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Strukturberichterstattung
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The Impact of Real Exchange Rates on Swiss Firms: Innovation, Investment, Productivity and Business Demography

Schwerpunktthema:
Die Schweizer Wirtschaft in einem schwierigen Währungsumfeld

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B,S,S. Volkswirtschaftliche Beratung AG

KOF Konjunkturforschungsstelle der ETH Zürich

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The Impact of Real Exchange Rates on Swiss Firms: Innovation, Investment, Productivity and Business Demography

This study is commissioned by the Swiss State Secretariat of Economic Affairs (SECO)

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Executive Summary (German)

Ausgangslage und Ziele

Schweizer Unternehmen sind regelmässig bedeutenden Wechselkursschwankungen ausgesetzt. In Zeiten wirtschaftlicher Turbulenzen im Ausland wertet sich der Franken teilweise deutlich auf, da er von den Finanzmärkten als „sicherer Hafen" wahrgenommen wird. Als die Schweizerische Nationalbank (SNB) die Kursuntergrenze zum Euro Anfang 2015 überraschend aufhob, stieg der reale Wechselkurs um rund 15%. Solch starke Währungsschwankungen beeinflussen Umsätze und Gewinne von international ausgerichteten Firmen stark.

Die vorliegende Studie verfolgt das Ziel, die Auswirkungen von Wechselkursbewegungen auf die Aktivitäten von einheimische Unternehmen anhand mehrerer Zielgrössen empirisch zu untersuchen: Ausgaben für Forschung und Entwicklung (F&E), Kostensenkungsmassnahmen, Produktivität, Investitionen sowie Aspekte der Unternehmensdemographie. Insbesondere kommt dem Innovations- und Investitionsverhalten der Unternehmen eine entscheidende Rolle zu, weil dieses die Produktivität und das Wirtschaftswachstum der Schweiz in der langen Frist beeinflusst. Weiter wird aufgezeigt, wie die Folgen einer Aufwertung zwischen verschiedenen Unternehmenssegmenten variieren. Damit leistet die Studie einen Beitrag zur Diskussion, wie sich das Währungsumfeld auf den Strukturwandel auswirken könnte.

Vorgehen und Daten

Wie in der jüngeren wissenschaftlichen Literatur wird in den empirischen Analysen der Umstand ausgenutzt, dass Unternehmen Wechselkursaufwertungen äusserst unterschiedlich ausgesetzt sind, je nachdem, wie sie mit dem Ausland verflochten sind. Wie stark eine Aufwertung die Gewinne einer Firma – und damit möglicherweise ihre Innovations- und Investitionstätigkeit – beeinträchtigt, hängt entscheidend von ihrer Nettoexponiertheit gegenüber dem Ausland ab: dem Unterschied zwischen Exportanteil und Importanteil am Umsatz. Wer mehr exportiert als importiert, gehört zu den wahrscheinlichen Verlierern einer Aufwertung. Diese Heterogenität der Firmen in Bezug auf die Nettoexponiertheit ermöglicht es, die kausale Wirkung einer Aufwertung des Frankens auf die Unternehmensaktivitäten mit ökonometrischen Methoden zu schätzen.

Für die empirischen Analysen kommen mehrere Datenquellen zur Anwendung, die es erlauben, die Aktivitäten von Schweizer Firmen im Zeitverlauf zu untersuchen. Die Datensätze basieren auf den Innovations- und Investitionsumfragen

der KOF Konjunkturforschungsstelle sowie auf der Betriebszählung und der Statistik der Unternehmensstruktur des BFS. Weiter werden für die Analyse *branchenspezifische* Wechselkurse gebildet, welche die unterschiedliche Zusammensetzung der Handelspartner in den Branchen berücksichtigen.

Effekte von Wechselkursen auf Produktivität, Forschung- und Entwicklungsausgaben und Kostensenkungen

Auf Basis der KOF-Innovationsumfrage der Jahre 1995 bis 2015 analysieren wir den Effekt der Aufwertung des Schweizer Frankens auf die F&E-Ausgaben, Produktionskostensenkungen und die Produktivität von Schweizer Industrieunternehmen. Die Stichprobe umfasst, je nach Analyse, zwischen 600 und 1500 Firmen.

Die Analyse zeigt, dass ein Grossteil der F&E-treibenden Unternehmen in der Schweiz eine positive Nettoexponiertheit aufweist, das heisst, die Unternehmen exportieren im Durchschnitt mehr als sie importieren. Da die Frankenaufwertung deren Erträge drückt, zeigen unsere ökonometrischen Schätzungen, dass diese Unternehmen die F&E-Ausgaben erheblich reduzieren. Unternehmen mit einer durchschnittlichen Nettoexponiertheit senken ihre F&E-Ausgaben um rund 17%, wenn sich der Franken um 10% aufwertet.

Während dieser negative Aufwertungseffekt bei international exponierten, F&E intensiven Unternehmen besonders stark auftritt, gibt es auch gewisse Unternehmenssegmente, die ihre F&E-Ausgaben sogar leicht erhöhen. Dazu gehören einerseits Unternehmen mit beträchtlichen finanziellen Ressourcen und hohen Gewinnmargen und andererseits kleinere, F&E-intensive «Nischen-Firmen», die weniger stark international exponiert sind und relativ geringem Preiswettbewerb ausgesetzt sind.

In weiteren Analysen stellen wir einen positiven Effekt von Aufwertungen auf das „Kostenbewusstsein“ der Firmen fest. Bei einer Aufwertung von 10% steigt die Wahrscheinlichkeit, dass Unternehmen durch Neuerungen die Produktionskosten senken, um 13 Prozentpunkte.

Aufgrund der empirischen Tatsache, dass niedrigere F&E-Ausgaben die Produktivitätsentwicklung mittelfristig abschwächen und Kosteneinsparungen die Produktivität tendenziell erhöhen, bleibt es unklar, wie sich eine Aufwertung längerfristig auf die Produktivität auswirkt. Unsere zusätzlichen Analysen zeigen zumindest einen kurzfristigen, direkten Effekt: Eine Aufwertung um 10% verringert die Arbeitsproduktivität der Unternehmen um 1.3% und die Multifaktorproduktivität um 2.3%.

Die Effekte des Frankenschocks auf die Investitionen in der Schweiz

In einem weiteren Kapitel gehen wir der Frage nach, wie sich der „Frankenschock" – die starke und unerwartete Aufwertung des Schweizer Frankens gegenüber dem Euro nach der Aufhebung der Wechselkursuntergrenze im Januar 2015 – auf die Investitionen von Schweizer Firmen auswirkte. Dazu erstellen wir auf Basis aller KOF Investitionserhebungen zwischen Herbst 2010 und Frühling 2017 einen Datensatz, mit dem die realisierten Investitionen der befragten Firmen in den Jahren vor und nach dem Frankenschock verglichen werden können. Die Stichprobe umfasst gut 4'000 Firmen des Industrie- und Dienstleistungssektors.

Den Effekt des Frankenschocks untersuchen wir anhand einer einfachen *Difference-in-Differences*-Analyse, welche die Veränderungen in den Investitionen von Firmen mit positiver Nettoexponiertheit mit den Veränderungen in den Investitionen in den restlichen Firmen vergleicht. Die Annahme dabei ist, dass sich die Investitionen in den beiden Gruppen ohne Frankenschock gleich verändert hätten. Zwischen 2012 und 2014, als die meisten realen Wechselkurse wegen der Untergrenze praktisch konstant waren, entwickelten sich die durchschnittlichen Investitionen beider Gruppen in der Tat ähnlich. Im Jahr des Frankenschocks hingegen nahmen die Investitionen von Firmen mit positiver Nettoexponiertheit sprunghaft ab – eine Entwicklung, die in den restlichen Firmen nicht beobachtet wird. Die ökonometrischen Ergebnisse deuten darauf hin, dass der Frankenschock die Investitionen von Firmen mit positiver Nettoexponiertheit 2015 und 2016 im Durchschnitt um rund 12 bis 15% senkte.

Vertiefende Analysen zeigen, dass dieser grosse negative Investitionseffekt des Frankenschocks alle Arten von Investitionen betraf: Exponierte Firmen reduzierten oder verschoben ihre Bau-, Ausrüstungs- und Maschinen- sowie F&E-Investitionen. Mittlere und grosse Investitionsprojekte kleiner und mittelgrosser Firmen waren besonders stark betroffen. Interessanterweise findet sich auch Evidenz, dass der Frankenschock gewisse kleine zusätzliche Investitionsprojekte auslöste. Die Wahrscheinlichkeit, gar nicht in Ausrüstung und Maschinen zu investieren, sank bei exponierten Firmen ab 2015 deutlich. Weitere Analysen suggerieren, dass es sich bei diesen zusätzlichen Investitionen um Ersatzinvestitionen handelt.

Der Hauptgrund für die negativen Investitionseffekte des Frankenschocks ist, dass er den finanziellen Spielraum der Firmen einschränkte. Der Frankenschock erhöhte den Anteil exponierter Firmen, die einen Mangel an finanziellen Mitteln als Grund angeben, um rund 50%. Eine andere Erklärung für den Rückgang der

Investitionen in der Schweiz ist, dass Firmen vermehrt im Ausland investieren. Der positive Effekt des Frankenschocks auf die Auslandsinvestitionen findet sich vor allem bei grossen Industriefirmen und bei jenen, die bereits vor dem Frankenschock im Ausland investiert hatten.

Hochgerechnet legen unsere Schätzungen nahe, dass der Frankenschock die nominalen Investitionen einer durchschnittlichen Firma, die in der Investitionsumfrage teilnimmt, in den Jahren 2015 und 2016 um 3% bis 8% reduzierte. Dieser Effekt ist in den gesamtwirtschaftlichen Investitionszahlen in der Schweiz nicht in gleichem Masse ersichtlich, weil er vor allem mittlere und kleine Firmen betraf.

Effekte von Wechselkursen auf die Unternehmensdemographie

Im letzten Kapitel wurde auf Grundlage der Daten der Betriebszählung und der Statistik der Unternehmensstruktur der Jahre 1995 bis 2014 untersucht, inwiefern sich eine Aufwertung des Schweizer Frankens auf das Beschäftigungswachstum und die Wahrscheinlichkeit von Unternehmensschliessungen auswirken. Die Analyse umfasst sämtliche private Unternehmen des Industriesektors, welche im genannten Zeitraum tätig waren (ca. 50‘000 Unternehmen). Die Hauptergebnisse zeigen, dass die Auswirkungen vor allem bei stark exponierten Firmen mit hohem Exportanteil und geringen oder keinen Importen von Vorleistungen spürbar sind. Erstens führt eine Aufwertung von 10% zu einem Beschäftigungsrückgang von 2.5% in stark exponierten Firmen relativ zu nichtexponierten Firmen. Zweitens hat eine Aufwertung von 10% zur Folge, dass die Schliessungsrate von stark exponierten Firmen relativ gesehen um rund 0.3 Prozentpunkte ansteigt. Obwohl sich die Resultate auf die kurze Frist beziehen, könnten sie auch für die Wirtschaftsstruktur in der langen Frist von Relevanz sein. Einerseits sind stark exponierte Industrieunternehmen in gewissen Branchen konzentrierter als in anderen Branchen. Zweitens ist die Industrie stärker gegenüber Wechselkursschwankungen exponiert als der Dienstleistungssektor.

Mögliche Implikationen für den Strukturwandel

Insgesamt zeigen unsere Untersuchungen, dass eine Aufwertung des Frankens sowohl die Investitionen wie auch die F&E-Ausgaben von nettoexponierten Firmen belastet. Während sich die Ergebnisse der vorliegenden Studie auf die kurze Frist beziehen, lassen sich dennoch mögliche Implikationen für den Strukturwandel der Schweizer Wirtschaft in der langen Frist ableiten. Da F&E und Investitionen für die langfristige Produktivitätsentwicklung entscheidend sind, legen die Ergebnisse den Schluss nahe, dass längere Aufwertungsphasen

die Wettbewerbsfähigkeit der betroffenen Firmen negativ beeinträchtigen dürften. Weiter ist für die Wirtschaftsstruktur in der langen Frist entscheidend, welche Unternehmen zu den „Verlierern“ von Wechselkursaufwertungen gehören: Dabei handelt es sich vornehmlich um nettoexponierte Firmen, die deutlich innovativer und exportorientierter sind als das durchschnittliche Unternehmen in der Schweiz. Es ist zu erwähnen, dass der negative Effekt auf die F&E-Ausgaben vor allem bei grossen, international exponierten Firmen auftritt, denen eine besondere volkswirtschaftliche Bedeutung zukommt. Letztlich sind unter den betroffenen Firmen auch viele aus der Industrie, insbesondere der High-Tech-Industrie, sodass längere Aufwertungsphasen den Prozess der De-Industrialisierung tendenziell beschleunigen dürften. Diese Schlussfolgerungen basieren teilweise auf Plausibilitätsüberlegungen und bedürfen weiterer, vertiefender Analysen.

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1. Introduction

Background and Motivation

Swiss firms are regularly subjected to considerable fluctuations in exchange rates. These strong currency movements are linked to the fact that Switzerland is a small open economy and that the Swiss Franc is a "safe haven" currency. In times of economic turmoil and financial distress in other countries, the Swiss franc usually appreciates. A striking example of the exchange rate exposure of Swiss firms was the strong and sudden appreciation of the Swiss franc that followed the unexpected abolition of the currency floor that the Swiss National Bank (SNB) had entertained relative to the Euro. In the immediate aftermath of the SNB's announcement on January 15 2015, the Franc appreciated by around 15% against the Euro.

The persistent appreciation of the currency had a strong negative impact on revenues of Swiss firms that sell a high proportion of their sales abroad and do not profit much from the decline in the price of imported intermediate inputs. How did these firms react to the loss in competitiveness? A recent survey among medium-sized and large firms conducted by the SNB (2015) provides some insights on the way in which negatively affected firms responded to the appreciation. The most frequent measures are related to reducing prices of domestic inputs and increasing purchases of imported intermediate inputs. Furthermore, a substantial fraction of firms respond by increasing their innovation efforts and optimizing their production processes. Despite these measures, about one in five firms reports that they are forced to dismiss workers and reduce investments, respectively. While the evidence of the survey is rather qualitative due to the small sample, it suggests that exchange rate swings have considerable short- and medium-term consequences on workers and firms in Switzerland with potential long-term implications for productivity and growth.

Research Questions and Focus

This report presents a comprehensive empirical investigation as to how exchange rate movements affect the size, investment, research and development activities, innovation driven production cost reductions, measured performance and the survival of Swiss firms. More specifically, the research questions are as follows: How do exchange rate movements affect firms' spending on research and development (R&D) and fixed capital as well as their efforts to reduce costs? What is the impact on labor productivity within firms? Do exchange rate movements have an impact on aspects of business demography such as employment growth and the survival of firms? In analyzing these questions, we also explore the heterogeneity of the ex-

change rate effects across different groups of firms, for example by the degree of international exposure, firm size and price-cost-margins.

Empirical Approach and Data

Following the recent literature, the empirical approach of this report is based on the notion that domestic firms are *heterogeneous in their degrees of exposure to exchange rates* depending on (i) how much they export, (ii) how many intermediate inputs they purchase from abroad, and (iii) to what extent their domestic market is affected by import competition. The effects of exchange rate swings can then be identified by comparing changes in outcomes with changes in exchange rates between groups of firms with different degrees of exchange rate exposure. To study the range of outcome variables suggested by the research questions above, the empirical analyses in this report exploit three different firm-level panel datasets: the Swiss Innovation Survey (1995–2015) and the Investment Survey (2011–2017), both conducted by the KOF Swiss Economic Institute, as well as the Business Census Statistics (1995–2014) from the Swiss Federal Statistical Office. To study the effects of exchange rate movements, we construct *industry-specific real effective exchange rates* to take into account the heterogeneity of Swiss industries with respect to the composition of their trading partners.

Implications for Economic Policy

The results of this report may be of interest to economic policy makers for two reasons. First, the results provide a quantitative assessment of the impact of exchange rate movements on relevant aspects of business activities such as investment and innovation. These activities are intimately linked to productivity and growth and therefore have a bearing on structural changes in the economy in the long run. Second, the empirical findings provide information on the importance of the (partly offsetting) transmission channels through which exchange rates operate. Besides the policy perspective, the report may also provide a contribution to the international academic literature that seeks to understand the impact of exchange rates and international competition on firm-level outcomes.

Structure of the Report

This report is structured as follows. In Section 0, we review the related academic literature that examines the exchange rate effects on innovation, investment, productivity and business demography. Section 3 contains a discussion on the theoretical transmission channels, running from exchange rates to the various firm-level outcomes, which have been studied and developed in theoretical economic

models. Section 4 provides an overview over the various data sources and explains the construction of the industry-specific exchange rates.

In Section 5, we study the impact of exchange rate swings on firm-level labor productivity, firms' spending on R&D and their efforts to reduce costs. The analysis exploits the rich information in the Swiss Innovation Survey, a panel dataset based on a representative sample of 6'000 Swiss firms which covers the period from 1996 to 2015.

Section 6 investigates the effects of the sharp appreciation in 2015 on firms' investment activities. This appreciation, often referred to as the "Franc shock", was sudden and unexpected and changed the environment of Swiss firms with international exposure. Using the KOF Investment Survey from 2011 to 2017, we analyze how the Franc shock influenced firms' spending on machinery and equipment, construction, R&D, and foreign direct investment in 2015 and 2016.

In Section 7, we deal with the effect of exchange rate movements on two business-demographic outcomes: within-firm employment growth and the probability of exit from the market. The analysis is based on business census panel data that covers the universe of the Swiss manufacturing sector from 1995 to 2014 and exploits information on the firms' degree of export and import activities.

Finally, Section 8 contains concluding remarks.

2. Related Literature

This section provides an overview of the relevant academic literature dealing with the effects of exchange rate movements on the outcomes studied in this report. We discuss the linkages between exchange rates and innovation activities (2.1), investment (2.2), labor productivity (2.3) and aspects of business demography (2.4). At the end of the review in Section 2.5, we briefly summarize the most salient findings.

2.1. Exchanges Rates and Innovation Activities

Empirical evidence on real exchange rate fluctuations and innovation activities is limited. Especially the impact on research and development expenditures (R&D), which constitute the most important input to the innovation process, remains under-investigated. So far, empirical studies have mainly concentrated on the broader relationship between import competition and innovation activities. Since exchange rates influence import competition, these studies may provide relevant insights.

Two recent contributions analyze the impact of increased import competition on the technology level of firms. Bustos (2011) investigates the effects of the MERCOSUR free trade agreement on technology upgrading in Argentinian firms. She finds that reductions in tariffs lead to increased investments in new technology, with the effect being most pronounced among large firms. Bloom et al. (2016) use different measures of technical change to investigate the impact of Chinese imports on US low-tech industries. They find that Chinese import competition increased technical change within firms over time.

Hashmi (2013) investigates how changes in competition affect patent applications in the US and the UK. He uses real exchange rates as exogenous instruments for competition; higher real exchanges rates imply higher levels of competition (measured by a Lerner index). The results show a mildly negative relationship between competition and citation-weighted patents in the US; for the UK, however he finds the pattern of an inverted U-shape. Since the effect of competition is identified over the real exchange rate, the results of Hashmi (2013) would imply a somewhat negative effect of real exchange rates on innovation output measures.

Alvarez and López (2015) investigate the relation between the real exchange rate and the acquisition of foreign technology in the case of Chile. In developing countries, innovation usually takes place through copying and imitating as well as through purchasing technology from developed countries. The authors contrast the higher export revenues caused by a depreciation of the real exchange rate with the ensuing more expensive foreign technology licensing. In their empirical analysis,

Alvarez and López (2015) find that a real depreciation increases foreign technology acquisition, but only among the subsample of exporting firms.

Zietz and Fayissa (1994) study the response of R&D spending to real exchange rate changes in a panel dataset of 360 US manufacturing firms. Similar to Hashmi (2013), the authors use appreciations of the real exchange rate to proxy for increases in international competitive pressure. The results show that a real appreciation leads to more R&D spending only among firms operating in industries with below average R&D-to-sales intensities. By contrast, firms operating in industries with above average R&D-to-sales intensities show no response to real exchange rate changes. Zietz and Fayissa (1994) conclude that only high-tech firms use R&D as a strategic variable to react to increased competitive pressure. They argue that less R&D intensive firms are more likely to react through increased capital investments, as they do not have the capabilities necessary to invent technologies.

Chen (2017) uses country-level data to examine how an undervaluation of the real exchange rate, defined as a deviation from purchasing power parity, affects R&D activity. He finds that an undervaluation of the real exchange rate decreases R&D expenditures, especially in developed countries. Chen (2017) primarily attributes this effect to the observation that a depreciation increases the costs of importing machinery and other inputs, thus raising the costs of investing in R&D facilities.

The evidence for Switzerland is restricted to descriptive statistics. In a recent report, BFS (2017) presents numbers on the development of aggregate R&D expenditures of Swiss firms. While the average growth rate of Swiss R&D expenditures rose sharply between 2000 and 2008, it has slowed down somewhat since then. The report suggests that this slowdown in the average growth rate of Swiss R&D expenditures could have been caused by the increase in uncertainty in the context of the appreciation of the Swiss Franc. Interestingly, the descriptive statistics show a decrease in the R&D expenditures among small firms (<50 employees) between 2012 and 2015. In contrast, medium sized and large firms did not show a decrease in the growth rates of their R&D expenditures in this period. Since the R&D expenditures of small firms constitute less than 10% of total R&D expenditures, their downscaling had only a small impact on aggregate numbers. However, the BFS (2017) acknowledges that the descriptive nature of their data does not allow for any causal conclusions. In particular, the R&D expenditures of Swiss firms could have risen much more in absence of the appreciation of the Swiss France.

2.2. Exchange Rates and Investment

There is an extensive literature on the effect of real exchange rates on fixed capital investments. The most prominent studies in this respect are Goldberg (1993) and

Campa and Goldberg (1995, 1999), who investigate different industries in the United States, the United Kingdom, Canada and Japan. All three studies find relatively small average effects of the real exchange rate on industry-level investment activities. The main insight arising from these studies is that there are several (partly counteracting) transmission channels of real exchange rates on investment activity. While profits are seen as the main channel through which the real exchange rate affects investment, the effect on profits itself depends on three variables: export revenues, imported intermediate inputs, and import competition on the domestic market. For example, Campa and Goldberg (1995) argue that, while in the 1970s the US dollar was negatively associated with investment activity, the shift of the US economy towards a higher reliance on imported inputs in the 1980s led the US dollar to be positively associated with investment activity. Using panel data on Italian manufacturing firms, Nuzzi and Pozzolo (2001) also find small negative elasticities between the real exchange rate and investment. They similarly emphasize the importance of firms' actual exposure to real exchange rate movements. The authors show that the real exchange rate has a positive effect on investment through the export revenue channel, and a negative effect through the imported inputs channel. On average, these two effects roughly offset each other.

Another finding from this literature is that the effect of the real exchange rate on investment is stronger for industries and firms with *lower mark-ups* (Campa and Goldberg 1995; Campa and Goldberg 1999; Nucci and Pozzolo 2001). This result is intuitive for two reasons. First, since monopoly power dampens the effect of exchange rate fluctuations on prices, the profits of firms with more market power remain more stable, as price increases can be passed on to consumers (Dornbusch 1987). Second, firms with higher mark-ups can absorb exchange rate fluctuations with their profits and thus also better maintain their desired levels of investments.

Besides the international literature highlighted above, there are two recent studies on Switzerland focusing on the abolition of the exchange rate floor of the Swiss Franc to the Euro (1.20 CHF/EUR) in January 2015. Binding and Dibiasi (2017) show that this unexpected decision of the Swiss National Bank led to considerable uncertainty among firms. They can show that the induced uncertainty negatively affected firms' investment plans: uncertainty led firms to decrease investments, especially irreversible investments in equipment and machinery. Erfing et al. (2016) investigate the impact of the abolition of the exchange rate floor on a sample of publicly listed, large Swiss corporations. They find that firms with large currency risk exposure (defined as firms with a high share of revenues in foreign currencies and a high share of costs in domestic currency) decreased their real investments by 8.1 percent half a year after the abolition of the exchange rate floor.

2.3. Exchange Rates and Productivity

Across countries, there is a positive correlation between real exchange rates and productivity levels that is explained by the so-called Samuelson-Balassa effect, referring to the divergent productivity growth between the tradable and the non-tradable sector. The higher productivity growth in the tradable sector causes wages in the tradable sector to increase. To hire labor, the non-tradable sector is forced to increase wages too, despite its lower productivity growth, which can only be achieved through price increases. Consequently, countries with a very productive tradable sector, which is the most important driver behind a country's wealth, also have relatively higher real exchange rates. There is quite a large empirical literature that connects the real exchange rate and productivity in the Samuelson-Balassa context (e.g., Canzoneri et al. 1999).

In the short-run, causality is likely to run in the other direction: swings in the real exchange rate lead to changes in firm productivity. Ekholm et al. (2012) investigate the idea that an appreciation of the real exchange rate forces firms to become more productive. The authors analyze how the real appreciation of the Norwegian Krone in the early 2000s affected Norwegian manufacturing firms. They show that the development of aggregate productivity in the Norwegian economy was mainly driven by changes within existing firms (the intensive margin), whereas exit and entry of firms (the extensive margin) played a relatively minor role. Their results suggest that only net-exporting firms experienced productivity gains, while import-competing firms did not show significant changes in their productivity.

2.4. Exchange Rates and Business Demography

A series of studies examine how exchange rates affect the growth of surviving firms measured in terms of their employment. In a theoretical model, Campa and Goldberg differentiate between the three transmission channels: i) revenue exposure through exports, ii) cost exposure through imported inputs, and iii) revenue exposure through import competition. Using data on US industries, Campa and Goldberg (2001) find only a very small average elasticity between real exchange rate movements and total employment. However, the elasticity increases in export orientation and declines in the share of imported inputs. Building on the same empirical framework, Nucci et al. (2010) find for a panel of Italian manufacturing firms also a small average effect of real exchange rate movements on total employment, as the revenue channel and the cost channel roughly offset each other. Using a representative sample of German firms, Moser et al. (2010) find a statistically significant, but relatively small effect of exchange rates on total employment,

which is driven by fluctuations in job creation rather than job destruction. The authors attribute this result to the inflexible German labor market.

Using panel data on Swiss firms, Kaiser and Siegenthaler (2016) confirm the finding that appreciations of real exchange rates have only a small effect on total employment. However, they show that real exchange rate fluctuations cause shifts in the composition of labor demand. Since imported inputs are likely to substitute unskilled workers and to complement skilled workers, an appreciation of the real exchange rate, which lowers the relative prices of imported inputs, increases employment of high-skilled employees and reduces employment of low-skilled employees. In contrast, the lower revenues caused by an appreciation of the real exchange rate decrease both low-skilled and high-skilled employment symmetrically.

While most of the literature deals with employment growth in surviving firms, a few studies also examine how real exchange rates affect firm survival. Baggs et al. (2009) evaluate the impact of large-scale exchange rate movements of the Canadian Dollar on the survival of Canadian firms. From 1986 to 1997, the Canadian dollar first appreciated by 30% and then depreciated by 30%. Baggs et al. (2009) find that appreciations are negatively related to firm survival, while the observed effect is less pronounced for firms with higher productivity. Holmes et al. (2010) investigate the survival of newly-established micro firms and small and medium enterprises (SMEs) in England. In a subordinate consistency check, they find that the real effective exchange has a negative impact on firm survival. However, this negative effect is only statically significant for the sample of micro firms. Finally, Moser et al. (2010) find that an appreciation of the real exchange rate leads to a significantly higher probability of bankruptcy among firms with a relatively large export share.

2.5. Summary

The most important insight of the existing literature on the effect of real exchange rate fluctuations on innovation, investment, productivity and business demography is probably the emphasis on the three main counteracting channels first described by Campa and Goldberg (1995, 1999, 2001). While on average fluctuations in real exchange rates have only a small impact on aggregate outcomes, they usually hurt exporting firms and benefit firms relying heavily on imported intermediate inputs. The effect on an individual firm therefore depends on the individual exposure to international markets. In contrast, firms that produce only for the domestic market and do not import intermediate inputs are not directly affected by real exchange rate movements. However, they may be affected by increased competition on the

domestic market. Following this important insight of the existing literature, this report will take into account all three potential channels.

3. Theoretical Considerations

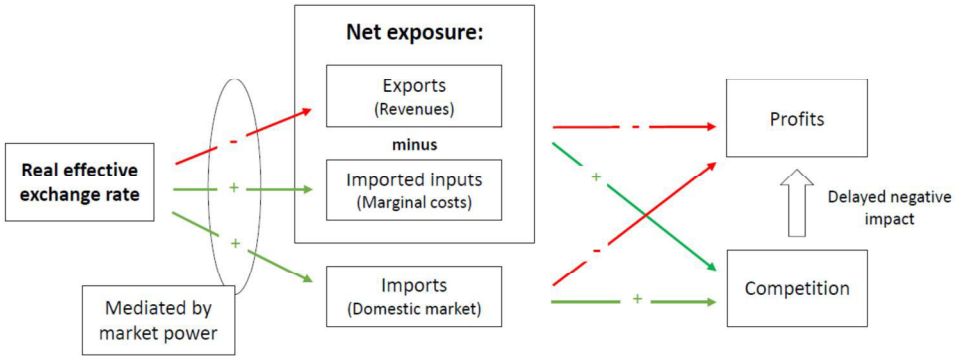
This section discusses the linkages between exchange rate movements and the relevant firm-level outcomes from a *theoretical perspective*. Based on the results of existing theoretical economic models, we sketch a framework that describes the array of the potential causal mechanism at play. To keep the ideas tractable and easily accessible, we abstain from using any mathematical formulations.

First, Section 3.1 describes the three main channels through which exchange rates can affect domestic firms. Second, in Section 3.2, we discuss in more detail the impact of exchange rates on the various outcome variables of interest. Section 3.3 provides a brief summary.

3.1. Exposure to Real Effective Exchange Rates

Figure 1 outlines the theoretical framework of Campa & Goldberg (1995, 1999, 2001) already hinted at in the literature review. Real exchange rate fluctuations affect firms' profits through three channels: i) export revenues, ii) imported intermediate inputs, and iii) import competition. In the event of an appreciation of the real exchange rate, the mechanisms can be described as follows. First, an appreciation increases the prices of firms' exports and is thus likely to diminish the amount of goods sold abroad, which will lower firms' export revenues. Second, it decreases the prices of imported intermediate inputs such as raw materials, production parts and service tasks. Since the prices of imported intermediate inputs are an essential part of marginal costs, an appreciation usually lowers the firm's cost base. Third, foreign competitors can sell their goods more cheaply on the domestic market. The lower priced imports are then likely to decrease the amount of goods domestic firms can sell on the domestic market and thus to lower their revenues.

Figure 1: Exposure and Theoretical Transmission Channels



Source: own design, based on the existing literature

The three channels described above directly affect the firms' profits: While decreased export revenues amount to lower profits, cheaper imported intermediate inputs constitute a natural hedge; the lower production costs lead to higher profits. In addition, reductions in domestic sales caused by cheaper imports from foreign competitors are likely to lower profits, too. The first two channels, export revenues and imported intermediate inputs, constitute what we will refer to as the "net exposure" of a firm. Firms that export many goods and import only a few intermediate inputs face a positive net exposure; they incur losses from a real exchange rate appreciation and make profits in case of a depreciation. Conversely, a negative net exposure leads to higher profits in case of a real exchange rate appreciation and lower profits in case of a depreciation. As mentioned in the literature section, market power is likely to dampen the effect of real exchange rate fluctuations on the three transmission channels, as price changes can be passed on to consumers more easily (Dornbusch 1987). Note that all three channels depicted in Figure 1 also affect the competitive environment a firm operates in, whereby the competitive environment is the mirror image of profits. Higher prices of exported goods and lower prices of imported goods increase competition for domestic firms, while lower prices of imported intermediate inputs decrease competition. With some delay, changes in competition will then also affect profits. However, how exactly profits respond to changes in the competitive environment depends on the response of the individual firm; firms may for example react to an appreciation with efficiency improvements. In the next section, we discuss such potential mechanisms in more detail.

3.2. Effects of REER on Outcome Variables

The top of Figure 2 again shows the impact of the real exchange rate on profits and competition. The placeholder "Figure: REER Exposure" shows where the first Figure 1 should be situated in this more encompassing Figure 2. As outlined, the impact on profits and the competitive environment depend on net exposure. Figure 2 now explains how exchange rate induced shifts in profits and competition affect the outcomes of interest: investments, R&D, and productivity. For simplicity, we explain the mechanisms in Figure 2 using the example of a firm with positive net exposure. Hence, an appreciation is expected to decrease profits and increase competition.

3.2.1. Investment

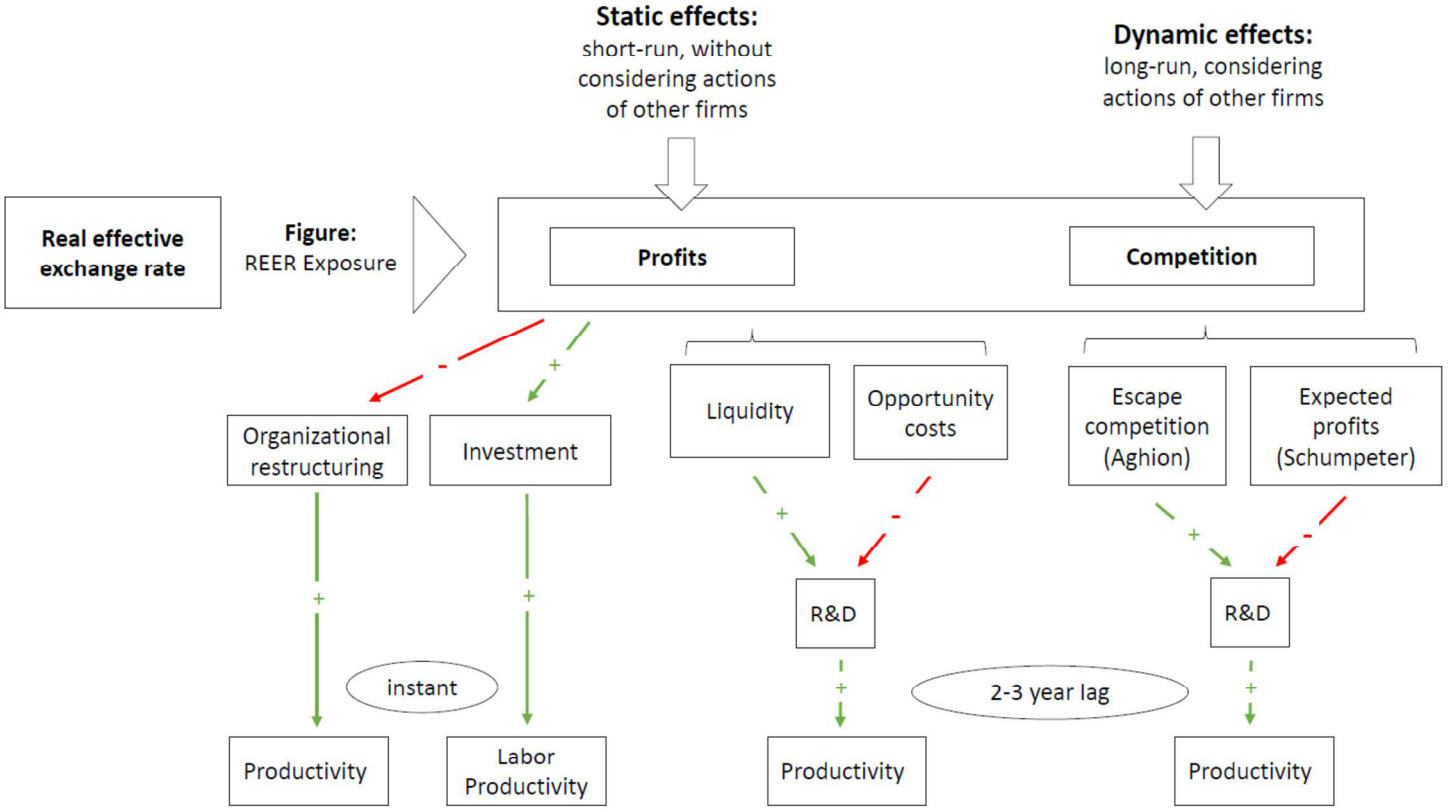
To begin with, we consider the effect an appreciation of the real exchange rate on fixed capital investment. In this context, the relevant literature emphasizes only the profit channel, thus neglecting the competitive environment (Campa and Goldberg

1995, 1999; Nuzzi and Pozzolo 2001). An appreciation lowers profits and therefore restricts the *financial resources* available for investments into capital goods. The lack of continued investments will in turn lead to foregone increases in labor productivity: without ongoing renewal of the firm's capital goods, employees will become less productive, ceteris paribus. Of course, this mechanism imposes imperfectly functioning financial markets, otherwise firms would be able to finance any potentially profitable investment projects through credit.

3.2.2. Organizations Restructuring

An appreciation of the real exchange rate can also directly affect within-firm productivity, without capital investments, mainly through organizational restructuring. This is probably the most intuitive mechanism; the lower profits brought about by an appreciation force firms to become more efficient and to get rid of any "slack" in their organization. Of course, "slack" is a rather vague concept and too strong a short-term focus on removing buffers in an organization may make the firm vulnerable to unexpected threats (Daniel et al. 2004). In contrast, organizational restructuring will be most beneficial to productivity when the firm has changed considerably in the year preceding an appreciation, opening up room for the organization to become more efficient. For example, Hall (1991) argues that the organizational capital of a firm deteriorates over time and therefore requires a "cleaning-up" from time to time. The economic slowdown caused by an appreciation phase may represent a good opportunity for restructuring in order to rebuild organizational capital.

Figure 2: Effect of REER on investment, R&D, and productivity



Source: own design, based on the existing literature

3.2.3. R&D Expenditures

For the present report, the main focus is on the impact of real exchange rate fluctuations on R&D expenditures. Fluctuations in R&D expenditures are of special importance for the competitiveness of a firm. For instance, if an appreciation caused R&D expenditures to decline, this could lower the firm's long-term growth potential, as it may diminish the quality and the variety of the future product range. Even if every appreciation phase is temporary, this may still adversely impact the competitiveness of firms. Coad and Rao (2010) show that R&D is most effective when carried out for a long time period, preferably without interruptions. Hence, should real exchange rate fluctuations increase the variability of R&D expenditures, long-term economic growth may be diminished.

The existing literature provides no theoretical contributions that discuss the potential channels through which real exchange rates could affect R&D expenditures. However, there exists an extensive literature investigating how the macroeconomic business cycle affects the innovation activities of firms (see, e.g., Arvanitis and Woerter 2014). In a small and open economy like Switzerland, the fall in aggregate demand caused by a recession has arguably similar effects on firms as an appreciation of the real exchange rate. Therefore, the respective theoretical channels described in the innovation - business cycle literature can be readily transferred to our setting analyzing the effect of real exchange rates on R&D expenditures.

The literature discussing the development of R&D expenditures over the macroeconomic business cycle portrays a complex relation between profits as well as competition and their impact on R&D expenditures. The top of Figure 2 labels the impact on profits "static effects" and the impact on competition "dynamic effects". The term "static effects" refers to the idea that the firm does not react strategically; fluctuations in the real exchange rate directly translate into profits. In contrast, the term "dynamic effects" implies that the firm takes the changed market environment into account and reacts pre-emptively to counter shifts in its competitive strength.

Static Effects

Consider first the "static effects" in Figure 2, i.e., how changes in profits can affect R&D expenditures. There are two channels: liquidity and opportunity costs.

The liquidity channel: An appreciation of the real exchange rate will diminish the firm's cash-flow and thus set constraints for the pursuit of further R&D projects. In contrast, a depreciation will provide the firm with additional financial means,

which can in turn be used to increase the firm's R&D expenditures. As in the case of investment, this perspective requires that financial markets are imperfect.

Opportunity cost channel: The most important channel counteracting liquidity constraints is probably the existence of opportunity costs. When a firm intends to expand its innovation activities, it must divert resources from other business activities (production, but also, e.g., managerial attention). Since an appreciation lowers the profitability of most other business activities, it may even become beneficial to increase R&D expenditures for a firm with a positive net exposure.

The question is of course whether either liquidity constraints or opportunity costs dominate. In the business cycle literature, Ouyang (2011) and Aghion et al. (2012) find convincing empirical evidence that liquidity constraints clearly outweigh opportunity costs. Hence, regarding the "static effects" in Figure 2, which emphasize the profit channel, we would expect that an appreciation of the real exchange rate leads to a decrease in R&D expenditures for a firm with a positive net exposure.

Dynamic Effects

If firms have a sufficiently forward looking perspective, the "dynamic effects" of Figure 2 come into play, meaning that firms start to react strategically to the exchange rate induced changes in their competitive environment. There is a very large literature on the effects of competition on various innovation outcomes. Aghion et al. (2005) describe two channels through which competition can affect R&D expenditures. First, the "escape competition" effect implies that firms have to be innovative if they want to beat their competitors and earn additional profits. Second, the "expected profits" effect, the Schumpeterian effect, means that competition lowers expected profits and thus reduces incentives to innovate in the first place. Aghion et al. (2005) therefore proposed an inverted-U relationship between the competitive environment and innovation activity, where the "escape competition" effect and the "expected profits" effect offset each other at intermediate levels of competition. The intuition behind the inverted U-shape is that intermediate levels of competition are superior to both no competition and too much competition. Perfectly monopolistic firms do not innovate, and neither do firms in markets where competitors instantly level out profits. Thus, how an appreciation of the real exchange rate affects R&D expenditures depends on the prevalent level of competition. If the "escape competition" outweighs the "expected profits" channel, an appreciation increases R&D expenditures among firms with a positive net exposure and decreases them among firms with a negative net exposure. Hence, over longer time periods, an appreciation of the real exchange rate may even for an export oriented economy have a positive effect on overall R&D expenditures.

3.2.4. Productivity

Ultimately, changes in R&D expenditures will translate into firm-level productivity, because new products or new production technologies will allow firms to achieve higher revenues or to produce more efficiently. However, R&D expenditures usually take time until they translate into visible productivity effects. On average, the literature finds a lag between an increase in R&D expenditures and innovation results of about 2-3 years (Hall et al. 2010). Due to these large time lags, analyzing how the real exchange rate affects productivity through R&D expenditures is a very delicate exercise. In this report, we will look at the direct impact of the real exchange rate on both R&D expenditures and firm productivity. The analysis of the impact of the real exchange rate on firm productivity will implicitly include any short-term effects through R&D expenditures. We do not analyze potential long-term relationships between R&D expenditures and firm productivity. However, we know from the relevant literature that fluctuations in R&D expenditures have large long-term effects on productivity levels (Hall et al. 2010).

3.2.5. Business Demography

Since exchange rate movements affect both profits and competition, they also influence business-demographic variables such as firm growth and the entry into and the exit from markets. Theoretical models that consider entry and exit decisions typically assume that starting a new business and operating an existing business are both associated with fixed costs (Luttmer 2007), or that firms have to pay a market penetration cost upon entry to earn positive profits (Arkolakis 2016). The importance of changes in business demography has also received attention in the macroeconomic literature, which studies how entry and exit dynamics affect business cycles (Hopenhayn 1992; Jaimovic & Floetotto 2008; Bilbiie et al. 2012; Clementi & Palazzo, 2017). In Bilbiie et al. (2012), for instance, the decision of a prospective entrepreneur to enter the market depends on the expected discounted future profits as well as on the sunk costs for entry, e.g. for setting up a business and develop products.

The relationship between exchange rate movements and firm dynamics has not been studied explicitly in theory. In the existing literature, firm dynamics over time are typically thought to be generated by permanent shocks to productivity or demand conditions. For example, a positive boost in productivity within an industry will increase profits and therefore stimulate the entry of new firms and reduce the exit of existing firms. This notion can be transferred to the case of exchange rate movements: An exchange rate appreciation lowers the profits in export-oriented

industries (i.e., positive net exposure). In general, the most unproductive net exposed firms will be driven out of the market relative to non-exposed or negatively exposed firms. In addition, prospective entrepreneurs are deterred from entry if expected discounted future profits fall due to exchange rate movements. Of course, the magnitude of these effects depends on the initial profit margin and the degree of market power: In industries with high market power and high profit margins, the effect is likely to be small, as firms are better able to absorb exchange rate shocks.

3.3. Summary

We have illustrated the theoretical channels depicted in Figure 2 in the case of a positive net exposure, meaning that firms generate more revenues on export markets than they pay for imported intermediate inputs. In this particular case, the theoretical predictions for both investments and organizational restructurings are quite clear. An appreciation of the real exchange rate decreases profits and therefore lowers investments and increases the likelihood that firms pursue organizational restricting. Hence, together, these two channels imply that the effect of an appreciation of the real exchange rate on productivity is ambiguous.

In the case of R&D expenditures, the theoretical predictions are even more complex. Seen from a static perspective, the literature suggests that an appreciation of the real exchange rate leads to a decrease in R&D expenditures, because liquidity constraints generally weigh heavier than opportunity costs. However, seen from a dynamic perspective, an appreciation of the real exchange rate could very well also lead to an increase in R&D expenditures. Consequently, the theoretical predictions of the static and the dynamic perspective counteract each other. Whether real exchange rate fluctuations have a positive or a negative effect on R&D expenditures thus remains a question that has to be settled empirically. Note that changes in R&D expenditures caused by potential trends in real exchange rates are very likely to be positively related to future productivity developments. In case real exchange rate appreciations lead to diminished R&D expenditures, it is very likely that productivity growth will be lower in the future.

Concerning business demography, theoretical considerations suggest that an appreciation of the exchange rate depresses employment growth within firms, increases exit of incumbent firms and deters entry of new firms.

4. Data Sources and Construction of Exchange Rates

This section presents the various data sources that are employed in the empirical analyses of this report. Section 4.1 contains only a brief overview of the three firm-level panel datasets that are employed in this report. The relevant features of these datasets and the construction of variables will be described in detail in the respective empirical sections below. In Section 4.2, we explain how industry-specific real effective exchange rates (REER) are constructed.

4.1. Firm-Level Datasets with Outcome Variables

Table 1 shows the firm-level datasets that contain the relevant outcome variables of interest. We draw on the Investment Survey and the Swiss Innovation Survey (SIS) of the KOF Economic Institute as well as on the Business Census Statistics of the Swiss Federal Statistical Office (SFSO). More in-depth descriptions are provided in the respective sections.

Table 1: Data Sources Containing Outcome Variables

Dataset	Source	Period	Outcomes studied
Swiss Innovation Survey (SIS)	KOF	1996-2015	R&D expenditures, cost reductions, labor productivity
Investment Survey	KOF	2011-2017	Investment
Business Census Statistics (German: *Betriebszählung, Statistik der Unternehmensstruktur*)	SFSO	1995-2014	Employment growth, firm exit

4.2. Industry-Specific Exchange Rates

The key causal variable throughout the report is the *real effective exchange rate* (REER). "Real" refers to the fact that exchange rate indices are adjusted for differences in inflation. "Effective" means that the exchange rate adequately reflects the mix of trading partner countries, that is, each bilateral exchange rate is appropriately weighted by the respective trade share. To account for the fact that the distribution of trading partners is heterogeneous across the economy, we construct *industry-specific* REERs.

4.2.1. Data Sources

The construction of industry-specific exchange rates requires several data sources, which are described below. Table 2 summarizes the relevant variables and the level of detail for which data is available.

Table 2: Variables and Data Sources for Constructing Industry-Specific Exchange Rates

variables	by producing industry	by using industry	by trading partner	time period, periodicity	source
exports and imports by end-use	yes	no	yes	1990-2015, annually	BTDIxE, OECD
imported and domestic intermediate inputs	yes	yes	no	2001, 2008	Swiss IOT, Nathani et al. (2014)
bilateral real exchange rates	-	-	yes	1990-2017, monthly	SNB

OECD Bilateral Trade Database by Industry and End-Use Category (BTDIxE): Bilateral trade data for Switzerland is available from 1990 to 2015 by industry, trading partner country and end-use category from the OECD. Industry codes are two-digit ISIC Rev. 4 which are equivalent to the two-digit NACE rev. 2. End-use is categorized as intermediate goods, household consumption goods and capital goods. In addition, there are five mixed end-use categories: computers, cars, phones, packed medicines and precious goods.

Input-output tables: Nathani et al. (2014) constructed input-output tables (IOT) for the years 2001 and 2008 for domestic and imported intermediate consumption of Swiss industries. The producing industries and using industries are classified according to NACE rev. 1.1. We use transition probabilities based on employment shares to convert the data to NACE rev. 2.

Bilateral real exchange rates: the time series are provided by the Swiss National Bank (SNB). We use monthly series from 1990 to 2016 for the 34 most important trading partner countries.[1] In addition, we use the series for the Euro area as a proxy for trade with "the rest of Europe" and the series for the US Dollar as a proxy for trade with "the rest of the world". For a number of smaller trading part-

[1] These are: Austria, Belgium/Luxemburg, Czech Republic, Germany, Denmark, Spain, Finland, France, the UK, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Russia, Sweden, Slovakia, Turkey, Brazil, Canada, Mexico, the United States, China, Hong Kong, India, Japan, South Korea, Saudi-Arabia, Singapore, Thailand and Australia.

ners, the starting date of the bilateral exchange rate series is later than 1990.[2] We use the series for the Euro area and the US Dollar to retropolate the bilateral series for these European and non-European countries, respectively, back to 1990.

4.2.2. Construction of REER Variables

Industry-specific REER variables may capture different types of exposure depending on the choice of trade weights. We define the following REER measures:

- *Export-weighted REER*: Bilateral series are weighted by the share of industry-level exports to the trading partners. → This captures the impact on export revenues.
- *Imported-inputs-weighted REER*: Bilateral series are weighted by the share of trading partners, from which domestic industries import intermediate products. → This captures the impact on input costs.
- *Import-weighted REER*: Bilateral series are weighted by the share of imports of products pertaining to the same industry from a foreign trading partner. → This captures the impact on import competition.
- *Net exposure REER*: A combination of the export weights and the imported-inputs weights. → This captures the first-order effect on profits (neglecting import competition).

The calculations proceed as follows. In a first step, we extract the permanent component of each bilateral real exchange rate by performing a Beveridge-Nelson decomposition of the time series (Campa & Goldberg 2001; Nucci & Pozzolo 2010; Kaiser & Siegenthaler 2016). The monthly time series of the permanent exchange rates are then averaged to obtain annual time series.

In a second step, industry-specific REERs are calculated by weighting bilateral exchange rates with the appropriate trade shares of the partner countries. Following the approach of the Bank of International Settlements (BIS), we use *chain-linked weighted geometric average growth rates.* Moreover, we lag the weights by three years to rule out potential simultaneity given that our main datasets exhibit three-year intervals.

The crucial point is to calculate the appropriate weights on the industry level. For the export- and import-weighted REER, the weights are directly based on the observed trade shares in the bilateral trade data. However, the construction of the

[2] This concerns the following 17 countries: Turkey, Poland, Czech Republic, Hungary, Slovakia, Greece, Finland, Russia, Brasil, Mexico, China, Hongkong, India, Singapor, Korea, Saudi Arabia and Thailand.

imported-inputs-weighted REER is more difficult because the corresponding trade shares are only observed on the aggregate level, but not *within industries*. Nevertheless, the IOT data and the trade data on imported intermediate goods can be combined to approximate the industry-specific weights (see Section A.1.2 for details). Finally, the *net exposure REER* is obtained by weighting the export-weighted and imported-inputs-weighted REER with the industry-specific shares of exports and imported intermediate inputs in gross output.

The reader is referred to Section A in the Appendix for a formal exposition on the construction of the weights and the various industry-specific REER measures.

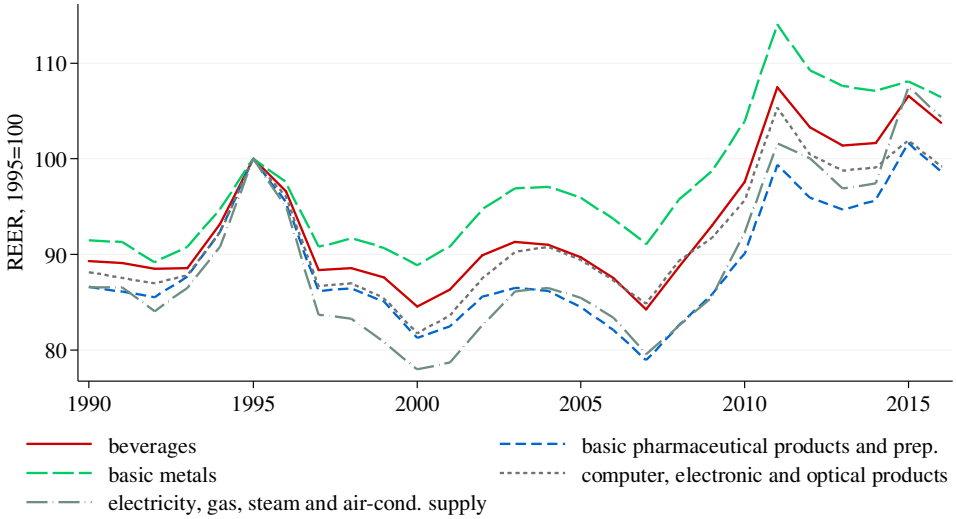
4.2.3. Descriptive Statistics

In Section A.2 in the Appendix, we document the country shares of trade on the industry level. Figure 23 in the Appendix illustrates that there is considerable heterogeneity with respect to industries' export destinations. For example, while energy products are only exported to the original Eurozone countries (Euro-12), most exports of basic metals go to major Asian countries and a sizable share of beverage products to the United States and Great Britain. Figure 24 shows that the variation in the origin countries of imports to Switzerland is less pronounced. In general, the trade share of Euro countries is higher for imports than for exports. Finally, Figure 25 shows the approximate country shares of intermediate inputs that Swiss industries import from abroad. Here the visible heterogeneity is smaller partly because certain industries are grouped together in the underlying data.

Figure 3 below presents our annual net exposure REER for selected industries during the period 1990 to 2016. Note that we choose 1995 as the reference year because it represents the beginning of the observation period in two of our empirical analyses. We see, for example, that industries were unevenly affected by the general depreciation of the Swiss franc from 1995 to 2000. While the REER for the industry "basic metals" dropped by only 10%, the decline was more than twice as large in the energy sector ("electricity, gas, steam and air-cond. supply"). More recently, when the currency peg on the Euro was lifted in January 2015, industries strongly exposed to the Euro, such as energy and pharmaceuticals, experienced a sharp rise in their effective exchange rate. In contrast, domestic producers of basic metals and computer, electronic and optical products (including watchmakers) were only moderately affected because their exports are more broadly diversified outside the Eurozone. For completeness, Figure 26 in the Appendix shows the average change in the REER for all industries.

Overall, the heterogeneous exposure of Swiss industries to specific bilateral exchange rate movements will be an important source of exogenous variation to estimate the effects of the REER on various firm-level outcomes.

Figure 3: REER Measure for Selected Industries



5. The Effects of Exchange Rates on Productivity, R&D, and Cost Reductions

5.1. Introduction

This section investigates the effect of real exchange rate fluctuations on the three firm level outcomes productivity, R&D, and cost reductions. All three outcome variables are investigated using the same dataset, the Swiss Innovation Survey (SIS), and are analyzed within the same econometric framework.

The most encompassing way to assess a potential non-neutrality of exchange rates on firms is to look at productivity outcomes. In the Swiss media there often appears the claim that appreciations of the Swiss Franc will eventually translate into higher firm productivity. This notion assumes that firms require external pressure to get rid of slack, restructure and innovate. The external constraint of an appreciation is seen as an inconvenient, but essentially beneficial trigger. To their own good, firms are forced to push forward to ever higher productivity levels. It is therefore key to assess whether this claim finds empirical support or whether firms are already at the technological frontier and thus have little room for potential productivity improvements. Our empirical analysis focuses on the short-term effects of real exchange rate swings with a horizon of two of three years. Long-term productivity improvements are hard to assess, as they are driven by too many confounding variables.

Another central focus of this chapter is the impact of real exchange rate movements on R&D expenditures. Private R&D expenditures are probably the most important determinant of long-run firm productivity. If real appreciations of the Swiss Franc have a negative effect on R&D expenditures, periods of strong real appreciations may severely diminish the future competitiveness of Swiss firms.

Finally, this chapter also assesses to extent to which firms respond to exchange rate fluctuations with measures to reduce costs. In the face of a real appreciation, cost reductions are an essential tool in restoring short-run productivity. A particular emphasis is laid on cost savings in the wake of introduction of process innovations.

5.2. Empirical Strategy

The econometric framework applied in this section is based on Campa and Goldberg (2001), Ekholm et al. (2012), and Kaiser and Siegenthaler (2016). The extent to which a firm is hit by currency movements depends on the degree of exposure of the firm to international markets. The econometric framework reflects this by modelling the counteracting channels through which real exchange rate fluctua-

tions can affect R&D expenditures: export revenues, imported intermediate inputs, and import competition. In the report as a whole, we focus on the initial net exposure of firms as the main treatment variable. Net exposure is defined as the export share minus the imported inputs share in total sales. It describes the degree to which firms are affected by real exchange rate shocks on a continuous scale. In order to identify the effect of the real exchange rate on the outcome variables, we interact the initial net exposure with the real exchange rate variable.

5.2.1. Regression Model

The empirical framework is described below using the example of R&D expenditures as the outcome of interest. Note that the basic specification is similar for the other outcomes, although the link function (linear vs. exponential) and the estimation method may be different.

We observe firm i in industry j and year t. The relevant observed outcome variable are the firm's R&D expenditures, $y_{it} \geq 0$. To take into account the fact that y_{it} may be often equal to zero, we use an exponential specification:

$$y_{it} = \exp\{\alpha_i + \theta_t + \gamma \ln R_{jt} + \delta(s_i \ln R_{jt}) + X_{it}\beta\}\,\varepsilon_{it}, \quad (1)$$
$$\text{for } i = 1, \ldots, N \text{ and } t = t_{0i}, \ldots, T_i,$$

where α_i is a firm-fixed effect that captures firm-specific unobserved heterogeneity in the level of R&D activities. The vector θ_t contains time dummies which account for macroeconomic effects common to all firms (such as interest rates, fiscal policy, regulatory changes etc.). The causal variable of interest is the log of the industry-specific REER, $\ln R_{jt}$, which is interacted with firms' initial net exposure, denoted by s_i. Finally, X_{it} is a vector of strictly exogenous covariates and ε_{it} is an idiosyncratic error term.

The effect of the REER is identified in the above model because the REER is *industry-specific* (varying across j and t) and because the effect of fluctuations in the real exchange rate depend on the firm-specific degree of initial exposure s_i. We assume that R_{jt} is exogenous to the individual firm, which appears to be a plausible assumption.

5.2.2. Estimation Method

The model is estimated using the *fixed effects Poisson estimator* with robust standard errors, which is a quasi-maximum likelihood estimator. As discussed in Wooldridge (2010, Ch. 18.7.4), this estimator has several attractive robustness properties:

- The fixed effect α_i is allowed to be arbitrarily correlated with the covariates in the model. This seems sensible given that the time-constant level of R&D activities (α_i) may be correlated with the exposure to exchange rates (s_i) and possibly also with other covariates.
- The correct specification of the conditional expectation function (CEF) is sufficient for the estimator to be consistent.[3]
- The distribution of y_{it} may be continuous or discrete. This means that the data need not be Poisson distributed.
- There is no restriction on the dependence between y_{it} and its lags.

The calculation of elasticities using the exponential model is straightforward. Taking the derivative of the CEF with respect to the REER and re-arranging terms yields the following expression for the elasticity:

$$\varepsilon_R(s_i) = (\gamma + \delta s_i)$$

Thus, we can calculate an average (or unconditional) elasticity in the population, $\varepsilon_R = \gamma + \delta E[s_i]$, or we can evaluate the elasticity at some specific value of firms' exposure to exchange rates, s_i.

5.3. Data

5.3.1. Swiss Innovation Surveys

In order to investigate the relationship between real exchange rate fluctuations and R&D-expenditures, cost reductions, and the productivity of firms, we make use of the Swiss Innovation Survey (SIS). The SIS is a recurrent survey based on the KOF enterprise panel. From 1996-2011 it was conducted every 3 years, from 2011-2015 every 2 years. The underlying KOF enterprise panel is a stratified random sample of about 6000 firms, drawn from the census of Swiss firms having more than 5 employees (full-time equivalent). Stratification is carried out on 34 industries (two-digit) and within each of those industries on three firm-size classes, covering the manufacturing, construction, and service sector (see Arvanitis et al. 2016 for a description of the most recent survey wave). For this report, we use only the subsample of manufacturing firms. There are three distinct reasons to justify this approach. First, manufacturing firms generally show a more pronounced international orientation than service or construction firms. Second, whereas manufacturing firms usually exhibit a high R&D propensity, service and construction firms

[3] The distributional assumption is not required that the estimator is consistent. Thus, there can be over- or underdispersion.

often pursue no R&D activities. Third, we can rely on industry-specific REERs only for the manufacturing sector. The inclusion of the service and construction sector to the analysis would markedly lower the precision of the estimates. Out of the about 6000 firms that are part of the KOF enterprise panel, 35% are manufacturing firms relevant for this report (i.e., without the energy, food, and textile industry). Since the response rates generally vary between 30% and 40%, we can make use of about 700 manufacturing firms in each cross-section. Without missing values, the total estimation sample thus reaches about 5400 firms (see Table 3). Since not all variables are available for all firms, the samples actually used can be much lower in some estimations (when, e.g., restricted to R&D active firms only).

Note that the stratification plan of the SIS implies that large firms are oversampled. This allows making statistical statements about large firms as well. A simple random sample of the Swiss economy would almost only contain the much more populous small firms. In order to account for the effect of firm size on our empirical results, we will in a separate estimation specification split the sample into different firm size classes. In order to assess potential biases inflicted by the non-response of firms to the written questionnaire, the KOF conducts a non-response analyses in every survey wave. To this end, the KOF carries out telephone interviews with a sample of 500 non-responding firms. They are asked about the most important questions such as R&D yes/no. Statistical analysis regularly shows that the answers do not differ between responding and non-responding firms.

5.3.2. Descriptive Statistics

Table 3 shows the descriptive statistics of the firm-level variables that we use for the empirical analysis. The distributions of all quantitative variables are highly right skewed. Whereas the average values of employees (FTE) is 207, the average value of sales is 105 million Swiss Francs, with maximum values reaching 15'170 employees and 31.1 billion Swiss Francs, respectively. The same is true for R&D expenditures; on average firms spend about 10 million Swiss Francs on R&D, with the maximum value of R&D expenditures reaching 3.4 billion Swiss Francs. Given the right skewed distribution of the continuous variables, it is appropriate to use an exponential specification.

The second half of Table 3 shows the variables used to construct the "treatment" variables, i.e. the variables indicating the extent to which firms are exposed to international markets. The descriptive statistics of these treatment variables are based on the sample of those firms that show positive R&D expenditures in at least one period. Note that all four treatment variables are measured as their initial value, meaning that the first observed value is used for all time periods and that the varia-

bles are thus time-invariant. In model (1), the respective main effects are absorbed by the firm fixed effect.

While the average initial export share of an R&D firm amounts to 44.7%, the average initial imported inputs share amounts to 13.1%. Subtraction of the average initial imported inputs share from the average initial export share therefore implies that the average initial net exposure of an R&D firm is 31.5%. Hence, on average, R&D firms are positively exposed to currency movements, i.e. they generate more export revenues abroad than they spend on imported inputs. Figure 4 presents a closer inspection of the distribution of the initial net exposure shares, using a kernel density plot. It reveals a bimodal distribution with a first peak at a slightly negative net exposure level and a second peak at a relatively high net exposure level of about 75%. These two observations align with the typical characterization of the Swiss manufacturing sector. On the one hand, we observe large amounts of imported goods, characterizing a developed economy with few raw materials, few primary goods, and many imported intermediate goods. On the other hand, we observe specialized high-tech firms supplying international markets with high-value products.

In the following list, we rank some examples of Swiss industries according to their respective *average* net exposure. This results in the following distribution:

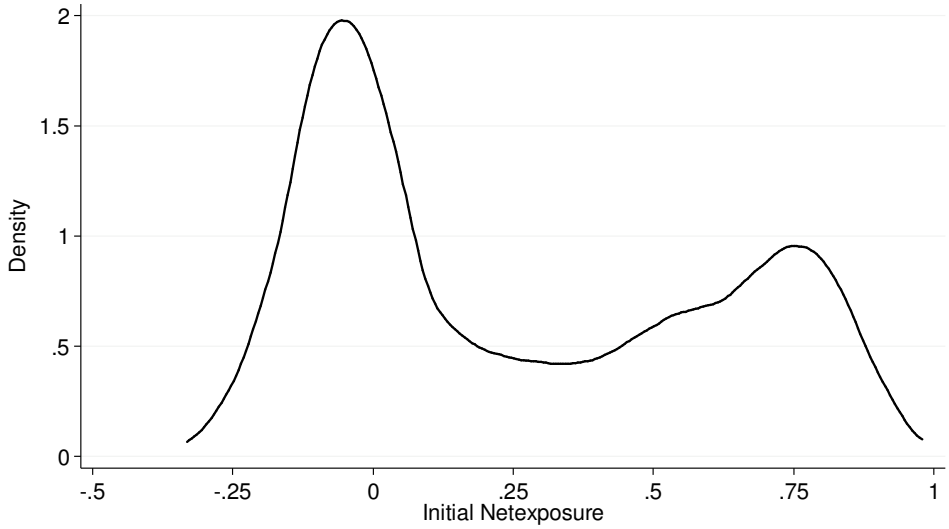
- High (35%-50%): Chemicals, Machinery, Electronics/Instruments, Electrical Engineering
- Medium (20%-35%): Pharma, Electrical Engineering, Automotives, Metal fabrication
- Low (0%-20%): Metal products, Plastics, Paper, Print, Minerals, Wood

Table 3: Definition and Descriptive Statistics of Variables

Variable	Definition and measurement	Obs	Mean	StdDev	Min	Max
Dependent variables						
$sales_{i,t}$	Sales in CHF	4977	105'000'000	913'000'000	99'800	31'100'000'000
$valadd_{i,t}$	Value added in CHF	4559	41'700'000	445'000'000	71'856	27'700'000'000
$empl_{i,t}$	Number of employees (FTE)	5402	207	726	1	15'170
$valadd\_pc_{i,t}$	Value added in CHF per employee	4550	156'474	236'493	4'039	14'000'000
$tfp_{i,t}$	Total factor productivity, natural log	2266	6'124	4'994	143	136'345
$rnd_{i,t}$	R&D activity yes/no	4337	0.735	0.441	0	1
$rndexp_{i,t}$	R&D expenditures	3406	9'921'805	129'000'000	0	3'400'000'000
$costred_{i,t}$	Cost reductions yes/no	2579	0.476	0.500	0	1
Independent variables (restricted to time-varying $rndexp_{i,t}$)						
NE_i	Net exposure, first observed value	3406	0.315	0.357	-0.331	0.78
$EXSH_i$	Export share, first observed value	3406	0.447	0.370	0	1
$IPSH_i$	Imported inputs share, first observed value	3406	0.131	0.070	0	0.374
$DMSH_i$	Domestic sales share, first observed value	3406	0.243	0.220	0	1.575

Notes: The table shows the summary statistics of the main variables of the KOF innovation survey used in the statistical analysis of Section 5. The variables consist of firm-period observations ranging in three year steps between 1996-2011 and in two year steps between 2011-2015. The number of observations for the different variables vary, as the panel is unbalanced and some variables do not appear in every survey wave. The independent variables are restricted to firms showing positive R&D expenditures in at least one period. The NE_i is defined as $EXSH_i$ minus the $IPSH_i$. Data source: Swiss Innovation Survey, KOF.

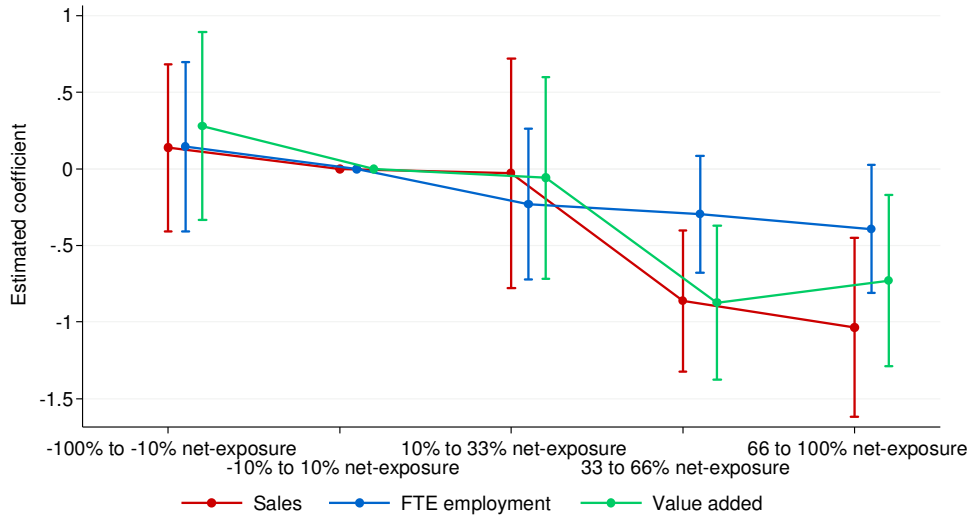
Figure 4: Distribution of initial net exposure of R&D active firms



Notes: The figure is a kernel density estimate of the initial net exposure variable used in the estimations of Section 5. The initial net exposure is calculated as the initial export share minus the initial imported inputs share and ranges from -1 to 1. The sample shown in this figure includes only firms that show positive R&D expenditures in at least one period. The average net exposure amounts to 0.315. Data source: Swiss Innovation Survey, KOF.

Figure 5 presents a plausibility test of the proposed empirical model. In particular, we use $sales_{i,t}$, $empl_{i,t}$, and $valadd_{i,t}$ as the dependent variables in model (1) to see whether we can reproduce, based on the SIS data, common findings from the literature (see Campa & Goldberg 2001; Nucci & Pozzolo 2010; Drechsel et. al. 2015; Kaiser & Siegenthaler 2016). As expected, we find that the higher firms' initial net exposure, the larger the negative effect of an appreciation of the real exchange rate on sales, value added, and employment of firms, respectively (see Figure 5). While the coefficients for sales and value added become significantly negative at a net exposure level ranging between 33% and 66%, we see no significant coefficients for employment. These results largely confirm the findings in the literature, providing additional reassurance about the quality of the data and the model applied in investigating our research questions.

Figure 5: Effect of REER on firm outcomes by net exposure level



Notes: Initial net exposure is divided into the 5 categories displayed on the x-axis. These categories are used as dummy variables in separate estimations of model (1). The category "-10% to 10% net-exposure" serves as the base category against which the other four categories are compared to. The y-axis shows to what extend the effects of the four separate categories differ from the base category. The effect of the net exposure REER on both sales and value added is significantly lower in the highest two net exposure categories than in the base category. Data source: Swiss Innovation Survey, KOF.

5.4. Empirical Results for Productivity

One of the most important questions is whether real exchange rate fluctuations have a significant effect on the competitiveness of those Swiss firms which earn a substantial part of their revenues on international markets. There are several indicators for firm-level competitiveness. However, in the innovation literature, value added and total factor productivity are the most commonly used measures (see Hall et al. 2010).

We use model (1) to estimate the direct effect of real exchange rate fluctuations on our proxies for productivity. Value added per employee is a productivity measure directly observed in the survey data. Total factor productivity (TFP), in contrast, is not observed by the researcher and has to be estimated. Using a standard Cobb-Douglas production function as a conceptual framework, TFP is equal to the error term of the production function. Olley and Pakes (1996) and Levinsohn und Petrin (2003) describe profound ways to separate productivity from the idiosyncratic errors on the micro-level. In this report, we pursue the Levinsohn and Petrin (2003) approach to estimate the unobserved TFP term, since it solves the truncation bias caused by the frequent observation of zero investments inherent to the approach by

Olley and Pakes (1996).[4] Note that all estimations control for the foreign demand development (trade-weighted GDP growth). This means we estimate the impact of real exchange rate changes, while controlling for the economic environment in the Swiss export destinations. This is especially relevant when considering that recessions in foreign economies often cause the Swiss Franc to appreciate (i.e., due to "save haven" effects).

Table 4 presents the exchange rate elasticities for five different outcome variables: sales, value added, employment, value added per employee, and TFP. The coefficients shown in Table 4 are the REER-outcome elasticities evaluated at the average net exposure of 31.5%. This means that the coefficients of Table 4 show the effect of the REER on the five outcome variables for an average manufacturing firm in Switzerland. Column 4 and 5 deserve our closest attention. Here we look at the effect of the real exchange rate on the two productivity measures value added per employee and TFP, both evaluated at the mean level of net exposure.[5] In both estimations, we see a significant and negative effect of real exchange rate appreciations on firm-level productivity. Conversely, a depreciation of the real exchange rate increases productivity of Swiss firms.[6] The economic values are significant in both cases. For example, a 10% real appreciation of the Swiss Franc decreases value added per employee by about 1.3% and total factor productivity by about 2.3%, respectively. Since we need investment data to calculate TFP, and investment data has only been available since the 2005 survey wave, the TFP estimation is based on less observations. Note that the observed negative effects refer to short-run productivity with a focus of about 1-2 years. Over longer time periods, productivity effects of real exchange rate fluctuations are hardly measurable, as in the long-run there are too many confounding factors interfering with the estimation.

[4] Levinsohn und Petrin (2003) extended the Olley and Pakes (1996) approach to solve the issue of endogenous labor and capital coefficients when estimating standard production functions. While Olley and Pakes (1996) use capital investments, Levinsohn and Petrin (2003) use intermediate inputs to proxy for the unobserved TFP term. Moreover, the Levinsohn and Petrin approach solves the truncation bias of the Olley and Pakes approach, which is caused by the fact that firm investments often take the value of zero. Olley and Pakes (1996: p. 1274) explicitly assume that labor is the only variable factor. However, both estimation approaches do not consider exchange rate fluctuations as covariates of TFP. Since our proxies for exchange rate fluctuations are exogenous to firm behavior, i.e. not correlated with the error in the mentioned TFP framework, we can easily introduce them to the model without violating the consistency of our estimation strategy.

[5] We also calculated the elasticities for a net exposure level of 100%. In the case of the TFP estimation, the economic value of an appreciation would become significantly larger; an appreciation of 10% would decrease TFP by 8% instead of the 1.9% observed at the mean net exposure.

[6] For the purpose of exposition, we focus on the effects of appreciations in the following.

We observe even stronger negative effects of real exchange rate appreciations on sales and value added (columns 1 and 2 of Table 4). The point estimate is largest for sales, followed by value added, TFP, and finally by value added per employee. The effect of the real exchange rate on employment is also negative, but considerably weaker than the effect on sales or value added. In light of labor market rigidities, this is not a surprising result; it is usually difficult to regain skilled staff after having dismissed it, which leads to labor hoarding behavior. It is also reasonable that more volatile measures like sales react faster and stronger than productivity measures.[7] The latter also contain production cost components. While real exchange rate appreciations have a negative effect on foreign demand, they have a positive effect on production cost reductions (see Section 5.6). However, the net effect remains negative, as shown by the productivity estimations in Table 4.

Importantly, the second variable in Table 4 shows that changes in import competition caused by exchange rate fluctuations do not significantly affect any of our five dependent variables. For example, an appreciation in the import REER does not lead to lower sales, even if the domestic sales share reaches a hundred percent. The other estimation specifications of this Chapter will similarly show that the import competition channel is only of minor importance for the overall REER effects.

[7] Kaiser and Siegenthaler (2016) detect a weak negative effect of the real exchange rate on employment as well, though not statistically significant. However, the more negative effect found in this report is clearly not statistically different from the less negative effect found in Kaiser and Siegenthaler (2016).

Table 4: Effect of the REER on Productivity Measures and Related Outcomes

VARIABLES	(1) ln(sales)	(2) ln(valadd)	(3) ln(empl)	(4) ln(valadd/pc)	(5) ln(TFP)
NE-REER$_{j,t}$ x $\overline{NE_i}$	-0.304***	-0.275***	-0.115*	-0.131*	-0.228**
	(0.087)	(0.087)	(0.069)	(0.068)	(0.088)
IM-REER$_{j,t}$ x $\overline{(1\text{-}EXSH_i)}$	-0.013	0.006	-0.010	0.024	0.052
	(0.046)	(0.046)	(0.034)	(0.030)	(0.034)
Observations	5,056	4,698	5,402	4,698	2,669
Number of firms	1,489	1,479	1,512	1,479	1,181
Industry-period FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1

Notes: The table shows the estimation results from the linear version of model (1) using the natural logarithms of sales, value added, employment, value added per employee, and total factor productivity as dependent variables. The estimation method is the OLS fixed effects estimator. The inclusion of industry-period fixed effects absorbs the two baseline variables net exposure REER and import REER. The first explanatory variables refers to the elasticity between the net exposure REER and the respective dependent variable, evaluated at the average net exposure of the estimation sample. For example, for a firm with an average net exposure, a 10% appreciation of the REER lowers firm sales by 3.04% on average. The second explanatory variable refers to the elasticity between the import REER and the respective dependent variable, evaluated at the average share of goods sold on the domestic markets of the estimation sample. The variable "foreign demand", i.e., the trade-weighted GDP growth of the export destinations, is included as a control variable in all estimations.

In sum, the results show a large negative relationship between real exchange rate fluctuations and the revenue measures sales and value added, with observed elasticities of about -0.3. Hence, firm revenues contract strongly in the face of an appreciation. Real exchange rate appreciations also have a negative effect on the two applied productivity measures value added per employee and TFP, although the elasticities are somewhat smaller. This latter result implies that firms tend to react to appreciations with cost reductions. The slightly negative effect of the real exchange rate appreciations on employment suggest that a part of the cost reductions happen through reducing total employment.

5.5. Empirical Results for R&D-Expenditures

In the following subsections, we will investigate whether real exchange rate fluctuations also have an indirect effect on the competitiveness of Swiss firms through influencing firms' incentives and capacities to invest in R&D and to reduce production costs. In the classical Cobb-Douglas production function, productivity is determined by the two factor inputs capital and labor. The aggregated capital variable comprises two types of capital: physical capital and the so-called knowledge

capital. While physical capital refers to gross investments (see section 6), knowledge capital refers to R&D investments (see Hall et al. 2011).

As discussed in the literature review, there does not exist convincing firm-level evidence that links real exchange rate fluctuations to R&D expenditures. Moreover, one cannot easily transfer the existing firm-level results regarding fixed capital investments to R&D investments. It is less severe in a technologically driven economy like Switzerland if exchange rate appreciations cause a temporary weakness in gross physical investments. Firms can usually easily catch-up in economically better times. However, it is much more difficult to catch up in R&D and knowledge creation, especially when the distance to the knowledge frontier increases. This might cause a permanent shift to lower productivity levels and a loss in competitiveness.

5.5.1. Exchange Rate Fluctuations and the R&D Propensity

Table 5 presents the effects of real exchange rate fluctuations on the R&D propensity, i.e., whether firms have pursued any R&D activity or not. We use a fixed effects logit estimator to study this binary outcome variable, but we have also conducted affirmative robustness checks with a standard OLS fixed effects estimator. Applying model (1) with the propensity of R&D as the dependent variable, we do not see any significant effects of real exchange rate fluctuations for the period under investigation. Real exchange rate fluctuations do not seem to drive firms to exit or enter R&D activity. This is not a surprising result, given the high fixed costs associated with R&D activity. Such fixed costs also act as a barrier to exit the R&D market, since they turn into so-called “sunk” costs, meaning that they are hardly recoverable by, e.g. selling the equipment or selling the accumulated knowledge (see Sutton 1992). This is also the main reason why the volatility of the R&D propensity is relatively low over time.

Table 5: Elasticity of the R&D Propensity (yes/no)

VARIABLES	FE Logit $rnd_{i,t}$
NE-REER$_{j,t}$ x $\overline{NE_i}$	0.056
	(0.396)
IM-REER$_{j,t}$ x $\overline{(1\text{-}EXSH_i)}$	0.344
	(0.250)
Observations	2,308
Number of firms	581
Period FE	Yes
Firm FE	Yes
p-value baseline coef = 0	0.11
*** p<0.01, ** p<0.05, * p<0.1	

Notes: The table shows the estimation results from the Logit version of model (1) using the binary indicator for R&D activities (yes/no) as the dependent variable. The estimation method is the logit fixed effects estimator. The baseline net exposure REER and the basline import REER are omitted, since they are together not significantly different from zero (p-value=0.11). The first explanatory variables refers to the elasticity between the net exposure REER and the probability to run R&D activities for a firm with an average net exposure. The second explanatory variable refers to the elasticity between the import REER and the probability to run R&D activities for a firm with an average share of goods sold on the domestic markets. The variable "foreign demand", i.e., the trade-weighted GDP growth of the export destinations, is included as a control variable.

5.5.2. Real Exchange Rate Fluctuations and R&D Expenditures

Variation is much higher if we look at the positive levels of R&D expenditures. As described in the theoretical part of this report, R&D expenditures tend to move in line with the macroeconomic business cycle, because R&D expenditures are to a large extend determined by cash-flows, which fluctuate pro-cyclically, too. Using model (1) with R&D expenditures as the dependent variable, Table 6 shows that real appreciations of the Swiss Franc have a significantly negative effect on R&D expenditures, as theoretically expected. The economic effect is quite substantial; for a firm with an average net exposure (=0.315), a 10% real appreciation of the Swiss Franc leads to a 17% reduction in R&D expenditures. The second variable in Table 6 shows that the import competition channel is only of minor importance also for the development of R&D expenditures. Fluctuations in the import real effective exchange rate do not significantly affect R&D expenditures, even in the case of a high domestic sales share and thus a high actual import exposure.

Table 6: Elasticity of R&D Expenditures

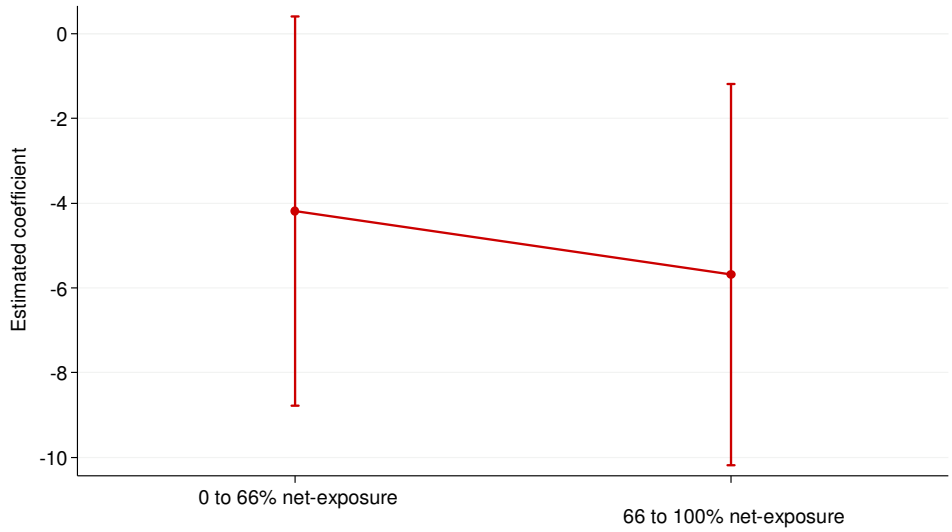
VARIABLES	FE Poisson $rndexp_{i,t}$
$NE\text{-}REER_{j,t} \times \overline{NE_i}$	-1.725** (0.823)
$IM\text{-}REER_{j,t} \times \overline{(1\text{-}EXSH_i)}$	0.222 (0.335)
Observations	3,406
Number of firms	960
Period FE	Yes
Firm FE	Yes
p-value baseline coef = 0	0.46
*** p<0.01, ** p<0.05, * p<0.1	

Notes: The table shows the estimation results from model (1) using R&D expenditures as the dependent variable. The estimation method is the Poisson fixed effects estimator. The estimation can rely on significantly more observations than the estimation in Table 3, since the logit fixed effects estimator drops firms where R&D expenditures are always positive. The baseline net exposure REER and the baseline import REER are omitted, since they are together not significantly different from zero (p-value=0.46). The first explanatory variable refers to the elasticity between the net exposure REER and R&D expenditures for a firm with an average net exposure. The second explanatory variable refers to the elasticity between the import REER and R&D expenditures for a firm with an average share of goods sold on the domestic markets. The variable "foreign demand", i.e., the trade-weighted GDP growth of the export destinations, is included as a control variable.

The negative impact of exchange rate appreciations on R&D expenditures is driven by firms with a large net exposure; firms with a higher net-exposure are more strongly affected than firms with a lower, still positive net-exposure (see Figure 6). Because R&D affects firm performance only with a considerable time lag, it is unlikely that these negative consequences of the appreciation will be immediately mirrored in lower competitiveness of firms. However, in the long-run, a shift towards less R&D intensive innovation activities could decisively affect overall firm productivity levels. Such a scenario seems likely if the real appreciation of the Swiss Franc is persistent, if firms fail to unlock means for funding R&D activities or if they cannot switch production to more competitive foreign destinations.[8]

[8] The latter strategy is more likely if firms already foreign production sites or at least experiences with foreign R&D activities (e.g. foreign R&D contracts), meaning that they can avoid large and risky upfront investments.

Figure 6: Elasticity of R&D expenditures for different levels of net exposure



Notes: This figure maps the increase in the elasticity between the net exposure REER and R&D expenditures for higher values of the average next exposure. The net exposure is divided into the 2 categories visible on the x-axis: 0-66% net exposure and 66-100% net exposure. While firms in the 0-66% net exposure category show no significant effect of the REER on R&D expenditures, firms in the 66-100% net exposure category show a significantly negative effect of the REER on R&D expenditures, visible by the distance of the right-hand confidence interval away from the top value of "0". Data source: Swiss Innovation Survey, KOF

5.5.3. Exchange Rate Fluctuations and R&D Expenditures – Heterogeneity by PCM and Firm Size

In this section, we investigate whether the negative effect of real exchange rate appreciations on R&D expenditures is heterogeneous. Even among firms with positive net exposures, an appreciation of the Swiss Franc might not hit all firms in the same way. In particular, we study how firms' price-cost margin and firm size interact with the negative REER-R&D elasticity. For example, large firms may differ from small firms in the extent to which they pass on exchange rate fluctuations to consumers.

Table 7 demonstrates the importance of internal funding for firms' R&D expenditures. The price-cost margin over sales ratio (PCM/SALES) serves as a proxy for the internal availability of financial means. It is the share of sales that remains within the firm after subtracting the share of wages in sales and the share of intermediate inputs in sales. Firms with a high PCM/SALES ratio usually have substantial cash-flows for all kinds of investments available, including R&D. Hence, they may not pass on real exchange rate fluctuations to their R&D expenditures. Note that the PCM/SALES ratio also serves as a proxy for the market power of a firm.

Table 7: Elasticity of R&D Expenditures, Sample Split by PCM/SALES Ratio

VARIABLES	rndexp 1st tercile	rndexp 2nd tercile	rndexp 3rd tercile
NE-REER$_{j,t}$ x $\overline{NE_i}$	-2.099***	-1.480	0.977
	(0.584)	(1.055)	(0.687)
IM-REER$_{j,t}$ x $\overline{(1\text{-}EXSH_i)}$	-0.490	0.024	-0.080
	(0.304)	(0.382)	(0.320)
Observations	1,041	943	1,019
Number of firms	300	256	281
Period FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1

Notes: The table uses the exact same approach as Table 6; it applies model (1) with R&D expenditures as the dependent variable. The estimation method is again the Poisson fixed effects estimator. The difference is that the sample is split, along the PCM/SALES ratio, into three equally sized subsamples. The PCM/SALES ratio is the share of sales that remains in the firm after paying for wages and intermediate inputs. The first column contains the firms in the lowest PCM/SALES ratio tercile, the third column the firms in the highest PCM/SALES ratio tercile. The two explanatory variables are the same ones as in the previous Tables, whereby the elasticities between the REER and the R&D expenditures are evaluated at the average net exposure as well as the average domestic sales share of the respective PCM/SALES ratio subsample. The variable "foreign demand", i.e., the trade-weighted GDP growth of the export destinations, is included as a control variable in all estimations.

Table 7 shows that firms with a low PCM/SALES ratio reduce their R&D expenditures disproportionately. For firms up to the 33rd percentile of the PCM/SALES distribution, a 10% real appreciation lowers R&D expenditures by about 21%. Among firms with low cash-flows, real exchange rates fully translate into lower R&D expenditures. The effect on R&D expenditures is also negative but not significant for firms between the 33rd percentile and the 66th percentile. Although not significant, the effect reverses and becomes positive for firms in the highest PCM/SALES tercile. This confirms the theoretical considerations outlined in Section 3; internal funds are of utmost importance for R&D investments. Firms with large internal funds react counter-cyclically to real exchange rate fluctuations. Profiting from lower opportunity costs, they increase their efforts to generate innovative products to regain their international competitiveness. Overall, Table 7 suggests that real exchange rate appreciations diminish the R&D efforts of less profitable firms, possibly increasing the innovation gap within a currency area.

However, the picture obtained in Table 7 is challenged when we investigate the real exchange rate effects for different firm size classes in Table 8. Surprisingly, it shows that, in the face of a real appreciation, very small firms with less than 25 employees actually increase their R&D expenditures, while only large firms with

more than 250 employees decrease their R&D expenditures. The economic effects are quite different for the two firm size classes. A 10% real appreciation of the exchange rate yields a 15% increase in R&D expenditures for very small firms and a 34% decrease in R&D expenditures for large firms. Hence, the observed overall negative effect of real exchange rate fluctuation on R&D expenditures is driven by large firms.

Table 8: Elasticity of R&D Expenditures, Sample Split by Firm Size

	(1)	(2)	(3)	(4)	(5)
	rndexp	rndexp	rndexp	rndexp	rndexp
VARIABLES	X<25	25<=X<50	50<=X<100	100<=X<250	X>=250
$NE\text{-}REER_{j,t} \times \overline{NE_i}$	1.532***	0.194	-0.163	-0.088	-3.451***
	(0.476)	(0.477)	(0.893)	(1.000)	(1.241)
$IM\text{-}REER_{j,t} \times \overline{(1\text{-}EXSH_i)}$	-0.211	0.907	-0.235	-0.129	0.235
	(0.459)	(0.717)	(0.313)	(0.255)	(0.344)
Observations	612	570	694	885	645
Number of firms	179	166	185	250	180
Period FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1

Notes: The table uses the exact same approach as Table 6; it applies model (1) with R&D expenditures as the dependent variable. The estimation method is again the Poisson fixed effects estimator. In this table, the sample is split into 5 different subsamples ordered from left to right by the number of the firms' employees. The first column contains the firms with less than 25 employees, the fifth column contains the firms with more than 250 employees. The elasticities between the REER and the R&D expenditures are evaluated at the average net exposure as well as the average domestic sales share of the respective frim size subsample. The variable "foreign demand", i.e., the trade-weighted GDP growth of the export destinations, is included as a control variable in all estimations.

In order to better understand these results, we consult the descriptive statistics of the two firm size classes. Here, we see that very small firms (X<25) show an on average low net exposure of 21% (the sample average is 31%) and a relatively high PCM/SALES ratio of 27%. Most importantly, they are very R&D intensive firms with an average sales share of R&D expenditures of 5.4%. In contrast, we see that the largest firms in our sample (X>250) have a high net exposure of 46%, an average PCM/SALES ratio of 23%, and an R&D intensity of about 4.2%. Moreover, they are more frequently exposed to intensive price competition (4.14 on a 5 point Likert scale) compared to the group of the very small firms (3.8 on a 5 point Likert scale).

Given this descriptive information, we conclude that very small, R&D intensive firms with low net exposure and low price-related competition actually increase their R&D expenditures in the face of a real appreciation. They are obviously able to make use of the lower opportunity costs prevalent in times of a real exchange rate appreciation. In contrast, large, highly exposed firms facing high-levels of price competition decrease their R&D expenditures in the face of a real appreciation.

These findings could have important structural implications. The real appreciation of the Swiss Franc might increase the growth potential of small, R&D intensive firms and decrease it for large, internationally exposed R&D intensive firms. Switzerland might become a less attractive destination for large, foreign high-tech firms, with consequences for employment and domestic growth. It is doubtful that the growth of R&D in small domestic firms could compensate for such a development.

Table 9 further reveals that large firms located in Switzerland tend to shed R&D employment in response to a real exchange rate appreciation, which implies a loss of skills that will be difficult to regain if the real exchange rate depreciates again, challenging the competitiveness of such large firms in a long term perspective.

Table 9: R&D employees, only firms >250 employees overall

VARIABLES	FE poisson R&D-Empl
NE-REER$_{j,t}$ x $\overline{NE_i}$	-0.995*
	(0.567)
IM-REER$_{j,t}$ x $\overline{(1\text{-}EXSH_i)}$	-0.033
	(0.106)
Observations	596
Number of firms	173
Period FE	Yes
Firm FE	Yes
*** p<0.01, ** p<0.05, * p<0.1	

Notes: The table shows the estimation results from model (1) using the variable number of R&D employees as the dependent variable. The estimation method is the Poisson fixed effects estimator. The sample contains only large firms with more than 250 employees. The first explanatory variables refers to the elasticity between the net exposure REER and R&D employment for the average net exposure of a large firm (X>250). The second explanatory variable refers to the elasticity between the import REER and R&D employment for the average share of goods sold on the domestic market of a large firm (X>250). The variable "foreign demand", i.e., the trade-weighted GDP growth of the export destinations, is included as a control variable.

5.5.4. Exchange Rate Fluctuations and R&D Expenditures – Asymmetry

Finally, we consider whether real exchange rate fluctuations have asymmetric effects on R&D expenditures, meaning that, for example, appreciations decrease R&D expenditures by more than depreciations increase them. To this end, we create the dummy variable "$Appr_{j,t}$", which takes the value "1" if the net exposure REER increased in the respective period and "0" if it decreased. Column 1 of Table 10 shows the interaction between this dummy variable and our main explanatory variable $NE\text{-}REER_{j,t}$ x NE_i. Strikingly, all variables become insignificant. This indicates that our baseline results in Table 6 are not one-sidedly driven by either appreciations or depreciations. Real exchange rate fluctuations have only a significantly negative effect on R&D expenditures when both types of fluctuations, ups and downs, are simultaneously taken into account. In order to investigate longer-term variation in real exchange rates, we split the sample along the sample year 2002. While the real Swiss Franc depreciated from 1995 to 2000, it somewhat appreciated from 2000 to 2007, and then, after the financial crisis, strongly appreciated from 2007 on. Hence, column 2 shows the estimation of model (1) for a period with a depreciation trend and column 3 the respective estimation for a period with an appreciation trend. Similar to the results in Table 6, we see in both time periods a significantly negative effect of real exchange rate appreciations on R&D expenditures. The negative effect seems to even be somewhat more pronounced in the period with the depreciation trend.

Table 10: Appreciation/Depreciation sample split

VARIABLES	(1) FE Poisson rndexp Appr 0/1	(2) FE Poisson rndexp Year<2002	(3) FE Poisson rndexp Year>=2002
NE-REERj,t x $\overline{NEi}$	-0.956	-3.601***	-2.227***
	(0.929)	(1.237])	(0.834)
IM-REERj,t x $\overline{(1\text{-}EXSHi)}$	0.222	0.812	0.187
	(0.353)	(0.966)	(0.195)
Apprj,t	0.067		
	(0.188)		
NE-REERj,t x $\overline{NEi}$ x Apprj,t	-0.054		
	(0.054)		
Observations	3,014	863	1,867
Number of firms	874	385	623
Period FE	Yes	Yes	Yes
Firm FE	Yes	Firm FE	Yes
*** p<0.01, ** p<0.05, * p<0.1			

Notes: The table uses the exact same approach as Table 6, it applies model (1) with R&D expenditures as the dependent variable. The estimation method is the Poisson fixed effects estimator. The additional variable $Appr_{j,t}$ is coded as 1 if the NE-$REER_{j,t}$ increased in the respective period and 0 if it decreased. The first column contains an interaction between the REER-R&D elasticity and the $Appr_{j,t}$ dummy. The second and the third column are sample splits, divided along the year 2002. The second column contains the real depreciation periods before 2001 and the third column the real appreciation periods from 2001 on. The variable "foreign demand", i.e., the trade-weighted GDP growth of the export destinations, is included as a control variable in all estimations.

5.5.5. Exchange Rate Fluctuations and R&D Expenditures - Summary

The question whether real appreciations have a negative effect on R&D expenditures is important because holding back R&D might lead to a permanent loss in international competitiveness. In order to not miss out on technologies developed by competitors, firms have to constantly maintain their R&D expenditures. The results of this section show that there is no evidence for an effect of real exchange rate fluctuations on the decision of firms to enter or exit R&D activity. In sharp contrast, a 10% real appreciation of the Swiss Franc leads on average to a 17% decrease in R&D expenditures. Note that this negative elasticity does not imply that firms have decreased their R&D expenditures since the real appreciation phase of the Swiss Franc starting in 2007. After all, the descriptive statistics of the BFS (2017) show that R&D expenditures have continuously increased over this time period. It rather demonstrates that in absence of this substantial real appreciation

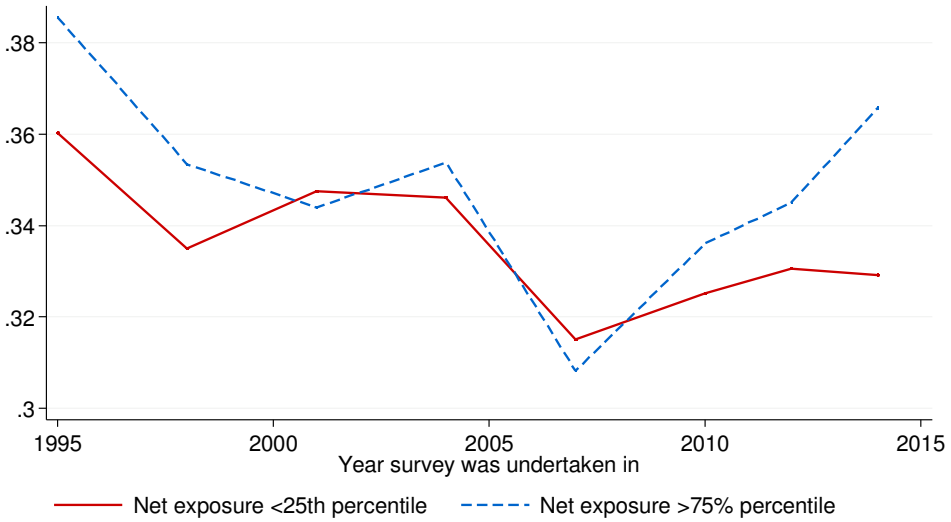
phase firms would have increased their R&D expenditures by even more. The observed negative elasticity is largely driven by firms with a low PCM/SALES ratio. Since these firms have only little financial excess resources available, they have no other option than to pass on real exchange rate movements to their R&D expenditures. In contrast, firms with high PCM/SALES ratios seem to pursue a forward strategy; they increase their R&D expenditures in the face of a real appreciation. Interestingly, only larger firms reduce R&D expenditures as a reaction to real exchange rate appreciations. Very small firms with less than 25 employees even follow a countercyclical R&D spending pattern. Finally, there is no difference in the effect of real appreciations and real depreciations on R&D expenditures, the exchange rate effect seems to be symmetric.

5.6. Empirical Results for Production Costs Reductions

This section deals with the question to what extent real exchange rate swings cause firms to take measures to reduce their production costs. The real appreciation of a currency increases the pressure on domestic firms to reduce their production costs in order to compensate for the ensuing loss in international competitiveness. Firms with a negative net exposure enjoy an "automatic" reduction in their production costs, since an appreciation of the currency decreases the prices for imported intermediate inputs. However, for firms with a positive net exposure, cost reductions are more difficult to achieve. They have to actively pursue measures to lower their production costs. The three most common measures are: i) switching suppliers, ii) decreasing labor costs, and iii) employing more efficient production technologies.

To investigate this question in more detail, we can use two firm level variables of the SIS: the share of labor costs in sales as well as the share of intermediate input costs in sales. Next to the costs of capital, these two variables are the key determinants of the cost basis of a firm. If firms want to compensate decreases in their revenues with cost reductions, they need to curtail either labor costs or intermediate input costs. The descriptive information on the development of the share of intermediate input costs in sales and the share of labor costs in sales reveals the expected trends. Until 2007, when the Swiss Franc mostly depreciated, the share of labor costs in sales had decreased significantly, while in the ensuing appreciation period after 2008, it has markedly increased. Figure 7 shows that in the appreciation period the share of labor costs in sales rose more strongly for firms with a high net exposure (above the 75^{th} percentile) as compared to firms with a low net exposure (below the 25^{th} percentile). Hence, the pressure to remain competitive by reducing labor costs was much greater for firms with a high net exposure.

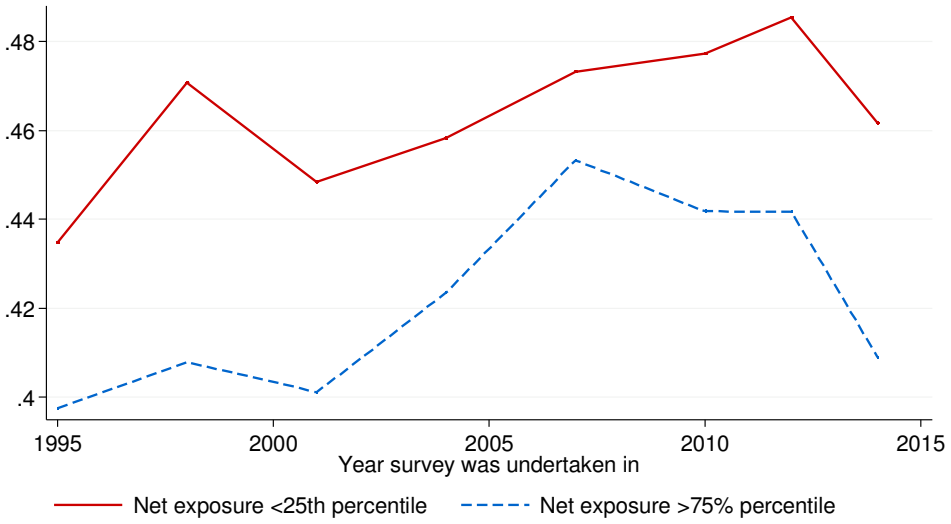
Figure 7: Development of the Average Share of Labor Costs in Total Sales:



Notes: The figure shows the development of the average firm labor share over the observed sample period. The firm labor share is defined as the sum of wage expenses relative to sales. The red line is the average firm labor share for firms in the lowest net exposure quartile. The blue line is the average firm labor share for firms in the highest net exposure quartile. Data source: Swiss Innovation Survey, KOF

Figure 8 shows that after 2008 the share of intermediate input costs in sales has decreased more for firms with a high net exposure as compared to firms with a low net-exposure. While firms with a low net exposure saw an increase in their share of intermediate input costs until 2012, firms with a high net exposure started reducing their share of intermediate input costs already after 2007. Most likely, these firms took additional measures to lower their production costs (switch suppliers, outsource activities, change production methods, etc). However, it is not clear whether the overall effect of exchange rate fluctuations on production cost reductions is positive or negative, since we see both, increasing labor cost shares and decreasing input cost shares. An answer to this question requires an econometric analysis.

Figure 8: Development of the Average Share of Intermediate Input Costs in Total Sales



Notes: The figure shows the development of the average share of intermediate input costs over the observed sample period. The share of intermediate input costs is defined as the amount a firm spends on intermediate inputs divided by the firm's sales. The red line is the average share of intermediate inputs for firms in the lowest net exposure quartile. The blue line is the average share of intermediate inputs for firms in the highest net exposure quartile. Data source: Swiss Innovation Survey, KOF

Table 11 presents the estimation results of model (1) with the binary variable whether process innovations led to significant cost reductions (yes/no) as the dependent variable. In addition to a Logit random effects estimation, we also run OLS random effects and fixed effects estimations. Mirroring the theoretical considerations in Section 3, we see that real exchange rate fluctuation are significantly positively related to the probability that firms have introduced process innovations that led to significant cost reductions. However, these results have to be interpreted carefully, since the results of the Logit random effects estimation might be driven by unobserved heterogeneity (time invariant). In this respect, the OLS FE estimation shows a negative, but not significant effect on the probability to have achieved cost reductions. Since the applied dependent variable has a relatively low time variance, it is, however, not clear whether the latter results are more trustworthy.

Table 11: Cost Reductions through Process Innovations yes/no

VARIABLES	RE Logit costred	RE OLS costred	FE OLS costred
NE-REER$_{j,t}$ x $\overline{NE_i}$	0.092***	0.013***	-0.113
	(0.020)	(0.003)	(0.079)
IM-REER$_{j,t}$ x $\overline{(1\text{-}EXSH_i)}$	0.136	0.019	0.036
	(0.086)	(0.012)	(0.032)
Observations	4,609	4,609	4,783
Number of firms	1,505	1,505	1,508
Industry-period FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
*** p<0.01, ** p<0.05, * p<0.1			

Notes: The table shows the estimation results from model (1) using the binary indicator whether the firm has implemented process innovations that led to cost reductions (yes/no) as dependent variable. The estimation method of the first column is the Logit random effects estimator. The second and the third columns apply the OLS random effects and the OLS fixed effects estimator, respectively. The first explanatory variables refers to the elasticity between the net exposure REER and the probability of cost reductions for a firm with an average net exposure. The second explanatory variable refers to the elasticity between the import REER and the probability of cost reductions for a firm with an average share of goods sold on the domestic markets. The variable "foreign demand", i.e., the trade-weighted GDP growth in the export destinations, is included as a control variable in all estimations.

In sum, the results regarding cost reductions are somewhat inconclusive. For net exposed firms, we observe an increase in relative labor costs and a decrease in relative intermediate input costs. Hence, there is no unambiguous decrease in the cost basis of net exposed firms. In contrast, Table 11 indicates that real exchange rate appreciations increase the probability that firms have implemented process innovations that led to significant cost reductions. However, the effect is not really robust to time invariant omitted variables. We therefore observe that net exposed firms react to a real appreciation by the introduction of process innovations that led to production cost reductions, but we cannot say whether there is indeed a causal impact of the real exchange rate on the probability to implement cost reductions.

5.7. Summary

Main findings

In this chapter, we have examined in a first step the effect of exchange rate appreciations on several performance variables in order to reproduce the estimation results obtained in the existing literature. The results provide re-assurance regarding the estimation strategy and the quality of the data. In a second step, we investigate the causal relationship between real exchange rate fluctuations and two important

productivity measures: value added per employee and total factor productivity (TFP). We find a significantly negative effect of real exchange rate appreciations on both productivity measures. A 10% real appreciation of the Swiss Franc decreases value added per employee by 1.3% and TFP by 2.2%.

In the longer term, productivity is also decisively influenced by R&D expenditures and production cost reductions. R&D expenditures increase the knowledge capital of the firm, leading to new, innovative products, which will in turn translate into increased firm sales. Process innovations frequently reduce production costs and – given constant sales – increase productivity and competitiveness. Thus, in a third step, we investigate the impact of real exchange rate fluctuations on these two outcome variables. We find a statistically significant negative effect of real exchange rate appreciations on R&D expenditures. The economic significance is considerable: For an average net exposure level, a 10% real appreciation of the Swiss Franc leads to a 17% decrease in R&D expenditures. The effect of a depreciation appears to be symmetric. In addition, we also find a significantly positive effect of real exchange rate appreciations on production cost reductions, pointing at additional efforts of firms to increase their competitiveness.

Further investigation of the real exchange rate effects on R&D reveal some interesting patterns. We find that more profitable firms with greater internal funds are likely to act "countercyclically", i.e., increase R&D if the exchange rate appreciates. They appear to make use of lower opportunity costs to increase their efforts to develop new, innovative products. In contrast, less profitable firm act "procyclically", they decrease their R&D efforts in the face of a real exchange rate appreciation. Hence, a persistent overvaluation might increase (ceteris paribus) the innovation performance gap in the longer run.

With respect to firm size classes, the overall negative effect of real exchange rate appreciations on R&D expenditures is driven by large firms with high levels of net-exposure, facing intensive price competition. In contrast, we detect a segment of very small exposed firms that increases its R&D expenditures when faced with a currency appreciation. These firms are characterized by relatively low levels of net-exposure, great R&D intensity, and relatively low levels of price competition (niche players).

Overall, these results suggest that real appreciations of the Swiss Franc might hinder the growth development of large, internationally exposed R&D intensive firms. This could have adverse consequences for future aggregate employment and economic growth in Switzerland. After all, the Swiss economy is dependent on the performance of the large, R&D intensive high-tech firms. The observed countercy-

clical R&D spending patterns of very small firms are unlikely to sufficiently compensate for this downscaling in R&D.

Implications for Structural Change

Given a persistently strong currency, the findings of this section might have considerable structural implications. Although the presented results are not entirely conclusive, they provide a starting point for further investigations. First, if the pressure on the production costs of Swiss firms with high levels of net exposure persists, they might further push the substitution of domestic suppliers with foreign ones. Second, manufacturing firms usually have higher levels of net-exposure than service firms. This might accelerate a structural shift – in terms of value added and employment – towards the service sector. Third, larger firms tend to decrease their R&D expenditures and R&D employment in Switzerland. This indicates that an appreciation reduces Switzerland's attractiveness as a destination for large, R&D intensive international firms. Fourth, small domestic firms often act as (specialized) suppliers for large firms. This symbiotic relationship requires large, R&D intensive firms in the domestic market. The observed domestic downsizing of larger firms, or the shift of R&D investments to foreign destinations, may thus feed back to the performance of smaller suppliers. Investigation of the domestic supply chain would be – among others – an important field for future research.

However, we also identified a group of small, R&D intensive firms, so-called "niche players" that increase their R&D expenditures. They adapt to the appreciation in a different way and might benefit from it in the longer run in terms of productivity and employment growth. The appreciation also increases the cost-consciousness of Swiss firms significantly, which might provide an additional impulse to their competitiveness when the currency depreciates.

6. The Effect of the "Franc Shock" on Investment

6.1. Introduction

In this section, we study the short-run effects of the strong and unexpected appreciation of the real exchange rate in Switzerland in early 2015 on firms' equipment, construction, and R&D investments, and their foreign direct investment (FDI). The appreciation was the consequence of the decision of the Swiss National Bank (SNB) to lift the floor on the Swiss Franc that it had entertained relative to the Euro. The SNB had implemented this floor in September 2011 to stop the strong appreciation of the currency in the preceding quarters, which put deflationary pressures on the Swiss economy. It decidedly defended the peg in the subsequent years. Studies analyzing the exchange rate floor in financial markets suggest that it was very credible (Buchholz et al., 2016; Hertrich & Zimmermann, 2015; Janssen & Studer, 2017; Mirkov, Pozdeev & Söderlind, 2016).

The exchange rate shock that followed the decision to lift the floor——soon termed "Franc shock" in Switzerland——led to an immediate and strong appreciation of the Swiss franc that was perceived to be permanent by firms, business cycle forecasters, and financial analysts (Buchholz et al., 2016; Kaufmann and Renkin, 2017).[9] The Franc shock is an almost ideal setting to study the investment consequences of a strong and sudden appreciation of the home currency. First, the removal of the peg led to an immediate and very strong appreciation of the Euro/CHF exchange rate, the most important exchange rate for Swiss firms. In the immediate aftermath of the SNB's announcement on January 15, the Franc appreciated by around 15% against the Euro. The Swiss franc depreciated slightly in the months following the event, but the appreciation remained substantial on a year-on-year basis (+12.3%). Second, the exchange rate had remained virtually constant while the exchange rate floor was in place. The setting thus gives rise to a period of three-and-a-half years with artificially stable exchange rates followed by a period with strongly appreciated currencies. It thus lends itself to straightforward be-

[9] The Franc shock also reintroduced exchange rate uncertainty to firms in Switzerland. During the time of the peg, the volatility of the exchange rates had been very limited, and most firms and economic observers expected the CHF/Euro exchange rate to be close to the peg (Binding and Dibias, 2017). As pointed out by Kaufmann and Renkin (2017), however, the observed volatility of the major exchange rates of Switzerland also remained low by historical standards after the abolition of the floor, reflecting that the SNB continued to intervene in the foreign exchange market. These interventions reduced the downward movements of the CHF/Euro exchange rate and hence limited the realized volatility. On January 15, 2015 the SNB also announced to push its target short-term interest rate, the 3-month Libor, further into negative territory, from -25bp to -75bp, in order to limit the attractiveness of the Swiss franc and to ease deflationary pressures.

fore-after comparisons to study the effects of currency appreciations on firm decisions. Third, the appreciation in 2015 was unanticipated.[10]

We use the exogenous appreciation of the Franc to study its effects on investment of manufacturing and service sector firms. It is noteworthy that previous firm-level studies on the investment effects of exchange rates focus only on manufacturing firms.

The chapter is organized as follows. Section 6.2 discusses the data. Section 6.3 presents the empirical strategy used to identify the effects of the Franc shock. Section 6.4 presents the effects of the Franc shock on total investment. In section 6.5 we discuss the effects on construction investment, investment in machinery and equipment, R&D, and FDI. Section 6.6 draws qualitative conclusions on the counterfactual investment Switzerland would have had in 2015 and 2016 absent the Franc shock. Section 6.7 summarizes the results from the analysis.

6.2. Data

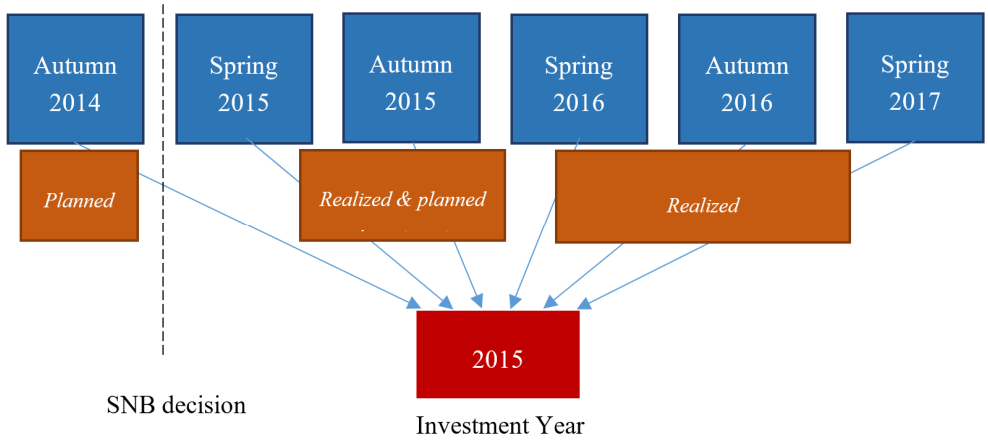
We use data from the KOF Investment Surveys to analyze the consequences of the Franc shock on firms' investment behavior in 2015 and 2016. KOF conducts these surveys bi-annually among a large panel of private firms in Switzerland. The surveys take place in autumn and in spring of a given year. The analysis is based on data from all surveys conducted between autumn 2011 and spring 2017.

An interesting feature of the surveys is that firms are asked about their investment in Switzerland in a given year at several different points in time. For instance, in the survey in autumn 2015, firms were asked for quantitative information on investment activity in 2014, 2015 and 2016. Some of the investment data collected in the surveys are hence *actual* investment made in the past, and some of the data refer to *planned* investment in the current and next year. Figure 9 illustrates this data feature for the year 2015. Our dataset contains firms' investment *plans* for 2015 as collected in the survey in autumn 2014, partly planned and partly realized investment as collected in the surveys in spring and autumn 2015, and *realized* investment in 2015 in three surveys (spring 2016, autumn 2016, and spring 2017).

[10] Both, financial markets (Buchholz et al., 2016; Hertrich & Zimmermann, 2015; Janssen & Studer, 2017; Mirkov, Pozdeev & Söderlind, 2016) and economic forecasters (Kaufmann & Renkin, 2017) did not foresee the timing of its abolition. In fact, even the national executive council of Switzerland (the "Bundesrat") had been informed only minutes before the announcement by the central bank (Flückiger, 2015), and in the days and weeks leading up to the announcement, members of the SNB continued to repeat that the exchange rate floor was necessary (Rathke and Sturm, 2015; Fuster, 2014).

For a firm that participates in all spring and autumn surveys, we thus observe investment data for a given year six times.

Figure 9: Illustration of Investment Data in KOF Investment Surveys.



Notes: KOF levies firms' investment data for a particular year on six different occasions. The first time a firm reports investment data for a certain year is in autumn prior to that year. In this case, the reported data represent investment plans. In spring and autumn of a particular year, firms report investment data for that specific year for the second and third time. Finally, in spring and autumn of the following year, firms report realized investment of the previous year. The sixth and last time that a firm reports investment for a given year is in spring two years after that specific year.

This data structure has two advantages. First, we observe realized investment in 2015 if a firm participated in only one of the three surveys collecting data on realized investment. Our investment panel dataset is thus quite balanced despite non-response in individual survey waves. Second, the data gives rise to a straightforward placebo test. The autumn survey in 2014 was conducted before the SNB decided to lift the floor on the Franc. The investment plans for 2015 collected in this survey were not affected by the decision (see Figure 9).

Using the surveys conducted between autumn 2011 and spring 2017, we construct a firm-level panel dataset providing yearly investment figures for the 2012–2016 period that covers, depending on the outcome, between 4000 and 5000 different firms.[11] We drop a small number of outliers from the investment data.[12] None of our results critically depend on this trimming, but the results tend to be more pre-

[11] To increase the reliability of the investment data, we use the mean from different surveys for firms that participated in more than one of the at most three surveys that levy information on realized investment.

[12] We identify these outliers by subtracting the average log investment from each firm-year observation, separately for total investment, equipment, construction, and R&D investment. We then discard observations for which firm-demeaned log investment is larger than 4 log points in absolute values. We drop roughly 35 firm-year observations per outcome using this procedure.

cisely estimated. If not mentioned otherwise, we use *realized* investment. The exception is the year 2016, as only the survey in spring 2017 provides realized investment for 2016. If a firm did not participate in the spring survey in 2017 but participated in the two surveys in 2016, we use investment from these surveys for this firm, prioritizing the autumn survey in the case a firm answered to both of them.

Using the surveys, we analyze the extent to which the exchange rate shock affected firms' log gross fixed capital formation, investment in machinery and equipment, construction, and R&D in Switzerland, and study how the shock affected firms' investment obstacles and foreign direct investment. These outcomes are all directly constructed from the information levied in the investment surveys. Appendix section B.2 contains a copy of the survey questionnaire.

6.3. Empirical Strategy

6.3.1. Construction of Net Exposure

The theoretical considerations in Section 3.1 imply that the effect of the appreciation in 2015 is likely to be larger, the larger the share of products or services that the firm sells abroad. The effect decreases, the more a firm is naturally hedged against the appreciation through relatively lower costs of imported intermediate inputs. Following Ekholm et al. (2012), we thus define firm i's net exposure to currency movements as $s_i = X_i - C_i$, where X_i is a firm i's initial export share in sales and C_i is its initial share of imported intermediate inputs in *total cost*. Because the export and imported inputs share lie in the interval [0,1], net exposure is a variable ranging from -1 to 1. Note that firms' net exposure is time-invariant: we use firms' initial (pre-shock) net exposure in the analysis. Note also that this definition of net exposure differs from the definition used in the other sections of the report, where net exposure is defined in terms of the share of imported inputs in sales (rather than costs).[13]

[13] In general, the definition of C_i in terms of firms' sales is preferable, as we do not expect an effect of an appreciation on firms with a net exposure of 0 using a definition with a common denominator. Conversely, if C_i is defined in terms of costs, as in this section and in Ekholm et al. (2012), firms' profits are affected by exchange rate movements even for a firm with zero net exposure. This is because sales is usually higher than costs. A one percent appreciation will thus have a larger effect on sales than on costs. We cannot adapt the definition of net exposure in terms of sales as the KOF investment surveys do not provide information on the relationship between costs and sales of firms.

The regular KOF investment surveys provide firms' export share in sales but only in four relatively broad categories: 0-5%, 5-33%, 33-66%, and 66-100%. In the KOF survey in 2012, however, firms were given 11 different options to report their export share (i.e. 0%, 10%, 20%, and so on). For firms participating in the 2012 survey (about 1/5 of all firms), we thus use the detailed information from the 2012 survey. Moreover, for these firms, we also observe both, the broad and the detailed export variable, i.e. we see whether the export share of a firm that falls into the 5%-33% category is closer to 5% or 33%. Using this information, we refine the measurement of the export share for the rest of the firms (for which we only observe the broad variable) using a simple regression procedure.[14] We follow a similar approach to impute missing data on the share of imported intermediate inputs in total costs. As with the export share, this variable was directly levied in the KOF investment survey in spring 2012. For firms that did not participate in this specific survey, we predict the imported inputs share using a regression approach.[15]

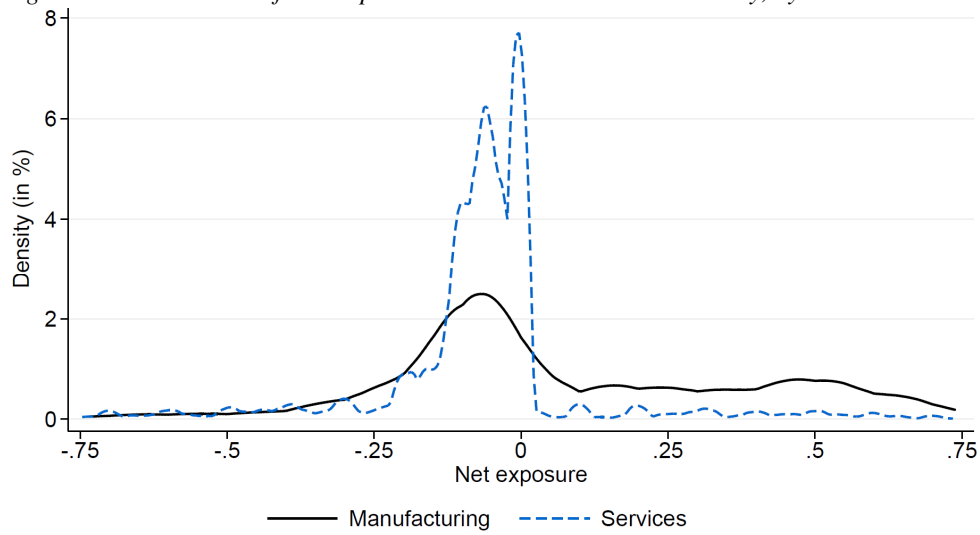
Figure 10 shows the distribution of initial net exposure for our sample of firms in the survey of spring 2012. To illustrate the measure, we estimate kernel densities separately for manufacturing and service sector firms. As is illustrated by the figure, most firms' net exposure is close to zero or slightly below zero, reflecting that many firms have no exports but import at least some intermediates. The median net exposure of the manufacturing firms in the sample is -0.01. In the service sector, the median is -0.06%.[16] In contrast to the service sector, in which only 9% of firms have positive net exposure, 43% of firms in the manufacturing sector have positive net exposure. The 90th percentile of net exposure in the manufacturing sector is 0.54. These firms are strongly exposed to currency fluctuations.

[14] For firms participating in the 2012 survey, we regress the detailed export share variable on the less detailed variable and a set of dummy variables (i.e. industry, canton and size dummies). Using the results from this regression, we predict the detailed variable for the firms which did not participate in the 2012 survey. In this regression we use a generalized linear model with a logit link, which deals with the fact that the outcome is a fractional response. Obviously, this imputation proves to be very accurate, as the less detailed export variable is an extremely good predictor of the detailed variable.

[15] The regression model contains the same covariates as the model for the export share (i.e. industry, size, and region dummies). We also include the broad export share variable as a further covariate, as heavy importers are often heavy exporters (Amiti et al., 2014). The imputation of the import share variable leads to some measurement error, which may lead to a classical measurement error problem, biasing our estimates towards zero. However, our analysis below is based on a simple DiD comparison of firms with positive and non-positive net exposure. Since we categorize firms into the two bins, measurement error is arguably only a concern for firms close to the net exposure threshold of 0. Our results are almost unchanged if we omit firms that are within close range to 0.

[16] Average and median net exposure is lower in this section compared to the previous chapter because we define net exposure as the difference between the export share in sales and the imported inputs share in total *costs*. In the other chapters, net exposure is defined as the difference between the export share in sales and imported inputs share in *sales*.

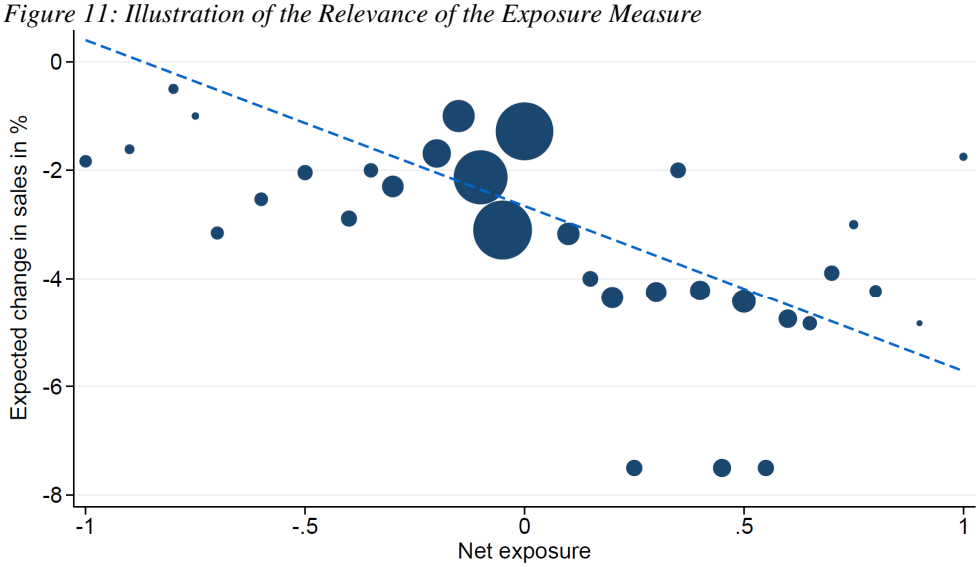
Figure 10: Distribution of Net Exposure in the KOF Investment Survey, by Sector



Notes: The figure shows the distribution of firms' net exposure as observed in the period in the spring survey 2012. Net exposure is firms' initial export share in sales minus its initial import share in total costs. The distributional plots are constructed using an Epanechnikov kernel function. A small number of firms with net exposure above 0.75 and below -0.75 are discarded.

Figure 11 illustrates the relevance of the net exposure measure in predicting the impacts of exchange rate appreciations on firms' revenues. The KOF investment survey in spring 2012 contained special questions in which KOF levied information on the hypothetical effects if the SNB were to change the ceiling from 1.20—which was the exchange rate peg defended by the SNB at the time—to 1.10. In this special survey, firms were asked about the expected consequences of such an appreciation on their nominal sales. Figure 11 provides a binned scatterplot, relating firms' answers to this question to firms' net exposure, averaging firms' responses in steps of 0.05. The size of the dots indicates the number of firms in the respective bin. The figure additionally provides the regression line of a weighted linear regression of the expected change in sales on firms' net exposure. We observe a negative relationship between the two variables. Firms with a large negative exposure (low export share but large imported input share) expect close to zero consequences of the appreciation on their sales. Firms with very high exposure, on the other hand, expect sales to decline by about 6%. The figure suggests that the exchange rate elasticity of nominal sales is about -0.2 for firms with average net exposure.

Figure 11: Illustration of the Relevance of the Exposure Measure



Notes: The figure shows a binned scatterplot of firms' net exposure as reported in the KOF investment survey in spring 2012 against the expected effect of an appreciation of the Euro/CHF exchange rate from 1.20 to 1.10 on firms' (nominal) sales. These effects were reported by firms in a special questionnaire of the KOF investment survey in spring 2012 about the effects of exchange rate appreciations. The size of the dot indicates the number of firms in the respective bin of net exposure. Net exposure is firms' initial export share in sales minus its initial import share in total costs.

6.3.2. Methodology and Regression Model

We use simple and transparent empirical strategies to assess the consequences of the Franc shock for investment activities. All approaches rely on the comparison of firms with different initial net exposure to the shock.

The first approach compares the distribution of investment *plans* for the year 2015, as gathered prior to the Franc shock, with the realized investment in 2015 for the same set of firms. The former information stems from the KOF investment survey in spring 2014, and the latter from the investment surveys in 2016 and 2017.

The second approach closely follows Ekholm et al. (2012). It is a simple and transparent Difference-in-Differences (DiD) approach, comparing the evolution of investment over the 2012–2016 period for firms with different initial net exposure. For this analysis, we assign firms into two groups based on their net exposure: firms are considered to be "exposed" to the exchange rate shock in 2015 if their net exposure is strictly positive, i.e.

$$Exposed_i = I[s_i > 0] = \begin{cases} 1 \; if \; s_i > 0 \\ 0 \; if \; s_i \leq 0 \end{cases}$$

where $I\left[s_i > 0\right]$ is an indicator function equal to one if $s_i > 0$. To formally evaluate the effects of the exchange rate shock on "exposed" firms, we then estimate the following event study Differences-in-Differences (DiD) model for the log of firm outcome y_{it} of firm i in period t:

$$\ln(y_{it}) = \alpha_i + \theta_t + \sum_{k=2012,2014,2015,2016} \delta_k \, I\left[s_i > 0\right] \cdot I[t = k] + \varepsilon_{it}$$

In order to identify the effects of the Franc shock, the DiD model compares the change in log nominal[17] investment in firms that are positively exposed – firms for which $I\left[s_i > 0\right]$ is one – with the change in log investment in firms that are non-positively exposed, over the period before and after the Franc shock. The differences in the growth rate between the two groups are estimated for each period k, i.e. the interaction term $I\left[s_i > 0\right] \cdot I[t = k]$ shows the extent to which exposed firms changed their investment differently than the rest of the firms in a specific period k.[18] Since the coefficient of interest are binary variables and the outcome is in logs, these coefficients can be interpreted as semi-elasticities, i.e. they represent the percent change in investment due to the appreciation among exposed firms relative to the rest of the firms. The model controls for firm fixed effects, α_i, which absorb all time-invariant differences between firms, such as their industry affiliation, initial size, and initial net exposure (s_i). Moreover, we control for period fixed effects, θ_t, which control for macroeconomic shocks that are common to exposed and not or negatively exposed firms.

In general, this DiD model identifies the *relative* causal effect of the Franc shock. The reason is that we compare the expected "losers" of the Franc shock (i.e. firms that have positive net exposure) with (i) firms that are likely to be not affected by the Franc shock, and (ii) with the possible "winners" (i.e. firms with strongly negative net exposure). This latter group of firms may actually benefit from the appreciation in the form of cheaper imports, and may thus invest more. If this were the case, δ_k would cumulate the losses of firms with positive exposure with the gains of firms with negative exposure.

The central identifying assumption in the DiD estimations is that firms with different levels of net exposure would have had the same within-firm changes in investment absent the Franc shock. This *common trend assumption* in the outcome ab-

[17] All estimations are run using nominal rather than real investment, as we do not observe firm-specific prices for investment goods. However, due to the presence of period fixed effects, changes in the prices of investment goods that are common to all firms are accounted for. The focus on nominal investment would be a concern if there were firm-specific changes in the price of investment goods that affect firms with positive and negative net exposure differentially. One potential concern could be that prices of imported capital goods and services react stronger or faster to the Franc shock than prices of domestic capital. However, it is unlikely that this would have a strong differential effect across firms with differing net exposure. The reason is that both, heavy exporters and heavy importers are likely to import a comparatively large share of their capital goods.

[18] Since the effects are estimated *relative* to each other, we normalize the event study coefficients δ_k by dropping the coefficient for the year 2013. All event study coefficients are therefore estimated relative to 2013.

sent of exchange rate movements is central for our empirical approach, because the investment trend of one group of firms is used to construct a counterfactual investment in the other for the case when the exchange rate shock would not have occurred. If this assumption is met conditional on the set of fixed effects, our regressions do not require further control variables, which is why we abstain from including further covariates.[19] Note that the common trend assumption is not directly testable. However, we provide evidence suggesting that it holds in our case by showing that the two groups of firms had similar investment developments in the period prior to the Franc shock, during which the exchange rates were artificially stable.[20]

Table 12 provides summary statistics of the main variables used in the analysis in this section, separately for firms with non-positive and positive net exposure. Roughly one fourth of all firms are considered "exposed" according to our sample split. Exposed firms have both higher export and imported inputs share than firms with non-positive exposure. "Investment" represents *annual gross fixed capital formation* in nominal terms and is the sum of equipment and construction investment. Average investment is slightly more than 6 million CHF per year in firms with non-positive net exposure and 4.9 million in exposed firms. Both distribution have a long right tail, with a small set of firms with very large investment projects. 87% of the exposed firms and 82% of the rest of the firms have positive investment expenditures in a year. Exposed firms are of similar size as firms with non-positive exposure (297 versus 305 FTE employees).

[19] Note that the firm fixed effects control for all *time-invariant* factors that affect firms' investment. We also experimented with the inclusion of certain time-varying control variables, all of which played little role for the results. Moreover, some of these controls may be directly affected by the Franc shock itself, in which case their inclusion would lead to endogeneity concerns.

[20] Arguably, the main concern regarding our empirical approach are other unobserved shocks in 2015 or 2016 that affect exposed and not or negatively exposed firms differently, such that the results would not be attributable to the Franc shock alone. The most obvious candidate is simultaneous changes in the demand in export markets, which likely affect positively exposed firms more. In general, however, this concern appears limited, as the Franc shock occurred at a time when the macroeconomic environment in Switzerland's most important trading partners was stable (see Kaufmann and Renkin, 2017, for a discussion).

Table 12: Descriptive Statistics (Franc Shock Analysis)

	(1) I[net exposure<=0]				(2) I[net exposure>0]			
	Mean	Median	s.d.	Obs	Mean	Median	s.d.	Obs
Net exposure	-.13	-.073	(.17)	9519	.38	.38	(.22)	2930
Export share (%)	.04	0	(.15)	9519	.74	.85	(.26)	2930
Imported input share (%)	.16	.085	(.22)	9519	.36	.33	(.22)	2930
Investment	6270183	169500	(6.3e+07)	8269	4900418	638000	(3.0e+07)	2495
Equipment investment	2624525	100000	(2.6e+07)	7992	3162646	500000	(1.8e+07)	2417
Construction investment	4052756	0	(5.4e+07)	7871	2098168	23000	(1.9e+07)	2373
R&D investment	339955	0	(5471264)	5388	2447029	11833	(1.4e+07)	1546
Investment (0/1)	.82	1	(.38)	8269	.87	1	(.33)	2495
Equipment investment (0/1)	.81	1	(.39)	7992	.87	1	(.33)	2417
Construction investment (0/1)	.5	0	(.5)	7871	.54	1	(.5)	2373
R&D investment (0/1)	.22	0	(.41)	5388	.54	1	(.5)	1546
FTE employment	297	50	(2054)	6833	305	119	(897)	2126
Manufacturing (%)	.31	0	(.46)	9519	.78	1	(.41)	2930
High-tech manufacturing (%)	.11	0	(.31)	9519	.48	0	(.5)	2930
Foreign owned (%)	.12	0	(.33)	5892	.3	0	(.46)	1705
High price competition (%)	.64	1	(.48)	5779	.73	1	(.45)	1705

Notes: The table shows summary statistics for the main variables used in the analysis of the Franc shock. Variables represent firm-year observations in the pre-shock period 2012-2014. Investment figures represent realized investment. Net exposure is firms' initial export share in sales minus its initial import share in total costs. "High-tech manufacturers" are firms in NACE rev. 2 two-digit sections 20, 21, 26–30 (excluding three-digit industry 30.1), and three-digit industries 25.4 and 32.5, following the definition of Eurostat. "High competition" is a dummy variable constructed from a self-reported measure of price competition. It is one if the firm perceives the price competition on the main selling market to be fierce or very fierce.

While total investment and firm size is relatively similar for the two groups, there are also noteworthy differences between them. In particular, exposed firms have higher annual R&D expenditures and a higher probability to have positive R&D expenditures in a given year. To some extent, this reflects that exposed firms are more likely to be manufacturing firms.[21] Finally, exposed firms are more likely to be foreign owned. Considering these differences in the sectoral composition between exposed and not or negatively exposed firms, we made sure that all the main results presented below hold if we only compare firms within the same industry at each point in time.

[21] A more detailed sectoral analysis shows that exposed firms are overrepresented in the following larger two-digit manufacturing industries: manufacturing of textiles, paper and paper products, chemicals, pharmaceuticals, rubber and plastic products, other non-metallic mineral products, basic and fabricated metal products, computer, electronic and optical products, electrical equipment, machinery and equipment, and furniture. In the services sector, the share of exposed firms is comparatively high (i.e. exceeds 15%) in warehousing and support activities for transportation, accommodation, computer programming, consultancy and related activities, in financial service activities, in real estate activities, in activities of head offices and management consultancy activities, and in architectural and engineering activities.

6.4. Empirical Results for Total Investment

In this section, we examine the consequences of the exchange rate shock on firms' total gross fixed capital formation. We proceed as follows. First, we examine descriptively how ex-post realized investment differs from ex-ante planned investment. Second, we employ the DiD framework to estimate the elasticity of investment with respect to the Franc shock. Third, we perform a placebo test to assess the plausibility of the results in our DiD framework. Finally, we study how the Franc shock affected firms' obstacles to carry out investment.

6.4.1. Realized versus Planned Investment

Figure 12 shows a kernel density plot of firms' realized investment in 2015 and compares it with a density plot for firms' investment plans for 2015 as collected by KOF in the investment survey in autumn 2014. The survey in autumn 2014 was conducted 1–3 months *before* the decision of the SNB and should thus be unaffected by the Franc shock.[22] Moreover, to keep observations with zero investment in the sample, we plot the inverse hyperbolic sine (IHS). This transformation normalizes the skewed distribution and, in contrast to other transformations, enables us to keep the zeros in the sample.[23] We make this comparison separately for firms with positive net exposure (Panel A) and firms with non-positive net exposure (Panel B).

The figure provides suggestive evidence that exposed firms downsized their investment in 2015 relative to what they planned at the end of 2014: the distribution of realized investment is shifted to the left compared to the distribution of investment plans. The difference between the two distributions is most obvious for medium to large investment projects of 12 log points and more (equivalent to a total investment sum of 200k CHF and more). In contrast, the distribution of planned and realized investment in 2015 are relatively closely aligned over the entire range of investment for firms that are not or negatively exposed to the currency shock.

The use of the IHS also allows us to study graphically whether the probability to have positive investment expenditures changed from plans to realizations. In both panels, we observe that the share of firms with zero investment is smaller when

[22] We focus on the sample of firms for which we observe both investment plans made in autumn 2014 and a corresponding realization.

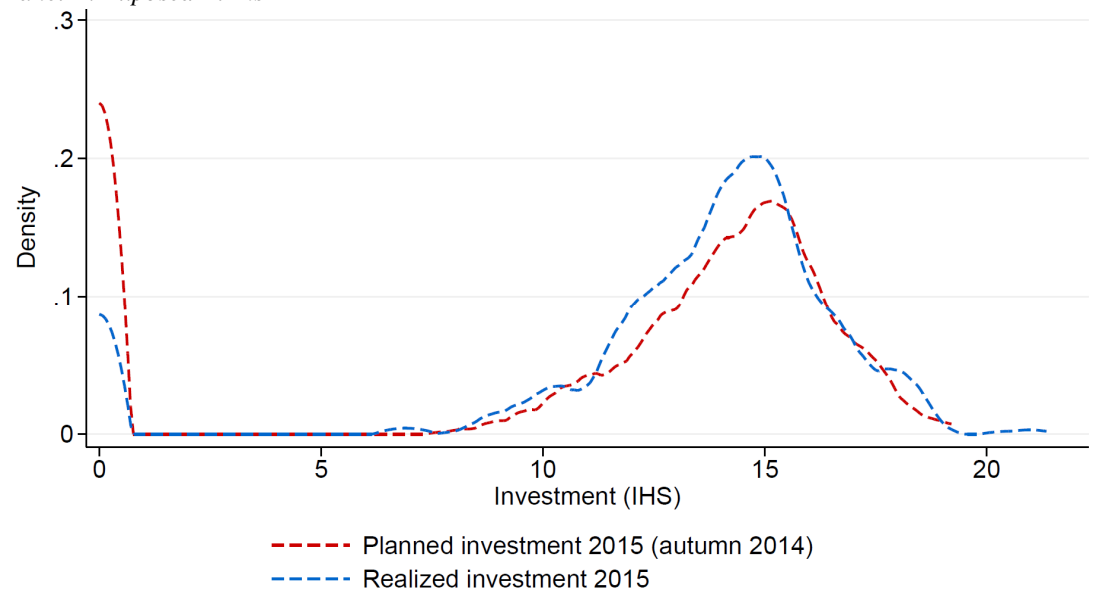
[23] The IHS of outcome y is $IHS(y) = ln(y + \sqrt{1 + y^2})$. As argued by Doran et al. (2015), using the IHS is an attractive retransformation with outcomes with a lot of zeros and a long right tail, because the IHS approximates the log of an outcome (and thus normalizes the skewed distribution) and has the advantage over a log transformation that it is defined at 0 (see Burbidge et al., 1988).

considering realized investment rather than investment plans. This is partly by construction.[24] But there is also some evidence that the *difference* between the shares of firms with zero investment in plans versus realizations is larger among exposed firms, suggesting that the Franc shock triggered some additional (small) investment projects. In fact, the DiD evidence below points into a similar direction.

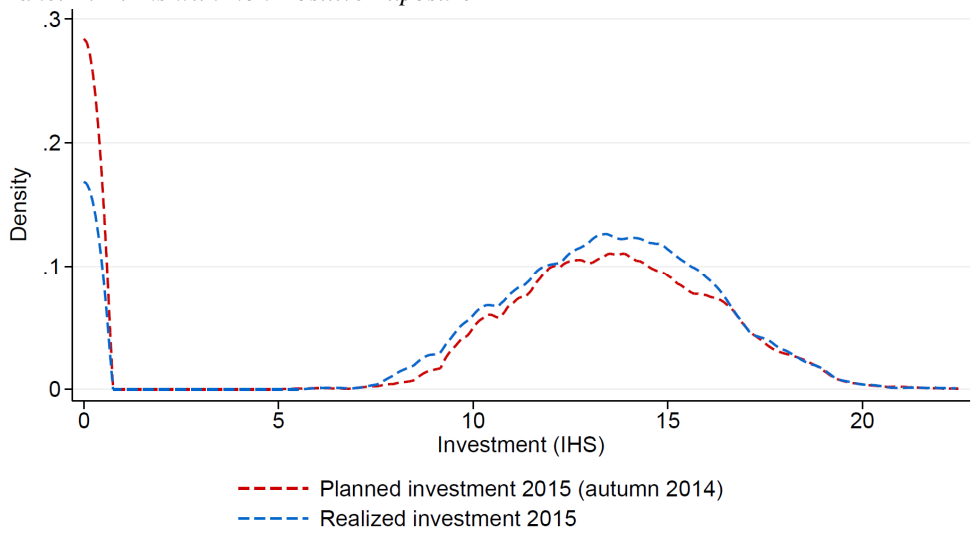
[24] The reason is that realized investment is an average of investment figures of up to three different surveys. The averaging makes it less likely that realized investment is exactly zero.

Figure 12: Planned Versus Realized Investment in 2015

Panel A: Exposed Firms



Panel B: Firms with Non-Positive Exposure



Notes: The figures show distributions of the inverse hyperbolic sine of nominal annual investment for firms with positive initial net exposure (Panel A) and non-positive initial net exposure (Panel B). The red line shows the distribution of nominal investment for 2015 as reported in the KOF investment survey in autumn 2014. The blue line shows realized investment for 2015, which is the firm-level average investment from the investment surveys between spring 2016 and spring 2017. Net exposure is firms' initial export share in sales minus its initial import share in total costs. The distributional plots are constructed using an Epanechnikov kernel function. The width of the density window around each point is set to 1/3.

6.4.2. Difference-in-Differences Evidence

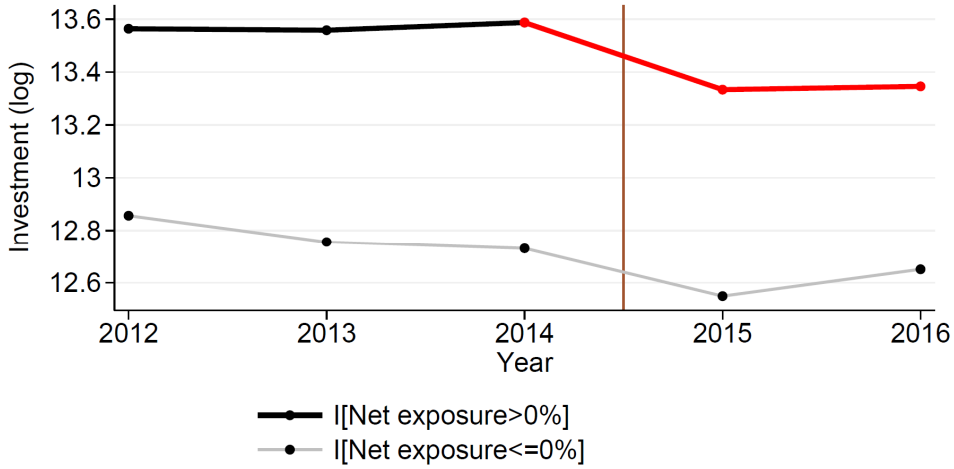
Figure 13 plots the evolution of log investment between 2012 and 2016 for exposed firms and firms with non-positive exposure. We observe that log nominal

investment declines by about 0.2 log points in exposed firms in 2015 compared to 2014. Prior to this year, nominal investment had increased. In not or negatively exposed firms, investment decreases as well between 2014 and 2015, but to a lesser extent. This pattern becomes even more striking in Panel B of Figure 13, which is based on the same data as the figure in Panel A, but we compute the average log investment over the 2012–2016 period for each firm and subtract this firm-level average from each observation. We then plot the evolution of *firm-demeaned* data. The figure clearly shows that the difference in log investment between 2014 and 2015 is more negative in exposed firms than in not or negatively exposed firms. We also note that investment remains depressed in exposed firms in 2016, while it recovers slightly in not or negatively exposed firms.

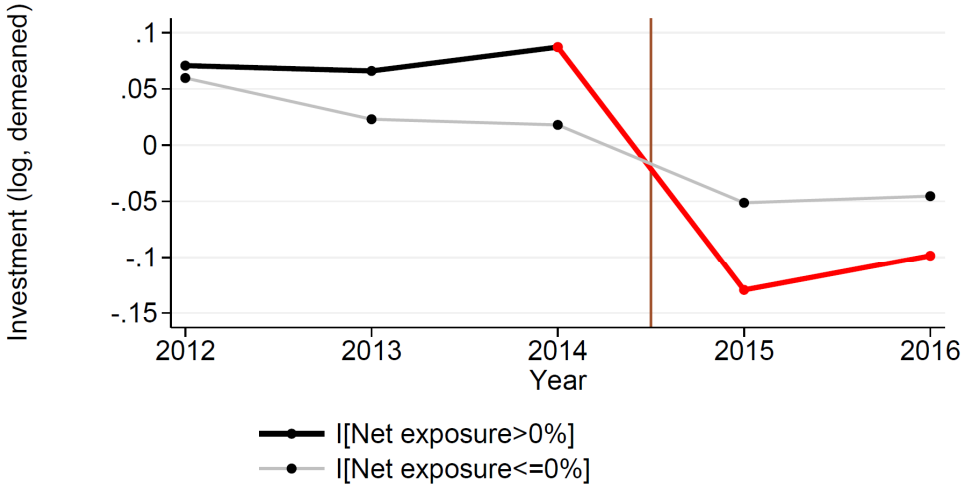
Our event study DiD model casts the firm-demeaned investment figures one-to-one into a regression framework. It tests whether the *difference in the differences* of log investment between exposed and not or negatively exposed firms are statistically significant. Figure 14 shows the series of event study coefficients, δ_k, and associated 90% confidence intervals, estimated with the model. Standard errors are robust to clustering on the level of the individual firm. The figure illustrates the sizeable reduction in investment in exposed firms relative to not or negatively exposed firms in the two periods after the shock. The event study coefficient in $t = 2015$ is clearly negative and statistically significant. The model also provides a formal way of testing whether the observed differences in trend inflation *prior* to the Franc shock are statistically significant. In this period, the exchange rate remained almost constant. If the identifying assumption is satisfied, we would not expect differences in the difference of log investment between exposed and not or negatively exposed firms. Reassuringly, we do not observe significant differences in investment in the years leading up to the exchange rate shock.

Figure 13: Log Investment Depending on Firms' Initial Net Exposure, 2012–2016

Panel A: Average log Investment

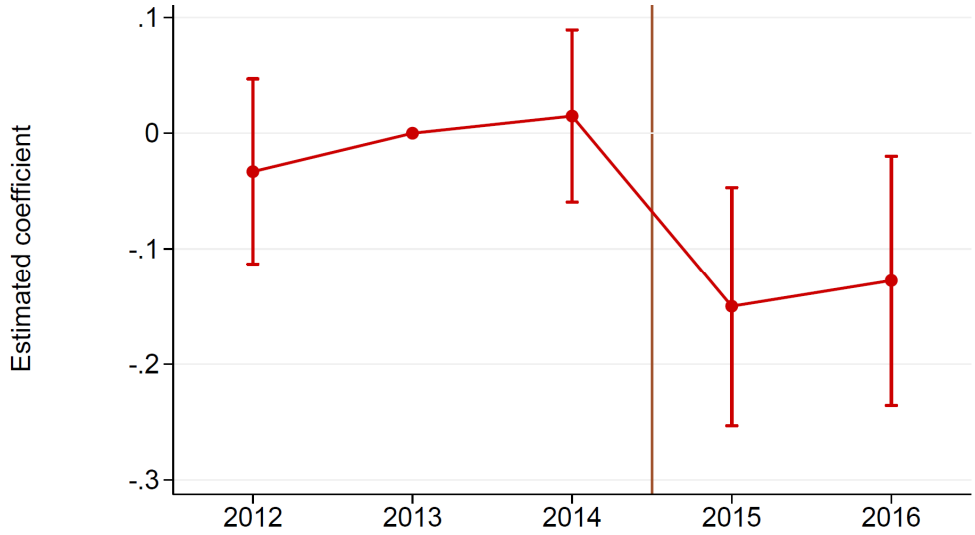


Panel B: Average Firm-Demeaned log Investment



Notes: Panel A of the figure shows the evolution of annual investment (i.e. log gross fixed capital formation), measured at current prices, for firms with positive initial net exposure and non-positive initial net exposure. Panel B shows the corresponding evolution of firm-demeaned investment. Net exposure is firms' initial export share in sales minus its initial import share in total costs.

Figure 14: Event Study DiD Estimates of the Effect of the Franc Shock on Investment in 2015 and 2016



Notes: The figure shows the series of event study coefficients, δ_k, and associated 90% confidence intervals, estimated using the event study model. The estimation period is 2012-2016. The outcome is annual investment (i.e. log gross fixed capital formation), measured in current prices. The estimated effects represent semi-elasticities.

The estimates from the event study model suggest that the Franc shock depressed investment in exposed firms *relative* to the rest of the firms by 15% in 2015 and by 12.7% in 2016. While these estimates are large, they are quite comparable to the evidence presented by Efing et al. (2016).[25] Moreover, these large effects are corroborated by corresponding reductions in firms' workforce. In unreported regressions, we find that FTE employment declined by 6.5% in exposed firms relative to not or negatively exposed firms by the end of 2016.

Overall, our baseline estimations suggest that the Franc shock depressed investment of exposed firms in 2015 and 2016. What are the characteristics of the firms that reduced their investment activity? This question is analyzed in Table 22 in the appendix. The results show the following:

- The negative investments effects of the Franc shock are concentrated among manufacturers.

[25] Their study also contains estimations on the consequences of the Franc shock on investment. Using a sample of roughly 140 publicly traded large firms, they find that firms with high currency exposure——defined as firms that sell most of their products abroad and, at the same time have a high share of domestic costs——reduced capital expenditures in 2015 by 8% relative to firms with less currency exposure. Our estimates are even slightly larger. As we show below, these differences likely arise because our sample contains more small firms. Investment of small firms was more sensitive to the Franc shock.

- Large firms responded significantly less to the Franc shock compared to small and medium-sized firms.
- Firms' perceived price competition and foreign ownership do not systematically mediate the responsiveness of firms' investment to the Franc shock.
- The short-run investment effects of the Franc shock are more strongly negative among firms that consider the realization of their investment for 2015 to be fairly or very uncertain at the end of 2014.

We also study how the Franc shock affected investment along the distribution of annual investment expenditures. To this end, we build indicator variables that are one if a firm's annual investment lies above a certain threshold. We then regress these dummy variables on the indicators of the Franc shock using simple linear probability models, controlling for firm fixed effects.

The results are reported Table 23 in the appendix. They suggest that the negative average effects of the Franc shock on total investment is driven by the fact that exposed firms downsize medium-sized to large investment projects, both in 2015 and 2016. We find the largest negative effects on the probability to have investment expenditures above 1 million Swiss francs. The analysis also reveals that there is a marginally statistically significant *positive* effect to have non-zero investment expenditures (see column 1 of Table 23). This suggests that the Franc shock induced some firms to start certain small investment projects. We return to this point below.[26]

6.4.3. Placebo Check

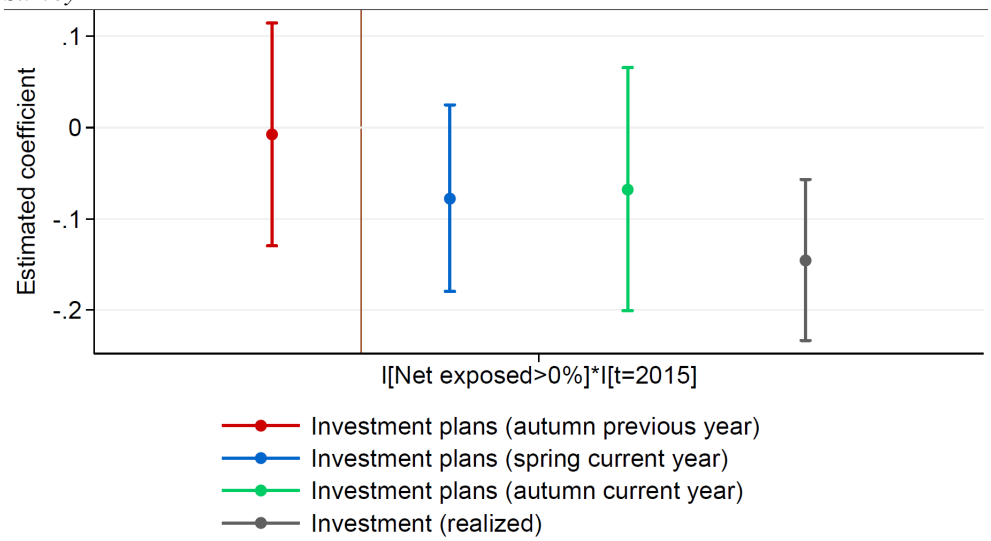
Our peculiar data structure allows us to conduct a straightforward placebo test on our baseline results. As is illustrated in Figure 9, the survey in autumn 2014 asked firms about their investment plans in 2015 but took place before the Franc shock occurred. If our estimation captures the effect of the exchange rate shock in January 2015, we should not be able to identify a significant difference in the investment of exposed and not or negatively exposed firms in these investment plans

[26] Our results so far are based on firms with only positive investment (since the log of zero is undefined). As there is an effect on the probability to have non-zero investment, our baseline results may be subject to a bias arising because the sample of firms with positive investment changes differently over time in the two groups that we compare. One important implication of the estimations in columns 2-7 of Table 23 is thus that they show that our baseline results are not driven by such a potential sample composition bias. We also re-estimated our model with estimation methods that retain the zeros in the outcome (such as FE poisson or OLS estimations using the investment rate, i.e. investment per worker). These results also confirmed the robustness of our results with respect to sample selection biases.

made before the currency appreciated. We thus re-estimate the panel regression model using the log of planned investment as collected in the autumn surveys of the previous year as outcome variable. We then focus on the coefficient capturing the effect of the Franc shock in the year 2015 (i.e. $I\left[s_i > 0\right] * I[t = 2015]$), as investment plans in autumn 2015 for 2016 are affected by the exchange rate shock.

The estimate of this interaction term is the first coefficient shown in Figure 15. Reassuringly, the point estimate in this placebo estimation is very close to and statistically indistinguishable from zero. The second coefficient shown in the figure uses investment plans as collected in the spring surveys of the respective investment years. The spring survey in 2015 took place 2–5 months after the exchange rate shock. The estimate in this regression is negative but not statistically significant. The comparison between the first and the second coefficient shows that firms revised their investment plans for 2015 downward between the survey in autumn 2014 and the survey in spring 2015. The third coefficient in the figure, using data from the autumn survey of the ongoing year, is also negative and of similar size as the second coefficient. The final column uses the realized investment data, which reveals the negative effect of the Franc shock on investment.

Figure 15: Effects of the Exchange Rate Shock in 2015 by Wave of the KOF Investment Survey



Notes: The figure shows the interaction term capturing the effect of the Franc shock in 2015, $I[s_i > 0] * I[t = 2015]$*, and associated 90% confidence intervals, estimated in four separate panel regressions of the baseline model. The outcome is log nominal investment in all regressions, constructed using only the investment data from the respective survey indicated in the legend. Net exposure is firms' initial export share in sales minus its initial import share in total costs.*

6.4.4. What Hinders Firms' Investment?

Our results show that the Franc shock depressed medium-sized and large investment projects. In this subsection, we study whether this negative effect arises because of the uncertainty that the shock caused, or whether it is because firms lack the financial resources to stem larger investment projects. To study this, we exploit that the KOF investment surveys in autumn also levy information on the main obstacles to firms' investment efforts. The possible answers are the demand development, the financial resources and/or the expected profit situation, the technological development, or other factors. We transform the original 5-point Likert scale variables, measuring firms' investment obstacles, into dummy variables that are equal to one if a certain factor has a negative or strongly negative impact on firms' investment, and zero otherwise. We then estimate simple linear probability models with firm fixed effects.

The results are presented in Table 24 in the appendix. They clearly show that it is the lack of financial resources and/or a difficult profit situation that prevents firms from investing more, particularly in 2015. The magnitude of the estimated effect is substantial. The probability to be hampered by financial constraints increases by almost 10 percentage points in 2015. In 2014, only 18% of all firms reported to be financially constraint. A ten percentage point increase is thus equivalent to a more than 50% increase in this outcome among exposed firms. We also find evidence

that the Franc shock increased the share of firms reporting that their investment activity is hampered by low demand.

6.5. Empirical Results for Different Types of Investment

In the last subsection, we show that the Franc shock depressed total investment among exposed firms because it reduced their financial capabilities. We now study how different types of investment were affected. We first investigate the effects on investment in machinery and equipment, construction investment, and R&D expenditures. Section 6.5.2. then examines whether the Franc shock affected firms' foreign direct investment.

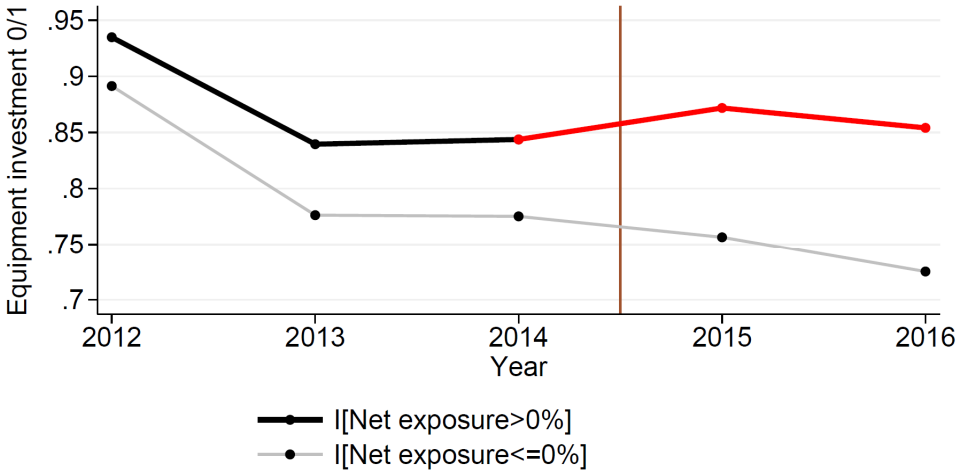
6.5.1. Effects on Equipment and Construction Investment and R&D Expenditures[27]

Columns 2–3 of Table 12 show how the Franc shock affected the investment in machinery and equipment and construction investment in 2015 and 2016. In the first column of Table 12**,** we re-estimate the effect of the Franc shock on total gross fixed capital formation, which is the sum of equipment and construction investment. The estimates are consistent with our event study results presented above. Columns 2 and 3 of the table suggest that the Franc shock depressed both, investment in machinery and equipment and construction investment. The effect on construction investment is somewhat larger, but the impact on investment in machinery and equipment is also economically very relevant (roughly -10% in both years).

Figure 16 provides an important qualification of this result. It presents the share of firms with non-zero investment in machinery and equipment in a given year. We observe an increase in this share among exposed firms between 2014 and 2015, while the share declines among not or negatively exposed firms. Column 5 of Table 12 reports the associated DiD estimates, using a simple linear probability model (LPM). They suggest that the Franc shock increased the probability to have investment into machinery and equipment by 2.2 percentage points in 2015 and by 3.7 percentage points in 2016 in exposed firms. Overall, these results also triggered some additional investment projects. We do not find robust evidence that the Franc shock affected the probability to have non-zero construction investment, although the estimates are generally positive, too.

[27] We investigate the effects of exchange rate fluctuations on R&D investments extensively in section 5.5. Here, we focus exclusively on the effects of the Franc shock in 2015 and we use a different dataset (investment survey) and a different estimation approach.

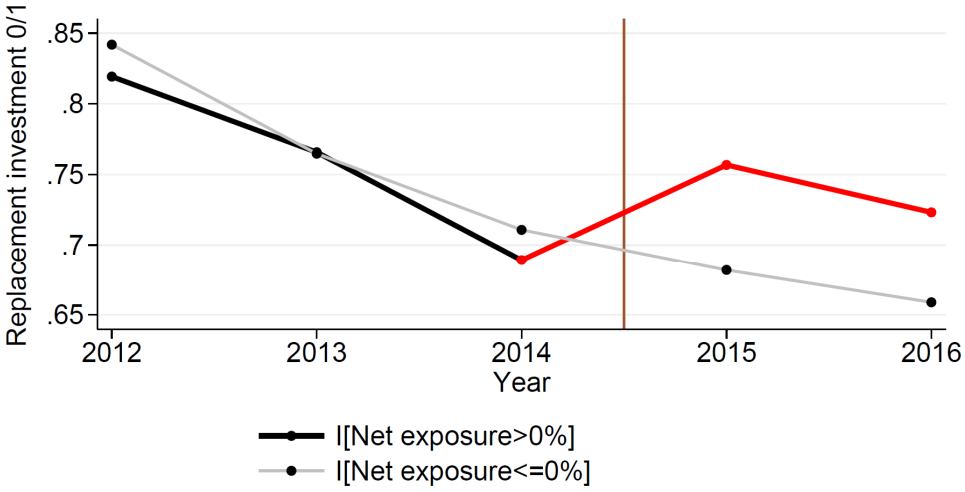
Figure 16: Effect of the Franc Shock on the Probability to Invest into Machinery and Equipment, by Initial Net Exposure



Notes: The figure shows the share of firm with non-zero investment into machinery and equipment in a given year, separately for firms with positive initial net exposure and non-positive initial net exposure. Net exposure is firms' initial export share in sales minus its initial import share in total costs.

To gain insights into the question what investment projects were triggered by the Franc shock, we examine how the Franc shock affected firms' investment motives. In the KOF investment surveys, firms are asked whether their investment serve one or more of the five following motives: replacement, extension of production capacity, streamlining production, fulfilling environmental protection and regulations by trade law, and other objectives. When studying these outcomes, the most robust result was that the appreciation of the Swiss Franc triggered replacement investment in 2015 and 2016. This can be seen clearly in Figure 17, which shows the share of firms reporting replacement investment, separately for exposed and not or negatively exposed firms. These results suggest that the investment in machinery and equipment triggered by the appreciation served to renew and update firms' capital stock.

Figure 17: Probability to Have Replacement Investment, by Initial Net Exposure



Notes: The figure shows the share of firms reporting that their investment in a given year serves to replace old machinery, equipment, and/or buildings, separately for firms with positive initial net exposure and non-positive initial net exposure. Net exposure is firms' initial export share in sales minus its initial import share in total costs.

We also investigate how the Franc shock affected firms' R&D expenditures. The KOF investment surveys ask firms for their annual R&D investment for three years (the survey in autumn 2014 covers 2013, 2014, 2015) in Switzerland since the survey in autumn 2014. The estimations are thus restricted to the 2013–2016 period. Note that the effects of exchange rate fluctuations on R&D investments are investigated extensively in chapter 5.5. Here, we focus exclusively on the effects of the Franc shock in 2015.

The impact of the Franc shock on R&D expenditures is studied in columns 5 and 6 of Table 12**.** The regression in column 5 suggests that the Franc shock had a substantial negative impact on R&D investment in Switzerland. The effect sizes are large, but these large effects are robust: we find them in different subsamples, across different specifications, and using different estimations methods. When analyzing the heterogeneity of this effect, we find suggestive evidence that the effect is driven by large firms. This is in contrast to the effects on other types of investment, where the effects are concentrated among small and medium-sized firms. Moreover, we find that the effects of the Franc shock on R&D only occur along the intensive margin. The Franc shock did not affect the probability to have non-zero investment (column 6 of Table 12). Overall, our findings suggest that R&D expenditures are as negatively affected by the Franc shock as the other components of investment. These results confirm the findings in section 5.5

Table 12: Effect of the Franc Shock on Total Investment, Equipment and Construction Investment, and R&D

variables	(1) Investment	(2) Construction investment	(3) Equipment investment	(4) Equipment investment 0/1	(5) R&D investment	(6) R&D 0/1
I(t=2015) x I[Net exposure>0%]	-0.145***	-0.245**	-0.113**	0.021*	-0.146*	0.005
	(0.054)	(0.098)	(0.048)	(0.012)	(0.078)	(0.015)
I(t=2016) x I[Net exposure>0%]	-0.123**	-0.170	-0.106**	0.037***	-0.239***	0.002
	(0.058)	(0.108)	(0.052)	(0.014)	(0.084)	(0.016)
Observations	14,236	8,131	13,663	17,032	3,924	13,444
R-squared	0.007	0.006	0.012	0.010	0.010	0.004
Number of firms	4,201	2,869	4,070	4,755	1,533	4,429
Period FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes

*Notes: The table shows results from our baseline FE regression model. The estimation period is 2012-2016. The dependent variable in column 1 is log gross fixed capital formation (total investment). The dependent variable in column 2 is log construction investment. The dependent variables in columns 3 and 4 are log investment in equipment and machinery (column 3) and a dummy equal to 1 if a firm has non-zero investment in equipment and machinery (column 4). The dependent variables in columns 5 and 6 are log R&D expenditures (column 5) and a dummy equal to 1 if a firm has non-zero R&D expenditures (column 6). All investment figures are measured at current prices. Net exposure is firms' initial export share in sales minus its initial import share in total costs. Standard errors are clustered on the firm level. *** p<0.01, ** p<0.05, * p<0.1*

6.5.2. Effects on Foreign Direct Investment

One possible measure for firms to cope with the Franc shock is the offshoring of business activities. According to the survey conducted by the SNB (2015) half a year after the shock, about 12% of all firms that are negatively affected by the Franc shock consider to move their production abroad. If firms' foreign investments are indeed driven by the Franc shock is investigated in Table 13. Here, we exploit that the KOF investment surveys in autumn ask firms whether they plan foreign direct investment (FDI) in the following year. If they indicate that they have FDI, they are also asked to which activities these FDI pertain (distribution, production, and R&D).

The first column of Table 13 uses the all firms in the survey. We do not find a statistically significant effect of the Franc shock on FDI in the subsequent year in this case. However, the fraction of firm-year observations with FDI is only 8% in the total sample (as shown at the bottom of the table). The remaining columns thus restrict the sample to subsets of firms with a higher prevalence of FDI. In column 2, we restrict the sample to firms that are observed to have FDI at least once prior to the Franc shock. In column 3, the sample is restricted to manufacturers, and in columns 4–7 to manufacturers with more than 100 FTE workers. The results in

these columns suggest that the Franc shock had a strong impact on the share of firms that plan FDI in the year ahead among firms that had FDI in the past, and among Swiss manufacturers with more than 100 FTE workers. These effects are not manifested yet in the autumn survey in 2015, but arise in 2016, suggesting that it took some time until exposed firms decided to increase FDI as a response to the Franc shock. The additional FDI do not just pertain to distribution (column 5) and production (column 6), but also to R&D (column 7). In fact, the estimated effect size in this last regression is large: it implies that the probability to plan FDI pertaining to R&D doubles among exposed firms.

Table 13: Effect of the Franc Shock on Foreign Direct Investment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	FDI	FDI	FDI	FDI	FDI distr.	FDI prod.	FDI R&D
	all	FDI	Manuf.	Manuf.	Manuf.	Manuf.	Manuf.
variables		before		>100 FTE	>100 FTE	>100 FTE	>100 FTE
I(t=2015) x I[Net exposure>0%]	0.015	0.064	0.006	0.015	0.006	0.025	-0.007
	(0.016)	(0.061)	(0.022)	(0.039)	(0.031)	(0.041)	(0.023)
I(t=2016) x I[Net exposure>0%]	0.005	0.158***	0.034	0.081**	0.053	0.094**	0.060**
	(0.016)	(0.059)	(0.022)	(0.040)	(0.033)	(0.044)	(0.029)
Observations	11,601	1,506	4,646	1,688	1,688	1,690	1,691
R-squared	0.002	0.062	0.004	0.011	0.006	0.013	0.007
Number of firms	4,702	517	1,867	600	600	601	600
Period FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Share with FDI	0.08	0.51	0.13	0.20	0.10	0.17	0.05

*Notes: The table shows results from our baseline FE regression model. The estimation period is 2013-2016. The dependent variable in columns 1-4 is a dummy equal to one if a firm plans foreign direct investment (FDI) in the year ahead. The dependent variable in column 5 is a dummy equal to one if a firm plans FDI pertaining to distribution in the year ahead. The dependent variable in column 6 is a dummy equal to one if a firm plans FDI pertaining to production in the year ahead. The dependent variable in column 7 is a dummy equal to one if a firm plans FDI pertaining to R&D in the year ahead. Column 2 is restricted to firms that had FDI at least once between 2012 and 2014. Column 3 is restricted to manufacturing firms. Columns 4–7 are restricted to manufacturing firms with more than 100 FTE workers. The "Share with FDI" at the bottom of the table reports the mean of the outcome variable for the respective estimation sample. Net exposure is firms' initial export share in sales minus its initial import share in total costs. Standard errors are clustered on the firm level. *** p<0.01, ** p<0.05, * p<0.1*

6.6. The Aggregate Effects of the Franc Shock

In this section, we analyze the quantitative effects of the Franc shock on aggregate investment in Switzerland in 2015 and 2016, i.e. we provide a qualitative assessment about the counterfactual investment Switzerland would have had in 2015 and 2016 absent the Franc shock. The empirical framework used so far does not identi-

fy this effect, as it focuses on the relative causal effect, comparing the potential losers (i.e. firms with negative net exposure) to a group which also incorporates the potential winners (i.e. firms with large negative net exposure).

In order to gain more insights about the total effect, we thus first analyze in Section 6.6.1. whether the possible "winners" invested more because of the appreciation. We also examine the extent to which the investment decisions of firms in Switzerland were affected by the increase in import competition caused by the Franc shock. Import competition is another channel through which firms with low net exposure are potentially affected.

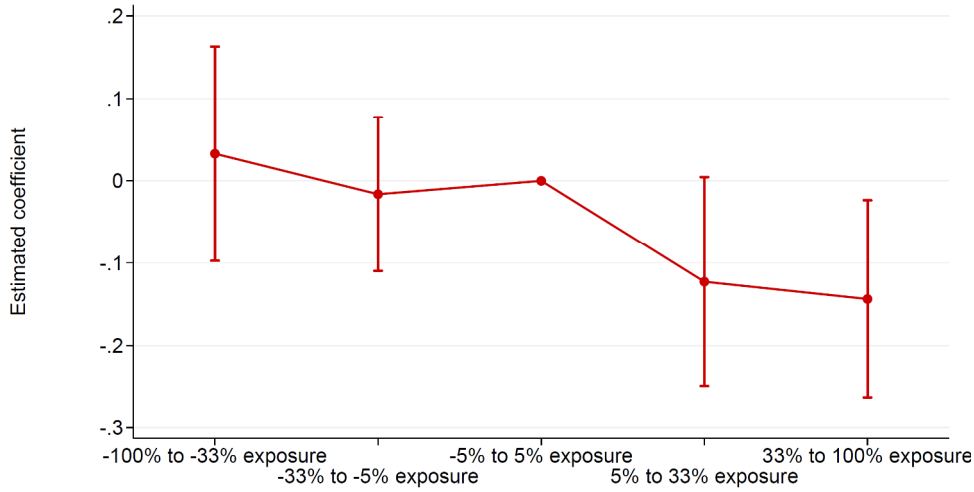
In Section 6.6.2. we then reconcile our findings with the macroeconomic development of investment in Switzerland. Here, the Franc shock is less apparent than in our micro data.

6.6.1. A Quantitative Assessment of the Aggregate Effects of the Franc Shock

What was the effect of the Franc shock on aggregate investment in Switzerland? The graphical comparison of firms' investment plans with the realized investment data, presented in section 6.4.1. , indicates that investment would have been higher in Switzerland in 2015 had the Franc shock not occurred. The DiD analysis, however, does not allow to draw such conclusions, as it focuses on the relative causal effects of the Franc shock. Firms with negative net exposure may benefit from cheaper imported intermediates after the Franc shock, and thus increase investments. The comparison of firms with positive and non-positive exposure may thus cumulate the negative effects on one group with the positive effects on the other.

We study the extent to which there is evidence for this in Figure 18. It shows estimates of the Franc shock effect on log gross fixed capital formation separately for firms with different degree of net exposure. The coefficients are estimated using firms with a net exposure close to zero (between -5% and 5%) as a reference category. The figure shows that firms with large negative net exposure do not invest more than firms with close to zero net exposure in 2015 and 2016. This appears to hold for most outcomes studied in this section, especially in 2015, which suggests that the positive investment effects from natural hedging through cheaper imported intermediates did not yet influence investment decisions in the first year after the shock. The large relative effects found in the previous sections appear to arise because positively exposed firms reduce investment and not because negatively exposed firms increase investment due to cheaper imported intermediates.

Figure 18: Investment Effects of the Franc Shock in 2015 and 2016 Depending on Firms' Initial Net Exposure



Notes: The figure shows the estimated effects of the Franc shock on total investment in 2015 and 2016, depending on firms' initial net exposure. The effects are estimated by regressing the outcome on an interaction between a dummy equal to one in 2015 and 2016 and indicators for the respective category of net exposure. The reference category is firms with net exposure between -5% and 5%. Net exposure is firms' initial export share in sales minus its initial import share in total costs.

In Table 14, we attempt to directly estimate the counterfactual investment of the average firm if the Franc shock had not occurred. To this end, we use a specification akin to the one in Figure 18, i.e. we augment our baseline model used with an interaction term that estimates a separate effect of the Franc shock for firms with negative exposure (firms with initial net exposure below -0.05) and firms with positive exposure (firms with initial net exposure above 0.05). Taking the point estimates of this estimation at face value, we can construct a rough estimate of the effect of the Franc shock on average investment of firms. Considering that firms with $I[s_i > 5\%]$ make up 23% of the sample, and reduce investment in 2015 and 2016 by 13.6% according to the estimation, while firms with $I[s_i < -5\%]$ represent 48% of the sample but do not change investment substantially, the estimates imply that average nominal investment would have been 3% higher without the Franc shock.

These estimates are likely to underestimate the aggregate investment effect of the Franc shock because the shock also affected non-exposed firms through lower domestic demand. In particular, the Franc shock likely increased import competition in the domestic markets. In column 2, we thus interact an indicator variable for the post-2015 period with the import penetration ratio of firms' industries. The ratio is computed on the NACE 2-digit level and is also used in the previous sections. Because our import penetration measure applies only to manufacturing industries, the estimation is restricted to manufacturing. As expected, the interaction term is negative, suggesting that increased import competition depressed invest-

ment. Although the coefficient is not statistically significant, it is economically relevant.[28] The "total" effect of the Franc shock in this model, adding up the contribution from the export, imported intermediates, and import competition channel, is -8%. Note that these are rough estimates, as they are estimated with large standard errors, depend on the specification, and on the exact thresholds chosen to assign firms into categories of net exposure. However, they suggest non-negligible negative effects of the Franc shock on investment of the average firm participating in the KOF investment survey.

Table 14: Accounting for the Effect of the Franc Shock on the Aggregate Economy

	(1)	(2)
	Investment	Investment
variables		Manufacturers
I[t>=2015] x I[Net exposure>5%]	-0.136**	-0.133
	(0.061)	(0.095)
I[t>=2015] x I[Net exposure<-5%]	-0.007	0.013
	(0.054)	(0.096)
I[t>=2015] x IP		-0.051
		(0.076)
Observations	14,236	6,093
R-squared	0.007	0.016
Number of firms	4,201	1,812
Period FE	Yes	Yes
Firm FE	Yes	Yes
Share exposed	0.23	0.42
Share negatively exposed	0.48	0.41
Average IP	.	0.56
Average effect	-0.03	-0.08

*Notes: The table shows results from our baseline FE regression model. The estimation period is 2012-2016. The dependent variable is log gross fixed capital formation (total investment). All investment figures are measured at current prices. Net exposure is firms' initial export share in sales minus its initial import share in total costs. "IP" measures the industry-specific import penetration ratio, constructed from Swiss trade data for manufacturing industries. Standard errors are clustered on the firm level. *** p<0.01, ** p<0.05, * p<0.1*

[28] As the average import penetration ratio is 56%, it suggests that the Franc shock depressed nominal investment by 2.5% in the average firm through increased import penetration.

6.6.2. Reconciling our Evidence with Macro Data

The evidence presented in the last section suggests that the Franc shock had a substantial negative effect on nominal investment in Switzerland. Do we see these negative effects in aggregate investment data? Figure 19 shows aggregate data on investment in machinery and equipment in Switzerland over the 2013–2016 period, taken from the Swiss national accounts. The light red line shows investment in equipment and machinery in real terms. The figure provides only limited evidence that the Franc shock depressed investment in equipment and machinery. It grew by 1.3% in 2015 and 4% in 2016. Investment growth was comparatively low in 2015 but comparatively strong in 2016 (the average growth rate of the series is around 2.3%). However, the dark red line shows that investment in machinery and equipment increased in 2015 only because of lower prices for investment goods. In nominal terms, investment stagnated. Moreover, the black line illustrates that part of the comparatively strong growth in 2016 is attributable to the small subcategory "miscellaneous vehicles", which grew substantially in 2016 due to the delivery of aircrafts to the national air carrier. Subtracting the one-off effects of these aircrafts by disregarding this subcategory, the Franc shock becomes more apparent in the aggregate data.

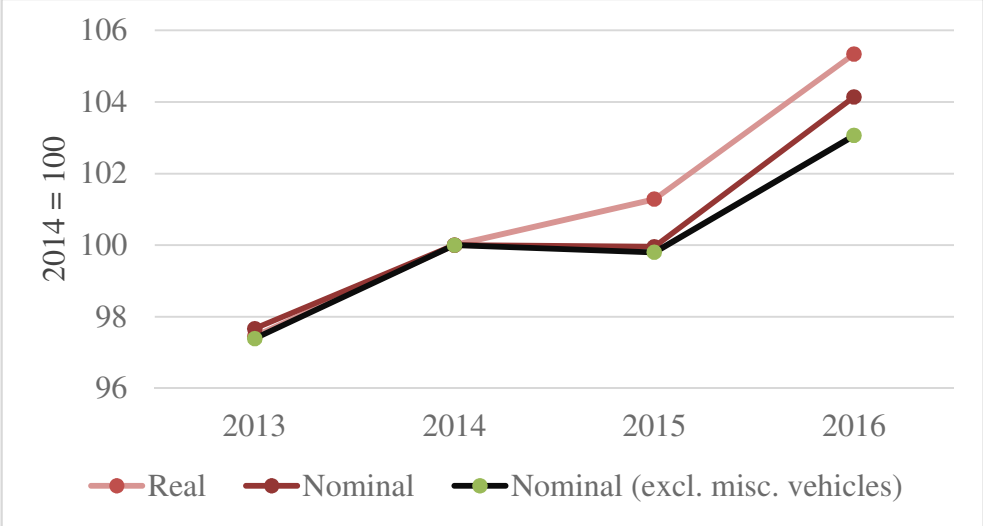
Yet, the case that the Franc shock depressed investment remains less striking in the macroeconomic data compared to our evidence from the KOF investment surveys. There are at least three reasons for this divergence apart from the differences in the underlying data sources. The first is trivial: only one of four firms in our sample is exposed. A decline of investment on machinery and equipment by 10% among exposed firms translates into a 2.5% decline for all firms. Second, the counterfactual aggregate investment is unknown. There are good reasons to believe that investment in equipment and machinery would have been solid in 2015 without the Franc shock.[29] Finally and most importantly, the micro evidence suggests that the negative investment effects of the Franc shock are concentrated in small and medium-sized firms. Large exposed firms do not reduce investment in machinery and equipment because of the Franc shock. The aggregate data, however, are strongly driven by the a small number of very large firms.[30] It is thus likely that the aggre-

[29] Economic forecasters were positive concerning the Swiss economy by the end of 2014, with a consensus year-on-year growth forecast for real GDP forecast of 1.8% for 2015. In March 2015, this consensus had dropped to 0.5%.

[30] For instance, although we observe investment from almost 3000 different firms in 2014, the 15 firms with the largest investment expenditures account for more than 50% of total investment.

gate data are uninformative about the effects of the Franc shock on the small and medium-sized exposed firms.

Figure 19: Investment in Machinery and Equipment in Switzerland According to the Swiss National Accounts, 2013-2016



Notes: The figure shows indices of real and nominal investment into machinery and equipment according to the Swiss national accounts. The black line shows nominal investment excluding the small category miscellaneous vehicles, which includes aircrafts.

6.7. Summary

Main Findings

In this section, we use the exogenous appreciation of the Franc after the removal of the exchange rate floor on January 15 2015 to study the consequences of a strong and sudden appreciation of the home currency on investment of manufacturing and service sector firms. The analysis is based on micro data from the KOF investment surveys. We compare ex-ante investment plans with ex-post realized investment and apply straightforward Differences-in-Differences methods using a firm-level panel data set covering the 2012–2016 period.

Our results suggest strong distributional consequences of the Franc shock between firms. We find robust evidence that firms that sell a large share of their products or services abroad and have a low cost share of imported intermediates invested less in 2015 and 2016 compared to firms whose imported inputs share exceeds the export share. The estimated negative effects on gross fixed capital investment are economically substantial. Exposed firms reduced investment by roughly 15% in 2015 and by 12% in 2016 relative to not or negatively exposed firms. These negative effects mainly arise because firms downsize or postpone medium-sized and large investment projects.

The Franc shock depressed all types of investment. We find statistically significant and economically large negative effects on both, investment in machinery and equipment and construction investment in Switzerland. We also find that the Franc shock had a similarly large negative impact on firms' R&D expenditures in Switzerland, particularly in 2016.

A central reason why firms reduced investment appears to be the loss in financial capabilities. The share of firms which reports that its investment activity is constrained by lack of financial resources increased by 50% in 2015 in exposed relative to not or negatively exposed firms. Another explanation for the reductions in investment in Switzerland is that some firms invest more abroad. We find evidence that the Franc shock had a positive effect on the probability that large manufacturers and firms that had FDI in the past invest abroad, both in production and in R&D units.

Despite the large negative effects on investment in exposed firms, the Franc shock also triggered certain (small) additional investment projects. In particular, it increased the probability to have non-zero equipment investment in 2015 and 2016. Studying firms' investment motives, we find that these additional investment projects appear to be replacement investments, i.e. the Franc shock induced exposed firms to renew their machinery and equipment.

Finally, we do not find evidence that the Franc shock led to more investment in 2015 and 2016 in firms in which the cost share of imported intermediates exceeds their export share in sales. Considering that the Franc shock also exposed some firms with a high share of domestic sales to higher import competition, we estimate that nominal investment would have been up to 8% higher in the average firm participating in the KOF investment survey if the Franc shock had not occurred. We argue that the investment effects of the Franc shock are not that visible in macroeconomic investment data mainly because the negative effects are concentrated in small- and medium-sized firms. Aggregate investment data are strongly driven by a few very large firms. These firms do not cut investment that much because of the Franc shock.

Implications for Structural Change

Our analyses of the Franc shock show that the Franc shock had substantial redistributive effects among Swiss firms in the short-run. Exposed firms lost out relative to the rest of the firms. What are the characteristics of these "losers" from the Franc shock? Exposed firms are of average firm size and have average total investment, but are clearly overrepresented among firms that have R&D expenditures. They are also more likely to be manufacturers (especially high-tech manu-

facturers), and more likely to be foreign owned. By construction, they are also firms with a high share of exports in total sales. The Franc shock thus reduced investment in 2015 and 2016 of firms that tend to be export-oriented, innovative, and mainly operate in the manufacturing sector. Due to its negative effect on the financial possibilities of these firms, the Franc shock appears to have hampered the competitiveness and economic development and the research activities of this important group of firms in 2015 and 2016.

Do our results suggest longer-term consequences of the Franc shock? A central question in this context is whether the investment projects affected by the Franc shock were postponed or abolished. The data do not (yet) cover enough post-treatment years to give a definitive answer to this question. If we use the investment plans for 2017 as levied in the surveys in spring 2017 and autumn 2016 to extend the estimation sample by one year, we find evidence that investment of exposed firms recovers in 2017. It does, however, not exceed investment of not or negatively exposed firms. If the reductions in investment in machinery and equipment and R&D in Switzerland were permanent, the foregone investment in machinery and equipment and in R&D would potentially cause losses in labor productivity compared to the situation in which the Franc shock had not occurred, which would reduce their competitiveness in the medium and longer term.

Finally, we find that a subset of exposed firms responded to the Franc shock by increasing FDI. Such shifts of production and R&D units to foreign countries tend to be persistent. For firms that recoursed to offshoring because of the Franc shock, the central question is whether the decrease in production and R&D costs associated with the offshoring activities will yield the expected profit in the future, potentially enabling them to increase employment in Switzerland in the future.

7. The Effect of Exchange Rates on Business Demography

7.1. Introduction

In this section, we investigate the relationship between exchange rate movements and changes in the business demography of the Swiss economy. In a dynamic perspective, changes in business demography are studied through entry into and exit from the market as well as through growth of existing firms over time. Therefore, studying business-demographic variables may deliver insights on *structural changes* that occur in the economy in the medium and long run.

The influence of exchange rates on business demography is interesting for two distinct reasons. First, the analysis can shed light on the question how the movements in the exchange rates can affect the composition of domestic firms over time: are certain firms more likely to exit from the market? Which firms grow more slowly over time? In this way, the analysis may provide important insights regarding the linkages between exchange rate fluctuations and structural change in Switzerland. For instance, it may be that exchange rate swings contribute to shifts towards the service sector or towards less productive and technology-intensive industries, which in turn has implications for education, growth perspectives and international competitiveness. Second, many empirical analyses on exchange rate effects, including those in this report, are based firm-level survey data. Thus, the estimated effects in such analyses are *conditional on the survival of firms*. It remains unknown how exchange rates would have affected the outcomes of firms that were forced to leave the market (or forewent entry) and are therefore no longer observed in the data. In other words, studying the impacts on entry and exit helps us to assess the importance of *selection effects*.

As in the other empirical section of this report, the empirical strategy is based on the notion that firms with different degrees of net exposure are expected to be affected differently by changes in the exchange rate. The empirical analysis exploits business census data for the period 1995 to 2014 which effectively comprises the universe of firms in Switzerland. For reasons of data availability, the focus is set as follows. First, we study the two outcomes *firm exit* and *firm size growth* (as measured by employment). Second, we examine the manufacturing sector given that industry-specific exchange rates are not available for the service sector.

7.2. Empirical Strategy

The objective of the empirical analysis is to estimate the impact of exchange rate movements on firm size growth (as measured by changes in employment) and the probability that a firm exits the market. The empirical strategy exploits the idea

that an appreciation of the exchange rate has adverse effects for firms with strongly positive net exposure, while there are only indirect effects on comparable firms without any exposure. For instance, by increasing import competition, an appreciation may affect non-exposed firms.[31] Exchange rate movements are therefore expected to cause different changes in the firms' outcomes over time depending on the level of net exposure.

7.2.1. Employment

We observe firm i in industry j and period t. The relevant outcome variable is a firm's full-time equivalent employment, Emp_{it}. The model is given by:

$$\Delta ln\, Emp_{it} = \gamma\, \Delta \ln R_{jt} + \left(S_i\, \Delta \ln R_{jt}\right)\delta + \Delta X_{it}\beta + \theta_t + \varepsilon_{it},$$

$$\text{for } i = 1, \ldots, N \text{ and } t = t_{0i}, \ldots, T_i,$$

The causal variable of interest is the log of the industry-specific REER, $\ln R_{jt}$, which is interacted with a firm-specific measure of *initial net exposure* to exchange rate shocks, denoted by S_i. X_{it} is a vector of exogenous time-varying covariates that may also include covariate-specific time trends. The vector θ_t contains time dummies which account for macroeconomic effects common to all firms. The specification is in first-differences such that individual fixed-effects are taken into account. These fixed effects absorb all time-invariant covariates such as location, size category, entry year and industry affiliation. Finally, ε_{it} is an idiosyncratic error term.

7.2.2. Firm Exit

Concerning the outcome firm exit, it is important to recognize that the variable already represents a change (in activity status) over time. Thus, individual fixed effects do not make sense here because we model the propensity of a one-time binary event.[32] Denoting $Exit_{it}$=1 if the firm exits between period t and t+1, and $Exit_{it}$=0 otherwise, we specify the model as follows:

$$Exit_{it} = \gamma \ln R_{jt} + \left(S_i \ln R_{jt}\right)\delta + Z_{it}\beta + \theta_t + \varphi_j + \varepsilon_{it},$$

$$\text{for } i = 1, \ldots, N \text{ and } t = t_{0i}, \ldots, T_i,$$

The vector Z_{it} contains exogenous time-varying and time-constant covariates that aim to control for heterogeneity in firm exit rates. Variables include the initial level

[31] However, this effect is of second-order and may take some time to materialize.

[32] Firm fixed effects capture unobserved heterogeneity in the time-constant *level* of the outcome across firms. This notion does not apply to firm exit.

of net exposure, firm size category and foreign ownership. We also include detailed industry fixed-effects (φ_j) that allow for industry-specific levels in exit rates and therefore capture unobserved heterogeneity in productivity and profit margins between industries.

7.2.3. Identification

The effect of the exchange rates on firms' outcomes is identified using a difference-in-difference type assumption: We assume that non-exposed firms are the "control group", while the exposed firms are the "treated group".[33] Different levels of S_i are thus interpreted as several treatment groups that differ in their intensity of the treatment. The identifying assumption is a common trend in exit rates and employment, conditional on covariates, in the absence of any exchange rate movements. The effect of a given change in the exchange rate $(r_1 - r_0)$ on a firm with net exposure level $S_i = s \neq 0$ relative to a non-exposed firm with $S_i = 0$ is then given by:

$$\delta_s = \left(E\left[Exit_{it}|X_{it}, S_i = s, R_{jt} = r_1\right] - E\left[Exit_{it}|X_{it}, S_i = s, R_{jt} = r_0\right]\right)$$
$$-\left(E\left[Exit_{it}|X_{it}, S_i = 0, R_{jt} = r_1\right] - E\left[Exit_{it}|X_{it}, S_i = 0, R_{jt} = r_0\right]\right)$$

Note that this identifying assumption is *weaker* than the standard orthogonality condition in the regression framework because the unconditional effect of the exchange rate on exit is allowed to be confounded by unobservables such as unobserved trends in productivity or demand, as long as these unobservables are uncorrelated with initial net exposure. While the difference-in-difference assumption is attractive, it somewhat constrains the interpretation. First, the causal effect is only identified for the subpopulation of the exposed firms ($S_i \neq 0$), and second, it represents a type of *relative causal effect* because we compare positively and negatively exposed with non-exposed units and we do not know the true effect on non-exposed firms. If we impose the more restrictive but plausible assumption that the (first-order) causal effect for non-exposed firms equals zero, then the *absolute causal effect* is also identified. This assumption is rendered more credible when we control for confounding factors such as changes in foreign demand.

[33] Here, "control group" does not mean that we assume the overall effect on these units is zero, but it means that the effects through the export revenue channel and imported input cost channel are zero.

7.3. Data

The empirical analysis is based on the business census microdata of the Swiss Federal Statistical Office which consists of an old and a new census. The old census (German: *Betriebszählung, BZ*) is available for the years 1995, 1998, 2001, 2005, and 2008. The new census (German: *Statistik der Unternehmensstruktur, STATENT*) is conducted annually and currently available for 2011 to 2014. The major difference between the two is that the former was based on the business register and only included establishments with at least half a full-time equivalent worker. In contrast, the latter makes use of social security register data. As a result, the new census covers many micro firms that were not previously recorded. In this context, the SFSO rightly mentions that care must be exercised when comparing the two conceptually different datasets. In our empirical analysis, however, the difference should not be of concern because we only consider firms that *already existed during the old census*.

As a crucial feature, the data has a panel structure that identifies firms over time. The SFSO mentions the possibility that in certain events (e.g. transfers of ownership, changes in legal form), a new identification number may have been issued, which compromises the correct identification of firms over time and possibly the quality of the results. To correct for this, we apply a multi-step procedure that exploits the information in the data, see Section C.1 in the Appendix for details. Another point worth mentioning is that mergers of firms may slightly overstate the number of firm exits. In Section C.2 in the Appendix, we use data from Reuters to show that the annual number of mergers involving two Swiss manufacturing firms is very small.

The business census data includes information on the composition of employment (number of employees and full-time equivalents), detailed industry affiliation, legal form, number of establishments and geographic location. However, details on firms' balance sheets and income statements (assets, revenues and profits) as well as the year of foundation are lacking. Crucial to our study, however, some additional variables were recorded in 1995 and 2005 that capture firms' integration with foreign markets:

- the share of exports in total revenues (with categories 0%, 1%-33%, 34%-66%, >66%),
- the share of imported inputs in total revenues (with categories 0%, 1%-33%, 34%-66%, >66%),
- indicators for foreign ownership and foreign investments (i.e., whether firms own establishments abroad).

7.3.1. Sample Selection and Variables

For the empirical analysis, we apply the following selection criteria to the data: (i) privately-owned manufacturing firms (codes 10 to 35, NACE rev. 2) and (ii) firms that existed in 1995 and/or 2005. The focus on the manufacturing sector is for two reasons. First, industry-specific exchange rates, which are the key variable in the estimation, are only available for manufacturing industries. Second, the import/export information in the census data appears either quantitatively unimportant or unreliable for service industries.[34] The second criterion is applied because the essential export/import information is only available for these two years. In addition to these selection criteria, the years 2012 and 2013 are omitted such that the panel dataset is equally spaced with three-year intervals.[35] The firm-level panel dataset is combined with the industry-specific REER and the industry-specific foreign demand variable described previously.

The main variables are summarized below:

- *Firm exit*: =1, if the firm exits between period *t* and *t*+1, otherwise = 0.
- *Employment*: the number of full-time equivalent workers.
- *Initial net exposure*: The categorical variables on the shares of exports and imports are combined to construct an ordinal measure of net sure: -2=strongly negative, -1=negative, 0=neutral, 1=positive, 2=strongly positive, where the levels are defined in Table 15. Note that we only use the *initially* observed value of net exposure to avoid issues of endogeneity.

Table 15: Definition of Net Exposure as a Function of Export and Import Shares

		share of exports			
		0%	1%-33%	34%-66%	>66%
share of imports	0%	0	1	2	2
	1%-33%	-1	0	1	2
	34%-66%	-2	-1	0	1
	>66%	-2	-2	-1	0

7.3.2. Descriptive Statistics

Before exploring the data, it makes sense to consider a number of stylized facts regarding business demography as summarized by Arkolakis (2016): (i) Small firms tend to have higher exit rates than large firms. (ii) Conditional on survival,

[34] For example, the industries „accommodation“ and „food and beverage services“ exhibit almost zero exports in the data, although these industries rely extensively on service exports (tourism).

[35] The only exception is the four-year interval from 2001 to 2005.

exit rates tend to decline with firm age. (iii) Most entering and exiting firms are small. (iv) Small firms tend to have higher growth rates than large firms. These stylized facts imply that it is important to consider firm size and firm age as potential sources of heterogeneity when studying outcomes.

To obtain a sense of the exposure in the Swiss manufacturing sector to exchange rates, Table 16 presents the absolute and relative distribution of our measure of net exposure as well as the export and import variable. As we can see, only about a quarter of Swiss manufacturing firms engage in exports and about 30% of firms import some intermediate inputs. It is therefore not surprising, that the majority of firms (73%) have a "neutral" net exposure, while 12% are positively exposed and 15% are negatively exposed. Of course, these numbers to not correspond to the share of the workforce subject to exposure: the table also shows the total number of employees across exposure levels. Since positively exposed firms are considerably larger than non-exposed firms, the share of employees subject to positive net exposure is 36% and the share of employees subject to neutral net exposure is only 50%. With respect to the macroeconomic implications, it is therefore important to highlight the difference between the impacts of exchange rates on *individual firms* vis-à-vis *macroeconomic aggregates* such as total employment.

Table 16: Distribution of Net Exposure Levels and Export and Import Shares

		no. of firms		no. of employees	
variable	level	absolute	percent	absolute	percent
net exposure	strongly negative	1,817	3,6%	24,109	2,7%
	negative	5,950	11,7%	106,532	11,8%
	neutral	36,735	72,5%	447,959	49,8%
	positive	3,550	7,0%	167,051	18,6%
	strongly positive	2,622	5,2%	154,083	17,1%
exports	0% of total revenues	38,800	76,6%	327,012	36,3%
	1%-33% of total revenues	6,688	13,2%	219,662	24,4%
	34%-66% of total revenues	2,211	4,4%	115,845	12,9%
	>66% of total revenues	2,975	5,9%	237,215	26,4%
imports	0% of total revenues	35,329	69,7%	302,554	33,6%
	1%-33% of total revenues	11,180	22,1%	407,759	45,3%
	34%-66% of total revenues	3,019	6,0%	150,201	16,7%
	>66% of total revenues	1,146	2,3%	39,220	4,4%

Notes: The table shows the distribution of initial net exposure, initial exports and initial imports in the population of private manufacturing firms. The number of employees refer to within-firm averages across time periods. The data includes all private manufacturing firms existing in 1995 and/or 2005. Data source: Swiss Business Census Statistics.

Table 17 summarizes the outcomes and explanatory variables for firms with different levels of initial net exposure. The data excludes the last time period because firm exit is measured prospectively. Annualized firm exit rates appear comparable across net exposure levels and range from 3.1% to 4.3%, whereas changes in full-

time equivalent (FTE) employment are quite different. Firms with either strongly positive or negative exposure exhibit positive growth, while the other firms have negative average growth rates. In levels, exporters (i.e. positive exposure) are on average sizably larger in terms of employment. Looking at the covariates, we note some important compositional differences between firms with different exposure. First, exporters are more likely to have foreign ownership or foreign investments. Second, the exposure level is also substantially correlated with industry affiliation: among positively exposed firms, the share of firms producing electronic and optical products including watches, other machinery and equipment, and pharmaceuticals are considerably larger than among non-exposed firms. By contrast, firm entry dynamics in the beginning of the observation period and the regional distribution appear to be fairly similar across net exposure levels. As an exception, positively exposed firms are more often located in the region Espace Mitteland, which suggests that this regional economy may have higher currency exposure.

Table 17: Descriptive Statistics by Net Exposure, Swiss Business Census

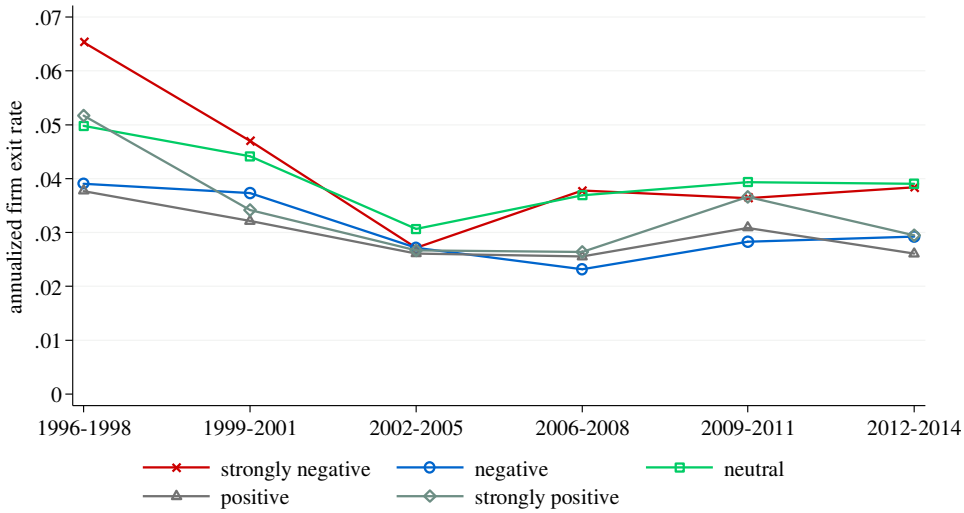
	net exposure					
	strongly negative	negative	neutral	positive	strongly positive	all firms
outcomes						
firm exit	4.3%	3.3%	4.0%	3.1%	3.5%	3.8%
dln(FTE employment)	0.4%	-2.2%	-2.2%	-1.6%	0.7%	-1.9%
FTE employment	13.9	17.5	12.9	47.7	66.6	18.9
firm characteristics						
corporation, LLP	71.8%	61.2%	43.7%	78.7%	84.8%	51.6%
other legal form	0.8%	0.8%	1.7%	0.9%	1.2%	1.5%
foreign owned firm	8.4%	2.6%	1.2%	6.7%	13.2%	2.6%
foreign investment	3.7%	2.5%	1.4%	10.6%	18.4%	3.2%
multi-establishment firm	6.6%	6.3%	3.8%	7.0%	7.4%	4.7%
industry group						
food and tabacco	6.4%	6.4%	8.7%	4.8%	2.5%	7.7%
textiles and apparel	12.8%	8.2%	4.4%	3.0%	3.4%	5.0%
wood, paper, printing	11.6%	18.3%	31.9%	11.5%	3.3%	26.5%
chemical products	3.2%	2.3%	1.1%	4.0%	4.3%	1.7%
pharmaceuticals	1.5%	0.3%	0.3%	1.5%	1.8%	0.5%
rubber and plastic	13.1%	10.8%	4.6%	6.3%	4.2%	5.8%
metal products	11.3%	16.5%	22.2%	26.1%	16.0%	21.1%
electronic / optical prod.	5.9%	4.2%	3.7%	13.3%	22.9%	5.6%
electrical equipment	3.5%	3.1%	1.8%	3.3%	4.4%	2.3%
oth. machinery / equip.	8.8%	6.8%	3.8%	15.4%	26.6%	6.4%
transport equipment	2.4%	2.0%	0.9%	0.9%	1.2%	1.1%
other manufacturing	19.2%	20.9%	15.9%	9.6%	9.0%	15.8%
electricity, gas, steam	0.4%	0.3%	0.8%	0.4%	0.3%	0.6%
entry period						

1996-1998	7.3%	8.3%	7.6%	7.6%	7.4%	7.7%
1999-2001	6.8%	7.4%	6.6%	7.0%	6.8%	6.8%
2002-2005	8.4%	5.1%	6.2%	4.3%	6.5%	6.0%
region (NUTS-2)						
Région Lémanique	14.0%	11.8%	15.1%	9.6%	12.2%	14.1%
Espace Mittelland	22.8%	22.7%	26.7%	30.1%	29.6%	26.5%
Northwestern CH	13.8%	14.2%	12.3%	13.7%	12.7%	12.7%
Zurich	17.4%	15.7%	14.8%	16.1%	13.9%	15.0%
Eastern CH	15.6%	18.7%	17.1%	18.7%	18.5%	17.4%
Central CH	10.5%	11.4%	10.4%	8.1%	8.9%	10.3%
Ticino	5.9%	5.5%	3.5%	3.8%	4.2%	3.9%
no. of time periods (T)	4.31	4.80	4.50	4.90	4.67	4.57
no. of firms (N)	1,817	5,950	36,735	3,550	2,622	50,674

Notes: Data includes all private manufacturing firms existing in 1995 or 2005. The time periods are 1995, 1998, 2001, 2005, 2008, 2011. Data source: Swiss Business Census Statistics.

Figure 20 depicts the evolution of firm exit rates for private Swiss manufacturing firms over time. Exit rates in the beginning of the period are higher partly because more young firms are included; this is due to the selection criteria. Moreover, firms with neutral net exposure have relatively high exit rates because they are smaller on average. Overall, aggregate firm exit rates do not appear to fluctuate much over time and it appears difficult to interpret the observed changes. It is interesting to not, however, that firms with "strongly positive" exposure exhibit the most pronounced increase in the exit rate from the period 2006-2008 to 2009-2011, which coincides with a sharp appreciation of the REER.

Figure 20: Evolution of Firm Exit Rates by Initial Net Exposure



Notes: The figure shows annualized firm exit rates for groups defined by initial net exposure. The data includes all private manufacturing firms existing in 1995 and/or 2005. The time periods are 1995, 1998, 2001, 2005, 2008, 2011. Data source: Swiss Business Census.

7.4. Empirical Results for Employment

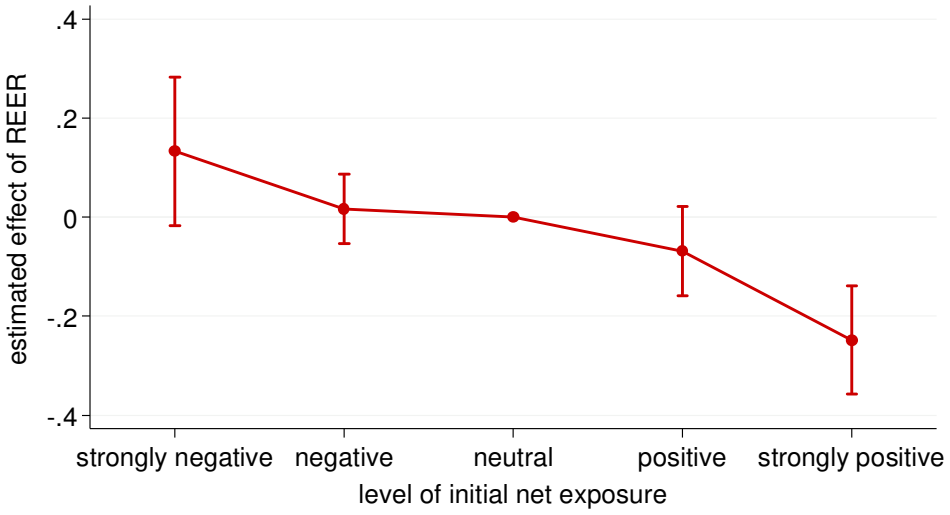
We first study the impact of changes in the REER on firms' FTE employment. We estimate the model for private Swiss manufacturing firms using the business census data from 1995 to 2014. Due to the first-difference specification, firms without two consecutive observations are not included. The benchmark model includes a measure of foreign demand interacted with export exposure, aggregate time effects as well as industry-specific time trends. (We also experimented with a measure of import penetration to control for import competition, but the coefficient was very imprecisely estimated and the sample size was reduced because information is not available for all industries. For this reason, we do not include this control variable.)

7.4.1. Main Results

Figure 21 presents the estimated elasticities of FTE with respect to the industry-specific exchange rates and 90% confidence intervals. As expected, the effect of the REER on employment decreases monotonically with the level of the initial net exposure. The elasticity for firms with strongly positive exposure is around -0.25 and statistically significant on the 1% level. Given an appreciation of 10%, firms with strongly positive exposure reduce their employment by roughly 2.5% relative to non-exposed firms. This means that firms with a high share of exports and no/few imports significantly adjust their labor demand in response to exchange rate movements. By contrast, firms with negative exposure have a positive elasticity, that is, they raise their employment in the case of an appreciation. While the elasticity has the expected sign, the effects are not statistically different from zero.[36]

[36] These findings are similar to those obtain using the Swiss Innovation Survey in Section 5.4.

Figure 21: Effect of REER on Employment



Notes: The figure shows estimated coefficients of the interaction terms between the initial net exposure levels and the change in the REER. The net exposure level "neutral" is the reference category. The model is estimated in first differences and controls for foreign demand, aggregate time effects and industry-specific time trends. The sample includes all private manufacturing firms existing in 1995 and/or 2005. Data source: business census statistics.

At this stage, it is important to mention that the results in this section are *conditional on the survival* of firms. If selection effects, that is, the impact of exchange rates on firm exit, were taken into account, the magnitude of the estimated elasticities would be likely to be larger than those reported.

7.4.2. Assessing Robustness

To assess the robustness of the above results with respect to the econometric specification, Table 18 below presents the estimated regression coefficients for several specifications. Model (1) includes only time effects, model (2) additionally controls for foreign demand, model (3) is the benchmark model used above with industry-specific time trends and model (4) uses a full set of industry-time fixed effects. Note that the main effects of the REER and foreign demand are absorbed by the industry-time fixed effects in the last model. Comparing the coefficients of the interaction terms between net exposure and the REER, we find that the qualitative and quantitative results are quite robust to the specification: the effect for strongly positively exposed firms is always statistically significant, while the other effects are mostly not significant. It is worth noting, however, that the main effect of the REER, which captures the effect of the REER on non-exposed firms, drops to zero when moving from model (2) to model (3). In the short run, we would expect that this effect is indeed close to zero, since the impact of import competition should be of second order and takes some time to materialize. Therefore, a model

that controls for industry-specific time effects, such as (3) and (4), appears adequate in the light of the results.

Table 18: Regression Results for Employment by Specification

variables	(1)	(2)	(3)	(4)
dln(REER)	-0.101**	-0.100**	0.004	
	(0.051)	(0.051)	(0.053)	
strongly negative NE x dln(REER)	0.134	0.133	0.133	0.174*
	(0.091)	(0.091)	(0.091)	(0.093)
negative NE x dln(REER)	0.024	0.021	0.016	0.038
	(0.043)	(0.043)	(0.043)	(0.043)
positive NE x dln(REER)	-0.076	-0.071	-0.069	-0.007
	(0.055)	(0.055)	(0.055)	(0.056)
strongly positive NE x dln(REER)	-0.250***	-0.244***	-0.248***	-0.149**
	(0.066)	(0.067)	(0.067)	(0.071)
dln(foreign demand)		0.009***	0.010***	
		(0.002)	(0.002)	
I(1%-33% exports) x dln(foreign demand)		-0.007	-0.007	-0.007
		(0.006)	(0.006)	(0.006)
I(34-66% exports) x dln(foreign demand)		0.006	0.006	0.006
		(0.016)	(0.016)	(0.016)
I(>66% exports) x dln(foreign demand)		-0.003	-0.003	-0.003
		(0.013)	(0.013)	(0.013)
Period FE	Yes	Yes	Yes	Yes
Industry Time Trend	No	No	Yes	No
Industry Time FE	No	No	No	Yes
R-squared	0.008	0.008	0.013	0.016
Firms	44,018	44,018	44,018	44,018
Observations	178,265	178,266	178,267	178,268

*Notes: The dependent variable is the log change in FTE employment. The models are estimated in first differences. Standard errors are clustered on the firm level. Significance levels are *** p<0.01, ** p<0.05, * p<0.1. The sample includes all private manufacturing firms existing in 1995 and/or 2005 which are observed for at least two consecutive time periods.*

7.4.3. Heterogeneity across Firm Size

Next, we explore the potential heterogeneity in the employment response. Table 19 presents the estimated effects for five firm size categories. Firms are assigned to the categories based on their average number of employees over all time periods. Naturally, the estimates are less precise than before due to the smaller sample sizes. We find that especially medium-sized and large firms with 20 to 200 employees are most responsive to exchange rate movements, with an elasticity of around -0.3. An appreciation of the REER of 10% leads to a reduction in employment of about 3% in firms with strongly positive exposure relative to non-exposed firms. By contrast, the corresponding effects for small firms (1 to 20) are smaller and not statistically significant, which may be linked to potentially stronger selection effects due to firm exit among small firms.

Table 19: Regression Results for Employment by Firm Size

	firm size category (average employment)				
variables	<5	5 - 20	21 - 50	51 - 200	>200
strongly negative NE x dln(REER)	-0.017	0.373***	-0.373	0.228	-0.006
	(0.150)	(0.130)	(0.341)	(0.222)	(0.613)
negative NE x dln(REER)	-0.084	0.100	-0.007	0.276	0.050
	(0.068)	(0.066)	(0.123)	(0.203)	(0.308)
positive NE x dln(REER)	-0.045	0.043	-0.022	-0.262	-0.101
	(0.111)	(0.088)	(0.112)	(0.181)	(0.314)
strongly positive NE x dln(REER)	-0.148	-0.105	-0.337**	-0.317**	-0.346
	(0.157)	(0.125)	(0.149)	(0.159)	(0.249)
R-squared	0.007	0.018	0.029	0.035	0.054
Firms	24,721	13,093	3,458	2,132	614
Observations	89,765	58,952	16,323	10,188	3,037

*Notes: The dependent variable is the log change in FTE employment. The benchmark model is estimated in first differences. Standard errors are clustered on the firm level. Significance levels are *** p<0.01, ** p<0.05, * p<0.1. The sample includes all private manufacturing firms existing in 1995 and/or 2005.*

7.4.4. Summary

To summarize the effects on employment growth, we find evidence that private manufacturing firms with strongly positive net exposure adjust their labor demand significantly in response to exchange rate movements. Across all firms, the average effect is likely to be close to zero, since the impacts on firms with negative and positive exposure largely offset each other. The estimates are well in line with other findings in the literature that report negative but small elasticities of overall employment with respect to the REER (cf. Nucci et al. 2010 for Italy; Moser et al. 2010 for Germany; Kaiser & Siegenthaler 2016 for Switzerland). Moreover, we document some interesting heterogeneity in that employment in medium-sized and large firms with strongly positive exposure is particularly responsive to exchange rate fluctuations.

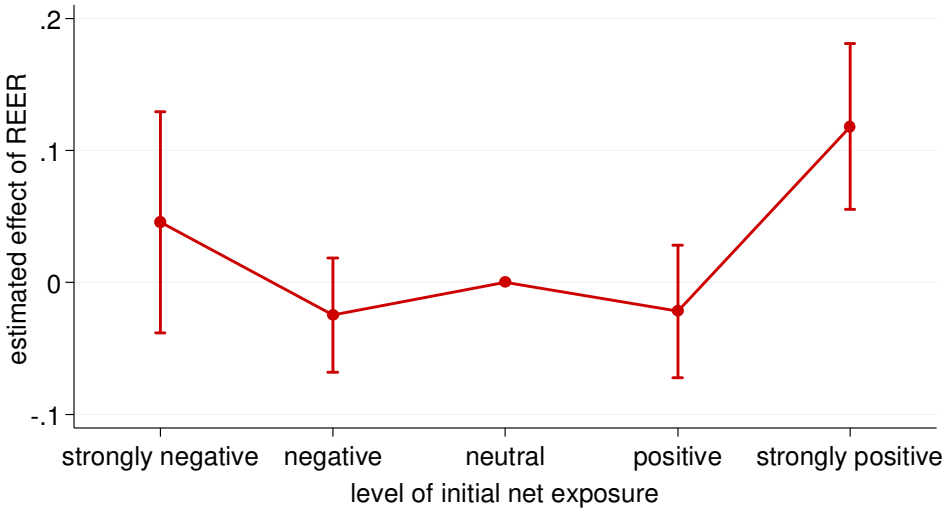
7.5. Empirical Results for Firm Exit

We now turn to the analysis of the probability of firm exit. We estimate the model for private Swiss manufacturing firms using the business census data from 1995 to 2011. (The year 2014 must be omitted because firm exit is measured prospectively.) Since exit probabilities are affected by entry dynamics, we only retain firms that existed in the initial year 1995 and exclude firms that enter the market later. In this way, changes in the composition of firms are only due to exit and exit probabilities are not confounded by entry. The benchmark model includes a measure of foreign demand interacted with export exposure, aggregate time effects, detailed industry fixed effects (6-digit level) and covariates that control for firm size cate-

gory, legal form, foreign ownership, foreign investment and multiple establishments.

Figure 22 presents the estimated effects of the REER on the probability of firm exit along with 90% confidence intervals. Compared to the employment estimates, these estimates are much less precise, which may be for two reasons. First, the baseline probability of firm exit is low. Naturally, the small variation in the outcome renders the precise estimation of causal relationships difficult. Second, the timing of exit is not precisely known which also contributes to the noise in the estimates. Nonetheless, we observe a statistically significant positive impact for firms with strongly positive exposure. The estimated coefficient of 0.12 can be interpreted as follows: A 10% appreciation of the REER raises the *annual exit probability* of firms with strongly positive exposure by about 0.3 percentage points relative to non-exposed firms.[37] In absolute terms, this effect appears fairly small, but in relative terms, it is not negligible: Given the average annual exit rate of about 4%, the *relative effect* of the REER on the exit probability for firms with strongly positive exposure amounts to 7.5% (=0.3/4). In contrast, the coefficients for the other levels of net exposure in Figure 22 are not statistically significant.

Figure 22: Effect of REER on the Probability of Firm Exit



Notes: The figure shows estimated coefficients of the interaction terms between the initial net exposure levels and the change in the REER. The net exposure level "neutral" is the reference category.

[37] Due to the level-log specification, the effect is: $\Delta P(Exit|x) = \left(\frac{\delta}{100}\right)\Delta\%REER = \left(\frac{0.12}{100}\right)10 = 0.012$, that is, 1.2 percentage point. Since exit rates refer to *three-year* intervals, the effect on the *annual* exit rate is roughly $\Delta P(Exit|x)_{annual} = \left(\frac{0.012}{3}\right) = 0.003$, that is, 0.3 percentage points.

The model is estimated by OLS and controls for foreign demand, aggregate time effects, detailed industry fixed effects and a number of firm characteristics. The sample includes all private manufacturing firms existing in 1995. Data source: business census statistics.

We again assess the robustness of the results with respect to the econometric specification of the model. Table 20 presents the regression results for four specifications that differ in their complexity: Model (1) only controls for foreign demand and time effects; model (2) contains additional covariates on firm characteristics; model (3) adds industry fixed effects; and model (4) adds industry-specific time trends. Model (4) is the benchmark model used above. Comparing the results across columns, we find that the coefficients of the interaction terms between net exposure and the REER are not sensitive to the specification: Their sign, magnitude and statistical significance are similar across all four models. We note further that the main effect of the REER, which captures the effect on non-exposed firms, only turns insignificant once industry-specific time trends are included (in model 4).

Besides the impact of the REER, the regression results in Table 20 also highlight some interesting associations between exit and firm characteristics: the probability of exit decreases with firm size, is higher for foreign owned and multi-establishment firms, but smaller for firms with foreign investments.

Table 20: Regression Results for the Probability of Exit, by Specification

variables	(1)	(2)	(3)	(4)
strongly negative NE	0.008	0.024***	0.013**	0.013**
	(0.005)	(0.005)	(0.005)	(0.005)
negative NE	-0.021***	-0.004	-0.008***	-0.008***
	(0.003)	(0.003)	(0.003)	(0.003)
positive NE	-0.030***	0.005*	-0.001	-0.001
	(0.003)	(0.003)	(0.003)	(0.003)
strongly positive NE	-0.019***	0.020***	0.007*	0.007*
	(0.004)	(0.004)	(0.004)	(0.004)
dln(REER)	-0.076*	-0.117***	-0.080**	-0.050
	(0.039)	(0.038)	(0.038)	(0.040)
strongly negative NE x dln(REER)	0.048	0.046	0.040	0.045
	(0.052)	(0.051)	(0.051)	(0.051)
negative NE x dln(REER)	-0.030	-0.028	-0.029	-0.025
	(0.027)	(0.026)	(0.026)	(0.026)
positive NE x dln(REER)	-0.029	-0.029	-0.032	-0.022
	(0.031)	(0.031)	(0.030)	(0.030)
strongly positive NE x dln(REER)	0.106***	0.103***	0.101***	0.118***
	(0.039)	(0.038)	(0.038)	(0.038)
dln(foreign demand)	-0.003**	-0.004***	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
I(1%-33% exports) x dln(foreign demand)	0.002	0.004	0.004	0.004
	(0.004)	(0.004)	(0.004)	(0.004)

I(34-66% exports) x dln(foreign demand)	-0.015	-0.013	-0.013	-0.012
	(0.012)	(0.012)	(0.013)	(0.012)
I(>66% exports) x dln(foreign demand)	0.019*	0.019*	0.020*	0.020*
	(0.011)	(0.011)	(0.011)	(0.011)
5-20 employees (av.)		-0.076***	-0.076***	-0.076***
		(0.002)	(0.002)	(0.002)
21-50 employees (av.)		-0.091***	-0.096***	-0.095***
		(0.003)	(0.003)	(0.003)
51-200 employees (av.)		-0.093***	-0.102***	-0.101***
		(0.004)	(0.004)	(0.004)
>200 employees (av.)		-0.106***	-0.117***	-0.115***
		(0.006)	(0.006)	(0.006)
corporations/LLPs		-0.017***	-0.022***	-0.022***
		(0.002)	(0.002)	(0.002)
other legal form		0.027***	0.021***	0.019**
		(0.007)	(0.007)	(0.007)
foreign ownership		0.022***	0.018***	0.019***
		(0.005)	(0.005)	(0.005)
foreign investment		-0.008**	-0.014***	-0.013***
		(0.004)	(0.004)	(0.004)
multi-establishment		0.012***	0.010***	0.010***
		(0.004)	(0.004)	(0.004)
Region dummies	No	Yes	Yes	Yes
Period FE	Yes	Yes	Yes	Yes
Industry FE	No	No	Yes	Yes
Industry Time Trends	No	No	No	Yes
R-squared	0.007	0.026	0.031	0.032
Firms	38,473	38,473	38,473	38,473
Observations	163328	163328	163328	163328

*Notes: The table shows regression results for the probability of firm exit. The models are estimated by OLS. Standard errors are clustered on the firm level. Significance levels are *** p<0.01, ** p<0.05, * p<0.1. The sample includes all private manufacturing firms existing in 1995. Data source: Swiss business census statistics.*

As a next step, we examine the potential heterogeneity in the effect of the REER on the probability of firm exit. Table 21 presents the estimated effects of interest for three firm size categories. The estimates for small firms (<5 and 5-20 employees) are bigger than for large firms (>50 employees), but they are quite imprecise. If the interaction terms for firms with strongly positive net exposure are taken at face value, the results suggest that a strong appreciation of the REER mainly drives small firms out of business given that they are heavily exposed to exchange rate movements. This finding is in line with intuition because the profitability of large firms is arguably more stable compared to smaller firms. However, it must be emphasized that the results are associated with considerable variance.

Besides firm size, we also estimated separate models for industry groups. However, the results turn out to be very erratic across industries due to sizable standard errors and are not reported.

Table 21: Regression Results for the Probability of Exit, by Firm Size Category

	average employment size		
variables	<5	5 - 20	>50
strongly negative NE x dln(REER)	0.122	0.007	-0.034
	(0.095)	(0.069)	(0.091)
negative NE x dln(REER)	-0.050	0.001	-0.017
	(0.046)	(0.039)	(0.048)
positive NE x dln(REER)	0.019	-0.030	-0.032
	(0.074)	(0.048)	(0.045)
strongly positive NE x dln(REER)	0.139	0.169**	0.066
	(0.099)	(0.068)	(0.049)
Period FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Industry Time Trends	Yes	Yes	Yes
R-squared	0.0182	0.0151	0.0182
Firms	21409	11474	5590
Observations	81894	53904	27530

*Notes: The dependent variable is firm exit. The benchmark model is estimated by OLS. Standard errors are clustered on the firm level. Significance levels are *** p<0.01, ** p<0.05, * p<0.1. The sample includes all private manufacturing firms existing in 1995. Data source: Swiss business census statistics.*

7.6. Summary

We have analyzed the effect of exchange rate movements on employment growth and the probability of exit using business census data on the universe of private manufacturing firms in Switzerland. The empirical strategy is a difference-in-difference regression framework in which outcomes are compared between groups of firms that differ in their initial level of net exposure to exchange rates.

Main findings

For employment growth, we find that the elasticity with respect to the REER falls monotonically with the level of exposure, which is in line with theoretical expectations. For firms with a strongly positive net exposure, the estimated elasticity is about -0.25 and is statistically significant at the 1% level. This means that a 10% appreciation causes these firms to lower their labor demand by about 2.5% relative to non-exposed firms. This results is quantitatively robust to the specification of the econometric model and in line with estimates of other studies (cf. Nucci et al. 2010; Moser et al. 2010; Kaiser & Siegenthaler 2016). For the other levels of exposure, the elasticity is not significantly different from zero. A separate analysis by firm size category reveals that the employment response appears more pronounced for large firms with more than 50 employees. This is in line with expectations because small firms are more likely to exit the market, which is not captured by the employment elasticities.

The analysis of the probability of firm exit has proven more challenging because the estimates are characterized by more noise. Nonetheless, we document a significant impact of the REER on the probability of exit for firms with strongly positive net exposure. A 10% appreciation increases the annual exit probability among these firms by 0.3 percentage points relative to non-exposed firms. This effect is significant on the 1% level and robust across a range of econometric specifications. By contrast, the effects for the other levels of exposure are not significant. Additional regressions suggest that the impact on the probability of exit is more relevant among smaller firms. This is consistent with empirical evidence from the literature that small firms have higher exit hazard rates (cf. Arkolakis 2016).

Implications for Structural Change

The results obtained in this section deliver some evidence as to how specific aspects of business demography in Switzerland, firm size growth and firm exit, are affected by exchange rate movements. The estimates describe economic responses in the *short and medium run* given that the panel dataset is based on three-year intervals. How do exchange rate movements affect the business demography in Switzerland in the *long run*? In our view, the analysis presented here may offer some useful insights in this regard.

First, the data allowed us to characterize the distribution of exchange rate exposure for the universe of the Swiss manufacturing sector. Firms with strongly positive exposure have different characteristics than those with a neutral/negative exposure (e.g. size, industry, ownership) which implies that an extended period of a strong currency has uneven effects across the "demographic groups" of Swiss firms.

Second, the econometric results may offer guidance with regard to long-term structural changes, despite the challenge to relate them to the long run. Over the course of the last ten years, from 2006 to 2016, the economy-wide REER appreciated by 22%. Our analysis therefore suggests that this period of appreciation substantially contributed to slower growth of *exporting* firms with few imported intermediate inputs. Based on a very rough calculation, FTE employment in these firms would have grown 5.5% more in the absence of any changes in the exchange rate. The prolonged appreciation period may also have contributed to slower growth of the *average* manufacturing firm, but the average effect is likely to be small because effects on firms with positive and negative net exposure largely offset each other.

Third, as regards the characteristics of firms, the adverse effects may be more marked among larger firms, both because their employment response is stronger and because they are more likely to be more export-oriented. This suggests that long-term appreciations of the exchange rate may tend to *compress the firm size*

distribution. Moreover, the results may also imply that longer-term changes in the exchange rate affect the *industrial composition* of Swiss firms given the fact that certain industries, such as producers of electronic and optical products, and machinery and equipment, rely more heavily on exports than others.

Fourth, besides the implications for the growth of *surviving* firms, our study provides novel empirical evidence that higher exchange rates can also affect the structural composition of firms by driving some (unproductive) firms out of the market if they have positive exposure to exchange rates. In this sense, exchange rates immediately contribute to structural changes occurring in the economy.

Finally, the results may also lend support to the notion that the share of the manufacturing sector in the economy is shrinking because its positive exposure to international markets is larger relative to the service sector. Our evidence suggests that a strong currency both contributes to slower within-firm employment growth and increases the probability for firms to leave from the market.

8. Conclusions

This report deals with the question whether and to what extent exchange rate fluctuations affect the activities of Swiss firms, with a focus on their efforts to innovate and invest. This question is of special importance for Switzerland, which is a small open economy, where exchange rate movements carry a relatively large weight. This report has considered several empirical outcomes on the firm level to contribute to the ongoing debate about the impact of exchange rates on the Swiss economy. In particular, we have investigated the effects on firm-level productivity, R&D expenditures, production cost reductions, investments, employment growth and exit from the market. While the effects we estimate refer to the short and medium run effects of exchange rates, some of these outcomes, notably spending on R&D and investment, also have implications for productivity and growth in the long run.

The empirical analyses exploit three different sources of firm-level panel data: the KOF Innovation Survey (productivity, R&D, production cost reductions), the KOF Investment Survey (investment) and Business Census Statistics (employment growth and exit). The applied empirical strategy largely follows previous papers studying the effects of exchange rates on investment and employment. It is based on the notion that firms are unevenly affected due to different degrees of exposure to exchange rates depending on (i) how much they export, (ii) how many intermediate inputs they purchase from abroad, and (iii) to what extent their domestic market is affected by import competition. Thus, the empirical approach allows for opposing effects: An appreciation simultaneously creates “winners” and “losers”, depending on the nature of international exposure of a firm. Whereas a real appreciation decreases the profits of firms with a positive net exposure (i.e. firms in which the export share exceeds the imported input share), it increases the profits of firms with a negative net exposure.

8.1. Main Findings

Productivity, R&D and Cost Reductions

Using the Swiss Innovation Survey (SIS), we study the effect of real exchange rate fluctuations on the three firm level outcomes productivity, R&D, and cost reductions. The analysis yields several important insights:

- *Effects on performance measures*: Exchange rate appreciations clearly have a negative effect on total revenues and value added for firms with positive net exposure.

- *Effects on cost reductions*: Firms appear to respond to real appreciations with cost reductions. Net exposed firms are more likely to introduce process innovations that lead to significant cost reductions.
- *Effects on productivity*: Firms cannot fully compensate the lower revenues with cost reductions in the short and medium term. A 10% real appreciation of the Swiss Franc decreases value added per employee by 1.3% and TFP (total factor productivity) by 2.2%.
- *Effects on R&D expenditures*: Overall, there is a negative effect of real exchange rate appreciation on R&D expenditures. The economic significance is considerable; for a firm with average net exposure, a 10% real appreciation of the Swiss Franc leads to a 17% decrease in R&D expenditures. There is no empirical evidence that exchange rate fluctuations have an impact on firms' decisions to enter/exit from R&D activities.
- *Heterogeneous effects by profitability*: The profitability of firms positively mediates the observed negative effect on R&D expenditures. In firms with only few financial resources, appreciations lower R&D expenditures. In contrast, firms with considerable financial means increase R&D expenditures if the exchange rate appreciates.
- *Heterogeneous effects by firm size*: Large, internationally exposed R&D intensive firms show the strongest negative reaction to exchange rate appreciations. In contrast, we also detected a segment of very small firms that increases its R&D expenditures in times of currency appreciation. These firms are characterized by low levels of net-exposure, large R&D intensity, and relatively low levels of price competition (niche players).
- *Appreciations vs. depreciations*: The negative effect of exchange rate movements on R&D expenditures is largely symmetric: the positive effects of real depreciations are of similar size as the negative effects of real appreciations.

Investment

The effects of exchange rates on investment are studied using a Differences-in-Differences approach by comparing the evolution of investment of firms with different net exposure before and in the two years following the "Franc shock". The Franc shock is the strong appreciation of the Swiss Franc that followed the unexpected abolition of the exchange rate floor of the Swiss Franc relative to the Euro in January 2015.

- *Effects on total investment*: Due to the Franc shock, firms with positive net exposure reduced gross fixed capital investment by roughly 15% in 2015 and by 12% in 2016 relative to not or negatively exposed firms.

- *Different types of investment*: Exposed firms reduce investment in machinery and equipment and construction investment in 2015 and 2016. They also substantially decrease R&D expenditures in Switzerland.
- *Possible reasons for the negative effects:* A central reason why exposed firms reduced investment in Switzerland appears to be the loss in financial capabilities. Another explanation is that larger manufacturers and firms that are experienced with foreign direct investments invest more abroad, both in production and in R&D units.
- *Positive investments effects:* the Franc shock triggered certain (small) additional investment projects. In particular, the Franc shock appears to have induced exposed firms to renew their machinery and equipment.
- *Effect on aggregate investment*: Because we do not find evidence that firms with negative exposure invested more in 2015 and 2016 and because the Franc shock also exposed some firms with a high share of domestic sales to higher import competition, we estimate that nominal investment would have been up to 8% higher in the average firm participating in the KOF investment survey if the Franc shock had not occurred.
- *Comparison to macroeconomic data*: The adverse effects on investment are less apparent in macroeconomic data because the negative investment effects of the Franc shock are particularly pronounced in exposed manufacturing and in small and medium-sized firms. Small and medium-sized firms do not have a large weight in macro data.

Aspects of Business Demography

We have analyzed the effect of exchange rate fluctuations on employment growth and the probability of exit from the market using business census data on the universe of private manufacturing firms in Switzerland.

- *Effects on employment growth*: We found that the elasticity with respect to the real exchange rate fluctuations falls monotonically with the level of exposure, which is in line with theoretical expectations. For firms with a strongly positive net exposure, a 10% appreciation causes a reduction in labor demand by about 2.5% relative to non-exposed firms. This effect is found to be more pronounced for large firms with more than 50 employees.
- *Effects on firm exit*: We document a significant impact of the real exchange rate fluctuation on the probability of exit for firms with strongly positive net exposure: A 10% appreciation increases the annual exit probability among these firms by 0.3 percentage points relative to non-exposed

firms. Further evidence suggests that the effect on the probability of exit is more relevant among smaller firms.

8.2. Implication for Structural Change

By focusing on the exchange rate effects within two to three years, our analyses capture the short- to medium-term effects of real exchange rate fluctuations on the above-mentioned outcome variables. But what are the consequences for structural changes in the long run? We have documented a series of significant effects of exchange rates on R&D expenditures, investments, and the composition of firms. Exchange rate effects on these outcomes are relevant for productivity and growth in the longer run. They have the potential to alter the structure of the Swiss economy, particularly if the Swiss Franc remained over- or undervalued for a longer period in time. Below, we summarize the most important insights, while recognizing that our results do not allow us to draw conclusive statements.

R&D Expenditures

R&D expenditures are central for the international competitiveness of the Swiss economy. The BFS (2017) reports that aggregate domestic R&D expenditures have increased since the beginning of the real exchange rate appreciation of the Swiss Franc in 2007. However, the observed negative elasticity of R&D spending to exchange rates suggest that R&D expenditures would have risen by even more in the absence of the real appreciation of the Swiss Franc. Other countries also increased their R&D expenditures substantially and it is the relative performance that matters for competitiveness. The competitiveness of Swiss firms could even be compromised by substantial temporary appreciations of the Swiss Franc. The problem is that a temporary decrease in R&D expenditures may create significant gaps to the technological leaders that are difficult to bridge in the future.

Our results also reveal that the negative effects of real exchange rate appreciations on R&D expenditures among exposed firms are mainly driven by large, internationally exposed firms. Since these firms have a disproportional weight, it could have potentially severe consequences for the Swiss economy. Switzerland might lose attractiveness as a destination for large, R&D intensive international firms. Moreover, there exists a symbiotic relationship between large, internationally exposed R&D firms and numerous small, domestic firms that act as specialized suppliers. If these large, internationally exposed firms forgone their R&D expenditures, the economic wealth of smaller domestic suppliers might be effected, too. However, we also identified a group of small, R&D intensive firms, so-called “niche players” that increase their R&D expenditures. They adapt to the apprecia-

tion in a different way and might benefit from it in the longer run in terms of productivity and employment growth. The appreciation also increases the cost-consciousness of Swiss firms significantly, which might provide an additional impulse to their competitiveness when the currency depreciates.

Since manufacturing firms usually have higher levels of net exposure than service firms, a longer run appreciation period might accelerate a structural shift – in terms of value added and employment – towards the service sector.

We also observed that the Franc shock in 2015 triggered additional activities on foreign R&D locations. At first sight this challenges Switzerland as a location for R&D. However, these activities might also benefit the Swiss location, if knowledge is successfully transferred and the innovation activities in Switzerland benefit from additional international knowledge sourcing activities.

Investments

Our results on physical investments show that the Franc shock had substantial re-distributive effects among Swiss firms in the short-run. Exposed firms lost out relative to the rest of the firms. The Franc shock reduced investment in 2015 and 2016 of firms that tend to be export-oriented, innovative, and mainly operate in the manufacturing sector. Due to its negative effect on the financial possibilities of these firms, the Franc shock appears to have hampered the competitiveness, economic development, and the research activities of this important group of firms in 2015 and 2016.

Whether our results suggest longer-term consequences of the Franc shock depends critically on whether the affected investment projects were postponed or abolished. If the reductions in investment in machinery and equipment and R&D in Switzerland were permanent, the foregone investment in machinery and equipment and in R&D would likely cause losses in labor productivity compared to the situation in which the Franc shock had not occurred, which would reduce their competitiveness in the medium and longer term.

Finally, we find that a subset of exposed firms responded to the Franc shock by increasing FDI. Such shifts of production and R&D units to foreign countries tend to be persistent. The central question regarding these firms is whether the decrease in costs associated with the offshoring activities will yield the expected profit in the future, potentially enabling them to increase employment in Switzerland in the future.

Business Demography

The results with regard to the business-demographic variables may offer some useful insights with respect to structural change in the long term. First, the descriptive evidence on the distribution of exchange rate exposure in the Swiss manufacturing sector clearly shows that firms with strongly positive exposure have different characteristics than those with a neutral/negative exposure, which implies that a strong Swiss Franc has uneven effects across the "demographic groups" of Swiss firms. Most importantly, firms with positive net exposure are by construction more export oriented, tend to be larger, are more often foreign owned, and are overrepresented in the production of electronic and optical products including watches, other machinery and equipment, and pharmaceuticals. The KOF investment data further suggests that they are more R&D intensive and are more likely to be manufacturers. In sum, exchange rate appreciations thus mainly affect R&D intensive, export-oriented manufacturing firms negatively.

Second, considering the extended appreciation period from 2007 to 2016, our estimates suggest that the strong currency substantially contributed to slower employment growth in *positively exposed* firms (many exports, few imports). Third, the adverse effects of exchange rate appreciations on employment growth and exit rates may *compress the firm size distribution* and affect the *industrial composition* of Swiss firms given the fact that net exposure varies across industries.

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Appendix

A. Industry-Specific Exchange Rates

This section explains the construction of the industry-specific real effective exchange rates (REER) used in the empirical section of the report.

A.1. Construction of Variables

A.1.1. Export-Weighted and Import-Weighted Exchange Rates

The methodology for constructing REER largely follows that of the Bank of International Settlement (BIS). For each Swiss two-digit manufacturing industry, we calculate the REER by appropriately weighting the growth rates of the bilateral real exchange rates (RER) with trade flows to/from 35 trade markets.

For Swiss industry j, the export weight of partner country p in year t is given by the following moving average:

$$w_{jpt}^{X} = \frac{\sum_{l=1}^{L} EX_{jp,t-l+1}}{\sum_{p=1}^{P}\sum_{l=1}^{L} EX_{jp,t-l+1}}.$$

The corresponding import weight is

$$w_{jpt}^{M} = \frac{\sum_{l=1}^{L} IM_{jp,t-l+1}}{\sum_{p=1}^{P}\sum_{l=1}^{L} IM_{jp,t-l+1}}.$$

Following the practice of the BIS, we use the sum of trade flows from three consecutive years (i.e., $L = 3$) to smooth out short-term variation that occurs in the presence of small trade volumes.

Denote the annual growth rate of the RER vis-à-vis partner country p between period t and $t-1$ by $r_{pt} = R_{pt}/R_{pt-1}$. We calculate the *weighted geometric average growth rate*:

$$r_{jt}^{q} = \exp\left(\sum_{p\in P} w_{jp,t-3}^{q} \ln\left(r_{pt}\right)\right) \text{ for } q = \{X, M\}.$$

In order to avoid potential endogeneity that results from effects of exchange rate swings on the mix of trading partners within an industry, the weights are lagged by three years because our firm-level panel data is based on three-year intervals.

The REER index for industry j is constructed by chain-linking the year-to-year growth rates:

$$R_{jt}^{q} = 100 \cdot \prod_{s=1}^{t} r_{js}^{q} \text{ for } q = \{X, M\}.$$

A.1.2. Industry-Specific Exchange Rates for Imported Intermediate Inputs

For each industry j, we calculate imported-inputs-weighted REER to capture the effects of changes in exchange rates on intermediate input costs. Therefore, each bilateral RER is weighted by the share of partner country p in overall imported intermediate inputs consumed by industry j. We denote this intermediate-input-weight by w_{jpt}^{II}. Since this quantity is not observed in the available data sources, we explain below how an appropriate estimate is constructed.

To formalize the exposition of the calculations, it is useful to think of imported intermediate input flows as a dataset in which each unit of currency (CHF) corresponds to one observation. We can then use conditional probabilities to refer to shares of intermediate input values. In other words, the object of interest can be written as $w_{jpt}^{II} = P(p|j,t)$.

In the Swiss IOT data, we observe for each industry j the share of (foreign) source industry s in total imported intermediate consumption, i.e., $P(s|j,t)$. In the OECD trade data, we observe the share of intermediate consumption imported from partner country p in total intermediate consumption from foreign source industry s, i.e., $P(p|s,t)$. These quantities will be used to calculate an estimate of $P(p|j,t)$. In a first step, we use Bayes' theorem to write:

$$P(p|j,s,t) = \frac{P(j|p,s,t)}{P(j|s,t)} P(p|s,t)$$

Second, we "integrate out" the source industry to obtain an expression for the object of interest:

$$P(p|j,t) = \sum_{s=1}^{S} P(s|j,t) \frac{P(j|p,s,t)}{P(j|s,t)} P(p|s,t)$$

Finally, to identify $P(p|j,t)$, we impose the homogeneity assumption $P(j|p,s,t) = P(j|s,t)$. This means that the share of intermediate inputs from foreign source industry s flowing to domestic industry j is the same across partner countries. Given this assumption, we can write

$$P(p|j,t) = \sum_{s=1}^{S} P(s|j,t) \cdot P(p|s,t)$$

Translating this expression back into "import value notation", we have:

$$w_{jpt}^{II} = \sum_{s=1}^{S} \left(\frac{II_{sjt}}{II_{jt}} \right) \left(\frac{II_{pst}}{II_{st}} \right),$$

where II_{sjt} is the value of imported intermediate inputs from source industry s in industry j and II_{pst} is the value of imported intermediate inputs from source industry s in partner country p.

The imported-inputs-weighted REER for a given industry j is again calculated using the weighted geometric average growth rate:

$$r_{jt}^{II} = \exp\left(\sum_{p=1}^{P} w_{jp,t-3}^{II} \ln\left(r_{pt}\right)\right).$$

A.1.3. Industry-Specific Exchange Rates for Net Exposure

Finally, we can combine the export-weighted and imported-inputs-weighted REER to obtain a REER that captures industry j's net exposure:

$$r_{jt}^{N} = \exp\left\{\left(v_{jt-3}^{X} + v_{jt-3}^{I}\right)^{-1}\left(v_{jt-3}^{X} \ln\left(r_{jt}^{X}\right) + v_{jt-3}^{I} \ln\left(r_{jt}^{I}\right)\right)\right\}.$$

The weights v_{jt-3}^{X} and v_{jt-3}^{I} are the lagged shares of exports and imported inputs in output of Swiss industry j.

A.1.4. Industry-Specific Foreign Economic Growth

In order to proxy for foreign demand development, we construct a variable that contains for each industry j the foreign output growth g. This variable is constructed by calculating the export-weighted sum of each trading partner p's output growth g in industry j. The assumption here is that the export-weighted foreign economic growth g of industry j follows the same demand pattern as the economic growth g of industry j in Switzerland. If, because of high demand in country p, industry j in country p shows strong growth, then industry j in Switzerland is likely to show strong growth too; this, of course, to the degree the Swiss industry j is linked, via exports, to the foreign country p. Consumers usually like variety and an increase in demand for industry j in a given country p will therefore also partly spread to other countries.

In order to construct the foreign demand development variable, we take the same 33 most important trading countries also used in the creation of the REER. From Eurostat we have information on output growth on 2-digit industry level (NACE Rev. 2) for AT, BE, CZ, DE, DK, ES FI, FR, GB, GR, HU, IE, IT, NL, PL, PT, SE, SK. From the OECD we have information on output growth on 2-digit level (ISIC Rev. 3 and ISIC Rev. 4) for KR, US, CA, JP, MX. Whereas ISIC Rev. 4 exactly corresponds to NACE Rev. 2, the ISIC Rev. 3 codes were first converted to NACE Rev. 2 codes. For AU, BR, CN, IN, RU, TR, HK, SA, SG, TH we rely on data from the World Bank, though this data only provides information on total

GDP growth. To have information for these countries too, we simply insert each country p's total GDP growth into all 2-digit industry j output growth rates g.

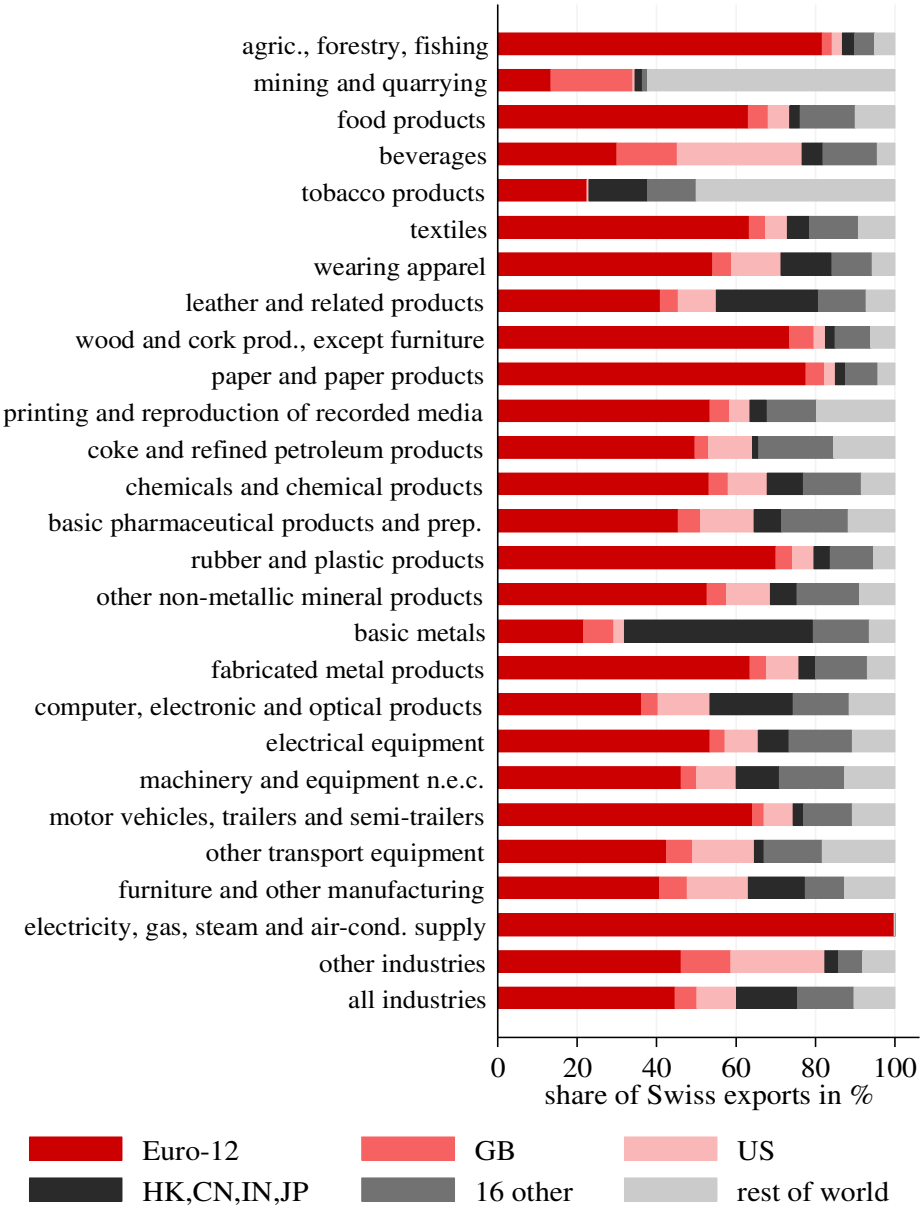
To calculate the export-weighted foreign industry output growth, we proceed in the same ways as with the REER: Denote the annual growth rate of output in industry j in partner country p between period t and $t-1$ by g_{jpt}. We then calculate the *geometric average growth rate* weighted by Swiss export share:

$$g_{jt}^{X} = \exp\left(\sum_{p=1}^{P} w_{jp,t-3}^{X} \ln\left(g_{jpt}\right)\right).$$

A.2. Additional Descriptive Statistics

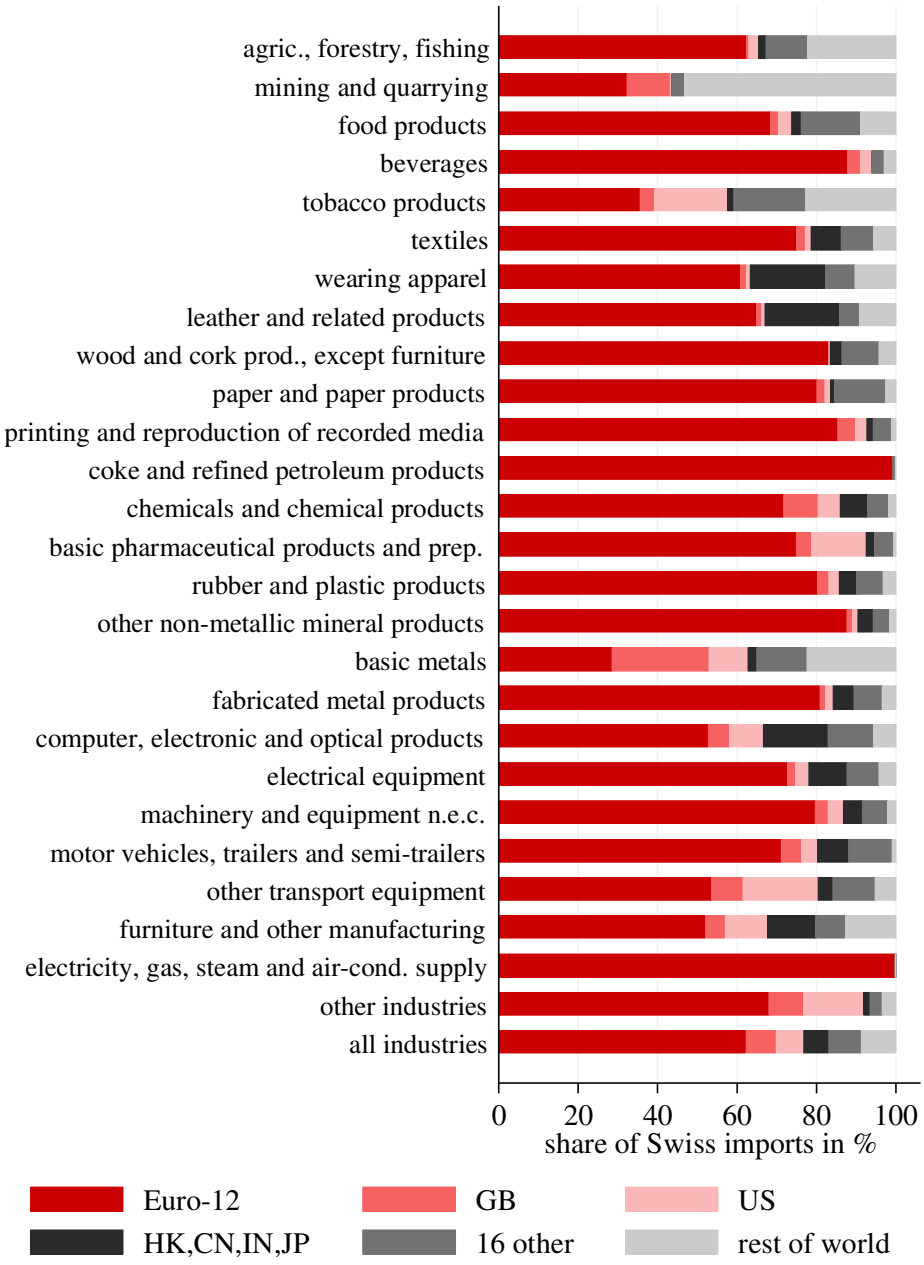
This section contains descriptive statistics on the calculated weights that are used to construct the industry-specific REERs. Moreover, industry-specific changes in the REER are presented.

Figure 23: Country Shares of Swiss Exports by Industry



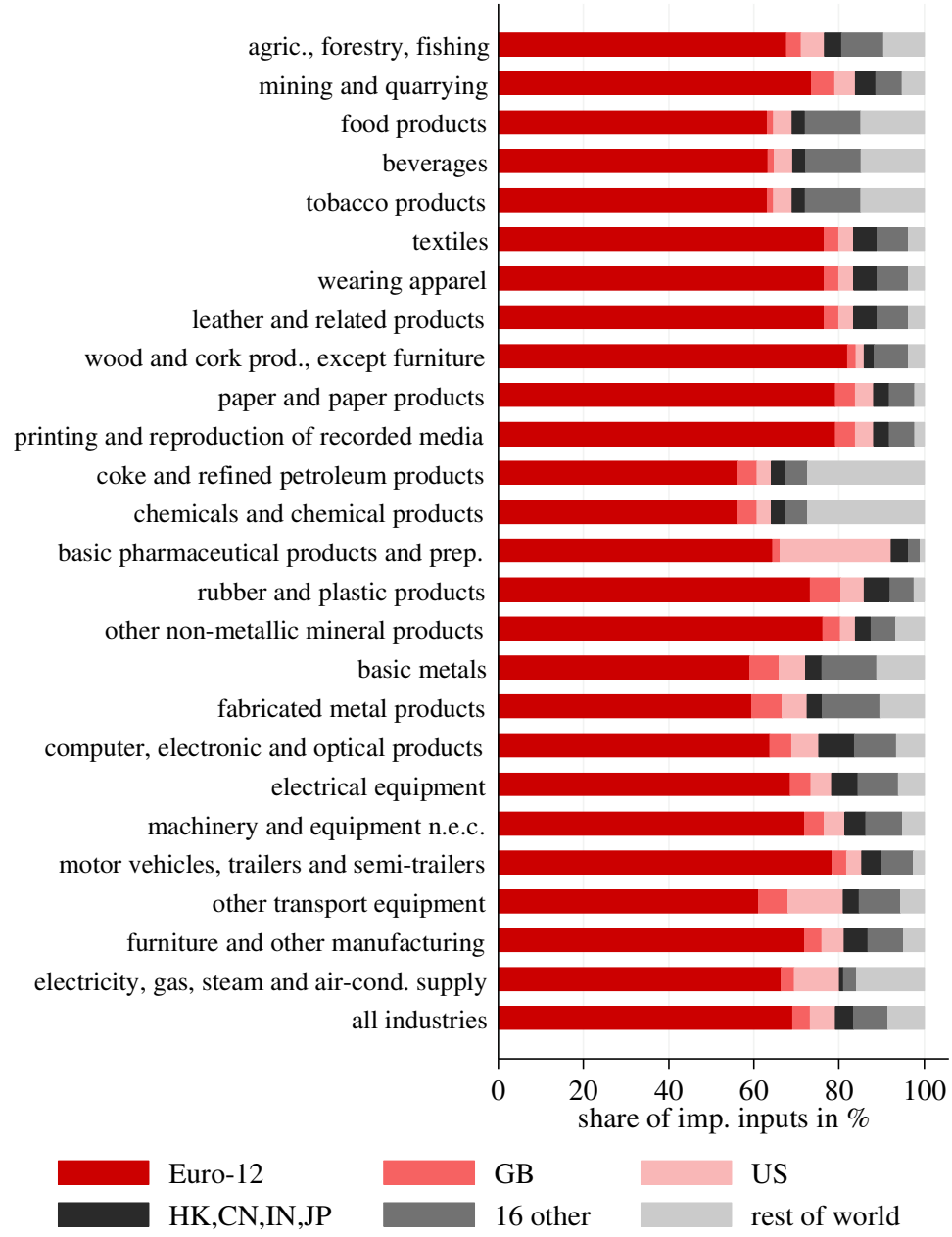
Notes: The figure shows country shares of Swiss industries' exports, averaged across the period 1995 to 2015. Country codes are Euro-12=initial 12 Euro countries; GB=Great Britain, US=USA; HK, CN, IN, JP=Hong Kong, India, China, Japan. Data Source: own calculations, BTDIxE database (OECD).

Figure 24: Country Shares of Imports to Switzerland by Industry



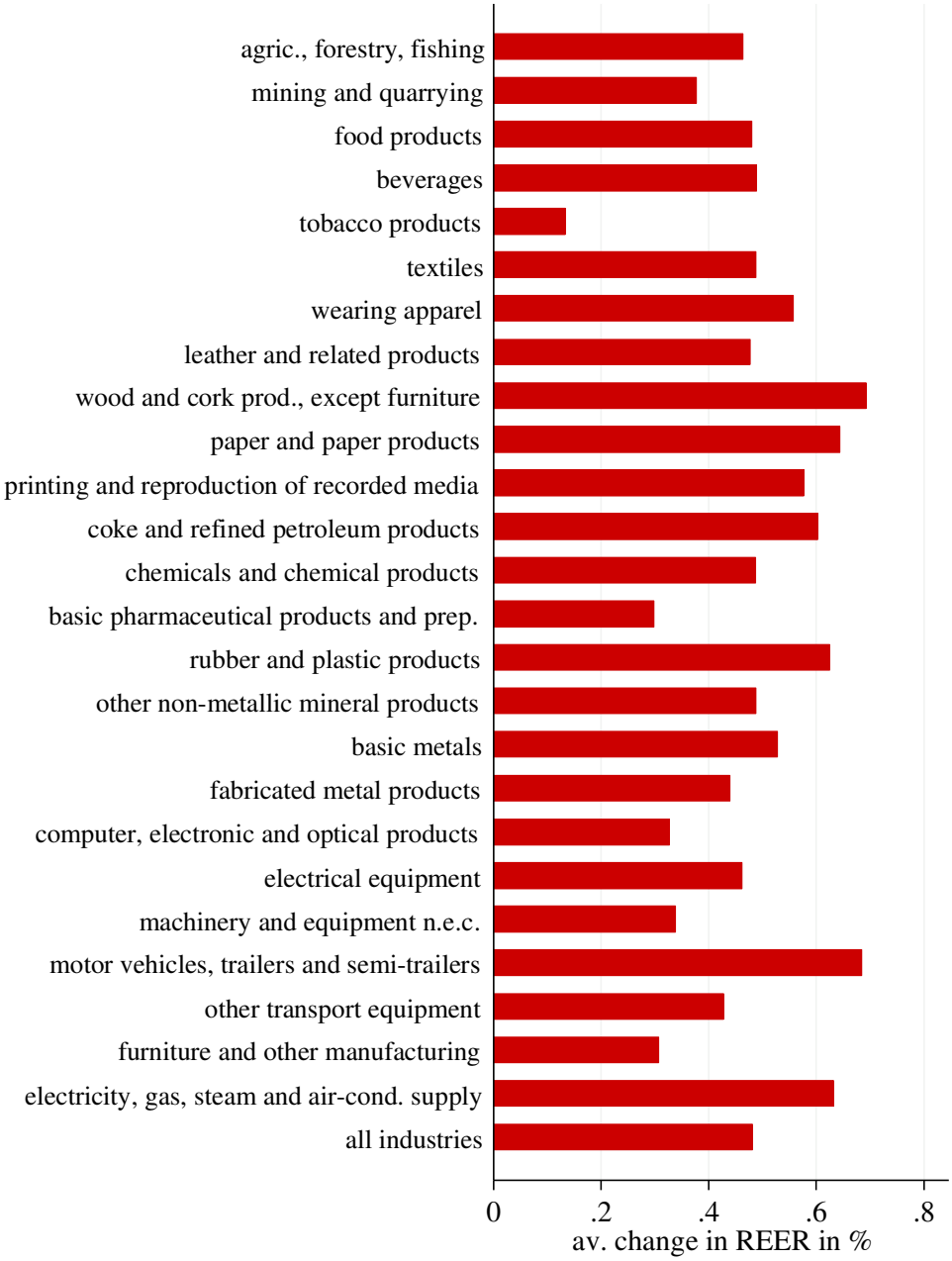
Notes: The figure shows country shares of imports to Switzerland, averaged across the period 1995 to 2015. Country codes are Euro-12=initial 12 Euro countries; GB=Great Britain, US=USA; HK, CN, IN, JP=Hong Kong, India, China, Japan. Data Source: own calculations, BTDIxE database (OECD).

Figure 25: Source Country Shares of Intermediate Inputs Imported by Swiss Industries



Notes: The figure shows the shares of source countries from which Swiss industries import intermediate inputs, averaged across the period 1995 to 2015. Country codes are Euro-12=initial 12 Euro countries; GB=Great Britain, US=USA; HK, CN, IN, JP=Hong Kong, India, China, Japan. Data Source: own calculations, BTDIxE database (OECD), Swiss IOT 2001 and 2008.

Figure 26: Average Annual Changes in REER by Industry, 1995-2015



Notes: The figure shows average year-to-year percentage changes in REER (log change x 100) for the period 1995 to 2015. Data Source: own calculations, SNB, BTDIxE database (OECD), Swiss IOT 2001 and 2008.

B. The Franc Shock and Investment

B.1. Further Empirical Evidence

This section provides further evidence on the effects of the Franc shock on investment.

What are the characteristics of the firms that reduced their investment activity? This question is analyzed in Table 22. It provides regressions in which the effect of the appreciation on investment in 2015 and 2016 is estimated separately for different types of firms depending on certain pre-shock firm characteristics. In the first column, we interact the coefficient that summarizes the investment effects of the appreciation in 2015 and 2016 ($I\left[s_i > 0\right] * I[t \geq 2015]$) with an indicator whether the firm is a manufacturer. The regression suggests that the negative investment effects of the appreciation are concentrated among manufacturers.

Columns 2–5 of Table 22 repeat similar exercises for firms belonging to high-tech industries[38], for large firms (i.e. firms with at least 250 FTE employees), for firms with foreign owners, and for firms reporting high or very high price competition in their main selling market. The estimated interaction term in column 3 indicates that large firms responded significantly less to the appreciation compared to small and medium-sized firms. The other firm characteristics do not systematically mediate the responsiveness of firms' investment to the Franc shock.

In the last column of Table 22, we test whether firms that consider their investment plans as certain prior to the shock do not downsize their investment in 2015 as much as firms which consider their investment in 2015 as uncertain. To this end, we exploit that the KOF investment surveys in autumn 2014 asked firms about the certainty regarding the realization of their investment plans for the following year. 16% of all firms consider their investment plans as "fairly uncertain" or "very uncertain" by the end of 2014. The results, although marginally insignificant at a 10 percent confidence level, suggest that the short-run investment effects of the Franc shock are more strongly negative among firms that consider the realization of their investment to be fairly or very uncertain.

[38] Firms belonging to the following industries are considered high-technology or medium-high-technology firms according to Eurostat's definition based on the three-digit industry code (NACE, rev. 2): manufacture of chemicals and chemical products (NACE 20), manufacture of basic pharmaceutical products and pharmaceutical preparations (21), manufacture of weapons and ammunition (25.4), manufacture of computer, electronic and optical products (26), manufacture of electrical equipment (27), manufacture of machinery and equipment (28), manufacture of motor vehicles, trailers and semi-trailers (29), manufacture of other transport equipment (30, excluding 30.1), manufacture of medical and dental instruments and supplies (32.5).

Table 22: Heterogeneity of the Investment Effect of the Franc Shock

variables	(1)	(2)	(3)	(4)	(5)	(6)
I[t>=2015] x I[Net exposure>0%]	0.036	-0.088	-0.182***	-0.105	-0.166	-0.093
	(0.100)	(0.064)	(0.059)	(0.066)	(0.118)	(0.061)
I[t>=2015] * I[Net exposed>0%] * I[Manufacturing=1]	-0.218**					
	(0.108)					
I[t>=2015] * I[Net exposed>0%] * I[High-tec industry=1]		-0.097				
		(0.088)				
I[t>=2015] * I[Net exposed>0%] * I[FTE>=250]			0.213**			
			(0.088)			
I[t>=2015] * I[Net exposed>0%] * Foreign owned				-0.097		
				(0.118)		
I[t>=2015] * I[Net exposed>0%] * High competition					0.040	
					(0.127)	
I[t>=2015] * I[Net exposed>0%] * Uncertain (2014)						-0.180
						(0.161)
Observations	14,236	14,236	14,236	9,472	9,398	9,558
R-squared	0.008	0.008	0.008	0.006	0.006	0.006
Number of firms	4,201	4,201	4,201	2,447	2,419	2,454
Period FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Effect on subcategory	-0.182***	-0.185***	0.032	-0.202*	-0.126**	-0.274*

*Notes: The table shows results from our baseline FE regression model. The estimation period is 2012-2016. The dependent variable in all columns is log gross fixed capital formation (total investment), measured at current prices. Net exposure is firms' initial export share in sales minus its initial import share in total costs. "FTE" reflects firms' full-time equivalent employment in the first year a firm is observed in the sample. "High-tech manufacturers" are firms in NACE rev. 2 two-digit sections 20, 21, 26–30 (excluding three-digit industry 30.1), and three-digit industries 25.4 and 32.5, following the definition of Eurostat. "High competition" is a dummy variable constructed from a self-reported measure of price competition. It is one if the firm perceives the price competition on the main selling market to be fierce or very fierce. "Uncertain (2014)" is constructed from a self-reported measure regarding the certainty of the realization of the investment projects in a given year (see main text for further information). Standard errors are clustered on the firm level. *** p<0.01, ** p<0.05, * p<0.1*

Table 23 studies how the Franc shock affected investment along the distribution of annual investment expenditures. To this end, we build indicator variables that are

one if a firm's annual investment lies above a certain threshold. For instance, the dummy variable in the third column is one if the firm has investment expenditures above 100k CHF, and zero otherwise. We then regress these dummy variables on the indicators of the Franc shock using simple linear probability models, controlling for firm fixed effects. We report simple DiD estimates by showing the coefficients on interaction terms between the two post-treatment periods (i.e. ($I[t = 2015]$) and ($I[t = 2016]$)) and the identifier of positive exposure ($I\left[s_i > 0\right]$). The estimations suggest that it was medium-sized to large investment projects which were downsized because of the Franc shock.

Table 23: Investment Effect of the Franc Shock along the Distribution of Investment Expenditures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	0/1	0/1	0/1	0/1	0/1	0/1	0/1
variables	1 CHF	10k CHF	100k CHF	500k CHF	1 mio CHF	2.5 mio CHF	5 mio
I(t=2015) x I[Net exposure>0%]	0.020	0.016	-0.012	-0.021	-0.041***	-0.023*	-0.013
	(0.012)	(0.013)	(0.015)	(0.016)	(0.015)	(0.014)	(0.011)
I(t=2016) x I[Net exposure>0%]	0.025*	0.013	-0.019	-0.034**	-0.032*	-0.028*	-0.015
	(0.015)	(0.015)	(0.016)	(0.017)	(0.016)	(0.015)	(0.012)
Observations	17,583	17,583	17,583	17,583	17,583	17,583	17,583
R-squared	0.008	0.010	0.007	0.004	0.003	0.001	0.001
Number of firms	4,823	4,823	4,823	4,823	4,823	4,823	4,823
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Share above threshold	0.81	0.76	0.58	0.39	0.30	0.18	0.12

*Notes: The table shows results from our baseline FE regression model. The estimation period is 2012-2016. The dependent variable in column 1 is a dummy equal to one if a firm reports positive (i.e. non-zero) total gross fixed capital formation. The dependent variables in columns 2-7 are dummies equal to one if total gross fixed capital formation exceeds the threshold in CHF given in the column header. The "Share above threshold" at the bottom of the table reports the share of firm-year observations above the respective threshold. Net exposure is firms' initial export share in sales minus its initial import share in total costs. Standard errors are clustered on the firm level.. *** p<0.01, ** p<0.05, * p<0.1*

Table 24 investigates whether the negative effect of the Franc shock on inveestment arises because of the uncertainty that the shock caused, or whether it is because firms lack the financial resources to stem larger investment projects. To study this, we exploit that the KOF investment surveys in autumn also levy information on the main obstacles to firms' investment efforts. The possible answers are the demand development, the financial resources and/or the expected profit situation, the technological development, or other factors. We transform the original 5-point Likert scale variables, measuring firms' investment obstacles, into dummy variables that are equal to one if a certain factor has a negative or strongly negative impact on firms' investment, and zero otherwise. We then estimate simple linear probability models with firm fixed effects. The results suggest that it is the lack of financial resources and/or a difficult profit situation that prevents firms from investing more, particularly in 2015. We also find evidence that the Franc shock increased the share of firms reporting that their investment activity is hampered by low demand.

Table 24: Effect of the Franc Shock on Investment Obstacles

	(1)	(2)	(3)	(4)
	Factor	Factor	Factor	Factor
variables	demand	fin. resources	technical	other
I(t=2015) x I[Net exposure>0%]	0.049*	0.095***	-0.011	0.033
	(0.026)	(0.029)	(0.014)	(0.032)
I(t=2016) x I[Net exposure>0%]	0.005	0.020	-0.009	-0.026
	(0.025)	(0.027)	(0.014)	(0.031)
Observations	9,711	9,749	9,462	5,108
R-squared	0.009	0.009	0.001	0.003
Number of firms	4,159	4,163	4,081	2,817
Period FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes

*Notes: The table shows results from our baseline FE regression model. The estimation period is 2012-2016. The dependent variable in column 1 is a dummy equal to one if a firm reports that their investment in the current year are hampered by low foreign demand. The dependent variable in column 2 is a dummy equal to one if a firm reports that their investment in the current year are hampered by its financial resources and/or the expected profit situation. The dependent variable in column 3 is a dummy equal to one if a firm reports that their investment in the current year are hampered by the technological development. The dependent variable in column 3 is a dummy equal to one if a firm reports that their investment in the current year are hampered by the other factors than the three aforementioned. Net exposure is firms' initial export share in sales minus its initial import share in total costs. Standard errors are clustered on the firm level. *** p<0.01, ** p<0.05, * p<0.1*

B.2. Questionnaire of the Regular KOF Investment Survey (Autumn 2014)

KOF Investment Cycles
Industry / Construction

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

Phone 044 632 25 96
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 (exception: Question 6).
- See explanatory information on the reverse.
- Please return the questionnaire by: **1 November 2013.**

All information will be treated strictly confidentially.

Questions autumn

Number of employees in Switzerland on 30 June 2013
(please convert part-time positions into full-time equivalent positions)

In 2013 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
(in CHF 1000)

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

b) Our investments in fixed assets and software in Switzerland amounted to/is likely to amount to
(in CHF 1000)

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

c) Relative to 2013, in the year 2014 our investment in Switzerland is likely to

	Machinery and equipment	Construction
increase	☐	☐
remain unchanged (or remain at zero)	☐	☐
decrease	☐	☐

d) We consider the realisation of our investment plans for 2014 as
☐ very sure ☐ fairly sure ☐ fairly uncertain ☐ very uncertain

2. Structure of the investment

Our investment in **2013/2014** serves
(you may pick one or more categories)

	2013	2014
a) replacement	☐	☐
b) extension of the production capacity	☐	☐
c) to streamline production	☐	☐
d) environmental protection and regulations by trade law	☐	☐
e) other objectives	☐	☐

3. Product programme

In terms of our product programme, in the year 2014 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	☐

4. Production capacity

In comparison to 2013, our technical production capacity in Switzerland in the year 2014 shall probably
☐ expand ☐ leave unchanged ☐ reduce

5. Factors influencing the investment activity

Our investment activity will be positively/negatively influenced in **2013** and **2014** respectively by the following factors:

a) 2013	++	+	=	–	– –	n.a.
Demand	☐	☐	☐	☐	☐	☐
Financial resources / expected profits	☐	☐	☐	☐	☐	☐
Technical factors	☐	☐	☐	☐	☐	☐
Other factors	☐	☐	☐	☐	☐	☐
b) 2014	++	+	=	–	– –	n.a.
Demand	☐	☐	☐	☐	☐	☐
Financial resources / expected profits	☐	☐	☐	☐	☐	☐
Technical factors	☐	☐	☐	☐	☐	☐
Other factors	☐	☐	☐	☐	☐	☐

++ very stimulating + stimulating = no influence
– limiting – – very limiting n.a. no answer

5. Non-domestic investment

In the year 2014 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

C. Additional Information on Business Census Data

C.1. Procedure to Adjust Firm IDs

This section explains the data-driven procedure that we employ to (i) re-assemble panels which have been split by a change in the identification number and (ii) split panels in which a new firm received an ID belonging to old firm in previous periods that no longer exists. We define the following variables:

- $T_{last,i}$ is the last observed period
- $T_{first,i}$ is the first observed period
- $DIST(T_i, T_k)$ is the distance in meters between the location of firm *i* in period T_i and the location of firm *k* in period T_j
- $IND2_i$ is the two-digit industry code
- $IND6_i$ is the six-digit industry code
- $ESTID_{iT}$ is the identification number of the main establishment of firm *i* in period *T*.

Note that the periods are enumerated by $T = \{1, 2, 3, \dots\}$ and not by calendar years. The algorithm is explained in Table 25.

Table 25: Algorithm to Re-Assemble and Split Firm IDs

Step	Procedure
Step 1	Two firm IDs (i, k) are merged if $ESTID_{i,T_{last}} = ESTID_{k,T_{first}}$ and $T_{last,i} = T_{first,k} - 1$ and $IND2_i = IND2_k$.
Step 2	Two firm IDs (i, k) are merged if $T_{last,i} = T_{first,k} - 1$ and $IND6_i = IND6_k$ and $DIST(T_{last,i}, T_{first,k}) < 20$. In addition we discard matches if the employment strongly differs between two matched firms (j, k): We discard matches if $I(EMP_{i,T_{\text{last}}} > 20) I(\lvert EMP_{k,T_{\text{first}}}/EMP_{i,T_{\text{last}}} - 1\rvert > 0.5) + I(EMP_{i,T_{\text{last}}} \in [11,20]) I(\lvert EMP_{k,T_{\text{first}}} - EMP_{i,T_{\text{last}}}\rvert > 10) + I(EMP_{i,T_{\text{last}}} \in [1,10]) I(\lvert EMP_{k,T_{\text{first}}} - EMP_{i,T_{\text{last}}}\rvert > 6) = 1.$
Step 3	We identify all panels with a gap in the time sequence $\{\dots T_{before}, T_{after}, \dots\}_i$ with $T_{after} - T_{before} > 1$. Among these firms, we split firm *i* into two new IDs if $IND2_{i,T_{before}} \neq IND2_{i,T_{after}}$ and $DIST(T_{i,before}, T_{i,after}) > 20$.

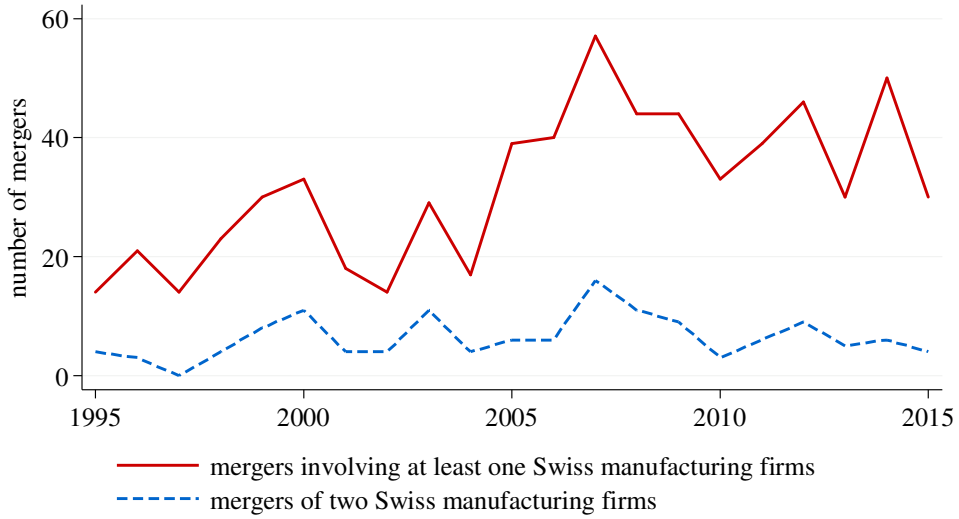
C.2. Data on Mergers

Mergers among Swiss manufacturing firms overstate the exit rates because if a merger *between two Swiss firms* occurs, at least one firm ID will "disappear" from the business census without being a true exit. In contrast, mergers between *Swiss*

and foreign firms are innocuous because the firm ID will most likely continue to exist or can be re-assembled by means of the procedure explained above.

To gauge the quantitative relevance of mergers, we analyze a comprehensive database provided by Reuters. Figure 27 shows annual numbers of mergers involving Swiss manufacturing firms. As we can see, the annual number of mergers of *two Swiss* manufacturing firms is very low and fluctuates between zero and 20. We therefore conclude that mergers are unlikely to affect the estimates of firm exit.

Figure 27: Number of Mergers of Swiss Manufacturing Firms



Notes: The figure shows the number of mergers involving Swiss manufacturing firms in the Reuters database.

In der Reihe „Strukturberichterstattung“ des Staatssekretariats für Wirtschaft sind seit 2000 erschienen:

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