firm-level irreversibility and to show that irreversibility matters for the negative effects of uncertainty. KOF introduced the identical question first in their extra survey on the consequences of the Mass Immigration Initiative in autumn 2014. Since spring 2015 the question is part of the regular KOF Investment Survey in spring.

Bearing in mind the type of equipment / machinery used in making your main product / services, we would like to know whether a second-hand market exists where in case of need it *could be sold*. (***Choose one of the following answers***)

- ☐ Yes, and it is relatively easy to find a buyer in a short time willing to pay a reasonable price.
- ☐ Yes, but it takes time to find a buyer and selling prices are not very rewarding.
- ☐ Yes, but it is very difficult to find a buyer and selling prices can become very low.
- ☐ No, there is no such market.

Notes: This question is designed to measure the degree of irreversibility of existing equipment and machinery. The question appeared first in an Italian business tendency survey in 1995. KOF Swiss Economic Institute at ETH Zurich added this question to the special survey on the consequences of the Initiative against Mass Migration in autumn 2014. Since spring 2015 the question is part of the regular KOF Investment Survey in spring.

As in Guiso and Parigi (1999) and Binding and Dibiasi (2017), we take the answer to this question and construct a binary variable that approximates firm-level irreversibility. This binary variable takes value 1 in case a firm states that there exists no second hand market to sell their existing machinery and equipment or if a firm states that there exists such a second hand market but it is difficult to find a buyer and selling prices can become very low.

Interestingly, we find evidence that firm-specific irreversibility does not correlate with other firm characteristics in an informative way. Table C.6 shows that answers to the irreversibility question do not systematically vary with other firm characteristics. The only firm characteristic that contains some information on the average level of irreversibility is disaggregated sector information (Table C.7). Table C.6 and Table C.7 suggest that irreversibility represents an idiosyncratic firm characteristic that cannot be explained by other firm characteristics.

Table C.6: Summary Statistics of Irreversibility

	(1) Full Reversibility	(2) Slight Irreversibility	(3) High Irreversibility	(4) Full Irreversibility	(5) Irreversible
Sector					
Manufacturing Industries (NACE 10-33)	4%	24%	39%	21%	60%
Construction Sector (NACE 41-43)	8%	25%	29%	24%	53%
Service Sector (NACE 45-96)	6%	18%	25%	39%	64%
Size Class					
Small (less than 50 employees)	5%	20%	27%	34%	61%
Medium (50 to 249 employees)	4%	21%	36%	27%	63%
Large (more than 250 employees)	7%	24%	30%	31%	60%
Export					
0 - 5%	6%	21%	30%	35%	65%
6 - 33%	2%	24%	40%	26%	66%
34 - 66%	4%	24%	40%	23%	63%
67-100%	4%	23%	35%	27%	62%
Foreign Owned					
No	5%	23%	35%	36%	71%
Yes	7%	24%	33%	36%	68%
Subsidiary					
No	4%	20%	31%	31%	62%
Yes	6%	20%	31%	28%	59%
Exposed					
No	6%	20%	27%	35%	62%
Yes	5%	21%	35%	27%	62%

Notes: Table C.6 describes the distribution of irreversibility among Swiss firms. The table displays firms' self-reported irreversibility according to various firm characteristics. Column 1 to 4 presents the share of firms that reported the respective degree of irreversibility. Column 5 represents the share of firms that we consider having irreversible investment, i.e. the share of firms reporting high or full irreversibility.

Table C.7: Irreversibility by Sector of Economic Activity

NACE	Description	(1) Full Reversibility	(2) Slight Irreversibility	(3) Strongly Irreversible	(4) Full Irreversibility	(5) Irreversible Irreversible
C	Manufacturing	4%	24%	39%	21%	60%
D	Electricity, gas, steam and air-conditioning supply	9%	13%	27%	51%	78%
E	Water supply; sewerage, waste management and remediation activities	5%	10%	14%	52%	67%
F	Construction	8%	25%	29%	24%	53%
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	5%	22%	30%	32%	62%
H	Transportation and storage	10%	26%	20%	38%	57%
I	Accommodation and food service activities	7%	11%	29%	31%	60%
J	Information and communication	2%	17%	33%	35%	67%
K	Financial and insurance activities	4%	9%	18%	58%	76%
L	Real estate activities	11%	21%	25%	36%	61%
M	Professional, scientific and technical activities	2%	17%	20%	48%	69%
N	Administrative and support service activities	6%	16%	26%	34%	60%
P	Education	4%	0%	27%	54%	81%
Q	Human health and social work activities	5%	22%	25%	39%	63%
R	Arts, entertainment and recreation	6%	6%	20%	53%	73%
S	Other service activities	12%	16%	19%	40%	60%

Notes: This table describes the distribution of irreversibility among sectors. Column 1 to 4 presents the share of firms that reported the respective degree of irreversibility. Column 5 represents the share of firms that we consider having irreversible investment, i.e. the share of firms reporting high or full irreversibility.

Figure C.2: Questionnaire Special Survey Spring 2014

KOF **Special survey on the impacts of the initiative "against mass immigration"**

KOF Swiss Economic Institute
ETH Zürich, LEE F 124, 8092 Zürich
www.kof.ethz.ch

Tel: 044 632 85 33
Fax: 044 632 13 52
ivu@kof.ethz.ch

4803037005

The initiative against mass immigration was accepted on February 9th 2014. As a consequence legislation concerning immigrant regulation has to be renegotiated and adapted within three years. This special survey is designed to collect information on the consequences on investment plans of businesses in Switzerland caused by the acceptance of the initiative. Did the acceptance of the initiative against mass immigration - compared with the situation before or the situation where the initiative would have bee rejected - have an impact on investment plans of your firm, or not?

A Investments within Switzerland

1. How did the acceptance of the initiative against mass immigration influence the **certainty of your firm's investment plans within Switzerland in the next three years?**

   Through the acceptance of the initiative has the certainty of our investment plans within Switzerland in the next three years been

   strongly decreased ○ | decreased ○ | not changed ○ | increased ○ | strongly increased ○

   more uncertain ◄——► more certain (plans)

2. Has there been a change in your **firm's investment plans (investment sums) within Switzerland** due to the acceptance compared to a situation where the initiative would have been rejected, or was there no change?

   *Due to the acceptance of the initiative, our firm's investment plans within **Switzerland** will*

	strongly decrease	decrease	not change	increase	strongly increase
year 2014	○	○	○	○	○
year 2015	○	○	○	○	○
year 2016	○	○	○	○	○
from 2017	○	○	○	○	○

B Investments abroad

3. *Which of the following statements concerning **foreign investments** is true for your firm?*

   a) *We **are a subsidary of a company and are not responsible for foreign investments*** — yes ○ → continue with question 5

   b) Our **firm already made foreign investments in the past** (2013 and before) — yes ○ no ○

   c) Our firm **will undertake foreign investments in the future** (2014 and after) — ○ → continue with question 5

   ↓ continue with question 4

4. Has there been a change in your **firm's foreign investment plans (investment sums)** due to the acceptance compared to a situation where the initiative would have been rejected, or was there no change?

   *Due to the acceptance of the initiative, our firm's **foreign investments** will*

	strongly decrease	decrease	not change	increase	strongly increase
year 2014	○	○	○	○	○
year 2015	○	○	○	○	○
year 2016	○	○	○	○	○
from 2017	○	○	○	○	○

C Personnel plannings

5. Has there been a change in your **firm's personnel planning (planned number of overall employees) in Switzerland** due to the acceptance compared to a situation where the initiative would have been rejected, or was there no change?

   *Due to the acceptance of the initiative, our firm's **number of employees in Switzerland** will*

	strongly decrease	decrease	not change	increase	strongly increase
year 2014	○	○	○	○	○
year 2015	○	○	○	○	○
year 2016	○	○	○	○	○
from 2017	○	○	○	○	○

6. Will there be a change of your **firm's recruitment costs** due to the acceptance of the initiative or will there be no change?

   *Due to the acceptance of the initiative, our firm's **recruitment costs** will*

strongly decrease	decrease	not change	increase	strongly increase
○	○	○	○	○

D General situation

7. It is in our interest to know if in your opinion Swiss medium term growth perspective (overall, not your firm specific) has been influenced be the acceptance of the initiative?

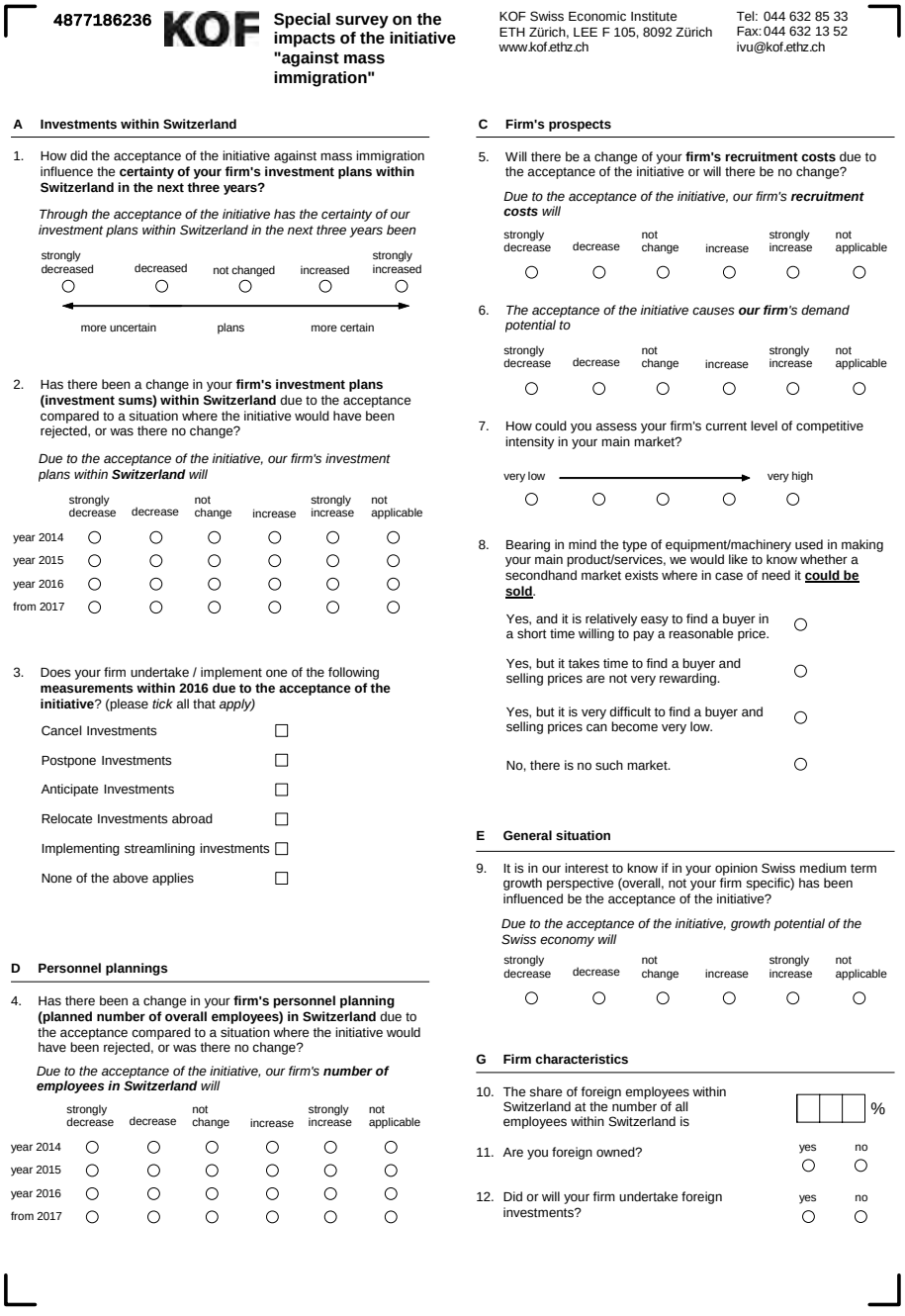
   Due to the acceptance of the initiative, growth potential of the Swiss economy will

strongly decrease	decrease	not change	increase	strongly increase
○	○	○	○	○

E Firm characteristics

The share of foreign employees within Switzerland at the number of all employees within Switzerland is ☐☐☐ %

Figure C.3: Questionnaire Special Survey Autumn 2014



4877186236 KOF **Special survey on the impacts of the initiative "against mass immigration"**

KOF Swiss Economic Institute
ETH Zürich, LEE F 105, 8092 Zürich
www.kof.ethz.ch

Tel: 044 632 85 33
Fax: 044 632 13 52
ivu@kof.ethz.ch

A Investments within Switzerland

1. How did the acceptance of the initiative against mass immigration influence the **certainty of your firm's investment plans within Switzerland in the next three years?**

   Through the acceptance of the initiative has the certainty of our investment plans within Switzerland in the next three years been

   strongly decreased ○ | decreased ○ | not changed ○ | increased ○ | strongly increased ○

   more uncertain ← → more certain (plans)

2. Has there been a change in your **firm's investment plans (investment sums) within Switzerland** due to the acceptance compared to a situation where the initiative would have been rejected, or was there no change?

   *Due to the acceptance of the initiative, our firm's investment plans within **Switzerland** will*

	strongly decrease	decrease	not change	increase	strongly increase	not applicable
year 2014	○	○	○	○	○	○
year 2015	○	○	○	○	○	○
year 2016	○	○	○	○	○	○
from 2017	○	○	○	○	○	○

3. Does your firm undertake / implement one of the following **measurements within 2016 due to the acceptance of the initiative**? (please *tick* all that *apply)*

   - Cancel Investments ☐
   - Postpone Investments ☐
   - Anticipate Investments ☐
   - Relocate Investments abroad ☐
   - Implementing streamlining investments ☐
   - None of the above applies ☐

D Personnel plannings

4. Has there been a change in your **firm's personnel planning (planned number of overall employees) in Switzerland** due to the acceptance compared to a situation where the initiative would have been rejected, or was there no change?

   *Due to the acceptance of the initiative, our firm's **number of employees in Switzerland** will*

	strongly decrease	decrease	not change	increase	strongly increase	not applicable
year 2014	○	○	○	○	○	○
year 2015	○	○	○	○	○	○
year 2016	○	○	○	○	○	○
from 2017	○	○	○	○	○	○

C Firm's prospects

5. Will there be a change of your **firm's recruitment costs** due to the acceptance of the initiative or will there be no change?

   *Due to the acceptance of the initiative, our firm's **recruitment costs** will*

   strongly decrease ○ | decrease ○ | not change ○ | increase ○ | strongly increase ○ | not applicable ○

6. *The acceptance of the initiative causes **our firm**'s demand potential to*

   strongly decrease ○ | decrease ○ | not change ○ | increase ○ | strongly increase ○ | not applicable ○

7. How could you assess your firm's current level of competitive intensity in your main market?

   very low ○ ○ ○ ○ ○ very high

8. Bearing in mind the type of equipment/machinery used in making your main product/services, we would like to know whether a secondhand market exists where in case of need it **could be sold**.

   - Yes, and it is relatively easy to find a buyer in a short time willing to pay a reasonable price. ○
   - Yes, but it takes time to find a buyer and selling prices are not very rewarding. ○
   - Yes, but it is very difficult to find a buyer and selling prices can become very low. ○
   - No, there is no such market. ○

E General situation

9. It is in our interest to know if in your opinion Swiss medium term growth perspective (overall, not your firm specific) has been influenced be the acceptance of the initiative?

   Due to the acceptance of the initiative, growth potential of the Swiss economy will

   strongly decrease ○ | decrease ○ | not change ○ | increase ○ | strongly increase ○ | not applicable ○

G Firm characteristics

10. The share of foreign employees within Switzerland at the number of all employees within Switzerland is ☐☐☐ %

11. Are you foreign owned? yes ○ no ○

12. Did or will your firm undertake foreign investments? yes ○ no ○

Figure C.4: Questionnaire Regular KOF Investment Survey Spring 2014

KOF Investment Cycles

KOF Swiss Economic Institute
ETH Zurich, WEC D 15, 8092 Zürich
www.kof.ethz.ch

Tel. 044 632 85 33
Fax 044 632 13 52
ivu@kof.ethz.ch

Please note

- Do not use a red pencil.
- Please tick relevant boxes ☒ or enter figures.
- Data applies to all production facilities in Switzerland
- See explanatory information below.
- Please return the questionnaire by: **March 21 2014**.

All information will be treated strictly confidentially.

Questions Spring

1. Investment activity

a) Our investments in construction in Switzerland amounted to/is likely to amount to
(in CHF 1000)

2012 ☐☐'☐☐☐'☐☐☐'000.–
2013 ☐☐'☐☐☐'☐☐☐'000.–
2014 ☐☐'☐☐☐'☐☐☐'000.–

b) Our investments in machinery and equipment and software in Switzerland amounted to/is likely to amount to
(in CHF 1000)

2012 ☐☐'☐☐☐'☐☐☐'000.–
2013 ☐☐'☐☐☐'☐☐☐'000.–
2014 ☐☐'☐☐☐'☐☐☐'000.–

c) Relative to 2014, in the year 2015 our fixed capital formation in Switzerland is likely to

– –	–	=	+	+ +	n.a.
☐	☐	☐	☐	☐	☐

– – strongly decrease – decrease = stay the same
+ increase + + strongly increase k.A. no answer

2. Number of employees

Number of employees in Switzerland on December 31, 2013
(please convert part-time positions into full-time equivalent positions)

☐☐☐'☐☐☐

Explanations

General remarks

The Investment Survey is an instrument for the early recording of planned investment trends.

Question 1

The "investment" addressed by this question means inflows minus outflows of fixed capital assets. These should be recorded before depreciation on the basis of their purchase price, i.e. this constitutes gross investment. It is irrelevant whether the equipment which is being used for the first time is new or second-hand, and whether this has been bought, hired or created in-house.

Fixed capital formation consequently encompasses:

Construction

- New construction, conversion work and renovation of commercial premises.

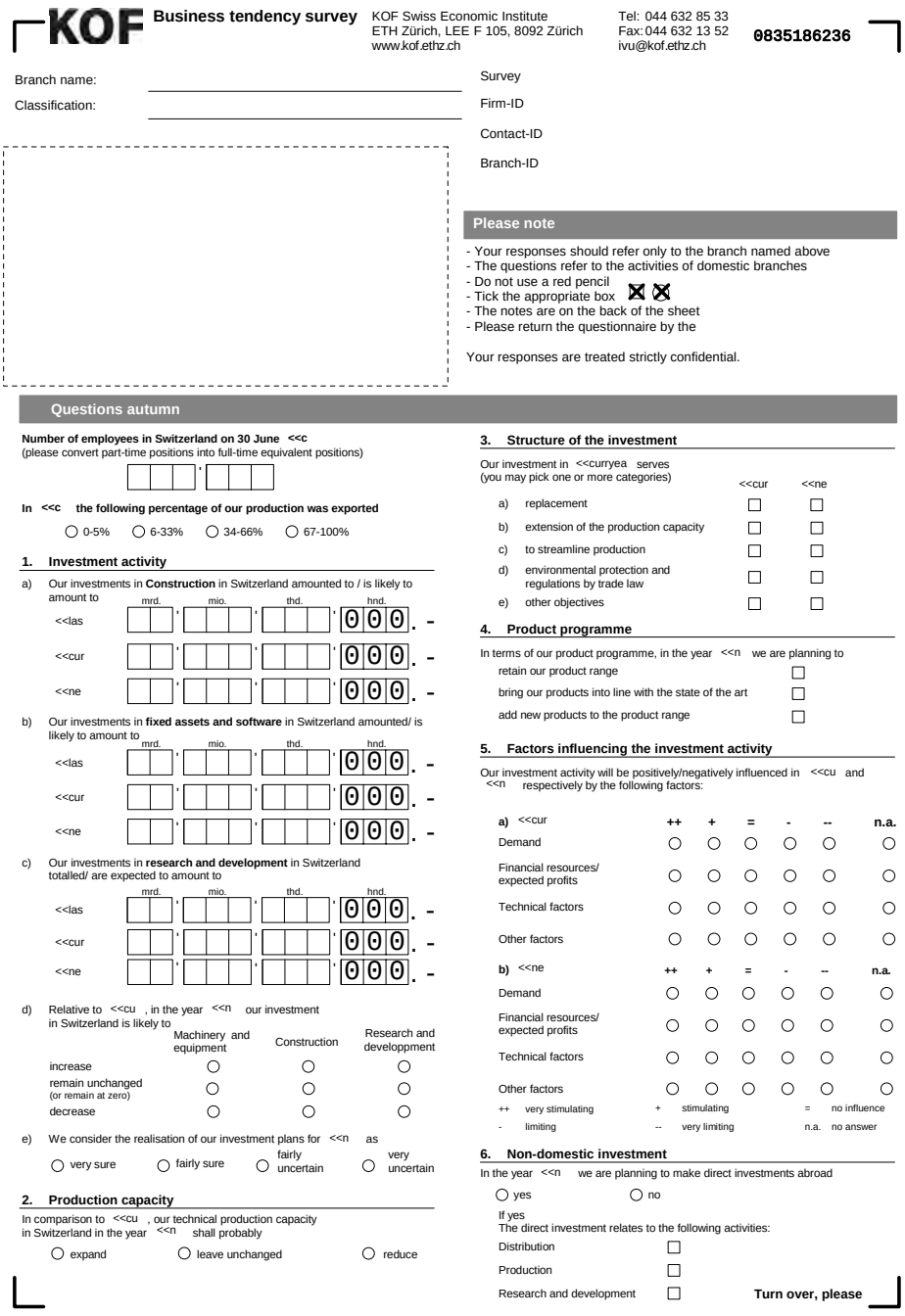
Machinery and equipment

- Machinery, mechanical plants, conveying equipment and warehouse equipment, office machines incl. IT (hardware and software), furniture and equipment, vehicles used for business purposes, and (only) such services which are designed to preserve, to improve or to renovate plants

This consequently means that fixed capital formation does not constitute:

- Financial investment (e.g. participations, securities)
- Investment in residential property
- Real estate costs
- Buildings and plants which are intended for hire by the lessor, where the lessor acts merely as a (third-party) financier
- Inventory investment (boosting inventories)
- Intangible assets (e.g. expenditure on marketing concepts; for human capital; for research & development; for patents and licences, excepting for software)

Figure C.5: Questionnaire Regular KOF Investment Survey Autumn 2014



KOF **Business tendency survey**

KOF Swiss Economic Institute
ETH Zürich, LEE F 105, 8092 Zürich
www.kof.ethz.ch

Tel: 044 632 85 33
Fax: 044 632 13 52
ivu@kof.ethz.ch

0835186236

Branch name: _____

Classification: _____

Survey

Firm-ID

Contact-ID

Branch-ID

Please note

- Your responses should refer only to the branch named above
- The questions refer to the activities of domestic branches
- Do not use a red pencil
- Tick the appropriate box ☒ ☒
- The notes are on the back of the sheet
- Please return the questionnaire by the

Your responses are treated strictly confidential.

Questions autumn

Number of employees in Switzerland on 30 June <<c
(please convert part-time positions into full-time equivalent positions)

In <<c the following percentage of our production was exported

○ 0-5% ○ 6-33% ○ 34-66% ○ 67-100%

1. Investment activity

a) Our investments in **Construction** in Switzerland amounted to / is likely to amount to

	mrd.	mio.	thd.	hnd.
<<las				000.–
<<cur				000.–
<<ne				000.–

b) Our investments in **fixed assets and software** in Switzerland amounted/ is likely to amount to

	mrd.	mio.	thd.	hnd.
<<las				000.–
<<cur				000.–
<<ne				000.–

c) Our investments in **research and development** in Switzerland totalled/ are expected to amount to

	mrd.	mio.	thd.	hnd.
<<las				000.–
<<cur				000.–
<<ne				000.–

d) Relative to <<cu , in the year <<n our investment in Switzerland is likely to

	Machinery and equipment	Construction	Research and developpment
increase	○	○	○
remain unchanged (or remain at zero)	○	○	○
decrease	○	○	○

e) We consider the realisation of our investment plans for <<n as

○ very sure ○ fairly sure ○ fairly uncertain ○ very uncertain

2. Production capacity

In comparison to <<cu , our technical production capacity in Switzerland in the year <<n shall probably

○ expand ○ leave unchanged ○ reduce

3. Structure of the investment

Our investment in <<curryea serves (you may pick one or more categories)

		<<cur	<<ne
a)	replacement	☐	☐
b)	extension of the production capacity	☐	☐
c)	to streamline production	☐	☐
d)	environmental protection and regulations by trade law	☐	☐
e)	other objectives	☐	☐

4. Product programme

In terms of our product programme, in the year <<n we are planning to

retain our product range ☐

bring our products into line with the state of the art ☐

add new products to the product range ☐

5. Factors influencing the investment activity

Our investment activity will be positively/negatively influenced in <<cu and <<n respectively by the following factors:

a) <<cur	++	+	=	-	--	n.a.
Demand	○	○	○	○	○	○
Financial resources/ expected profits	○	○	○	○	○	○
Technical factors	○	○	○	○	○	○
Other factors	○	○	○	○	○	○

b) <<ne	++	+	=	-	--	n.a.
Demand	○	○	○	○	○	○
Financial resources/ expected profits	○	○	○	○	○	○
Technical factors	○	○	○	○	○	○
Other factors	○	○	○	○	○	○

++ very stimulating + stimulating = no influence
- limiting -- very limiting n.a. no answer

6. Non-domestic investment

In the year <<n we are planning to make direct investments abroad

○ yes ○ no

If yes
The direct investment relates to the following activities:

Distribution ☐

Production ☐

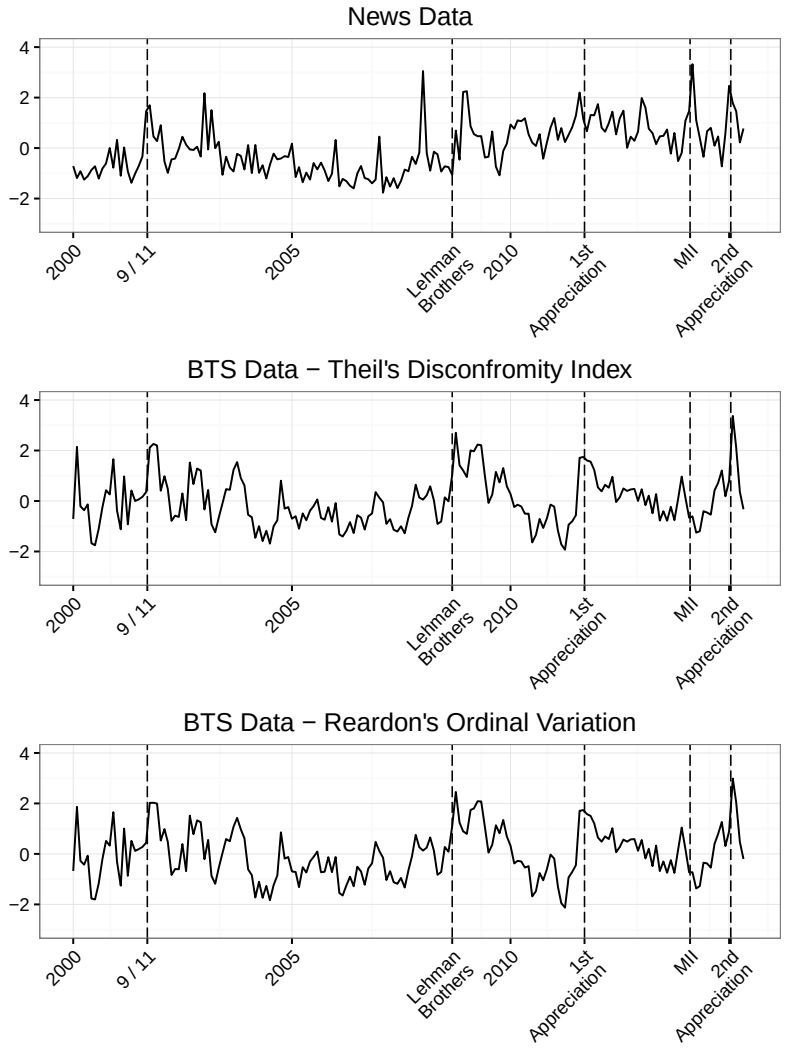
Research and development ☐

Turn over, please

Appendix D

Appendix Chapter 4

Figure D.1: Uncertainty Indicators for Switzerland



Notes: This figure compares the uncertainty indicator of Figure 4.1 to an alternative measure. The disconformity index of Theil (1955) is defined as the sum of the percentage of firms indicating an increase and that of those indicating a decrease, minus the squared difference of the two shares. Formally, $d_t = U_t + D_t - (U_t - D_t)^2$, where U_t stands for the share of firms indicating an increase and D_t stands for the share of firms indicating a decrease. Although Theil's disconformity index implicitly incorporates the share of firms indicating "no change", one could fear that the index does not weigh the "no change" category appropriately. Therefore, we construct Reardon (2009)'s entropy-based disagreement measure that explicitly takes into account the ordinal nature of our qualitative data. Formally, Reardon (2009) defines its measure of ordinal variation as $r_t = \frac{1}{K-1} \sum_{i=1}^{K-1} [F_{i,t}\ log_2(\frac{1}{F_{i,t}}) + (1 - F_{i,t})\ log_2(\frac{1}{1-F_{i,t}})]$, where K entails the numbers of categories, "decrease", "no change" and "increase" in our case. $F_{i,t}$ is the cumulative percentage of answers in category i. For instance, $F_{2,t}$ consists of the share of respondents reporting either a "decrease" or a "no change". Reardon's index is bounded between 0 and 1, obtaining its maximum when all respondents are equally distributed on the outer categories and its minimum when all respondents are concentrated in one category. The figure below demonstrates that Theil's Disconformity Index and Reardon's Ordinal Variation produce nearly identical results. The correlation between the two measures is above 0.99.

Table D.1: Variable Description

Abbreviation	Full description
$\Delta I_{i,t=2014}$ (GFCF)	Gross Fixed Capital Formation, Revision of logged Investment Plans (2014)
$\Delta I_{i,t=2015}$ (GFCF)	Gross Fixed Capital Formation, Revision of logged Investment Plans (2015)
$\Delta I_{i,t=2014}$ (construction)	Construction, Revision of logged Investment Plans (2014)
$\Delta I_{i,t=2015}$ (construction)	Construction, Revision of logged Investment Plans (2015)
$\Delta I_{i,t=2014}$ (equipment)	Equipment, Revision of logged Investment Plans (2014)
$\Delta I_{i,t=2015}$ (equipment)	Equipment, Revision of logged Investment Plans (2015)
$\Delta I_{i,t=2014}$ (R&D)	R&D, Revision of logged Investment Plans (2014)
$\Delta I_{i,t=2015}$ (R&D)	R&D, Revision of logged Investment Plans (2015)
expected exchange rate$_i$	Expected Exchange Rate (24 months)
uncertainty$_i$	takes value 1 if firm experienced an increase in uncertainty, 0 otherwise
irreversibility$_i$	takes value 1 firms' irreversibility is high, 0 otherwise
employees$_i$ (fte)	firms' FTE on December 31st, 2014
exchange rate$_i$	closing exchange rate on date of response
comp$_i$	takes value 1 if firms operates in a competitive market, 0 otherwise
foreign owned$_i$	takes value 1 if firm is owned by foreign entity, 0 otherwise
export$_i$	takes value 1 if firms' share of revenue abroad is above 5%, 0 otherwise
distance border$_i$	distance to border in km
share foreign employees$_i$	percentage of foreign employees
days snb$_i$	number of days between SNB announcement and responding the survey
certainty s2014$_i$	level of realisation certainty for investment plans 2015 in Autumn 2014

Notes: This table provides a detailed description of variables that are used in the paper. The first column contains the variables' abbreviations and the second column the description.

Table D.2: Summary Statistics (Firms Indicating Uncertainty)

Statistic	N	Mean	St. Dev.	Min	Median	Max
$\Delta I_{i,t=2014}$ (construction)	19	0.025	0.248	−0.719	0.001	0.586
$\Delta I_{i,t=2015}$ (construction)	19	−0.022	0.205	−0.490	−0.007	0.578
$\Delta I_{i,t=2014}$ (equipment)	31	−0.016	0.394	−1.733	0.010	0.556
$\Delta I_{i,t=2015}$ (equipment)	31	−0.053	0.275	−0.910	−0.016	0.492
$\Delta I_{i,t=2014}$ (R&D)	11	0.042	0.625	−1.072	0.000	1.391
$\Delta I_{i,t=2015}$ (R&D)	11	0.090	0.473	−0.471	0.000	1.322
Δuncertainty$_i$	33	1.000	0.000	1	1	1
irreversibility$_i$	33	0.697	0.467	0	1	1
expected exchange rate$_i$	33	1.081	0.066	0.950	1.080	1.230
employees$_i$ (fte)	33	367.606	552.950	29	140	2,950

Table D.3: Summary Statistics (Firms Indicating No Uncertainty)

Statistic	N	Mean	St. Dev.	Min	Median	Max
$\Delta I_{i,t=2014}$ (construction)	71	0.022	0.350	−1.236	0.000	1.236
$\Delta I_{i,t=2015}$ (construction)	71	0.011	0.431	−1.296	0.000	1.675
$\Delta I_{i,t=2014}$ (equipment)	127	−0.007	0.212	−1.306	0.000	0.677
$\Delta I_{i,t=2015}$ (equipment)	127	0.081	0.390	−0.651	0.000	2.945
$\Delta I_{i,t=2014}$ (R&D)	49	0.006	0.779	−2.854	0.000	2.311
$\Delta I_{i,t=2015}$ (R&D)	49	−0.011	0.665	−2.206	0.000	2.048
Δuncertainty$_i$	139	0.000	0.000	0	0	0
irreversibility$_i$	139	0.597	0.492	0	1	1
expected exchange rate$_i$	139	1.084	0.053	0.900	1.100	1.220
employees$_i$ (fte)	139	360.612	592.271	4	153	3,795

Table D.4: Models - Full Specification

	Dependent variable:							
	Δ GFCF		Δ Equipment Investment		Δ Construction Investment		Δ RnD Investment	
	OLS		*OLS*		*OLS*		*OLS*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
uncertainty	−0.042*	−0.003	−0.070***	−0.004	0.0004	0.074	0.132*	0.211
	(0.022)	(0.036)	(0.024)	(0.040)	(0.053)	(0.087)	(0.080)	(0.147)
irreversibility		0.014		0.018		0.050		−0.093
		(0.018)		(0.019)		(0.042)		(0.071)
irreversibility × uncertainty		−0.056		−0.094**		−0.111		−0.099
		(0.042)		(0.046)		(0.101)		(0.175)
ΔI_{2014}	−0.174***	−0.173***	−0.225***	−0.224***	−0.322***	−0.316***	−0.426***	−0.429***
	(0.043)	(0.043)	(0.043)	(0.043)	(0.068)	(0.068)	(0.051)	(0.051)
expected exchange rate	0.175	0.172	0.147	0.140	−0.022	−0.010	−0.074	−0.059
	(0.131)	(0.132)	(0.146)	(0.146)	(0.304)	(0.304)	(0.507)	(0.506)
employees (fte, log)	0.006	0.006	0.014**	0.014**	−0.007	−0.006	0.020	0.023
	(0.006)	(0.006)	(0.006)	(0.006)	(0.014)	(0.014)	(0.024)	(0.024)
exchange rate	1.285	1.270	3.215**	3.227**	−1.531	−1.693	0.256	0.609
	(1.363)	(1.365)	(1.491)	(1.492)	(3.247)	(3.252)	(5.246)	(5.257)
comp	−0.015	−0.015	−0.008	−0.008	−0.070	−0.070	0.057	0.041
	(0.018)	(0.018)	(0.020)	(0.020)	(0.045)	(0.046)	(0.078)	(0.078)
foreign owned	0.012	0.012	−0.014	−0.014	0.042	0.045	0.076	0.086
	(0.021)	(0.021)	(0.023)	(0.023)	(0.051)	(0.052)	(0.081)	(0.081)
export	0.012	0.011	0.0002	−0.001	0.034	0.031	0.106	0.102
	(0.021)	(0.021)	(0.023)	(0.023)	(0.055)	(0.055)	(0.081)	(0.081)
distance to border	0.0003	0.0003	0.0002	0.0002	0.0003	0.0004	0.005*	0.005**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
share of foreign employees	0.0001	0.0001	−0.0002	−0.0002	0.001	0.001	−0.002	−0.002
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.001)	(0.001)	(0.002)	(0.002)
days past since SNB decision	0.002	0.002	0.003	0.003	−0.003	−0.003	0.008	0.008
	(0.002)	(0.002)	(0.003)	(0.003)	(0.005)	(0.005)	(0.009)	(0.009)
days past since SNB decision (squared)	−0.00001	−0.00001	−0.00001	−0.00001	0.00001	0.00001	−0.0001	−0.0001
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00003)	(0.00003)	(0.00005)	(0.00005)
certainty s2014	−0.008	−0.010	−0.001	−0.004	−0.041	−0.043	0.031	0.034
	(0.025)	(0.025)	(0.027)	(0.027)	(0.064)	(0.064)	(0.091)	(0.091)
Constant	−1.849	−1.855	−3.776**	−3.822**	1.726	1.866	−0.965	−1.286
	(1.538)	(1.540)	(1.684)	(1.684)	(3.632)	(3.637)	(5.887)	(5.891)
Observations	1,025	1,025	948	948	414	414	314	314
R^2	0.076	0.078	0.105	0.109	0.179	0.184	0.370	0.378

Note: *p<0.1; **p<0.05; ***p<0.01

Additionally controls for sector and geographic region are not shown

Table D.5: Conventional OLS Standard Errors

	Dependent variable:							
	Δ GFCF		Δ Equipment Investment		Δ Construction Investment		Δ RnD Investment	
	OLS		*OLS*		*OLS*		*OLS*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
uncertainty	-0.042^{*}	-0.003	-0.070^{***}	-0.004	0.0004	0.074	0.132^{*}	0.211
	(0.022)	(0.036)	(0.024)	(0.040)	(0.053)	(0.087)	(0.080)	(0.147)
irreversibility		0.014		0.018		0.050		-0.093
		(0.018)		(0.019)		(0.042)		(0.071)
irreversibility × uncertainty		-0.056		-0.094^{**}		-0.111		-0.099
		(0.042)		(0.046)		(0.101)		(0.175)
ΔI_{2014}	-0.174^{***}	-0.173^{***}	-0.225^{***}	-0.224^{***}	-0.322^{***}	-0.316^{***}	-0.426^{***}	-0.429^{***}
	(0.043)	(0.043)	(0.043)	(0.043)	(0.068)	(0.068)	(0.051)	(0.051)
expected exchange rate	0.175	0.172	0.147	0.140	-0.022	-0.010	-0.074	-0.059
	(0.131)	(0.132)	(0.146)	(0.146)	(0.304)	(0.304)	(0.507)	(0.506)
Constant	-1.849	-1.855	-3.776^{**}	-3.822^{**}	1.726	1.866	-0.965	-1.286
	(1.538)	(1.540)	(1.684)	(1.684)	(3.632)	(3.637)	(5.887)	(5.891)
Observations	1,025	1,025	948	948	414	414	314	314
R^2	0.076	0.078	0.105	0.109	0.179	0.184	0.370	0.378
Note:								*p<0.1; **p<0.05; ***p<0.01
	We report conventional OLS standard errors. Additional controls are included but coefficients not reported.							

Notes: Conventional OLS Standard Errors - Per default, we report robust clustered standard errors in our results. Although our main variables of interest, i.e. uncertainty and uncertainty ×*irreversibility*, are not fixed within groups, we worry that investment plan revisions as well as the effect of uncertainty on revisions might be correlated within an industry. Table D.5 reports the results presented in Table 4.5 using conventional OLS standard errors. Comparing Table D.5 and Table 4.5 shows that standard errors do not substantially change.

Table D.6: Moulton Factor

Variable	1	+	$(\frac{V(n_g)}{\bar{n}} + \bar{n} - 1)$	*	ρ_{res}	*	ρ_x	=	$\frac{V_{OLS}(\hat{\beta})}{V_c(\hat{\beta})}$
				Gross Fixed Capital Formation					
uncertainty	1	+	36.482	*	-0.073	*	0.006	=	0.984
irreversibility	1	+	36.482	*	-0.073	*	-0.012	=	1.032
irreversibility × uncertainty	1	+	36.482	*	-0.073	*	-0.011	=	1.029
ΔI_2014	1	+	36.482	*	-0.073	*	-0.009	=	1.024
expected exchange rate	1	+	36.482	*	-0.073	*	0.012	=	0.968
				Investment in Equipment					
uncertainty	1	+	33.876	*	-0.078	*	0.004	=	0.989
irreversibility	1	+	33.876	*	-0.078	*	-0.011	=	1.029
irreversibility × uncertainty	1	+	33.876	*	-0.078	*	0.001	=	0.997
ΔI_2014	1	+	33.876	*	-0.078	*	-0.024	=	1.063
expected exchange rate	1	+	33.876	*	-0.078	*	0.016	=	0.958
				Investment in Construction					
uncertainty	1	+	14.502	*	-0.16	*	0.009	=	0.979
irreversibility	1	+	14.502	*	-0.16	*	-0.009	=	1.021
irreversibility × uncertainty	1	+	14.502	*	-0.16	*	-0.012	=	1.028
ΔI_2014	1	+	14.502	*	-0.16	*	-0.013	=	1.03
expected exchange rate	1	+	14.502	*	-0.16	*	-0.033	=	1.077
				Research and Development					
uncertainty	1	+	22.077	*	-0.15	*	-0.007	=	1.023
irreversibility	1	+	22.077	*	-0.15	*	0.009	=	0.97
irreversibility × uncertainty	1	+	22.077	*	-0.15	*	-0.022	=	1.073
ΔI_2014	1	+	22.077	*	-0.15	*	-0.034	=	1.113
expected exchange rate	1	+	22.077	*	-0.15	*	0.015	=	0.95

Notes: Moulton Factor - This table presents the Moulton Factor for the models 2, 4, 6 and 8of Table D.5. The Moulton Factor represents the ratio of the conventional (OLS) variance around the coefficient estimate over robust clustered variance around the coefficient estimate, i.e. $\frac{V_{OLS}(\hat{\beta})}{V_c(\hat{\beta})}$. The Moulton Factor is the defined as $\frac{V_{OLS}(\hat{\beta})}{V_c(\hat{\beta})} = 1 + (\frac{V(n_g)}{\bar{n}} + \bar{n} - 1)\rho_{res}\rho_x$, where $n \in N$ and $g \in G$. N is the number of observations and G is the number of clusters. ρ_{res} represents the interclass correlation of the residuals and ρ_x the interclass correlation of the independent variable. The interclass correlation is defined as $\rho = \frac{z}{1+z}$ with $z = \frac{(F-1)*G}{N}$. F is defined as $F = \frac{R^2(N-G)}{(1-R^2)*G}$ and $R^2 = 1 - \frac{\sum_{g=1}^{G}\sum_{n=1}^{N}(x_{ng}-\bar{x_g})^2}{\sum_{n=1}^{N}(x_n-\bar{x})^2}$

Table D.7: Falsification Test

	Dependent variable:							
	Δ GFCF 2014		Δ Equipment Investment 2014		Δ Construction Investment 2014		Δ RnD Investment 2014	
	OLS		*OLS*		*OLS*		*OLS*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
uncertainty	0.020	0.003	0.028	0.024	0.031	−0.048	−0.132	−0.105
	(0.021)	(0.025)	(0.023)	(0.023)	(0.035)	(0.077)	(0.088)	(0.194)
irreversibility		−0.00002		0.004		−0.025		−0.040
		(0.010)		(0.013)		(0.037)		(0.095)
irreversibility × uncertainty		0.024		0.006		0.115		−0.032
		(0.036)		(0.041)		(0.097)		(0.296)
expected exchange rate	0.042	0.045	−0.035	−0.033	0.181	0.166	0.323	0.327
	(0.110)	(0.112)	(0.127)	(0.127)	(0.229)	(0.228)	(0.751)	(0.716)
Constant	1.219	1.241	1.172	1.200	4.452	4.242	−6.091*	−6.233
	(1.034)	(1.039)	(1.095)	(1.093)	(2.766)	(2.752)	(3.656)	(3.792)
Observations	1,025	1,025	948	948	414	414	314	314
R^2	0.079	0.079	0.071	0.071	0.186	0.191	0.137	0.138

*p<0.1; **p<0.05; ***p<0.01
Coefficients of additional controls are included but not reported. Standard Errors are clustered at industry (NACE 2) levels.

Notes: Falsification Test - This table presents the results of a falsification test. In causal analysis, it is common to test a claim that is very unlikely to be causally related to an intervention. In our case, we test whether firms' investment revisions for 2014 - rather than 2015 - are influenced by the appreciation of the Swiss Franc. Investment in 2014 should not have been affected by the decision of the Swiss National Bank, if the decision were to be truly exogenous. Our model does not explain investment revisions for 2014. This adds an additional layer of confidence to our results, even if falsification analysis is not a perfect tool for validating causality.

Table D.8: Alternative Uncertainty Measure

	Dependent variable:							
	Δ GFCF 2015		Δ Equipment Investment 2015		Δ Construction Investment 2015		Δ RnD Investment 2015	
	OLS		*OLS*		*OLS*		*OLS*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
uncertainty	−0.034	0.118	−0.011	0.277***	−0.082	−0.083	−0.428	−0.687
	(0.077)	(0.090)	(0.083)	(0.097)	(0.201)	(0.336)	(0.289)	(0.468)
irreversibility		0.030		0.046**		0.044		−0.152
		(0.023)		(0.023)		(0.087)		(0.097)
irreversibility × uncertainty		−0.223*		−0.415***		−0.021		0.391
		(0.133)		(0.144)		(0.444)		(0.648)
ΔI_{2014}	−0.189*	−0.189*	−0.237**	−0.234**	−0.359***	−0.360***	−0.438***	−0.443***
	(0.097)	(0.097)	(0.115)	(0.115)	(0.102)	(0.100)	(0.105)	(0.103)
expected exchange rate	0.178	0.177	0.156	0.155	0.012	0.012	−0.035	−0.014
	(0.138)	(0.137)	(0.153)	(0.153)	(0.238)	(0.228)	(0.492)	(0.474)
Constant	−1.517	−1.435	−3.555*	−3.448*	2.970	3.018	−1.387	−1.639
	(1.664)	(1.652)	(1.883)	(1.839)	(3.717)	(3.743)	(6.050)	(5.975)
Observations	981	981	907	907	398	398	305	305
R^2	0.076	0.077	0.095	0.099	0.190	0.193	0.370	0.377

Note: *p<0.1; **p<0.05; ***p<0.01
Coefficients of additional controls are included but not reported. Standard Errors are clustered at industry (NACE 2) levels.

Notes: This table presents a modification of our main specification in which we use an alternative measure to proxy uncertainty. One could argue that the main measure used in this paper could be endogenous as a revision of investment plans might itself affect the realisation certainty of investment plans (see Section 4.3.4). This endogeneity might result in biased estimates. Therefore, we re-estimate our model using an alternative proxy for uncertainty. The survey in Spring 2015 asked firms to indicate the range within which the exchange rate will most likely lie in the short-, medium-, and long-term. Here, we replace our preferred proxy of uncertainty with the range reported, i.e. we use the difference between the upper and lower bound of the expected exchange rate reported by a firm as a proxy for uncertainty. We insert the continuous range of the expected exchange rate in 24 months as the independent variable proxying uncertaint. The estimation results presented here show that the negative effect of uncertainty prevails for investment in equipment and equipment. The larger the difference between the upper and lower bound of the expected exchange rate, the stronger the downward revision of investment plans. However, we do not find a positive impact of uncertainty on research and development in this specification.

Table D.9: Neglect Covariates

	Dependent variable:							
	Δ GFCF 2015		Δ Equipment Investment 2015		Δ Construction Investment 2015		Δ RnD Investment 2015	
	OLS		*OLS*		*OLS*		*OLS*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
uncertainty	-0.046^{***}	-0.017	-0.069^{***}	-0.019	0.0003	0.040	0.086^{*}	0.114
	(0.015)	(0.030)	(0.019)	(0.031)	(0.037)	(0.062)	(0.051)	(0.075)
irreversibility		0.013		0.016		0.030		-0.087^{*}
		(0.016)		(0.018)		(0.044)		(0.048)
irreversibility × uncertainty		-0.043		-0.073^{*}		-0.061		-0.029
		(0.036)		(0.040)		(0.082)		(0.114)
ΔI_{2014}	-0.205^{**}	-0.204^{**}	-0.267^{**}	-0.267^{**}	-0.282^{***}	-0.278^{***}	-0.451^{***}	-0.454^{***}
	(0.096)	(0.096)	(0.118)	(0.119)	(0.087)	(0.086)	(0.090)	(0.089)
expected exchange rate	0.130	0.129	0.096	0.092	-0.130	-0.123	-0.058	-0.062
	(0.110)	(0.110)	(0.125)	(0.126)	(0.206)	(0.204)	(0.422)	(0.383)
Constant	-0.118	-0.125	-0.067	-0.073	0.145	0.118	0.028	0.088
	(0.119)	(0.116)	(0.135)	(0.135)	(0.228)	(0.230)	(0.452)	(0.409)
Observations	1,057	1,057	980	980	424	424	323	323
R^2	0.031	0.033	0.057	0.060	0.053	0.055	0.223	0.229

*p<0.1; **p<0.05; ***p<0.01

Coefficients of additional controls are included but not reported. Standard Errors are clustered at industry (NACE 2) levels.

Notes: We include several covariates in our main specification in order to avoid omitted variable issues. Footnote 10 provides an extensive discussion of all explanatory variables that are included in estimation but not reported in Table 4.5. The table below neglects all additional covariates and reports coefficients for a restricted model that only includes variables reported in the table. Note that the precision of the estimates decreases and the significant positive effect of uncertainty on research and development disappears. However, the significant negative effect of uncertainty on irreversible investment plans prevails for investment in machinery and equipment.

Table D.10: Neglect Lagged Dependent Variable

	Dependent variable:							
	Δ GFCF 2015		Δ Equipment Investment 2015		Δ Construction Investment 2015		Δ RnD Investment 2015	
	OLS		*OLS*		*OLS*		*OLS*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
uncertainty	-0.046^{**}	-0.004	-0.076^{***}	-0.010	-0.009	0.089	0.188^{***}	0.256
	(0.019)	(0.031)	(0.026)	(0.030)	(0.042)	(0.078)	(0.071)	(0.158)
irreversibility		0.014		0.017		0.058		-0.076
		(0.019)		(0.020)		(0.054)		(0.063)
irreversibility × uncertainty		-0.060^{*}		-0.095^{**}		-0.148		-0.085
		(0.037)		(0.037)		(0.095)		(0.185)
expected exchange rate	0.169	0.166	0.156	0.148	-0.083	-0.064	-0.209	-0.197
	(0.131)	(0.131)	(0.158)	(0.159)	(0.241)	(0.234)	(0.308)	(0.321)
Constant	-2.063	-2.070	-4.040^{**}	-4.092^{**}	0.293	0.527	1.626	1.388
	(1.648)	(1.675)	(1.909)	(1.908)	(3.581)	(3.633)	(5.895)	(5.957)
Observations	1,025	1,025	948	948	414	414	314	314
R^2	0.060	0.062	0.077	0.081	0.124	0.132	0.198	0.204

*p<0.1; **p<0.05; ***p<0.01

Coefficients of additional controls are included but not displayed. Standard Errors are clustered at industry (NACE 2) levels.

Notes: This table presents a specification that does not control for firm investment revisions for 2014. Firms' investment revisions in 2014 should not be affected by the removal of lower bound of the exchange rate in 2015 (as estimated in Table D.7). Including this variable in the main specification allows us to control for unobserved idiosyncratic shocks to firms' investment for 2014 between the two survey waves. However, the benefit of conditioning on past investment revisions might be risky. One could re-write our model as a panel data model that varies in firm, time, and survey periods. One can argue that including revisions of past investments as an explanatory variable gives the model a dynamic component. The underlying problem is the well established issue that including lags of the dependent variables as explanatory variables introduces endogeneity. The endogeneity results from the correlation of the lag dependents variables with a firm's idiosyncratic error. Usually one would address this problem with a generalized method of moments estimator for dynamic panel data as proposed by Arellano and Bond (1991). However, the estimator requires taking the first difference of the regression equation, which is hardly feasible in our case as not all variables are levied in every survey period. Instead, we prefer to present a version of our main model that neglects firms' investment revisions in 2014, giving us static panel data which we can estimate consistently. Omitting this variable does not influence our results in a substantial way. The main change is the marked decrease of the model's R^2, as past investment plan revisions are the strongest predictor for investment plan revisions for 2015. The effect of uncertainty on GFCF, investment in equipment, and in construction is virtually unchanged, the effect of uncertainty on investment plans in research and development becomes slightly more pronounced.

Table D.11: Sample Split

Statistic	N	Mean First N obs.	St. Dev. First N obs.	Mean Last N obs.	St. Dev. Last N obs.	p-Value
export	10	0.6	0.516	0.25	0.5	0.287
	25	0.591	0.503	0.333	0.5	0.213
	50	0.5	0.509	0.44	0.507	0.669
	100	0.423	0.497	0.408	0.497	0.87
employees (fte)	10	80	91	699	854	0.243
	25	270	363	506	738	0.382
	50	255	330	287	473	0.778
	100	235	535	248	396	0.875
irreversibility	10	0.7	0.483	0.25	0.5	0.181
	25	0.727	0.456	0.556	0.527	0.408
	50	0.643	0.488	0.64	0.49	0.983
	100	0.705	0.459	0.592	0.497	0.201
uncertainty	10	0.2	0.422	0.25	0.5	0.867
	25	0.091	0.294	0.111	0.333	0.877
	50	0.071	0.262	0.16	0.374	0.329
	100	0.128	0.336	0.184	0.391	0.414

Notes: Sample Split - Wallace and Mellor (1988) outline methods to identify non-response bias in survey data. One proposition is to compare the profile of early respondents to the profile of late respondents, with the underlying presumption that late responders are similar to non-responders. The conventional method consists of comparing the means of respondents responding in the final week before the survey deadline with those responding earlier. We modify the test slightly because there are very few observations that trickled in in the last week of the survey period. Instead, we compare the profile of the first N respondents to the last N respondents. We select several N in order to avoid accidental outcomes. For each N we test the equality of means between the two groups for several characteristics. We use a two-sided t-test allowing for unequal variances to test for equality of means. As shown in the table below, no significant differences exist.

Table D.12: Inverse Probability Weighting - First Stage

	Dependent variable:
	Firm participated in Autumn 2014 and Spring 2015
	probit
Respondent Language English	1.518^{**}
	(0.641)
Respondent Language French	0.119^{*}
	(0.062)
Respondent Language Italian	0.394^{***}
	(0.109)
Gender: unknown	-0.055
	(0.304)
Gender: female	0.023
	(0.065)
No person addressed	0.180
	(0.123)
Online Participant	0.480^{***}
	(0.052)
Historic Non-Response	-4.722^{***}
	(0.103)
Constant	2.779^{***}
	(0.799)
Observations	8,011
Log Likelihood	$-1,803.000$
Akaike Inf. Crit.	3,780.000

*p<0.1; **p<0.05; ***p<0.01
Probit Estimations, log Ratios reported
NACE 2-digit dummies are included but not shown

Notes: Inverse Probability Weighting - First Stage - The sample of contacted firms is a representative sample of Swiss firms on a NACE-2 Digit size class level. Despite this and the results presented in Table D.11 comparing early and late respondents, we fear that non-response might bias our results. Table 4.1 indicates different response rates for different sectors. We know that unit non-response can bias results. For instance, firms in manufacturing may suffer more from the appreciation of the Swiss Franc than firms of the service sector. Furthermore, these firms may have a higher likelihood to participate in a survey for historical reasons. These factors could lead to an overrepresentation of such firms and subsequently to an overestimated effect. To address this potential non-response bias, we estimate the underlying non-response process and weight each firm with the inverse of their inclusion probability in our main specification. The following table presents the estimates of the underlying non-response process that is based on Bannert and Dibiasi (2014), which use a similar model to describe the non-response process for KOF business tendency surveys. The dependent variable takes value one for firms that participated in both survey waves, i.e. in Autumn 2014 and Spring 2015, and zero otherwise. Using a probit estimator we explain unit non-response using characteristics specific to the firm, the respondent and the survey design. We include NACE 2-digit dummies (not reported in the table), the language of the respondent (English, French, Italian, and German as the reference category), the sex of the respondent (male, female, unknown or no person addressed, with male being the reference category), the mode of participation (online or paper-based, with paper-based as the reference category) and a firm's historic non-response (ration of a firms history of non-response over the number of past survey invitations). Similar to Bannert and Dibiasi (2014), we find that a unit's past non-response rate and the mode of participation are the strongest predictors for responses. We re-estimate our main specification with Weighted Least Squares (WLS) using inverse probability weighting and report these results in Table D.13.

Table D.13: Inverse Probability Weighting - Second Stage

	Dependent variable:							
	Δ GFCF 2015		Δ Equipment Investment 2015		Δ Construction Investment 2015		Δ RnD Investment 2015	
	WLS		*WLS*		*WLS*		*WLS*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
uncertainty	−0.031	−0.007	−0.099***	−0.016	0.049	0.082	0.146**	0.276**
	(0.023)	(0.036)	(0.024)	(0.030)	(0.074)	(0.087)	(0.067)	(0.137)
irreversibility		−0.0001		0.015		0.054		−0.058
		(0.028)		(0.023)		(0.055)		(0.060)
irreversibility × uncertainty		−0.034		−0.117***		−0.051		−0.166
		(0.051)		(0.039)		(0.148)		(0.139)
ΔI_{2014}	−0.174*	−0.173*	−0.237*	−0.237*	−0.368***	−0.365***	−0.384***	−0.392***
	(0.089)	(0.089)	(0.126)	(0.127)	(0.111)	(0.109)	(0.103)	(0.099)
expected exchange rate	0.160	0.156	−0.016	−0.034	−0.016	−0.006	−0.043	−0.006
	(0.153)	(0.154)	(0.141)	(0.145)	(0.387)	(0.360)	(0.421)	(0.401)
Constant	−2.738	−2.769	−4.429*	−4.541**	−2.367	−2.295	6.470	6.284
	(1.951)	(1.985)	(2.298)	(2.226)	(4.515)	(4.400)	(7.328)	(7.788)
Observations	1,025	1,025	948	948	414	414	314	314
R^2	0.093	0.094	0.138	0.144	0.284	0.287	0.370	0.376

*p<0.1; **p<0.05; ***p<0.01

Coefficients of additional controls are included but not displayed. Standard Errors are clustered at industry (NACE 2) levels.

Notes: Inverse Probability Weighting - Second Stage - The following table presents WLS estimates of our main specification. The WLS estimates weigh each observation according to the inverse of its inclusion probability. This controls for a potential bias caused by unit non-response. We use the fitted values from the probit model presented in D.12 as the inclusion probability. The findings presented in the table below show that weighting for inclusion probability does not change our results in a significant way. The coefficients of uncertainty are somewhat smaller, but remain statistically significant for investment in equipment. The coefficient for investment plans in research and development becomes insignificant.

Table D.14: Limit to BTS

	Dependent variable:							
	Δ GFCF 2015		Δ Equipment Investment 2015		Δ Construction Investment 2015		Δ RnD Investment 2015	
	OLS		*OLS*		*OLS*		*OLS*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
uncertainty	−0.075*	0.049	−0.139**	0.015	−0.031	0.085	0.103	0.252
	(0.041)	(0.079)	(0.056)	(0.074)	(0.056)	(0.110)	(0.181)	(0.166)
irreversibility		0.048		0.046		0.081		−0.058
		(0.054)		(0.046)		(0.111)		(0.108)
irreversibility × uncertainty		−0.185		−0.234*		−0.179		−0.234
		(0.134)		(0.132)		(0.147)		(0.190)
ΔI_{2014}	−0.242**	−0.259*	−0.276***	−0.306***	−0.497***	−0.476***	−0.195	−0.198
	(0.123)	(0.135)	(0.067)	(0.075)	(0.170)	(0.166)	(0.142)	(0.146)
expected exchange rate	−0.165	−0.156	−0.380	−0.376	−0.318	−0.216	−0.605	−0.532
	(0.497)	(0.491)	(0.554)	(0.525)	(0.556)	(0.578)	(0.819)	(0.833)
Constant	0.220	0.183	0.491	0.460	0.367	0.207	0.647	0.604
	(0.533)	(0.522)	(0.596)	(0.553)	(0.614)	(0.647)	(0.866)	(0.914)
Observations	172	172	158	158	90	90	60	60
R^2	0.028	0.038	0.062	0.076	0.173	0.184	0.064	0.075

*p<0.1; **p<0.05; ***p<0.01

We do not include additional control variables due to the limited amout of observations. Standard Errors are clustered at industry (NACE 2) levels.

Notes: Limit to BTS - This table presents the results of a specification that limits our sample to those firms that participate in KOF Business Tendency Surveys, i.e. the subsample of firms that is used to construct Figure 4.3. The table below shows that the coefficients maintain the same sign and magnitude as the coefficients reported in the main specification. Nevertheless, most of the coefficients turn insignificant.

Table D.15: Tackle Possible Collinarity Issues

	Dependent variable:											
	Δ GFCF 2014			Δ Equipment Investment 2014			Δ Construction Investment 2014			Δ RnD Investment 2014		
	OLS			*OLS*			*OLS*			*OLS*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
uncertainty	-0.042^{**}	-0.043^{**}	-0.003	-0.070^{***}	-0.070^{***}	-0.004	0.0004	-0.003	0.074	0.132^{**}	0.141^{**}	0.211^{*}
	(0.018)	(0.018)	(0.031)	(0.025)	(0.025)	(0.028)	(0.040)	(0.040)	(0.079)	(0.061)	(0.059)	(0.119)
irreversibility		0.004	0.014		0.002	0.018		0.031	0.050		-0.111^{**}	-0.093^{*}
		(0.017)	(0.019)		(0.018)	(0.020)		(0.045)	(0.051)		(0.055)	(0.052)
irreversibility × uncertainty			-0.056			-0.094^{**}			-0.111			-0.099
			(0.038)			(0.039)			(0.100)			(0.141)
ΔI_{2014}	-0.174^{*}	-0.174^{*}	-0.173^{*}	-0.225^{*}	-0.225^{*}	-0.224^{*}	-0.322^{***}	-0.322^{***}	-0.316^{***}	-0.426^{***}	-0.429^{***}	-0.429^{***}
	(0.100)	(0.100)	(0.100)	(0.122)	(0.123)	(0.124)	(0.100)	(0.098)	(0.098)	(0.104)	(0.102)	(0.101)
expected exchange rate	0.175	0.176	0.172	0.147	0.148	0.140	-0.022	-0.023	-0.010	-0.074	-0.077	-0.059
	(0.128)	(0.128)	(0.128)	(0.144)	(0.144)	(0.145)	(0.229)	(0.224)	(0.220)	(0.392)	(0.358)	(0.368)
Constant	-1.849	-1.836	-1.855	-3.776^{**}	-3.769^{**}	-3.822^{**}	1.726	1.681	1.866	-0.965	-1.488	-1.286
	(1.628)	(1.636)	(1.653)	(1.871)	(1.863)	(1.878)	(3.571)	(3.568)	(3.603)	(5.846)	(5.663)	(5.875)
Observations	1,025	1,025	1,025	948	948	948	414	414	414	314	314	314
R^2	0.076	0.076	0.078	0.105	0.105	0.109	0.179	0.181	0.184	0.370	0.377	0.378

*p<0.1; **p<0.05; ***p<0.01

Coefficients of additional controls are included but not reported. Standard Errors are clustered at industry (NACE 2) levels.

Notes: Tackle Possible Collinarity Issues - This table inspects possible multicollinearity problems. Table 4.5 reveals large changes in parameter estimates and sharp drops in absolute t-values once we include the variables *irreversibility* and *uncertainty* × *irreversibility* in the regression. Large changes in coefficients and t-values are symptoms of the presence of multicollinearity in the explanatory variables. In regression analysis, multicollinearity is a well know problem. In general, multicollinearity does not impair the reliability of the model as a whole. However, multicollinearity affects estimations regarding single predictors. That is, a regression model with multicollinearity can indicate how well the entire model explains the variation in the dependent variable, but it may not give valid results about any single explanatory variable. Consequently, a possible correlation between the explanatory variables, *uncertainty* and *irreversibility*, might downgrade the validity of our empirical results. Regarding our case, one could argue that the degree of irreversibility influences the way a firm perceives and reports uncertainty. This presents a possibility that we cannot deny and that we must encounter with an additional robustness test. In this table we add an additional specification to the specification that we presented in Table 4.5. Particularly, we add a model that includes *uncertainty* and *irreversibility* but neglects its interaction, i.e. *uncertainty* × *irreversibility*. The results present below show that the sole inclusion of *irreversibility* does not change the coefficients of *uncertainty* in any substantial way. Especially, we do not observe sharp changes in the coefficients for the specification of gross fixed capital formation (GFCF), investment in equipment and construction investment. Nevertheless, the coefficient of *uncertainty* does change slightly for research and development. However, we do think that this change is still minor and should not be of great concern. Finally, this table provides evidence that possible multicollinearity issue caused by a correlation between *uncertainty* and *irreversibility* are not a mayor concern. The large changes in the coefficients of *uncertainty* source in the inclusion of *uncertainty* × *irreversibility*. This is what one would expect as uncertainty should negatively influence investment decisions solely when they are irreversible.

Table D.16: Effect of Size

	Dependent variable:															
	Δ GFCF 2014				Δ Equipment Investment 2014				Δ Construction Investment 2014				Δ RnD Investment 2014			
	OLS				*OLS*				*OLS*				*OLS*			
	(>0%)	(>25%)	(>50%)	(>75%)	(>0%)	(>25%)	(>50%)	(>75%)	(>0%)	(>25%)	(>50%)	(>75%)	(>0%)	(>25%)	(>50%)	(>75%)
uncertainty	−0.003	−0.005	0.004	−0.130**	−0.004	−0.008	−0.020	−0.092	0.074	0.065	0.121	−0.080	0.211*	0.250*	0.208	0.791
	(0.031)	(0.035)	(0.046)	(0.062)	(0.028)	(0.032)	(0.043)	(0.079)	(0.079)	(0.088)	(0.087)	(0.121)	(0.119)	(0.139)	(0.180)	(0.643)
irreversibility	0.014	0.014	0.011	0.008	0.018	0.018	0.022	0.001	0.050	0.047	0.036	0.106	−0.093*	−0.043	−0.078	−0.089
	(0.019)	(0.021)	(0.029)	(0.058)	(0.020)	(0.023)	(0.031)	(0.064)	(0.051)	(0.054)	(0.071)	(0.116)	(0.052)	(0.047)	(0.056)	(0.140)
irreversibility × uncertainty	−0.056	−0.062	−0.081	0.009	−0.094**	−0.102**	−0.126**	−0.132	−0.111	−0.100	−0.171	−0.049	−0.099	−0.193	−0.164	−0.585
	(0.038)	(0.043)	(0.059)	(0.088)	(0.039)	(0.044)	(0.058)	(0.102)	(0.100)	(0.110)	(0.127)	(0.216)	(0.141)	(0.151)	(0.212)	(0.648)
ΔI_{2014}	−0.173*	−0.172*	−0.170	−0.257**	−0.224*	−0.219*	−0.203	−0.235**	−0.316***	−0.318***	−0.334***	−0.421***	−0.429***	−0.423***	−0.410***	−0.301**
	(0.100)	(0.101)	(0.110)	(0.112)	(0.124)	(0.124)	(0.130)	(0.108)	(0.098)	(0.099)	(0.098)	(0.129)	(0.101)	(0.103)	(0.112)	(0.140)
expected exchange rate	0.172	0.194	0.259	0.162	0.140	0.170	0.304	0.227	−0.010	−0.042	−0.187	−0.476	−0.059	−0.199	−0.623	−1.542
	(0.128)	(0.150)	(0.226)	(0.348)	(0.145)	(0.172)	(0.278)	(0.513)	(0.220)	(0.233)	(0.293)	(0.411)	(0.368)	(0.337)	(0.555)	(1.591)
Constant	−1.855	−1.898	−2.780	−4.609	−3.822**	−4.200**	−5.824**	−6.382	1.866	2.043	4.457	−2.330	−1.286	−1.519	−1.047	−16.030
	(1.653)	(1.745)	(2.465)	(4.165)	(1.878)	(1.998)	(2.893)	(4.586)	(3.603)	(3.693)	(4.181)	(7.049)	(5.875)	(6.217)	(6.988)	(11.690)
Observations	1,025	920	666	331	948	855	619	310	414	392	317	196	314	282	206	101
R^2	0.078	0.081	0.093	0.173	0.109	0.114	0.137	0.207	0.184	0.188	0.209	0.293	0.378	0.418	0.392	0.488

*p<0.1; **p<0.05; ***p<0.01

Coefficients of additional controls are included but not reported. Standard Errors are clustered at industry (NACE 2) levels.

Notes: Effect of Size - This table examines if the effect of uncertainty increases with firm size. Bachmann and Bayer (2013) claim that the effect of uncertainty is stronger for larger firms. The authors show that the importance of uncertainty for aggregate fluctuations increases with firm size and conclude that limiting an analysis to publicly listed firms overestimates the effect of uncertainty. We re-estimate the models presented in Table 4.5 for different subsamples. Particularly, we limit our analysis to the largest 75%, 50% and 25% of firms in our sample. This exercise confirms the observation made by Bachmann and Bayer (2013). The effect of uncertainty appear to increase when focusing on larger firms. This finding holds especially for investment in machinery and equipment.

Table D.17: Interacting Size with Uncertainty

	Dependent variable:							
	Δ GFCF 2015		Δ Equipment Investment 2015		Δ Construction Investment 2015		Δ RnD Investment 2015	
	OLS		*OLS*		*OLS*		*OLS*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
uncertainty	0.066	0.006	0.155**	0.027	0.074	0.068	0.232	0.217*
	(0.059)	(0.027)	(0.077)	(0.025)	(0.123)	(0.069)	(0.335)	(0.124)
uncertainty × employees	−0.024		−0.050**		−0.015		−0.023	
	(0.015)		(0.021)		(0.026)		(0.075)	
irreversibility		0.016		0.025		0.049		−0.091*
		(0.019)		(0.020)		(0.051)		(0.050)
irreversibility × uncertainty × employees		−0.016		−0.031***		−0.021		−0.024
		(0.010)		(0.011)		(0.020)		(0.032)
employees (fte, log)	0.011**	0.008*	0.024***	0.018***	−0.004	−0.003	0.023	0.025
	(0.005)	(0.005)	(0.007)	(0.006)	(0.016)	(0.015)	(0.022)	(0.022)
expected exchange rate	0.170	0.174	0.134	0.140	−0.029	−0.015	−0.067	−0.043
	(0.131)	(0.129)	(0.150)	(0.147)	(0.233)	(0.219)	(0.388)	(0.361)
ΔI_{2014}	−0.169*	−0.169*	−0.215*	−0.220*	−0.321***	−0.313***	−0.428***	−0.431***
	(0.099)	(0.099)	(0.121)	(0.124)	(0.100)	(0.098)	(0.101)	(0.099)
Constant	−1.855	−1.894	−3.766*	−3.916**	1.761	1.852	−0.909	−1.298
	(1.649)	(1.676)	(1.957)	(1.934)	(3.585)	(3.601)	(5.845)	(5.849)
Observations	1,025	1,025	948	948	414	414	314	314
R^2	0.079	0.080	0.117	0.118	0.180	0.184	0.370	0.378

*p<0.1; **p<0.05; ***p<0.01
Coefficients of additional controls are included but not reported. Standard Errors are clustered at industry (NACE 2) levels.

Notes: Interacting Size with Uncertainty - This table examines the interaction effect of uncertainty with the number of employees.

KOF **Business tendency survey**

KOF Swiss Economic Institute
ETH Zürich, LEE F 105, 8092 Zürich
www.kof.ethz.ch

Tel: 044 632 85 33
Fax: 044 632 13 52
ivu@kof.ethz.ch

0835186236

Branch name: _____

Classification: _____

Survey

Firm-ID

Contact-ID

Branch-ID

Please note

- Your responses should refer only to the branch named above
- The questions refer to the activities of domestic branches
- Do not use a red pencil
- Tick the appropriate box ☒ ☒
- The notes are on the back of the sheet
- Please return the questionnaire by the

Your responses are treated strictly confidential.

Questions autumn

Number of employees in Switzerland on 30 June 2014
(please convert part-time positions into full-time equivalent positions)

In 2014 the following percentage of our production was exported

○ 0-5% ○ 6-33% ○ 34-66% ○ 67-100%

1. Investment activity

a) Our investments in **Construction** in Switzerland amounted to / is likely to amount to

	mrd.	mio.	thd.	hnd.
2013				000.–
2014				000.–
2015				000.–

b) Our investments in **fixed assets and software** in Switzerland amounted/ is likely to amount to

	mrd.	mio.	thd.	hnd.
2013				000.–
2014				000.–
2015				000.–

c) Our investments in **research and development** in Switzerland totalled/ are expected to amount to

	mrd.	mio.	thd.	hnd.
2013				000.–
2014				000.–
2015				000.–

d) Relative to 2014, in the year 2015 our investment in Switzerland is likely to

	Machinery and equipment	Construction	Research and developpment
increase	○	○	○
remain unchanged (or remain at zero)	○	○	○
decrease	○	○	○

e) We consider the realisation of our investment plans for 2015 as

○ very sure ○ fairly sure ○ fairly uncertain ○ very uncertain

2. Production capacity

In comparison to 2014 our technical production capacity in Switzerland in the year 2015 shall probably

○ expand ○ leave unchanged ○ reduce

3. Structure of the investment

Our investment in 2014/2015 serves (you may pick one or more categories)

		2014	2015
a)	replacement	☐	☐
b)	extension of the production capacity	☐	☐
c)	to streamline production	☐	☐
d)	environmental protection and regulations by trade law	☐	☐
e)	other objectives	☐	☐

4. Product programme

In terms of our product programme, in the year 2015 we are planning to

retain our product range ☐
bring our products into line with the state of the art ☐
add new products to the product range ☐

5. Factors influencing the investment activity

Our investment activity will be positively/negatively influenced in 2014 and 2015 respectively by the following factors:

a) 2014	++	+	=	-	--	n.a.
Demand	○	○	○	○	○	○
Financial resources/ expected profits	○	○	○	○	○	○
Technical factors	○	○	○	○	○	○
Other factors	○	○	○	○	○	○

b) 2015	++	+	=	-	--	n.a.
Demand	○	○	○	○	○	○
Financial resources/ expected profits	○	○	○	○	○	○
Technical factors	○	○	○	○	○	○
Other factors	○	○	○	○	○	○

++ very stimulating + stimulating = no influence
- limiting -- very limiting n.a. no answer

6. Non-domestic investment

In the year 2015 we are planning to make direct investments abroad

○ yes ○ no

If yes
The direct investment relates to the following activities:

Distribution ☐
Production ☐
Research and development ☐

Figure D.2: Questionnaire Investment Survey Autumn 2014

KOF **Investment survey**

KOF Swiss Economic Institute
ETH Zürich, LEE F 105, 8092 Zürich
www.kof.ethz.ch

Tel: 044 632 85 33
Fax: 044 632 13 52
ivu@kof.ethz.ch

5907638019

Branch name: _____

Classification: _____

Survey IVU 2015 1 2

Firm-ID

Contact-ID

Branch-ID

Please note

- Your responses should refer only to the branch named above
- The questions refer to the activities of domestic branches
- Do not use a red pencil
- Tick the appropriate box ☒
- The notes are on the back of the sheet
- Please return the questionnaire by the

Your responses are treated strictly confidential.

Questions spring

1. Investment activity

a) Our investments in **construction** in Switzerland amounted to / is likely to amount to

	bn.	mio.	thd.	hnd.
2013				000. -
2014				000. -
2015				000. -

b) Our investments in **fixed assets and software** in Switzerland amounted / is likely to amount to

	bn.	mio.	thd.	hnd.
2013				000. -
2014				000. -
2015				000. -

c) Our investments in **research and development** in Switzerland totalled / are expected to amount to

	bn.	mio.	thd.	hnd.
2013				000. -
2014				000. -
2015				000. -

d) Relative to 2014 , in the year 2015 our investment in Switzerland is likely to

	Machinery and equipment	Construction	Research and development
increase	○	○	○
remain unchanged (or remain at zero)	○	○	○
decrease	○	○	○

e) Relative to 2015 , in the year 2016 our investment in Switzerland is likely to

	Machinery and equipment	Construction	Research and development
increase	○	○	○
remain unchanged (or remain at zero)	○	○	○
decrease	○	○	○

f) We consider the realisation of our investment plans for 2015 as

○ very certain ○ fairly certain ○ fairly uncertain ○ very uncertain

2. Irreversibility

Bearing in mind the type of equipment / machinery used in making your main product / services, we would like to know whether a secondhand market exists where in case of need it **could be sold**.

Choose one of the following answers

○ Yes, and it is relatively easy to find a buyer in a short time willing to pay a reasonable price.

○ Yes, but it takes time to find a buyer and selling prices are not very rewarding.

○ Yes, but it is very difficult to find a buyer and selling prices can become very low.

○ No, there is no such market.

3. Number of employees

At the end of the year, the number of employees (in full time equivalent) in Switzerland will amount

	thd.	hnd.
2014		

4. Structure of the investment

Our investment in 2015 / 2016 serves (you may pick one or more categories)

		2015	2016
a)	replacement	☐	☐
b)	extension of the production	☐	☐
c)	to streamline production	☐	☐
d)	environmental protection and regulations by trade law	☐	☐
e)	other objectives	☐	☐

5. Exchange rate CHF - EUR

a) On 15 January 2015, the SNB removed the exchange rate floor of 1.20 CHF for one euro. In order to enable investment plans for 2015 to be assessed more effectively, please can you indicate the level at which, in your view, the exchange rate is most likely to lie in future.

	6 months	12 months	18 months	24 months
maximum	☐.☐☐	☐.☐☐	☐.☐☐	☐.☐☐
minimum	☐.☐☐	☐.☐☐	☐.☐☐	☐.☐☐

b) If possible, please also state the most likely level of the exchange rate within the interval.

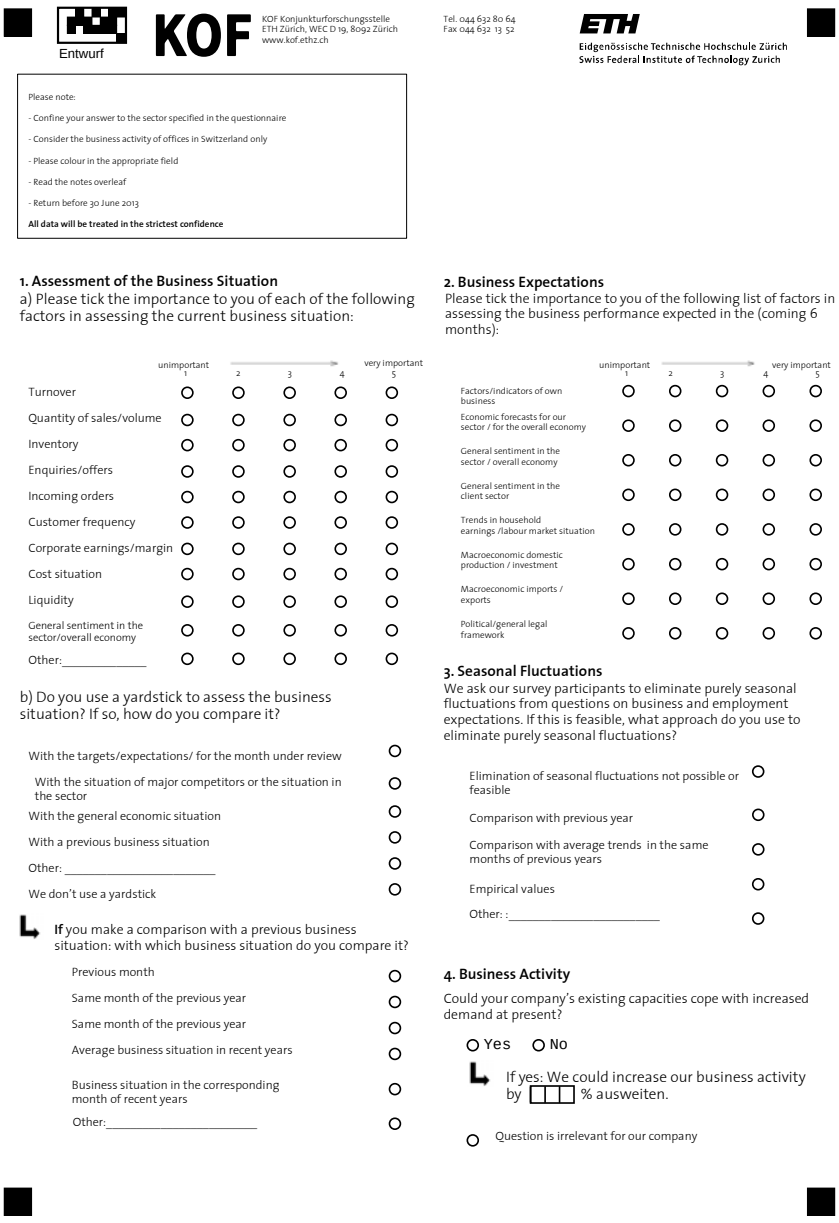
	6 months	12 months	18 months	24 months
Expected figure	☐.☐☐	☐.☐☐	☐.☐☐	☐.☐☐

Figure D.3: Questionnaire Investment Survey Spring 2015

Appendix E

Appendix Chapter 5

Figure E.1: Feedback Questionnaire - First Page



Entwurf

KOF Konjunkturforschungsstelle
ETH Zürich, WEC D 19, 8092 Zürich
www.kof.ethz.ch

Tel. 044 632 80 64
Fax 044 632 13 52

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Please note:

- Confine your answer to the sector specified in the questionnaire
- Consider the business activity of offices in Switzerland only
- Please colour in the appropriate field
- Read the notes overleaf
- Return before 30 June 2013

All data will be treated in the strictest confidence

1. Assessment of the Business Situation

a) Please tick the importance to you of each of the following factors in assessing the current business situation:

	unimportant 1	2	3	4	very important 5
Turnover	○	○	○	○	○
Quantity of sales/volume	○	○	○	○	○
Inventory	○	○	○	○	○
Enquiries/offers	○	○	○	○	○
Incoming orders	○	○	○	○	○
Customer frequency	○	○	○	○	○
Corporate earnings/margin	○	○	○	○	○
Cost situation	○	○	○	○	○
Liquidity	○	○	○	○	○
General sentiment in the sector/overall economy	○	○	○	○	○
Other:_____	○	○	○	○	○

b) Do you use a yardstick to assess the business situation? If so, how do you compare it?

- With the targets/expectations/ for the month under review ○
- With the situation of major competitors or the situation in the sector ○
- With the general economic situation ○
- With a previous business situation ○
- Other: _____ ○
- We don't use a yardstick ○

If you make a comparison with a previous business situation: with which business situation do you compare it?

- Previous month ○
- Same month of the previous year ○
- Same month of the previous year ○
- Average business situation in recent years ○
- Business situation in the corresponding month of recent years ○
- Other:_____ ○

2. Business Expectations

Please tick the importance to you of the following list of factors in assessing the business performance expected in the (coming 6 months):

	unimportant 1	2	3	4	very important 5
Factors/indicators of own business	○	○	○	○	○
Economic forecasts for our sector / for the overall economy	○	○	○	○	○
General sentiment in the sector / overall economy	○	○	○	○	○
General sentiment in the client sector	○	○	○	○	○
Trends in household earnings /labour market situation	○	○	○	○	○
Macroeconomic domestic production / investment	○	○	○	○	○
Macroeconomic imports / exports	○	○	○	○	○
Political/general legal framework	○	○	○	○	○

3. Seasonal Fluctuations

We ask our survey participants to eliminate purely seasonal fluctuations from questions on business and employment expectations. If this is feasible, what approach do you use to eliminate purely seasonal fluctuations?

- Elimination of seasonal fluctuations not possible or feasible ○
- Comparison with previous year ○
- Comparison with average trends in the same months of previous years ○
- Empirical values ○
- Other: :_____ ○

4. Business Activity

Could your company's existing capacities cope with increased demand at present?

○ Yes ○ No

If yes: We could increase our business activity by ☐☐☐ % ausweiten.

○ Question is irrelevant for our company

Figure E.2: Feedback Questionnaire - Second Page

5. Number of Surveys

a) How many surveys do you (personally) complete on average in a year?

	0	1	2	3	4	>4
KOF	○	○	○	○	○	○
Official statistics/FSO	○	○	○	○	○	○
Market researchers	○	○	○	○	○	○
Industry association	○	○	○	○	○	○
Other::_____	○	○	○	○	○	○

b) Does your company have a routine for replying to surveys?

The KOF Business Tendency Surveys are usually....

- ...answer immediately after receiving the questionnaire ○
- ...answered when time permits ○
- ...answered just before the deadline for submission ○
- ...answered when a reminder is received ○

c) How long does it usually take to fill out the KOF Business Tendency Surveys (in minutes)?

<5	<10	<15	<20	<30	<45	<60	>60
○	○	○	○	○	○	○	○

6. Personal Data

a) In which department of your company are KOF Business Tendency Surveys normally completed?

- Management ○
- Staff Position ○
- Controlling ○
- Accounts ○
- Statistics ○
- Procurement ○
- Sales ○
- Marketing ○
- Other:_____ ○

b) What position does the person who usually completes the surveys occupy in the company? (With reference to the questionnaire)

- Owner/manager/board member ○
- Departmental head ○
- Administrator ○
- Other:_____ ○

c) How many people are involved in completing the KOF Questionnaire (Quarterly Business Tendency Survey)?

one ○ two ○ tree ○ more than three ○

7. Significance of Business Tendency Surveys

How do you rate the benefit of business tendency surveys in general?

unnecessary 1	2	3	4	important 5
○	○	○	○	○

8. Capacity Utilisation

a) Please tick the importance to you of each of the following factors in assessing the capacity utilisation of your business:

	unimportant 1	2	3	4	very important 5
Working hours	○	○	○	○	○
Personnel	○	○	○	○	○
Productivity per employee	○	○	○	○	○
Tech. Capacities	○	○	○	○	○
Surface area/existing stock of buildings and premises	○	○	○	○	○
Material consumption	○	○	○	○	○
Capital used	○	○	○	○	○
Licences	○	○	○	○	○
Customer frequency	○	○	○	○	○
Other :_____	○	○	○	○	○

b) If the demand for your services exceeds your existing capacities, would you be able to increase your capacities at short notice?

	impossible 1	2	3	4	perfectly possible 5
Personnel-related factors	○	○	○	○	○
Other, non personnel-related factors	○	○	○	○	○

9. Recording Capacity Utilisation

a) If possible, assess the average capacity utilisation in the last 3 months based on...

...personnel-related capacity (in %):

50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

or: question is not relevant to our company ○

...non personnel-related, technical capacity (in %):

50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

or: question is not relevant to our company ○

b) If the demand for your services exceeds your existing capacities, would you be able to increase your capacities at short notice?

productive □□□ % unproductive □□□ % ○ not specified

c) Do you use a time recording system?

- Yes ○
- No, but we plan to introduce one ○
- No ○

10. Staff Shortage

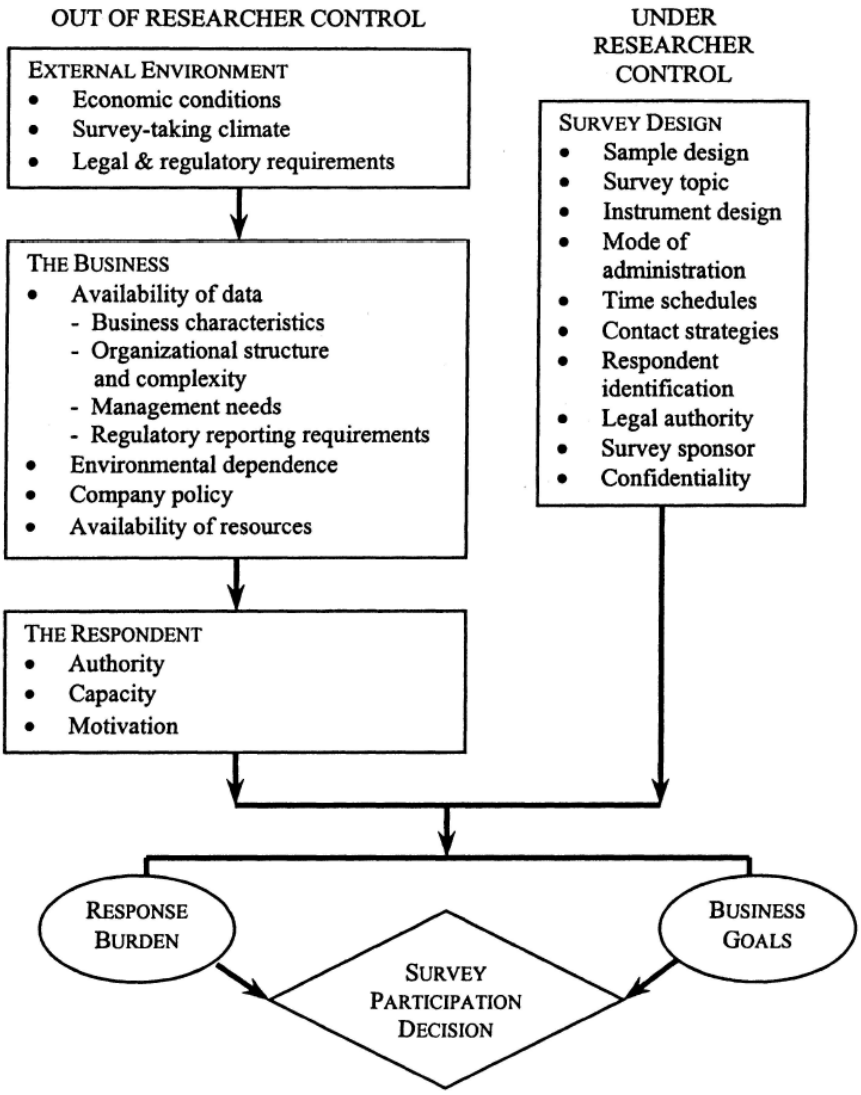
a) Have your activities been hindered in the past by a staff shortage?

○ Yes ○ No

b)) If there were problems recruiting suitably qualified staff, this was attributable to

- the lack of availability of staff with relevant qualifications ○
- the excessive costs of employing staff with relevant qualifications ○

Figure E.3: Conceptual Framework for Non-response in BTS



Curriculum Vitae

Personal Details

- Name: Andreas Dibiasi
- Date of Birth: April 2, 1988
- Place of Birth: Bozen, Italy
- Citizenship: Italian

Current Position

- Research Assistant, KOF Swiss Economic Institute, ETH Zurich, Switzerland (since 2/2012)

Education

- Ph.D. student in Economics, ETH Zurich, Switzerland (since 3/2013)
  - *Courses at ETH:*
    - Program Evaluation Econometrics - Christoph Moser - ETH Zurich - Spring 2013
    - Experimental Methods - Christan Waibel - ETH Zurich - Autumn 2016
  - *Courses outside ETH:*

    * Mathematics - Prof. Johann K. Brunner - University of Innsbruck - Autumn 2012
    * Microeconomics - Prof. Markus Walzl - University of Innsbruck - Autumn 2012
    * Statistics - Prof. Stefan Lang - University of Innsbruck - Spring 2012
    * Econometrics - Prof. Janette Walde - University of Innsbruck - Spring 2012
    * Game Theory - Prof. Rudi Kerschbamer - University of Innsbruck - Spring 2012
    * Macroeconomics - Prof. Johann Scharler - University of Innsbruck - Spring 2012

- Dipl. oec. in Economics, University of Innsbruck, Austria, 2007–2011
- Matura, Handelsoberschule, Auer, Italy