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Exchange rate shocks and equity prices: the role of currency denomination[*]

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Abstract

We find that the response of stock prices to the exchange rate reflects a currency denomination effect—that is, a change in the relative international value of firms' cash flows and equity—rather than a change in domestic economic conditions. To do so, we compute exogenous movements for the Swiss franc on SNB announcement days and trace their effects on Swiss stocks. Exploiting firm heterogeneity reveals that the prices of stocks with foreign-denominated cash flows are considerably more sensitive to the exchange rate. Using the staggered introduction of American Depositary Receipts in Switzerland, we provide causal evidence that cross-listing markedly amplifies the sensitivity of domestic stock prices to exchange rate fluctuations, consistent with the law of one price. Stock market movements that follow central bank announcements should therefore be interpreted with caution because they partially reflect parity movements and not only economic information.

Keywords: International asset pricing, law of one price, exchange rate shocks, cross-listing
JEL Codes: F31, G12, G15

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1 Introduction

Movements in exchange rates are generally associated with movements in financial asset prices. An extensive literature indicates that equity prices and portfolio rebalancing are important determinants of exchange rates, as documented in Hau et al. (2010), Pavlova and Rigobon (2007), Hau and Rey (2006), Hau and Rey (2004), Gavin (1989) and Stulz (1987). However, asset prices react to exchange rate movements. We disentangle these feedback effects and measure the reaction of asset prices to exogenous exchange rate shocks.

A large strand of the literature studies the relationship between exchange rates and asset prices. On the financial side, it is well-known that assets are priced globally (Karolyi and Stulz, 2003) and that the cost of capital in small-open economies depends on exchange rates (see, e.g., Stulz 1995 for Switzerland). Asset prices have been shown to incorporate exchange rate risk (Dumas and Solnik, 1995; Bodnar and Gentry, 1993; Adler and Dumas, 1984), and financial valuation models often include a currency risk premium.[1] This relationship has been widely studied empirically, concluding that firms tend to significantly lower their exposure through hedging (Bartram et al., 2010).[2] Despite hedging, considerable financial research has shown that asset prices and exchange rates are strongly correlated, focusing on measuring their cointegration rather than the reasons underlying the comovements.[3] The macroeconomic literature provides additional answers on the mechanisms through which exchange rate shocks might affect asset prices. Exchange rate shocks affect firms directly via their debt valuation (Aguiar, 2005), invoice currency and consumer prices (Auer et al., 2021) as well as general behavior (Dominguez and Tesar, 2006). Exchange rate shocks also impact the macroeconomy in which firms operate since domestic fundamentals are tied to the exchange rate (as shown in Engel and West, 2005). This includes an effect on aggregate demand (Gavin, 1989), competitive and import spaces (Hodder, 1982) as well as terms of trade (Pavlova and Rigobon, 2007), all of which ultimately affect firms.

These mechanisms cannot fully explain the empirical reaction of international firms to currency shocks. If it were true that exchange rate shocks affected asset prices because they lead to a change in domestic economic conditions, large international companies that have close to no domestic business would be unaffected by a domestic currency shock. However, we will show that the inverse relationship is observed in our dataset, with large foreign-oriented firms being more sensitive to domestic currency shocks than purely domestic firms. Our results reveal another transmission mechanism from exchange rate shocks to asset prices: the currency denomination channel. Because firms are listed in the domestic currency, a currency shock immediately impacts the international relative value of domestic firms' equity. That is, a currency appreciation makes domestic equity relatively more expensive, while a currency depreciation reduces its international value. As a corollary, firms that are listed on several markets should

[1] For instance, the widely used international capital asset pricing model pioneered by Solnik (1974), Stulz (1981) and Adler and Dumas (1983) includes a currency risk premium based on firms' foreign exchange rate exposure.

[2] The literature commonly refers to this as the exchange rate exposure puzzle, since firms' exposure has been observed to be much smaller empirically than what financial theory would suggest.

[3] See, e.g., Bahmani-Oskooee and Saha 2015; Phylaktis and Ravazzolo 2005; Ajayi and Mougoué 1996.

react more strongly since cross-listing makes it easier for foreign investors to compare the values of similar companies. Even single-listed firms that are large enough to be comparable to some foreign firms will be substituted by investors for those foreign assets when the domestic currency appreciates (or attract new investors when the currency depreciates).

We use exogenous exchange rate shocks and the introduction of cross-listings in Switzerland to causally assess whether the reaction of asset prices to the exchange rate is driven by changes to the domestic economic conditions or if it reflects an international parity correction. Identifying exogenous exchange rate shocks is challenging because exchange rates result from the interaction of global macroeconomic and financial flows. Exchange rate movements therefore reflect myriad intertwined changes in the economic and financial spheres. To overcome this challenge, we focus on the exchange rate movements on the monetary policy announcement days of the Swiss National Bank (SNB). As the SNB's announcements are typically the only significant domestic economic event on these days, exchange rate movements are, after controlling for interest rate surprises and changes in the nominal effective exchange rate of foreign currencies, close to pure exogenous shocks.

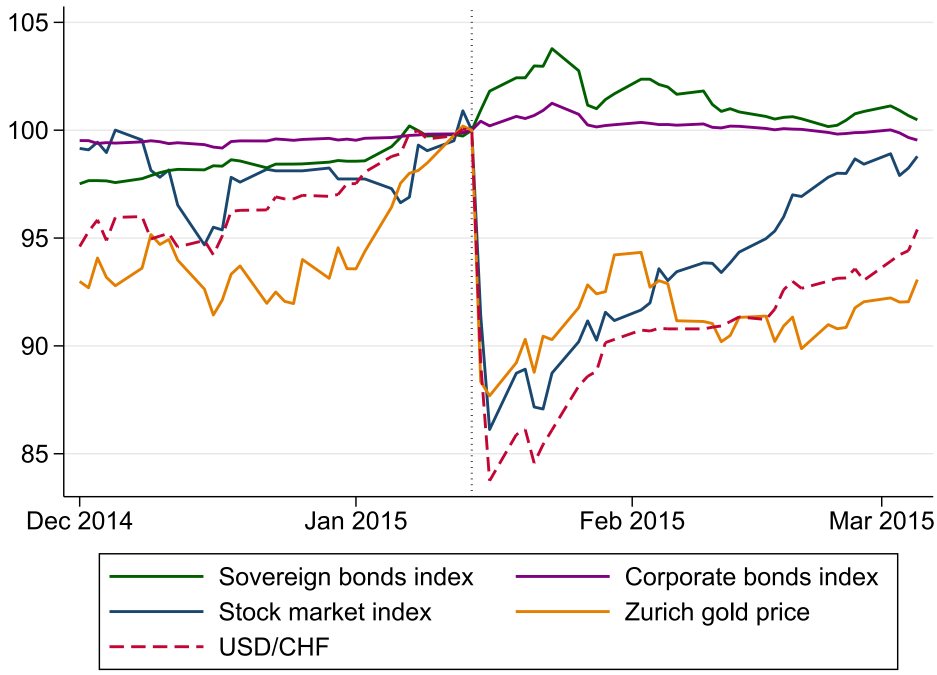
Prime examples are the unexpected introduction of the minimum exchange rate of 1.2 Swiss francs against the euro decided by the SNB on September 6, 2011, and its unexpected discontinuation on January 15, 2015.[4] The Swiss franc depreciated by 8.8% against the US dollar on September 6, 2011, and it appreciated by 10.8% on January 15, 2015, yielding two exogenous exchange rate shocks. We extend this idea to all SNB monetary policy announcements, which all conveyed some information on the Swiss franc, to build a series of exogenous shocks and obtain clean estimates of how asset prices react to the exchange rate.

We show that a domestic currency appreciation (depreciation) decreases (increases) domestic stock and gold prices but has no effect on bond prices. This can be seen in Figure 1, which shows a very differentiated response across asset classes to the large and unexpected Swiss franc appreciation that took place on January 15, 2015. While the price of some assets such as bonds hardly reacted at all to changes in the exchange rate, the price of other assets such as gold or stocks reacted strongly. We show that this marked difference holds across the whole sample of exchange rate shocks that span the years 2000 to 2022. In particular, we estimate that a 100 basis point (bp) increase of the USD/CHF is associated with an immediate 101 bp increase in gold prices, a 35 bp increase in stock prices, and a 0 bp reaction of corporate and sovereign bond prices. The response of asset prices is persistent: the 60-day average response since the shock is 63 bp, 35 bp, -5 bp, and 1 bp for gold, stocks, sovereign bonds, and corporate bonds, respectively.

What are the factors driving the price response of these asset classes to exchange rate movements? Two hypotheses can rationalize the reaction. On the one hand, asset prices can react because exchange rate shocks affect domestic economic conditions. Most notably, exchange rate shocks might impact the domestic and foreign demand for firms' products, which end up

[4] See Jermann (2017).

Figure 1: Swiss asset prices around the January 2015 Swiss franc appreciation



Notes: Series in Swiss francs and indexed to 100 on the day before the January 15, 2015, announcement (vertical line), when the SNB discontinued the EUR/CHF minimum exchange rate. The indexes used are the S&P Swiss Sovereign Bond Index, S&P Switzerland IG Corporate Bond Index, Swiss Performance Index, and Zurich 995 gold price. Source: Refinitiv Datastream.

affecting the firms' profits and competitive space.[5] On the other hand, asset prices can react because exchange rate shocks affect the international relative value of cash flows and equity. For example, a currency appreciation reduces the domestic currency value of foreign cash flows, which induces a decline in the domestic price of equity.

To decide between these two hypotheses, the analysis of Swiss equities offers a twofold advantage. First, as a small-open economy that relies extensively on trade, Swiss economic activity is highly sensitive to the exchange rate. The effects of Swiss franc movements on nominal and real activity have been extensively studied;[6] we add to this literature by providing evidence on the transmission to stock prices. If stock prices react to exchange rate shocks due to changes in domestic economic activity, this should be particularly the case in Switzerland. Second, as a small-open economy, Switzerland is home to several companies whose economic activity takes place mainly abroad, Nestlé being a perfect example with over 98% of its sales (and the majority of its production) being outside Switzerland. If stock prices react to exchange rate shocks due to changes in domestic economic activity, stocks such as Nestlé should hardly react. It would

[5] Oktay (2022) shows evidence that currency shocks impact consumer prices heterogeneously across sectors. However, given the large interconnectedness of the economy, even firms in sectors that are not directly impacted by exchange rate shocks will be impacted indirectly through their customers and suppliers in other sectors, thus transmitting the shock across sectors and causing aggregate fluctuations (Acemoglu et al., 2012).

[6] Examples include the effect on import prices and expenditures (Auer et al., 2021), on consumer prices (Oktay, 2022), on product quality and export prices (Freitag and Lein, 2023), on investor and firm behavior (Efing et al., 2022) and on the current account (Eugster and Donato, 2022).

be difficult to find companies in large currency zones with such a large proportion of their cash flows in foreign currencies, which would make it impossible to clearly separate the effect of economic conditions from that of currency denomination.

Our analysis indicates that the response of stock prices to exchange rate shocks is largely driven by the currency denomination of the underlying cash flows. The response is increasing with the proportion of cash flows denominated in foreign currencies. We show that the stock prices of international foreign-oriented firms are close to five times more sensitive to the shocks than those of domestically oriented firms. In line with this, firms whose products have a higher pass-through to consumer prices, that are cross-listed in the US, that are in more international sectors (such as healthcare, tourism, retail, industrial, and technology) and that are larger are more sensitive to exchange rate shocks. All of these characteristics are linked to the proportion of foreign cash flows of firms and to how foreign-oriented they are. Accordingly, our results contradict the hypothesis that asset prices fall after a currency appreciation because of worsened domestic economic conditions. If that were true, domestically oriented firms should be more impacted by the shocks than firms that have close to no domestic business.

We provide further causal evidence of the currency denomination effect on equity denomination through cross-listed firms. Over our sample period of 2000-2022, 49 Swiss firms became cross-listed on the US stock market via American Depository Receipts (ADRs). We exploit this staggered introduction with a synthetic difference-in-differences approach to show that cross-listing significantly amplifies the sensitivity of stock prices to exchange rate shocks. The effect is sizeable: approximately one-third of the domestic stock price movements that follow exchange rate shocks can be attributed to cross-listing. Because cross-listing enhances the degree of substitutability of domestic stocks with their foreign peers, the domestic price of cross-listed stocks reacts much more strongly to the exchange rate. This is illustrative of the law of one price, which states that the domestic listing should react negatively to a currency appreciation while the foreign listing should react positively. It confirms that the currency denomination of equity is a major driver of the sensitivity of stock prices to exchange rate shocks.

To our knowledge, we are the first to highlight this currency denomination channel. Related evidence can be found in Lane and Shambaugh (2010), who show that the currency exposure of firms' balance sheets can partly explain the valuations of net foreign assets. In a similar vein, Fung et al. (2022) show that a flexible exchange rate regime better enforces the price parity of cross-listed Chinese stocks. We also contribute to the understanding of asset pricing. By providing conclusive evidence of a thus-far undocumented transmission mechanism of the exchange rate on stock prices, we give an international perspective on asset pricing (as suggested by Brunnermeier et al., 2021).[7] The results that we obtain for Swiss firms have some external validity. Indeed, the currency denomination channel operates for any firm with cash flows denominated in foreign currencies. The evidence that we provide on cross-listing also has implications for the interpretation of stock price movements on monetary-policy announcement

[7]Nestlé was used by Stulz (1995) to argue that the international version of the capital asset-pricing model was needed to estimate the costs of capital in small-open economies.

days. The response of the stock market not only conveys changes in economic beliefs but also mechanically illustrates the law of one price.

In Section 2, we discuss how the law of one price applies to cross-listed assets. Section 3 describes the identification of exchange rate shocks, and Section 4 presents the data on asset prices and cross-listings procedures. Section 5 computes the impulse responses of Swiss asset prices to exchange rate shocks, emphasizing the heterogeneity across firm characteristics. In Section 6, we use synthetic difference-in-differences (DID) to identify the causal impact of cross-listing on stock market returns. Section 7 concludes the paper.

2 Considerations on the law of one price

In efficient markets, securities or commodities listed on multiple financial markets must have equalized local prices: the law of one price must hold. Otherwise, arbitrage opportunities would arise. For example, if the price of gold differs between two trading venues, arbitrageurs will buy gold on the cheap market to sell it at a profit on the expensive market. Arbitrage incentives will diminish as prices adjust and will dissipate entirely when prices equalize. This relationship tends to hold well empirically up to some exceptions. Frictions between markets, such as transaction and transportation costs, different trading hours or legal restrictions, limit arbitrage opportunities and may yield persistent deviations from the law of one price, as shown in Shleifer and Vishny (1997).

2.1 The law of one price with two currencies

By extension, the law of one price can apply when the price of an asset is expressed in two currencies:

$$p_t^{CH} = p_t^{US} \times USDCHF_t. \tag{1}$$

The price of an asset in domestic currency p_t^{CH} (in our case the Swiss franc) must be equal to the price of the same asset in foreign currency p_t^{US} (in our case the US dollar) translated to the domestic currency. Importantly, the law of one price is silent on whether it is the domestic price or the foreign price that is adjusted in the wake of exchange rate movements. For the law of one price to hold, an appreciation of the domestic currency ($USDCHF \downarrow$) must be met with a decrease in the domestic price $\left(p_t^{CH} \downarrow\right)$ or an increase in the foreign price $\left(p_t^{US} \uparrow\right)$ or a combination of both.[8]

The question of whether it is the domestic price or the foreign price that adjusts to exchange rate movements remains relevant even if the asset is not actually quoted and traded in foreign currency. As we show, however, direct trading of an asset in foreign currency (through ADRs) influences how exchange rate movements affect domestic and foreign prices.

[8] While it is technically possible that the law holds if both move in the same direction, this would require an exchange rate pass-through to domestic asset prices greater than 1, which we do not observe in the data. We thus focus on the incomplete pass-through case.

The reaction of domestic and foreign prices to exchange rate movements is mainly driven by the denomination of the asset and related cash flows. Two boundary cases illustrate the role of the denomination in the adjustment of the domestic price to an exchange rate shock.

On the one end of the spectrum, real assets such as gold do not derive their value from any cash flows. Since these assets do not derive their value from any monetary flow, their price in domestic currency will fluctuate according to movements in the domestic exchange rate to satisfy the law of one price. If the domestic currency appreciates by 10% against foreign currencies, the price of gold in the domestic currency will decline by 10% while the price of gold in foreign currencies will remain, all else being equal, stable.

On the other end of the spectrum, nominal assets such as bonds derive their value from being a claim on a nominal amount of money. The domestic price of these assets will not fluctuate with movements in the domestic exchange rate, unless such movements affect the creditworthiness of the debtor. If the domestic currency appreciates by 10% against foreign currencies (and assuming the creditworthiness of the debtor is unchanged), the domestic price of a bond will remain unchanged while its price in foreign currency will increase by 10% so that the law of one price holds. Since domestic currency is worth 10% more, 10% more foreign money is needed to buy the domestic bond.

Between the two boundary cases provided by gold and bonds lie stocks, which are real assets whose value depends on monetary cash flows. An exchange rate shock affects the value of a domestic share to the extent that it affects its cash flows in the domestic currency.

2.2 Economic conditions vs. currency denomination hypotheses

There are two hypotheses that can rationalize why stock prices react to exchange rate movements. The first hypothesis states that stock prices react to an exchange rate shock because of its effect on the economic conditions of the company. According to this *economic conditions* hypothesis, stock prices fall after an appreciation of the domestic currency because domestic economic activity is slowed by a stronger currency. This could be due to shocks to macroeconomic fundamentals (following Engel and West, 2005), aggregate demand (following Gavin, 1989) or competitive space and import prices (following Hodder, 1982). The second hypothesis states that stock prices react to an exchange rate shock because of the denomination of the firm's cash flow and equity. According to this *currency denomination* hypothesis, stock prices fall after an appreciation of the domestic currency because the value of foreign cash flows expressed in domestic currency falls and the value of equity expressed in foreign currency increases.

Although these hypotheses are not mutually exclusive, they provide a very different assessment of the effect of an exchange rate shock on stock prices and the economy. If the domestic stock market falls in the wake of an appreciation of the domestic currency, the *economic conditions* hypothesis will infer a future economic slowdown, while the *currency denomination* hypothesis will simply observe that, because of its appreciation, less domestic currency is needed to acquire domestic companies. The economic interpretation of stock price movements following an exchange rate shock is therefore very different depending on the prevailing hypothesis.

Depending on their business model, firms might be more sensitive to the *economic conditions* or the *currency denomination* hypothesis. In Section 5, we exploit firm heterogeneity to provide support to the role played by currency denomination. Swiss firms follow three types of business model that each come with distinct predictions.

First, the stock price of domestically oriented companies with a strong domestic economic activity (such as Swiss Prime Site) should only react if the exchange rate shock affects domestic economic activity, while their cash flows—all denominated in domestic currency—would not be subject to any valuation effect. Movements in the stock price of these companies would support the economic conditions hypothesis.

Second, the stock price of international companies with strong foreign economic activity (such as Nestlé) should react to the exchange rate shock independently of its effect on domestic economic activity and simply because of its denomination effect on foreign currency profit. Even if the foreign currency profit remains stable (because all expenses and income are in foreign currencies), an appreciation will lead to a decline in profit in domestic currency. Movements in the stock price of these companies would support the denomination effect hypothesis.

Third, the stock price of exporting companies (such as Swatch) should react to the exchange rate shock because of a double-denomination effect on revenues and profit. If expenses are denominated in domestic currency and revenues in foreign currencies, an appreciation will lead, first, to a decline in the profit in foreign currencies (because expenses expressed in foreign currencies will increase) and, second, to a decline in the profit in domestic currency. Movements in the stock price of these companies would support the denomination effect hypothesis, particularly if they are stronger than movements of stock prices of international companies (and stronger than that of domestically oriented companies).

What effect can we expect from companies hedging their exchange rate risk and from the denomination of invoices? Bartram et al. (2010) show that firms isolate themselves from foreign exchange rate exposure via hedging and provide explanations for the relatively low exposure that is observed empirically. We have omitted the role of hedging thus far, which partially dampens the currency denomination hypothesis. Because firms may hedge their exchange rate risk related to their cash flows or exposures in foreign currencies, hedging may attenuate the effect of exchange rate shocks on equity prices through the currency denomination hypothesis. Firms, however, do not hedge their exposure to the changes in macroeconomic conditions that result from exchange rate shocks. Therefore, hedging should not affect the response of equity prices to exchange rate shocks through the economic condition hypothesis. Moreover, as firms can hedge their exposure only over a limited period of time, the effect of hedging of equity prices should be limited. We have also omitted the role of the invoicing currency of firms. Auer et al. (2021) show that the invoicing currency affects how fast firms adjust their prices following an exchange rate shock. While the invoicing currency determines who gains or loses on the exchange rate for a particular invoice between buyer and seller, the invoicing currency does not affect the exchange rate effect on future economic relationships. For example, it would be naive to believe that an exporting company can protect itself from a currency appreciation simply by choosing the appropriate invoicing currency. The invoicing currency therefore has only a fleeting effect on a company's exposure to exchange rates.

Even if the domestic asset is actually not traded in foreign currency, the law of one price (equation 1) can be computed to assess how domestic and foreign assets react to exchange rate movements, since the two are relatively substitutable. However, most large Swiss stocks are cross-listed in the US via ADRs, offering a perfect foreign-denominated substitute to domestic stocks. Interestingly, our analysis shows that the introduction of an ADR amplifies the reaction of the domestic and foreign prices to exchange rate movements, consistent with the law of one price.

ADRs are often used by non-US companies to be listed in the US without having to undergo a costly public offering or comply with reporting standards. ADRs are issued by commercial banks and are then traded on the New York Stock Exchange (NYSE), the Nasdaq stock exchange or over-the-counter. Both the ADR price and dividends are denominated in USD, which makes it easier for American-based and international investors to access foreign stocks (see Alexander et al., 1987 for a discussion on how cross-listing removes trading frictions). An ADR can be converted into its underlying domestic stock and vice-versa. Applying the exchange rate, any price deviation between the two listings can thus be arbitraged to make a riskless immediate profit. In line with this, price parity between cross-listed Swiss stocks and their US listings holds in our data, as shown in Section 5.2.2.[9] Beyond the validation of the law of one price, Section 6 shows that the introduction of an ADR strengthens the reaction of domestic prices and, consequently, weakens that of foreign prices to exchange rate shocks.

3 Isolating exchange rate shocks

One of our contributions is to identify exchange rate movements that are true shocks in the sense that they reflect unexpected news on the exchange rate itself. Identifying exchange rate shocks proves challenging since exchange rates are the result of overall economic activity. Real exchange rates are pinned down by the ratio of domestic and foreign prices in international real business cycle models (Backus et al., 1992). In the New Keynesian literature (Gali and Monacelli, 2005) and in international asset pricing models (Pavlova and Rigobon, 2007), the terms of trade determine the real exchange rate. Differences in money supplies and interest rates (Stulz, 1987 and Obstfeld and Rogoff, 1995) also affect the exchange rate. These determinants are in turn driven by underlying fundamental shocks, so that the observed exchange rate movements reflect myriad unexpected changes in the economy. This makes it challenging to isolate *exoge-*

[9] Lamont and Thaler (2002) observe that the law of one price does not always hold in the ADR stock market. The reasons for the ADR discrepancies include high transaction fees, illiquidity, large dividend payments, as well as the US macroeconomic and consumer sentiment Grossmann et al. (2007).

nous shocks to the exchange rate that are orthogonal to the rest of the newly available economic information.[10]

We overcome the identification difficulty by focusing on a specific subsample of exchange rate movements, namely those that take place on the monetary policy announcement days of the SNB. This allows us to select movements that are not the result of a mixed variety of shocks. We accordingly draw on the by-now extensive research agenda (see Miranda-Agrippino and Ricco, 2021, Jarociński and Karadi, 2020 and Ramey, 2016 for a literature review) that uses time windows around announcements to identify monetary policy shocks. Doing so allows us to focus on the unanticipated – and thus exogenous – component of monetary policy announcements instead of their preemptive effects. The exchange rate plays an important role for Swiss monetary policy. As such, SNB announcements were accompanied by rich exchange rate variations during our sample period. Because SNB announcements are typically the only significant domestic economic event on those days, monetary policy news are not contaminated by other domestic shocks. Our approach builds on the literature on exogenous exchange rate shocks, which typically uses a single large shock as an event study,[11] by instead using a series of shocks.

We construct a series of shocks to the Swiss franc as the daily change in the USD/CHF bilateral exchange rate on SNB announcement days.[12] This bilateral rate is relevant for the Swiss economy and accordingly has a nontrivial weight in nominal effective exchange rate measures. Its movements are also highly correlated with those of the predominant bilateral rate for the Swiss franc (namely, the EUR/CHF), in particular on SNB announcement days.[13] Even more important for our analysis, Swiss stocks that are quoted on multiple exchanges are typically listed in the US[14]—either on the NYSE, the Nasdaq or over-the-counter—which justifies the use of the USD/CHF rather than the EUR/CHF. Figure 2 plots the daily changes (in percentage points) that took place on SNB announcement days, together with a corresponding series that was further purged from the controls detailed in the next paragraph. The series contains a total of 106 shocks. Two noticeably large shocks are those in September 2011 and January 2015, when the minimum EUR/CHF exchange rate was introduced and discontinued, respectively. These two shocks highlight the adequacy of studying the Swiss case. The exchange rate movements were not only large, they were also completely unexpected by financial market participants, in turn providing exogenous variations (consistent with this, the purged series have similar magnitudes in Figure 2). While these two shocks are key parts of the identification strategy, the results presented in this paper are robust to removing these extremely large shocks (see Appendix E).

[10] This is particularly true when estimating the effect of the exchange rate on stock prices because these prices reflect the current information set of market participants (see Phylaktis and Ravazzolo, 2005 for an application via Granger causality and cointegration).

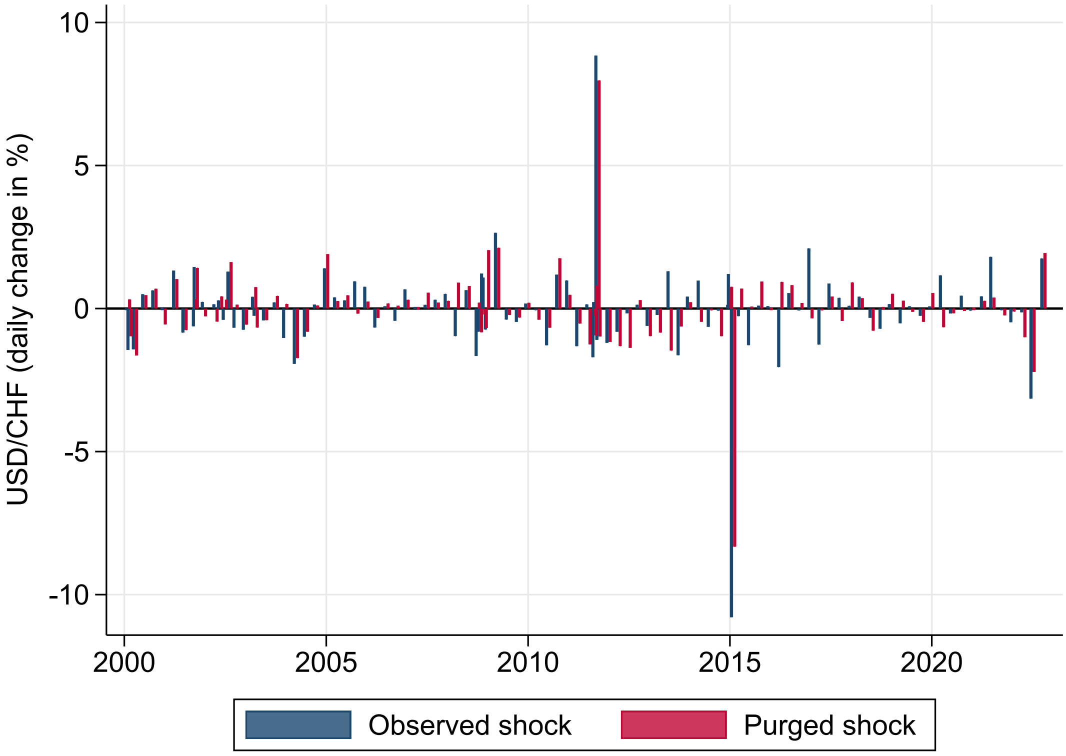
[11] In the case of Switzerland, the unexpected 2015 Swiss franc appreciation is used idiosyncratically in Freitag and Lein (2023), Efing et al. (2022), Eugster and Donato (2022), Oktay (2022) and Auer et al. (2021) among others.

[12] We use the 4 p.m. London fixing; all of the SNB announcements are thus contained in the constructed daily changes.

[13] On these days, the correlation coefficient of the bilateral rate movements (USD/CHF and EUR/CHF) is 0.88.

[14] A few Swiss firms are also cross-listed in the euro area and in the United Kingdom. We focus on cross-listing in the US since it is by far the most common type of cross-listing.

Figure 2: USD/CHF shocks



Notes: USD/CHF movements on SNB announcement days. Positive shocks reflect a CHF depreciation. The purged series consists of the residual from regressing the USD/CHF movements on monetary policy shocks, information effect shocks, and the NEER USD (specification 2). The two series displayed have a correlation coefficient of 0.84.

The purged series in Figure 2 reveals that the USD/CHF variations on SNB announcements are not materially driven by the other information provided on those days. Consistent with this, the observed shocks $\Delta\text{USDCHF}_t = 100(\text{USDCHF}_t/\text{USDCHF}_{t-1}-1)$ and the purged series z_t displayed in the figure are highly correlated (the correlation coefficient is 0.84). Throughout the paper, we account for these additional information sources. Because we trace the effect of exchange rate shocks, our purged shock series z_t controls for the interest rate and information effect shocks that take place on those days as well as for *foreign* exchange rate movements. To do so, the purged series z_t is the residual obtained from regressing the observed USD/CHF movement (on announcement day t) against the three key other information provided on the day:

$$\Delta\text{USDCHF}_t = \alpha + \beta_1 \Delta\text{NEER}_t + \beta_2 \Delta\text{MoPo}_t + \beta_3 \Delta\text{Info}_t + z_t\,. \tag{2}$$

Movements in the USD/CHF reflect movements in both the Swiss franc and US dollar; we thus control for the US dollar nominal effective exchange rate (NEER_t) computed by the BIS. By doing so, we isolate the Swiss franc part of the bilateral rate movements.[15] In our specifications,

[15] Instead using the Swiss franc NEER to compute the exchange rate shocks directly is not an option. The Swiss franc NEER is almost entirely determined by the USD/CHF and EUR/CHF via the large respective trade positions. It therefore includes movements in the US dollar and the euro. On the other side, the US dollar NEER contains several bilateral exchange rates, to which the Swiss franc does not contribute substantially. It thus captures US dollar movements irrespective of the Swiss franc.

we also control for the exchange rate movements that took place since a given announcement. We thus trace the effect of a shock over the next days, accounting for the subsequent movements in the Swiss franc. Similarly, we control for the interest rate surprises (MoPo_t) that take place on SNB announcement days by using the shocks of Koeniger et al. (2022).[16] Last, we control for information effects (Info_t) by computing the Bu et al. (2021) and Ciminelli et al. (2022) shocks for Switzerland that are based on the information contained in the yield curve. This identification through the heteroskedasticity approach relies on only one key structural assumption: that the variance of the monetary component of a series is higher on central-bank announcement days. The assumption is adequate for Switzerland since SNB decisions have been shown to have a sizeable impact on asset prices (Ranaldo and Rossi, 2010). Appendix A provides a detailed description of the approach, which we replicate with Swiss data on SNB announcement days. It is worth noting that controlling for information effects does not eliminate the exchange rate shocks. This is not surprising given that the SNB notably discusses the exchange rate during its announcements, in addition to communicating its interest rate decision. In line with this, our information shocks capture information regarding interest rates and not information linked to exchange rates.

Once all of these factors are controlled for, our purged shocks z_t capture Swiss franc movements that are due to the SNB communication on the exchange rate, which we regard as exchange rate shocks.[17] The results detailed in Section 5 therefore isolate the footprint of a purely domestic currency shock to the Swiss franc. Unsurprisingly, all of these results are invariant to instead using the simpler observed series ΔUSDCHF_t and adding the controls directly in the specification.[18]

4 Data on asset prices and cross-listings

Our sample period runs from January 2000 to December 2022, matching the SNB monetary policy regime that was adopted in 2000. If not mentioned otherwise, the data come from Refintiv Datastream. We use daily closing prices. The domestic listings of Swiss assets are in Swiss francs, while the corresponding US listings – if they exist – are in US dollars.

We capture all of the 212 free-floating stocks commonly traded as part of the Swiss Performance Index (SPI), the broadest Swiss stock index. The heterogeneity among stocks permits a refined assessment of the economic channels discussed in Section 2. Our analysis in Section 5.2 resorts to variations in economic sectors, market capitalization and in the currency denomination of

[16] Koeniger et al. (2022) extract the unexpected movements in short-term rates on SNB announcement days from futures contracts. Following Miranda-Agrippino and Ricco (2021), the shocks of Koeniger et al. (2022) are purged from potential auto-correlation. Appendix F shows that all results are robust to using an alternative control method for these shocks, namely the Bu et al. (2021) monetary policy shocks.

[17] The results presented in this paper are qualitatively unchanged when instead considering exchange rate movements outside of monetary policy announcements. Because these movements are confounded with other economic news, we choose to focus on the SNB announcements – which provide more causal estimates.

[18] See Appendix D.

sales.[19] Firms that export more are also more likely to have a higher proportion of their cash flows in a foreign currency. We thus use the proportion of foreign sales (namely, the ratio of sales realized in foreign countries over total sales) as a proxy for foreign-denominated cash flows since the latter is typically not reported by firms.[20]

Importantly, the cross-listing of some stocks allows us to conduct the synthetic DID identification presented in section 6. Among the 212 Swiss stocks, 54 are cross-listed[21] in the US via ADRs, which gives investors ownership in a foreign-listed firm. Working with cross-listed stocks requires a common fixing time. Using London time, our exchange rates are fixed at 4 p.m., domestic asset prices at 4.30 p.m. and the US-listed ADR prices at approximately 9–10 p.m.[22] Our exchange rate shocks are tied to Swiss monetary policy announcements; all shocks take place between the fixings we use.[23] One potential issue would be if asset prices faced movements between the domestic and US fixing times that are systematically correlated with our exchange rate shocks. Such movements would be accounted for at t for the US price but at $t+1$ for the domestic price. Importantly, we do not find evidence of such movements between the fixing times.[24]

Last, we extend our analysis to other asset classes focusing on bonds and gold. We use the S&P Switzerland Investment Grade Corporate Bond Index and the S&P Swiss Sovereign Bond Index for bond prices, which cover the main Swiss bond issuers and maturities. These bonds do not have foreign listings. For gold, we use the price per kilogram of 995-purity bars, as measured by UBS in Zurich. The immediate equivalent US listing is the price of the same gold bars in US dollars measured by Handy & Harman, which we convert from ounces to kilograms.[25]

[19]The characteristics of firms come from their financial statements reported in December 2022 (via Refinitiv Datastream).

[20]While this does not hold true in all cases – such as for firms that invoice exporting goods in the domestic currency as in Auer et al. (2021) – this proxy works well on average since foreign sales are a prerequisite for foreign-denominated cash flows. Given that we are interested in the direction rather than the exact magnitude of our estimated responses, this proxy should yield an adequate representation of the effect of foreign-denominated cash flows.

[21]The terms dual-listing and dually listed stocks are also used similarly in the literature to describe cross-listed firms.

[22]The exact fixing time depends on the asset and whether it is traded over-the-counter or as part of a larger exchange, but the majority are fixed at 4 p.m. or 5 p.m. New York time (9–10 p.m. London time). Some variations from these times may arise with daylight savings.

[23]Although SNB announcements are usually circa 9–10 a.m. (Zurich time), our fixing windows also cover the few announcements that took place in the afternoon.

[24]We cannot test this directly for stocks without intraday data. However, we can test it for gold using closing prices in multiple locations. We thus ran the regressions involving gold (shown in Section 5) twice, with the London and New York fixings. The results for gold are extremely robust to the change in fixing, hinting that the fixing time difference should not be a concern for gold or stocks.

[25]The standard USD gold price is that measured by LBMA with a fixing at 4 p.m. London time, which matches well with Swiss market hours. We instead use the less standard New York Handy & Harman fixing to match the ADR data that are also fixed at New York time. That way, the results for stocks and gold are comparable.

5 Response of asset prices to the exchange rate

Our shock series permits us to estimate the causal effects of a change in the exchange rate. We trace the effect of an exchange rate shock on domestic asset prices via local projections (see Jordà, 2005). The corresponding price response of asset k on day $t+h$ since the SNB announcement day t is obtained by regressing the cumulative asset returns $\Delta p_{k,t+h} = 100(p_{k,t+h}/p_{k,t-1} - 1)$ against the exchange rate shocks:

$$\Delta p_{k,t+h} = \alpha_{k,h} + \beta_{k,h} z_t + \Gamma'_{k,h} X_{t+h} + \epsilon_{k,t+h}, \tag{3}$$

where z_t is the shock on announcement day t (detailed in Section 3) and X_{t+h} is a vector of controls that contains the post-shock cumulative USD nominal effective exchange rate (ΔNEER_{t+h}, $h \geq 1$) and domestic exchange rate movements ($\Delta \text{USDCHF}_{t+h}$, $h \geq 1$). The footprint of a given exchange rate shock on asset prices is then readily obtained by plotting the estimates $\hat{\beta}_{k,h}$ and their respective confidence intervals for up to $H = 60$ business days.[26]

The resulting estimates are presented in the following section and show that the effect on the broad domestic asset classes (namely stocks, bonds and gold) reflects the law of one price. Section 5.2 then uses the heterogeneity provided by the individual stocks to provide support to the *currency denomination* hypothesis.

5.1 Asset classes

Overall, the effect of exchange rate shocks on domestic asset classes supports the law of one price considerations that are discussed in Section 2. This is shown in Figure 3, which plots the asset price responses to a 100 bp USD/CHF shock (that is, a Swiss franc depreciation). According to our estimates, a currency depreciation has no significant effect on bond prices, either sovereign or corporate.[27] In contrast, the depreciation immediately and persistently increases stock and gold prices. On impact, the price of both asset classes increases by approximately 35 bp and 101 bp, respectively. The effect then persists over the next 60 days, reaching an average effect of 34 bp and 63 bp over the time horizon considered. Conversely, a Swiss franc appreciation decreases gold and stock prices but has no significant effect on bond prices, as was highlighted by the large appreciation shock of January 2015 shown in Figure 1.

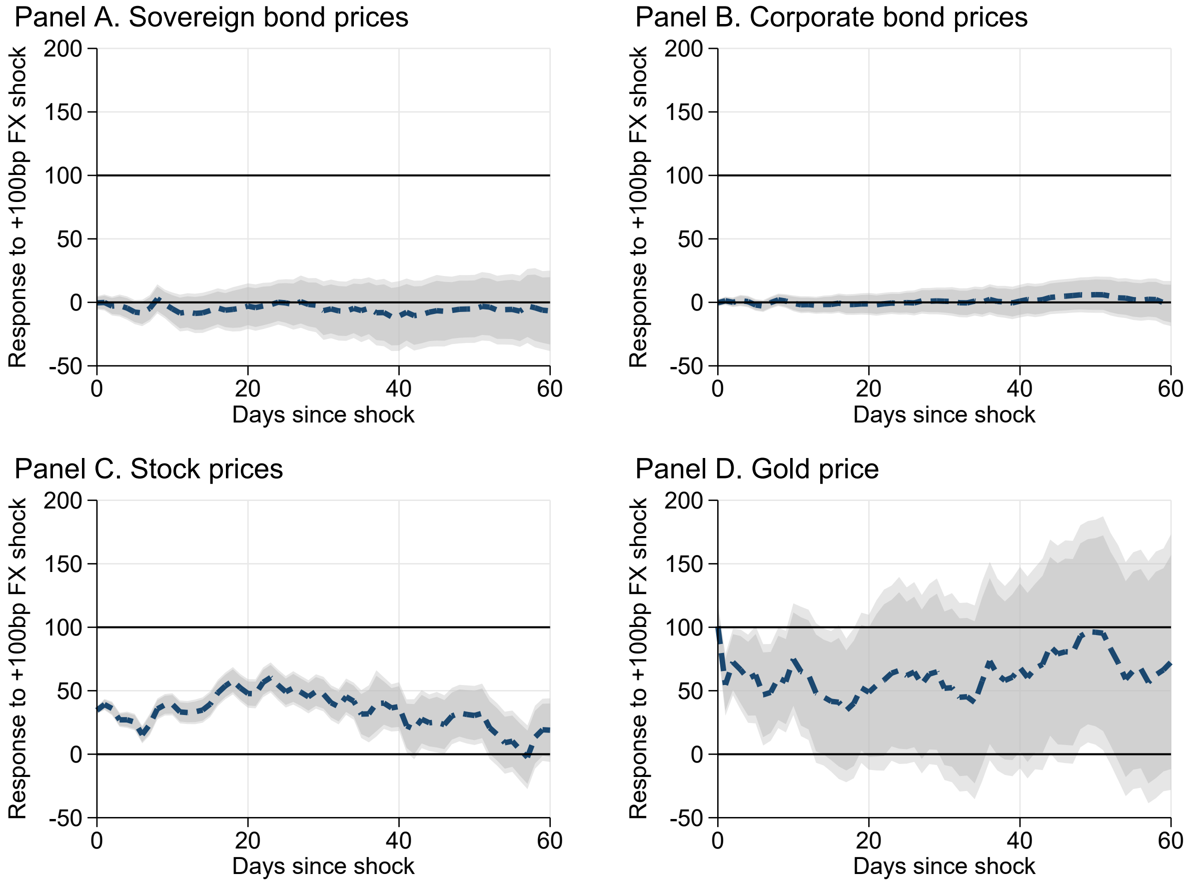
The marked differences in price responses across asset classes highlights the role played by currency denomination. In this regard, the gold and bond price responses provide boundary cases for stocks. On the one end of the spectrum, bond prices do not respond because bonds deliver cash flows that are entirely denominated in Swiss francs. The cash flows of the asset remain unaffected by the exchange rate movement, and there is thus no reason for the valuation of domestic bonds to adjust.[28] Swiss bonds are not cross-listed in the US. Accordingly, the law of

[26] We do not control for liquidity in our regressions since the considered assets are typically often traded.

[27] The absence of a response from corporate bonds provides evidence that the exchange rate shocks do not affect the creditworthiness of corporate bond debtors in Switzerland.

[28] Naturally, bond prices adjust to the unexpected interest rate movements that take place on SNB announce-

Figure 3: Response of domestic asset prices to a 100 basis point Swiss franc depreciation



Notes: Responses in basis points to a purged USD/CHF shock of +100 basis points (CHF depreciation). Using specification 3, 90% (95%) confidence intervals in dark (light) grey area. Stock price responses use pooled regressions with the individual stocks. All prices are in CHF and traded in Switzerland. Corresponding regression results are displayed in Appendix Table A2.

one price manifests itself simply via exchange rate movement: an investor who operates in US dollars faces a mechanically higher price when purchasing the domestic bond and translating it into US dollars. On the other end of the spectrum, gold displays the sharpest price response because it does not deliver monetary cash flows but is priced at multiple locations simultaneously. The price of gold in Switzerland must therefore be equal to the price of gold in the US converted to Swiss francs. Because Swiss franc shocks have little implications for the worldwide gold market, any arbitrage opportunities are cleared via the adjustment in the domestic Swiss price. A Swiss franc depreciation thus forces the Swiss price of gold to increase almost one-to-one to maintain price parity. The response of stocks lies between the boundary cases provided by bonds and gold. As a real asset, a stock provides monetary cash flows that depend on the exchange rate, in turn affecting the asset valuation. This is depicted in the empirical responses shown in Figure 3.

Price parity should strictly hold for assets that are perfectly substitutable, such as cross-listed stocks or gold. This is the case in our data, which we interpret as both supporting evidence for

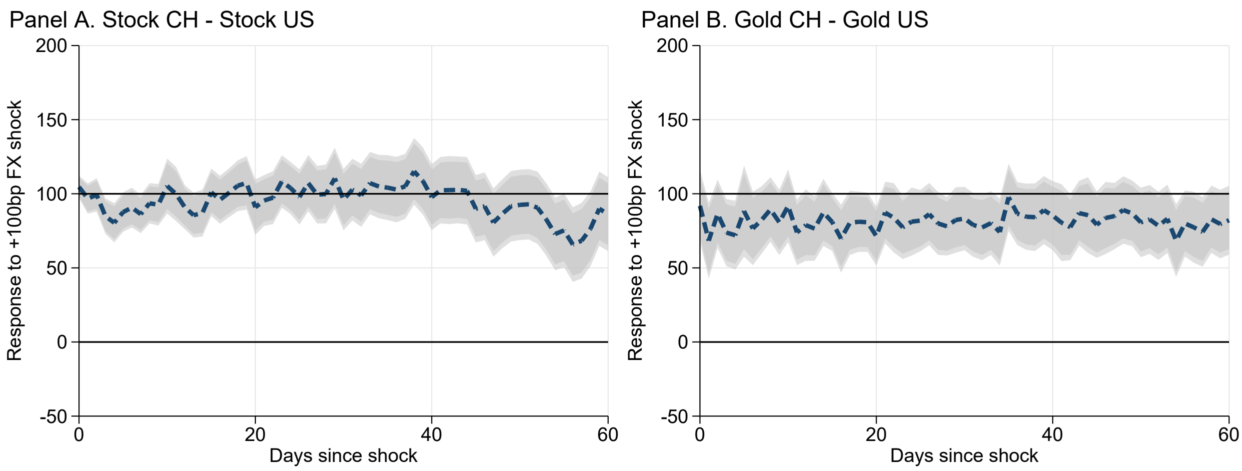
ment days. This effect is captured by the control for interest rate shocks – which directly affect bond prices at all maturities (see Koeniger et al., 2022) – not by exchange rate shocks.

the currency denomination mechanism and as a quality check (see Figure A1 for two individual examples over all trading days). We assess this by running pooled local projections on the difference in currency returns for each of the 54 cross-listed stocks (as well as for gold):

$$\Delta p^{CH}_{i,t+h} - \Delta p^{US}_{i,t+h} = \alpha_h + \beta_h z_t + \Gamma'_h X_{t+h} + \epsilon_{i,t+h}, \tag{4}$$

which uses the same controls X_{t+h} as in specification 3 and in which $p^{US}_{i,t+h}$ denotes the ADR price of stock i in the US. Price parity is strictly respected when β_h is equal to one over the time window considered as arbitrage opportunities would arise otherwise. This is illustrated in Figure 4, which reveals a strictly enforced price parity for both cross-listed stocks and gold over the 60 days that follow the exchange rate shocks. If anything, our estimation of price parity is marginally affected by specific stocks with very low liquidity, for which differences can arise. However, only 3 or 4 stocks display such large jumps, so that they do not significantly impact our pooled results.[29] We therefore do not find evidence of profitable arbitrages for cross-listed Swiss firms, which is in line with the existing evidence on cross-listing.[30]

Figure 4: Response of difference in currency returns to an exchange rate shock



Notes: Responses in basis points to a purged USD/CHF shock of +100 basis points (CHF depreciation). Using specification 3, 90% (95%) confidence intervals in dark (light) grey area. Stock price responses use pooled regressions with the individual stocks. Corresponding regression results are displayed in Appendix Table A4

We contribute to the literature by identifying the mechanism that drives the response of stock prices to the exchange rate. In Section 2, we presented two mechanisms that can explain this reaction — namely, the *economic conditions* and *currency denomination* hypotheses. Although

[29] See Figure A1 for an extreme example of a low-volume stock compared to a high-volume stock. In that case, the foreign listing price moves periodically in large jumps when the difference with the domestic price grows too large, showing realized arbitrage opportunities.

[30] Using intra-day ADR data on cross-listed stocks from different countries, Gagnon and Karolyi (2010b) also report minor deviations from the law of one price. The deviations are correlated with measures that reflect frictions (such as holding and transaction costs as well as foreign investment restrictions). The role of frictions is also documented in Fung et al. (2022), who show that a flexible exchange rate regime enforces better the price parity of cross-listed Chinese stocks. Similarly, Rosenthal and Young (1990) find no profitable trading rules for two firms that are listed in the US and the UK. Although De Jong et al. (2009) find some evidence of abnormal returns for cross-listed firms, it is accompanied by large volatility and negative returns, in turn jeopardizing arbitrage.

the empirical reaction of stocks that we find is consistent with both hypotheses, its economic interpretation differs. The cash flows of several Swiss stocks are denominated in foreign currencies before being converted into Swiss francs. Accordingly, a Swiss franc depreciation increases the (current and expected) cash flows expressed in Swiss francs, which makes the firm relatively more profitable. When instead thinking in terms of *economic conditions*, the depreciation makes it cheaper to export Swiss products, in turn pushing up aggregate demand in the domestic country. By examining the response of the individual stocks in the next section, we provide supporting evidence that the *currency denomination* mechanism dominates and thus drives how stock prices react to the exchange rate.

5.2 Stock heterogeneity

Examining the heterogeneity across stock price responses reveals the role played by currency denomination in the transmission of exchange rate shocks. We use the 212 individual Swiss stocks i, which we aggregate into J groups. We then analyze the sensitivity on impact of each group j to purged exchange rate shocks by interacting the exchange rate shocks with group dummies:

$$\Delta p_{i,t} = \alpha + \sum_{j=1}^{J} \beta_j \left(x_{i,j,t} \times z_t \right) + \sum_{j=1}^{J-1} \alpha_j x_{i,j,t} + \epsilon_{i,t}, \tag{5}$$

where $x_{i,j,t}$ is a binary variable that equals one if stock i belongs to group j so that α_j captures group fixed effects. The response of group j to the exchange rate shock is thus given by β_j. We explore four possible ways of grouping firms: by sector, size, share of foreign sales, and cross-listed presence in the US. The groups constructed from continuous variables are created such that the number of firms in each group is approximately equal.

To what extent currency denomination drives the price responses is first seen via differences in the currency denomination of the stocks' cash flows. A second set of supporting evidence is given by the stocks' degree of international substitutability, for which the cross-listing of stocks permits us to provide further evidence. We discuss these two heterogeneity dimensions in turn.

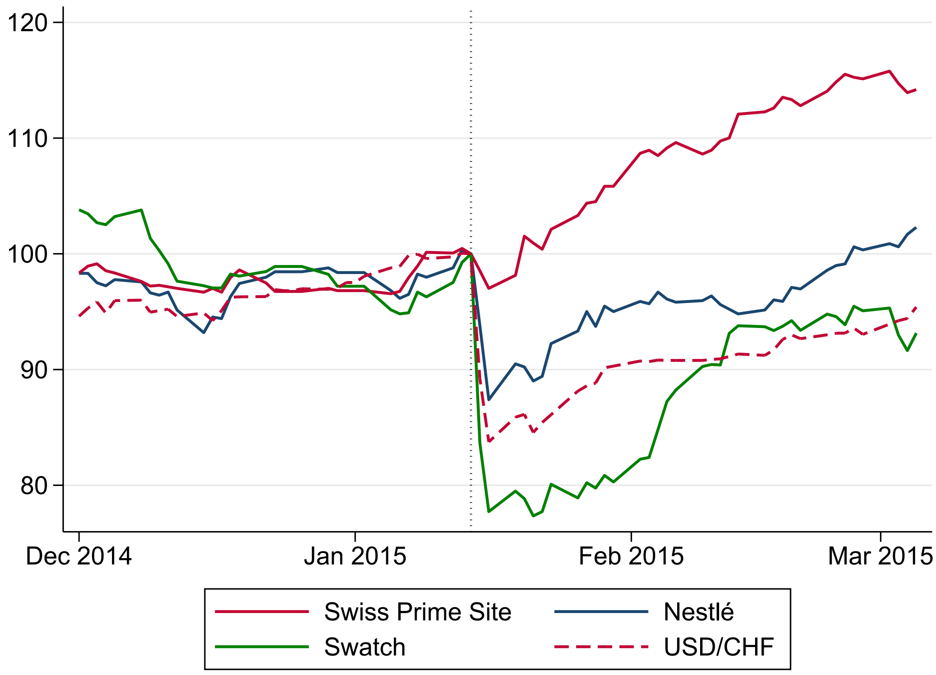
5.2.1 Currency denomination of cash flows

The role played by cash flow denomination is well illustrated by examples of the three firm categories discussed in Section 2. Over the two days following the large and exogenous Swiss franc appreciation shock in January 2015, the stock price of Swiss Prime Site, a *domestically oriented* firm, fell by 3%, Nestlé, an *international* firm, by 13% and Swatch, an *exporting* firm, by 22% (Figure 5).

Swiss Prime Site only operates in the Swiss real estate market, and its cash flows are entirely denominated in Swiss francs. Its stock price barely reacts to the exchange rate shocks.

Nestlé produces and sells food and beverage products throughout the world. The Swiss market represented only 1.2% of Nestlé's total sales in 2022. Its cash flows are thus largely denominated in foreign currency, mostly in US dollars. While exchange rate movements do not necessarily

Figure 5: Three Swiss stock prices around the January 2015 Swiss franc appreciation



Notes: Series in Swiss franc and indexed to 100 on the day before the January 15, 2015, announcement (vertical line), when the SNB discontinued the EUR/CHF minimum exchange rate. Source: Refinitiv Datastream.

affect profits expressed in foreign currencies, they do affect profits expressed in Swiss francs.

Swatch produces watches in Switzerland but sells almost all of them abroad.[31] Exchange rate movements thus affect the firm's revenues but not its costs, in turn affecting its profitability in foreign currencies. Moreover, exchange rate movements also affect the conversion of profits into Swiss francs. The appreciation shock therefore decreased Swatch's profitability by relatively more than that of Nestlé.[32]

It is worth noting that the difference in the observed responses between Nestlé and Swiss Prime Site cannot be easily explained by a change in domestic macroeconomic conditions. The widely discussed mechanism through which the exchange rate impacts asset prices via altered domestic fundamentals (see, e.g., Engel and West, 2005) does not dominate in Figure 5. For this to be the case, Swiss Prime Site should have been more affected than Nestlé, because it relies entirely on Swiss domestic demand whereas Nestlé operates almost exclusively abroad. Changes to the economic conditions that firms operate in — as in explanations based on the current account (e.g., Dornbusch and Fischer, 1980) or on aggregate domestic demand (e.g., Gavin, 1989) — thus cannot explain the observed stock price responses.

We show that variations in stock price responses can instead be explained to a large extent by the currency denomination of the firms' cash flows. This is seen in Figure 6, which plots the

[31] 92.3% of Swatch's total sales were made abroad in 2022.

[32] Stock prices are linked to their expected discounted cash flows, be it at the firm's cash flow (Ma and Kao, 1990) or dividend (Black and Scholes, 1974) levels. The observed price declines of exporters such as Swatch can also reflect an increased currency risk (Karolyi and Stulz, 2003).

price responses of the firm groups that are obtained from specification 5. In Panel A, firms are grouped by the proportion of their sales that are in foreign currencies.[33] This simple ratio can explain wide variations in stock price responses. With a price response of just 0.12, purely *domestically oriented* firms (such as Swiss Prime Site) are far less sensitive to the exchange rate shocks — and significantly so — than firms with foreign sales. In line with the *currency denomination* hypothesis, the price response is increasing in the foreign sales ratio. The response is as high as 0.55 for *international* firms (such as Nestlé), which have a foreign sales ratio of at least 95%.

The role played by cash flow denomination is further corroborated when instead considering the transmission of the exchange rate to the prices of goods and services. One way to measure how exposed the income of firms is to the exchange rate (such as via currency denomination) is the exchange rate pass-through to consumer prices. We find that the economic sectors[34] with higher pass-through estimates also display higher stock price responses to the exchange rate shocks. To see this, Panel B of Figure 6 plots the *sectoral* responses of stock prices to the exchange rate against the corresponding sectoral exchange rate pass-through to consumer prices (computed for Switzerland by Oktay, 2022). Sectors with more sensitive consumer prices, such as tourism and industrial, display a sharper stock price response to exchange rate shocks. In contrast, sectors with a lower pass-through (such as real estate or banking) are associated with weaker responses. One outlier is the energy sector, which is omitted in the regression line of Panel B. Although energy prices are found to be highly sensitive to exchange rates (see Oktay, 2022), energy stock prices do not respond substantially to our exchange rate shocks because energy prices are typically administratively set in Switzerland. In other words, changes in energy costs are passed on to consumers. This implies little variation in the net cash flows generated by energy stocks, which leaves their valuations relatively unaffected. The sectoral exchange rate pass-through is linked to the average sectoral share of foreign sales with a correlation coefficient of 0.43, showing that the products that are most affected by exchange rate shocks are also those that are the most exported.

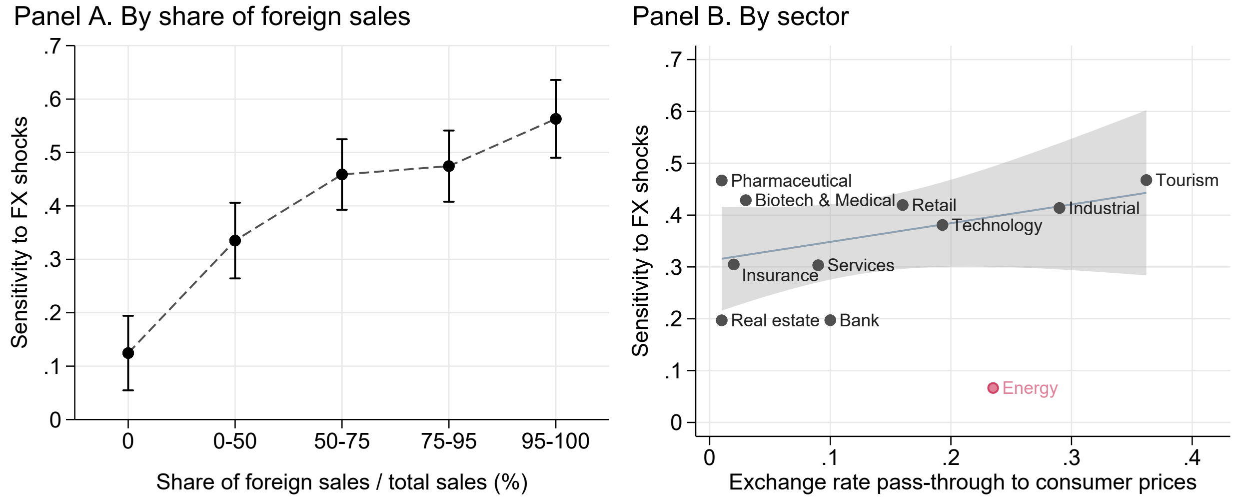
5.2.2 Degree of international substitution

Another way to illustrate how currency denomination drives the stock price responses to the exchange rate is via their degree of international substitutability. The sensitivity of stock prices is partly driven by the degree of substitution of stocks across markets. For instance, Griffin and Stulz (2001) show that the returns of industries that produce traded goods are more sensitive to the exchange rate. In our case, a currency appreciation makes domestic stocks relatively more expensive for international investors since they have to convert the stock price into their reference currency. When the Swiss franc appreciates, foreign-based investors have an incentive to

[33] There is approximatively the same number of firms in each of the 5 obtained groups.

[34] We group the 212 Swiss stocks into 11 economic sectors. This grouping fits the Swiss stock market, which contains several financial and health firms, and permits us to highlight the specific cases of tourism-related and energy firms.

Figure 6: Stock price responses and heterogeneity in cash flow denomination



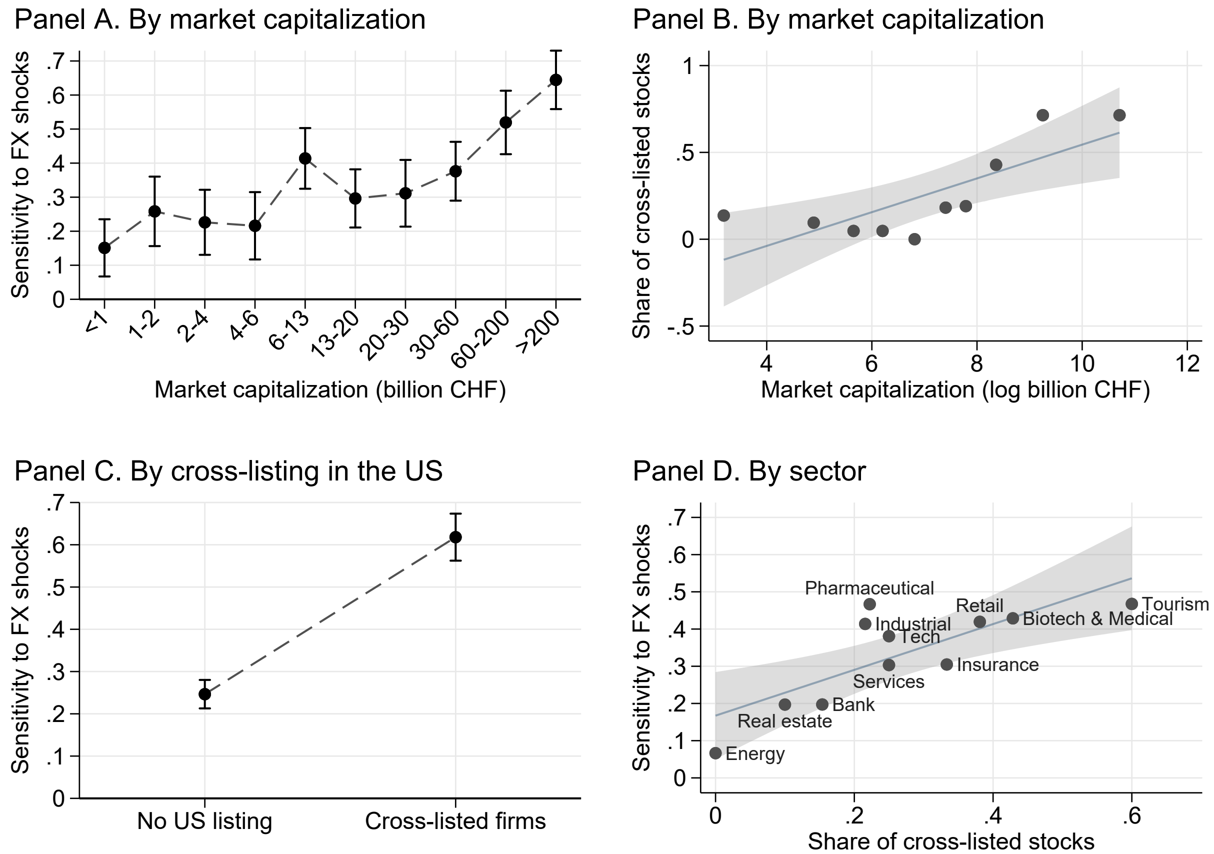
Notes: Using specification 5, 95% confidence are intervals given by whiskers (Panel A) and the grey area (Panel B). Sensitivity to FX shocks is an elasticity (hence a hundred times smaller than that reported in Figure 3). Foreign sale ratios are as of December 2022. Exchange rate pass-through estimates for Switzerland are from Oktay (2022). As discussed in the text, the regression line in Panel B omits the energy sector. The coefficient of the slope in Panel B is 0.361 (p-value 0.206). The regression results of Panel A are displayed in Appendix Table A3.

sell some of their now-higher Swiss shares (say, Nestlé) to buy foreign shares that are to some degree substitutable (say, PepsiCo or Unilever). The incentive for this portfolio substitution prevails until the corresponding stock prices adjust to respect currency-adjusted price parity.

Our results show that stocks with a higher degree of international substitution display sharper price reactions to the exchange rate. Naturally, larger firms tend to sell their products abroad and are thus more directly comparable with foreign competitors. In line with this, our estimated price responses are increasing in the stock's market capitalization (see Panel A in Figure 7). It is worth noting that our results should not be weakened by currency hedging. Firms cannot hedge indefinitely; cash flows are eventually affected by currency movements. In addition, because hedging is expensive, we would expect the larger firms to resort relatively more to it. Despite this, Figure 7 shows that larger firms display sharper stock price responses to our exchange rate shocks. These findings add to the existing result of Hau et al. (2010), who showed that countries with a higher degree of international stock substitutability have sharper exchange rate responses to an exogenous change in equity index representation. Our results obtained from our identification of exchange rate shocks permits us to instead show a corollary result. Namely, higher substitutability also enhances the stock price response to an exogenous change in the exchange rate.

Another way to measure the degree of international substitutability across stocks is via cross-listing. In line with the law of one price, the price response of cross-listed firms to the exchange rate is substantially more marked. As described in Section 4, 54 of the 212 Swiss stocks are also listed in the US via an ADR. Unsurprisingly, larger firms are more likely to be cross-listed (see Panel B in Figure 7). The Swiss firms that are cross-listed in the US are of particular interest because they offer a perfect substitute to foreign investors. Panel C in Figure 7 shows that

Figure 7: Heterogeneity of international substitution



Notes: Using specification 5, 95% confidence intervals are given by whiskers (Panels A and C) and the grey area (Panels B and D). Sensitivity to FX shocks is an elasticity (hence a hundred times smaller than that reported in Figure 3). Market capitalizations and cross-listing shares as of December 2022. The coefficient of the slope is 0.097 for Panel B (p value 0.007) and 0.615 for Panel D (p value 0.005). The regression results of Panels A and C are displayed in Appendix Table A3.

cross-listed firms have an initial price response of 0.60, which is both significantly and sizably different from the response of firms only listed in Switzerland (with a response of just 0.25). The presence of cross-listing appears to be important quantitatively, as it explains a considerable portion of the price response variations observed across sectors. This is shown in Panel D, which plots the proportion of cross-listed stocks against our estimated price responses at the sectoral level. The least impacted sectors are energy, real estate and banks. These sectors are also those that have the smallest proportion of cross-listed firms. Similarly, tourism-related firms and biotech stocks are among the most impacted and have a large share of their firms cross-listed in the US. Accordingly, cross-listed firms appear to react more sharply to exchange rate shocks than single-listed firms. The sectoral responses partly account for the cash flow denomination effect that was documented in the previous section (and illustrated in Panel B of Figure 6). In Section 6, we will present more causal evidence of cross-listing via the staggered introduction of ADR.

5.2.3 Evidence from ADR excess returns

How is an exchange rate shock expected to affect the relative performance of US-based ADR prices of Swiss stocks compared to their US peers?

If the exchange rate mostly impacted stock prices via altered *economic conditions*, an appreciation of the Swiss franc would lead ADR prices to perform relatively worse than their US peers. By weakening economic conditions in Switzerland, an appreciation would lead Swiss companies to perform less well than US companies. The return of ADR prices in excess to that of their US peers would thus be positively correlated with our exchange rate shocks. However, if the exchange rate mostly impacted stock prices via the *currency denomination* mechanism, an appreciation of the Swiss franc would lead ADR prices to perform relatively better than their US peers. The return of ADR prices in excess to that of their US peers would thus be negatively correlated with our exchange rate shocks.

We test whether the Swiss stocks listed in the US exhibit excess returns with respect to comparable US firms after exchange rate shocks. To do so, we compare the individual ADR returns $\Delta p_{i,t}^{US}$ to the return of their respective sectoral index $\Delta p_{s,t}^{US}$, measuring the 11 sectors described previously by the corresponding S&P500 indices.[35] For each sector s, the individual excess returns are regressed against the exchange rate shocks:

$$\left(\Delta p_{i,t}^{US} - \Delta p_{s,t}^{US}\right) = \alpha_s + \beta_s z_t + \epsilon_{i,t}\,, \tag{6}$$

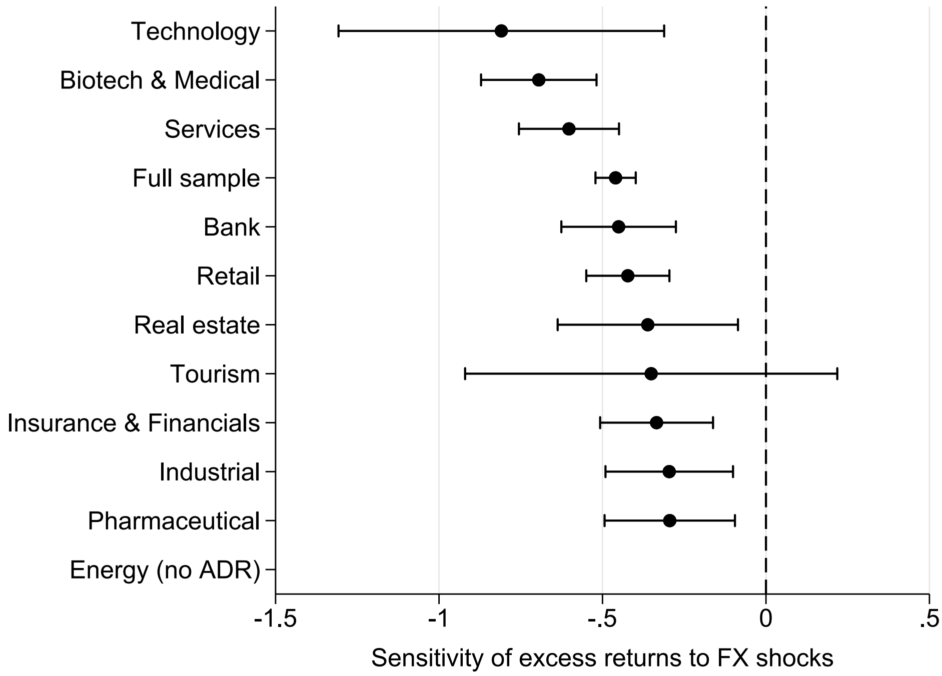
where systematic differences in risk between the US-listed Swiss firms and the corresponding US indices are captured via the intercepts α_s. If the mechanism of altered economic conditions dominates, $\beta_s > 0$, whereas $\beta_s < 0$ instead indicates that currency denomination drives the ADR price responses.

The response of the US-based excess returns clearly supports the currency denomination hypothesis. Figure 8 shows a significantly negative relationship between excess returns and the exchange rate shocks, consistent with the large role played by currency denomination. The negative response of the excess returns holds across all sectors (though not significantly for one) and appears homogeneous in terms of statistical significance.

We can further exploit cross-listing to find supporting evidence for the currency denomination hypothesis. We do so in the next section by using the staggered introduction of the ADRs.

[35] The indices used are the S&P500 Banks, S&P500 ES Health Care, S&P500 ES Energy, S&P500 EW Industrial, S&P500 Insurance Brokers, S&P500 Chemicals, S&P500 ES Real Estate, S&P500 ES Consumer Staples, S&P500 Telecom & IT, S&P500 Tech and Datastream US Travel and Tourism index since S&P does not provide a sectoral index for tourism.

Figure 8: Response of ADR excess returns to a (Swiss franc) exchange rate shock



Notes: Sensitivity to FX (USD/CHF) shocks is an elasticity (hence a hundred times smaller than that reported in figure 3). Using specification 6. Whiskers give 95% confidence intervals. Corresponding regression results are displayed in Appendix Table A5.

6 Causal evidence on the currency denomination effect

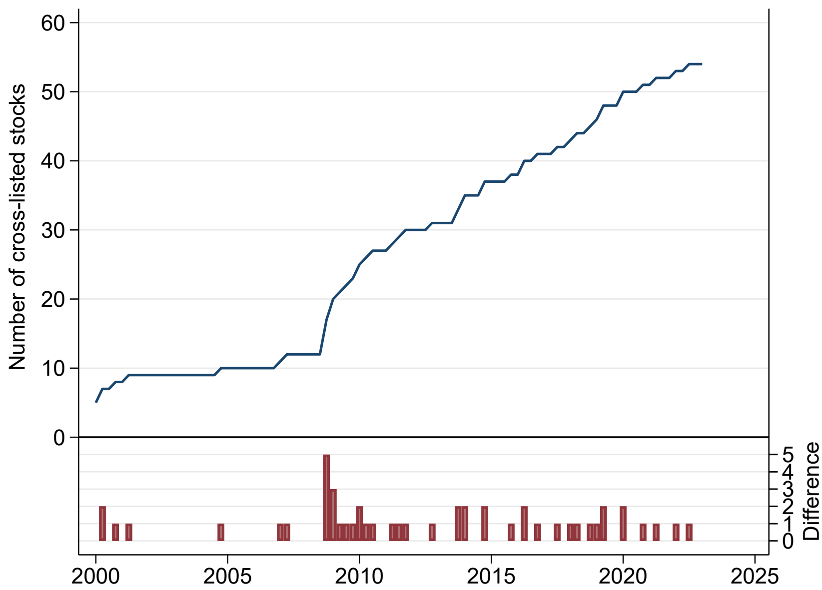
The foreign listing of Swiss stocks provides additional identification on how currency denomination shapes the response of stock prices to the exchange rate. Cross-listing is a stringent case of international substitution because it makes domestic and foreign assets perfect substitutes. Absent marked frictions (such as large transaction costs), exchange rate movements should be compensated by changes in the listings' prices at home and abroad. Figure 4 illustrates the law of one price by showing that this is true for Swiss stocks with an ADR in the US. In practice, the presence of an ADR makes it easier for USD-denominated investors to trade the stock. Thanks to the ADR, foreign investors no longer need to convert the domestic stock price into foreign currency and can operate at their usual trading time. Cross-listing thus reduces trading frictions, in turn making it easier for USD-denominated investors to compare the ADR prices to other USD-denominated substitutable stocks (for instance, the Novartis ADR versus the Pfizer stock). Section 5.2.3 documented that domestic exchange rate shocks do not substantially alter the economic conditions faced by cross-listed firms (which are typically international firms). To remain comparable with other USD-denominated substitutable stocks, ADR prices can only react to some extent to the domestic exchange rate. By the law of one price, the response of the domestic stock prices of cross-listed firms is accordingly enhanced (as discussed in Section 2). An ADR can be converted into the underlying domestic stock and vice-versa; arbitrage opportunities would thus arise from any price deviations. This mechanism is akin to the previously discussed case of gold: a shock to the Swiss franc will be reflected in the Swiss price of gold to respect parity with the global USD quotation.

We exploit cross-listing to provide causal evidence of the degree of substitution that is due to currency denomination. To do so, we exploit the staggered introduction of ADRs with a synthetic DID approach. We analyze ADRs since they are by far the most frequent cross-listing vehicle for Swiss stocks, but our findings should hold for any type of cross-listing.[36] We show that the introduction of an ADR amplifies domestic stock returns by exacerbating their reaction to exchange rate shocks. The effect is sizeable: approximately one-third of the Swiss stock price movements that follow exchange rate shocks are attributed to cross-listing.

6.1 Identification via synthetic difference-in-differences

Our identification strategy relies on the staggered introduction of foreign listings in Switzerland. Throughout the sample period, Switzerland went from having only 5 firms[37] listed in the US in 2000 to 54 in 2022, all of which took place via the issuance of ADRs. In line with the DID literature, we refer to the introduction of an ADR as a *treatment* for the domestic stock. The ADR introductions provide adequate treatment variations. They were spread over time, with approximately one new listing per quarter (see Figure 9). The listings are thus well scattered around the exchange rate shocks that take place on (the typically quarterly) SNB announcement days.

Figure 9: Introductions of American Depositary Receipts for Swiss stocks



Notes: Quarterly difference. Total of 212 Swiss-listed firms; see Section 4 for details on cross-listing.

Our identification is based on the DID framework to address the fact that the firm's decision to be cross-listed is not random. The endogeneity issue that would bias a standard linear re-

[36]This includes listings on non-US markets via global depositary receipts (GDRs) and direct foreign listings, although these cases are marginal given the prevalence of ADRs.

[37]Namely Credit Suisse, Logitech, Nestlé, Roche and Swisscom.

gression lies in the fact that Swiss stocks also listed in the US are systematically different from stocks that are solely listed domestically. Directly comparing stocks with and without an ADR would thus yield biased results. Among other factors, foreign firms cross-listed in the US display higher valuation levels (Doidge et al., 2004) and a higher investment-to-price sensitivity (Fresard and Foucault, 2012). In line with this, Table 1 reports binary regressions on the probability that a given Swiss firm is cross-listed. Independent of their sector, cross-listed firms are significantly larger and have greater international exposure, as measured via market capitalization and the foreign sales ratio. They also tend to be in more international sectors such as tourism, biotech and medical or banking. By taking this into account, our DID identifies the impact of cross-listing (the *treatment*) on domestic stock returns. The DID uses the non-treated stocks as a control group that provides an imperfect counterfactual for the treated stocks. The key assumption for the DID to correctly estimate the treatment effect is that stock prices would have followed parallel trends without the treatment. We argue that this is the case given the integration of stock markets over our sample period. While it is not feasible to check this assumption for each of the 212 stocks, Figure 5 shows that stock prices tend to be strongly correlated and move in a parallel way. Despite this, a standard DID would yield biased results because ADR introductions are staggered and may have heterogeneous effects across stocks. Staggered introduction over the 22 years considered is problematic since the standard DID is usually implemented with a two-way fixed effects (TWFE) estimator. This estimator takes already-treated units as controls for the units treated afterwards, which has been shown to generate biased estimates of the average treatment effect on the treated (ATET) because each unit is weighted (Goodman-Bacon, 2021). Alternative specifications with dynamic TWFE such as Callaway and Sant'Anna (2021) or with randomized adoption dates such as Athey and Imbens (2022) can address this issue. A similar problem arises with heterogeneous treatment effects. This is likely to be the case in our dataset. As Section 5.2.2 revealed, stocks are characterized by a marked heterogeneity in their price response to exchange rate shocks. Sun and Abraham (2021) showed that heterogeneity across adoption cohorts may yield a similar ATET bias, even in a dynamic TWFE setting. This bias can be eliminated through the estimation of switchers as shown in De Chaisemartin and d'Haultfoeuille (2020). The combination of these two issues is likely to yield biased estimates that may be significant with the wrong sign, even if the treatment were random (Baker et al., 2022).

We thus use a synthetic difference-in-differences (SDID) approach to mitigate these issues and additionally relax the parallel-trends assumption. SDID follows a long line of work on synthetic controls; Arkhangelsky et al. (2021) showed its appealing features. SDID optimally weights each unit of the control group to mimic the treated group. The resulting synthetic control group, which replicates the price of the treated stocks before the treatment, provides an adequate counterfactual. The parallel-trends assumption is forced to hold and is thus mechanically relaxed. The SDID estimator is also able to address the issue of staggered treatment adoption because it is repeated for every adoption date.[38] It also solves the heterogeneous treatment effect

[38]See the staggered-adoption appendix of Arkhangelsky et al. (2021) for a more detailed description.

Table 1: Probability of a firm being cross-listed in the US

	Baseline		With sectors	
	Probit	Logit	Probit	Logit
Log market capitalization	0.41***	0.75***	0.44***	0.84***
	(0.07)	(0.14)	(0.08)	(0.17)
Foreign sales ratio	1.21***	2.04***	1.27***	2.29***
	(0.38)	(0.70)	(0.47)	(0.88)
Dividend yield	0.08	0.19^{+}	0.11	0.27^{+}
	(0.07)	(0.12)	(0.09)	(0.16)
Constant	-4.60***	-8.42***	-4.37***	-8.60***
	(0.63)	(1.31)	(0.92)	(1.85)
Sectoral dummies	No	No	Yes	Yes
Pharmaceutical			(base level)	
Bank			1.38^{+}	2.45^{+}
Biotech and medical			1.25^{+}	2.35*
Industrial			0.63	1.26
Insurance and financials			0.61	1.08
Real estate			0.61	1.25
Retail			0.75	1.44
Services			0.64	1.06
Technology			0.82	1.44
Tourism			2.48**	4.68***

Notes: Probit and Logit regressions on $Pr(ADR_i = 1)$, namely the probability that a firm i is dually-listed in the US by the end of the sample period (in 2022). Significance levels: $+\ p < 0.20$, $*\ p < 0.10$, $**\ p < 0.05$, $***\ p < 0.01$. Standard errors in brackets.

issue shown in De Chaisemartin and d'Haultfoeuille (2020) through its weights. By addressing these issues and improving the comparability of the control group, SDID provides a more adequate approach to assess the effect of cross-listing than the alternative TWFE estimators mentioned previously. In particular, it should yield estimates that are interpretable causally.

An additional benefit of the SDID approach over other estimators such as De Chaisemartin and d'Haultfoeuille (2020) is that it relaxes the concern that firms might self-select into receiving the treatment at a specific time. Of course, the DID approach allows parallel but not equal trends, such that systematic differences between firms are not a concern, but a preemptive effect of the treatment would bias the coefficients since firms directly induce the treatment introduction. For instance, it would be possible that firms decide to introduce a cross-listing when their domestic stock returns are at their highest, the effect of which would be confounded by the treatment in a non-synthetic TWFE. This issue is similar to the setting of Bilicka (2019), which uses propensity score matching to compare similar international firms. The synthetic approach is similar to theirs in spirit: we place larger weights on firms whose asset returns are similar before the treatment, such that we avoid the possibility of comparing firms with temporarily exceptional profits to ordinary firms. Even if a bias were still present, we would most likely underestimate the effect of the introduction of ADR since it is unlikely that the post and pre-treatment effects (if they even exist) go in opposite directions, which would not be a threat to the validity of our lower-bound estimates.

The SDID of Arkhangelsky et al. (2021) is computed as follows. The unit weights of the synthetic control group $\hat{\omega}_{i,h}$ are computed such that the resulting control group is as parallel as possible to the treated group before the treatment. The time weights of the SNB announcement days $\hat{\lambda}_{t,h}$ are computed such that the pre- and post-treatment exposures are balanced, which reduces the impact of extreme shocks. Appendix B details the two minimization problems that compute these weights. Finally, a weighted TWFE estimates the treatment effect:

$$\{\hat{\mu}_h, \hat{\gamma}_h, \hat{\delta}_h, \hat{\beta}_h\}_{h \in H} = \underset{\mu,\beta,\gamma,\delta}{\arg\min} \sum_{i \in I} \sum_{t \in M} \left(\Delta p_{i,t+h} - \mu - \gamma_i - \delta_t - \text{treat}_{it}\beta\right) \hat{\omega}_{i,h} \hat{\lambda}_{t,h}, \tag{7}$$

where $\hat{\beta}_h$ is the ATET for stock returns h days after a given SNB announcement. As in the standard DID, the TWFE includes a constant μ_h, time and unit fixed effects $\gamma_{i,h}, \delta_{t,h}$ and a treatment dummy $\text{treat}_{it} \in \{0,1\}$. For the sake of comparison, we also report the standard DID estimates, which are computed via the same TWFE without the weights $\hat{\omega}_{i,h}, \hat{\lambda}_{t,h}$.

The standard errors of both the DID and SDID are computed using a clustered bootstrap. Arkhangelsky et al. (2021) propose three approaches for variance estimation in SDID: bootstrap, jackknife, and placebo. Although the placebo approach is the most computationally efficient, it is better designed for a small number of treated units. Because we have a large number of treated stocks and time periods, bootstrap and jackknife estimations are better suited. We choose bootstrapping since it is the most common and well-known estimator, is straightforward to implement in both the DID and SDID, and yields robust performance in the experiments of Arkhangelsky et al. (2021).

Assessing the causal effect of cross-listing via synthetic DID requires us to divide the sample into two groups to capture whether ADR introduction decreased or increased the average market returns of the treated stocks. Although our ATET estimates the effect of introducing the ADR on domestic stock returns, the currency denomination hypothesis predicts a positive stock return after a depreciation (that is, a positive exchange rate shock) and a negative return after an appreciation (a negative shock). The effect should therefore be symmetric. Since the two effects have opposite signs, running the DID or SDID on all exchange rate shocks would yield an ATET close to zero if the positive and negative exchange rate shocks were balanced. Similarly, using the absolute stock market returns would also mischaracterize the ATET since not all stock price responses may have the same sign. A straightforward solution is to instead run the estimation twice: first for the effect of ADR introduction on the stock returns that follow *positive* exchange rate shocks and second for the effect on stock returns that follow *negative* exchange rate shocks.[39]

[39] We use $\Delta USDCHF_{t+h} - \Delta NEER_{t+h}$ up to $H = 15$ days after the monetary policy announcements to determine whether the shock was positive or negative. By doing so, we only keep the Swiss franc part of the bilateral

6.2 The causal effect of cross-listing on stock prices

Our identification reveals that cross-listing has a sizeable causal effect on the sensitivity of domestic stock prices to exchange rate shocks. The corresponding estimates are reported in Table 2. The DID and SDID ATET estimate the effect of an ADR introduction on its respective stock returns (in percentage points). Our results are more easily interpreted when converting the coefficients into how cross-listing contributes to the sensitivity of domestic stock returns to exchange rate shocks. To do so, we divide the estimated contribution of cross-listing by the average stock return for the treated firms. The resulting cross-listing contribution is computed from the SDID ATET since it is robust to staggered and heterogenous treatments and relies on relatively weaker assumptions. Using the first row of Table 2 as an example, the average domestic stock return of 1.47% on announcement days with a positive exchange rate shock (that is, a depreciation), together with an ATET of 0.55, gives a cross-listing contribution of $\frac{0.55}{1.47} = 37\%$. Figure 10 plots the corresponding cross-listing contributions of Table 2 over the 10 days that follow SNB announcements.

Cross-listing meaningfully affects the response of stock prices to the exchange rate shocks. Table 2 and Figure 10 show that the SDID coefficients and corresponding contributions are significant. The contribution of cross-listing is overall symmetric for positive and negative exchange rate shocks. On SNB announcement days, more than one-third of the average stock return that followed a positive exchange rate shock is due to the presence of cross-listing. For returns that followed the negative shocks, we obtain a similar contribution of 36%. By increasing the stocks' degree of substitution across denominations, cross-listing causes much of the variation in stock prices in Swiss francs that is observed following exchange rate shocks. By a mirror effect of the law of one price, cross-listing reduces the effect of exchange rate shocks on the dollar price of Swiss companies.

The effect of cross-listing on domestic stock returns is not only sizeable but also lasting. The SDID estimates are significant regardless of the time horizon h considered. In the 10 days that follow SNB announcements, the effect of cross-listing on stock market returns ranges between 30% and 51% for returns that follow positive shocks (41% on average). Following negative shocks, the contribution is between 20% and 49% (31% on average). These results are thus rather symmetric for positive and negative shocks, with a 10-day overall average of 36% that matches the cross-listing contribution on impact.

The effect of cross-listing on domestic stock prices is also large when compared to the effect of other fundamental shocks. This can be seen in Figure 11, which shows the proportion of the SPI returns' standard deviation for the various time horizons (h) since SNB announcements for both cross-listing and the monetary policy and information shocks that are used as controls throughout the paper and were described in Section 3. In Figure 11, the contribution of those

exchange rate USD/CHF. We use the cumulative exchange rate shock up to 15 days after the monetary policy announcement to only keep the shocks that are clearly positive or negative. That is, the shocks that are positive or negative on impact and are not reverted in the following 15 days. This yields a subsample of 30 balanced and large shocks (16 positive and 14 negative).

Table 2: Effect of cross-listing on cumulated stock market returns

	Positive FX shocks				Negative FX shocks			
Days after MPA (h)	Average return	DID ATET	SDID ATET	Cross-listing contribution	Average return	DID ATET	SDID ATET	Cross-listing contribution
0	1.47	0.68**	0.55**	0.37	-2.01	-0.69**	-0.73***	0.36
		(0.30)	(0.24)			(0.31)	(0.26)	
1	2.97	1.25***	1.36***	0.46	-2.86	-1.34***	-1.40***	0.49
		(0.33)	(0.33)			(0.44)	(0.41)	
2	3.13	1.60***	1.05***	0.34	-2.75	-0.55	-0.77$^+$	0.28
		(0.40)	(0.39)			(0.44)	(0.60)	
3	2.63	1.11***	0.80**	0.3	-2.63	-0.73$^+$	-1.02*	0.39
		(0.36)	(0.39)			(0.46)	(0.56)	
4	2.47	0.98*	1.09**	0.44	-3.33	-0.99$^+$	-0.90$^+$	0.27
		(0.54)	(0.55)			(0.62)	(0.65)	
5	3.01	1.15*	1.54***	0.51	-3.75	-0.72$^+$	-1.04**	0.28
		(0.60)	(0.55)			(0.54)	(0.53)	
10	5.35	1.62*	1.94***	0.36	-3.70	-0.62	-0.91$^+$	0.25
		(0.86)	(0.74)			(0.73)	(0.65)	
15	6.62	1.26	1.85*	0.28	-2.36	-0.61	-1.62**	0.69
		(1.24)	(0.95)			(0.71)	(0.68)	
20	2.69	-2.69*	0.18	0.07	-1.01	-1.03$^+$	-0.33	0.33
		(1.45)	(1.13)			(0.67)	(0.69)	
30	6.01	-0.36	2.81*	0.47	0.23	0.86	0.93	3.97
		(1.68)	(1.48)			(0.93)	(1.19)	
40	8.20	0.44	3.51**	0.43	1.79	-2.32	-4.75	-2.65
		(1.69)	(1.60)			(1.96)	(3.77)	

Notes: Using specification 7. Average treatment effects on the treated (ATET) and average stock return on the treated. Cross-listing contributions are the ratio of the SDID ATET over the average return on the treated. Significance levels: $+\ p < 0.20$, $*\ p < 0.10$, $**\ p < 0.05$, $***\ p < 0.01$. Bootstrap standard errors (with 100 replications) in brackets.

shocks is obtained by dividing their respective local projection estimates[40] on the SPI returns' standard deviation at time horizon h since the SNB announcements.

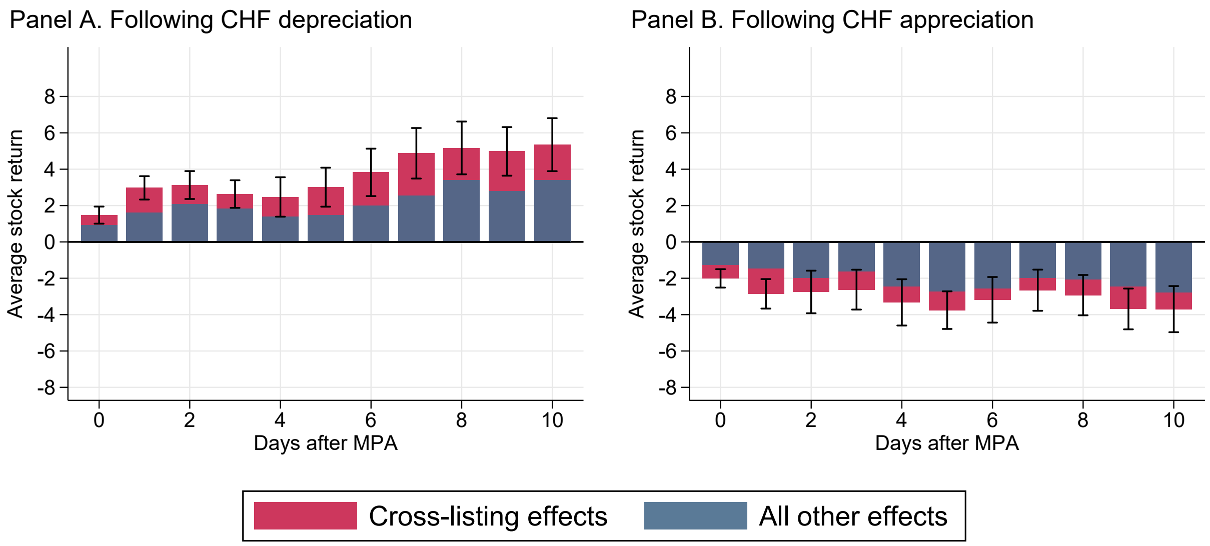
Cross-listing can explain more variations in domestic stock price movements on announcement days than the combined effect of monetary policy and information shocks. Figure 11 shows that in the 10 days that follow SNB announcements, approximately 14% of the average domestic stock returns can be attributed to monetary policy shocks, whereas just 6% is due to information shocks. [41] In comparison, approximately 39% of the average stock returns is due to cross-listing. While exchange rate movements are known to explain stock returns,[42] our causal evidence provides support for a *currency denomination* mechanism of sizeable magnitude that underlies the observed correlation.

[40]These are obtained via regressing $\Delta p_{t+h} = \alpha_h + \beta_{1,h}\Delta\text{NEER}_t + \beta_{2,h}\Delta\text{USDCHF}_t + \beta_{3,h}\text{MoPo}_t + \beta_{4,h}\text{Info}_t + \epsilon_{t+h}$.

[41]Instead using the monetary policy surprises of Bu et al. (2021) yields a similar magnitude (see Appendix Figure A25).

[42]For instance, Dunne et al., 2010 use 800 million stock trades in the US and France to find that more than half of the daily returns of the SP100 can be explained by exchange rate movements and aggregate flow orders.

Figure 10: Effect of cross-listing on cumulated stock market returns



Notes: Cumulative average domestic stock return for cross-listed firms conditional on direction of exchange rate movement following the SNB announcement. Whiskers indicate 95% confidence intervals of the cross-listing contribution computed in Table 2. All other effects is the difference between the average stock return and the cross-listing contribution.

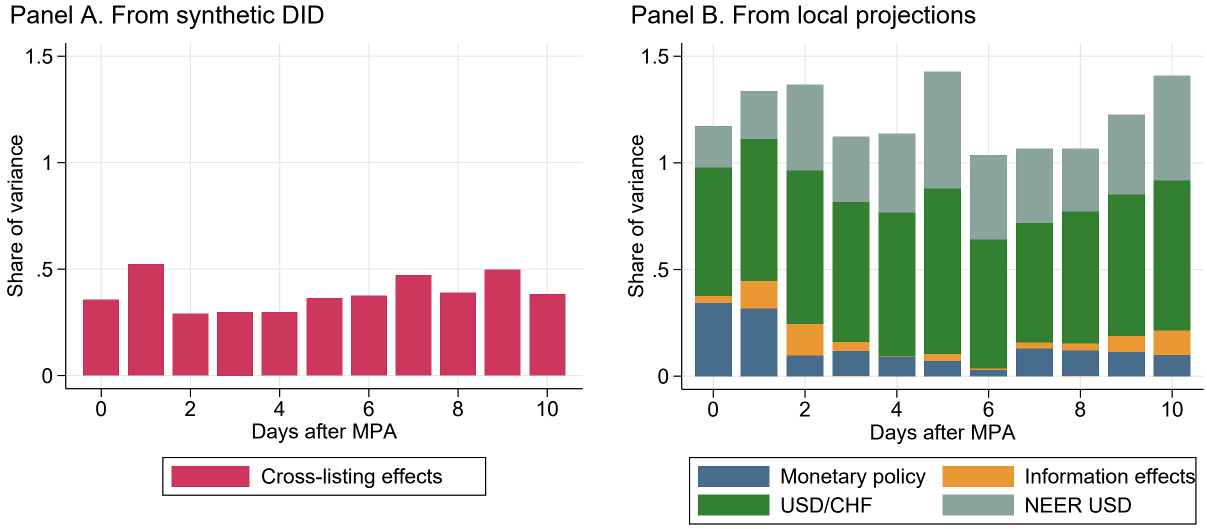
As a corollary, cross-listing sizably *amplifies* domestic stock responses to exchange rate shocks. The issuance of ADR comes with a high degree of substitution between the corresponding domestic and foreign stocks. As a result, a depreciation of the domestic currency led to a stronger rise in the domestic asset price and a smaller decline in the foreign asset price, so that the law of one price holds. Hau and Rey (2006) also find that a currency depreciation is associated with domestic stock returns that are relatively higher than the foreign returns.[43] In Hau and Rey (2004), portfolio rebalancing is found to be consistent with this relationship. While these results suggest that the exchange rate movements are related to stock market developments, we provide causal evidence via our exchange rate shocks for the Swiss franc. The announcement days that we use are associated with high exchange rate volatility, under which portfolio rebalancing tends to be more intense (Camanho et al., 2022 provide evidence at the fund level). Together with our use of staggered cross-listing introduction, we show that currency *denomination* can explain a sizeable part of the observed correlation (and thus a resulting portfolio rebalancing) on central-bank announcement days.

It is straightforward to extrapolate this sizeable amplification to the *overall* domestic stock market index. Although only 54 Swiss stocks out of 212 are cross-listed in the US, they make up the majority of the stock volume and thus almost single-handedly drive the Swiss stock indices. Consequently, the presence of cross-listing can explain approximately one-third of the Swiss stock index movements that follow exchange rate shocks.[44] This illustrates again that currency

[43] They document the relationship for 17 countries (versus the US) at the daily, monthly and quarterly frequencies.

[44] At the end of 2022, 96% of the core Swiss stock market index (SMI) stocks and 81% of the broader index (SPI) stocks were cross-listed in the US. The two indices are weighted by market capitalization and rely heavily on a few large companies (such as Nestlé, Roche or Novartis).Consequently, the treatment is applied to 96% of the SMI and

Figure 11: Variance decomposition of Swiss stock returns



Notes: The cross-listing effect is the average of the cross-listing contributions in the two subsamples computed in Table 2. Panel A relates the SDID coefficients to the standard error of stock returns $\Delta p_{i,t+h}$ with: $|\hat{\beta}_h^{SDID}|/\sigma_{\Delta p_{i,t+h}}$. Panel B relates the local projection results to the relative standard deviation of each independent variable with $\sigma_{x_{j,h}}$: $|\hat{\beta}_{j,h}|\sigma_{x_{j,h}}/\sigma_{\Delta p_{i,t+h}}$, in which $\hat{\beta}_{j,h}$ is the coefficient obtained from the specification described in footnote 40 for the shock x_j. We show the absolute values of the coefficients for visual reasons.

denomination plays an important role in stock price fluctuations that are due to the exchange rate.

In light of the meaningful role played by cross-listing, stock market movements on monetary policy announcement days should be interpreted with caution. The response of stock prices to monetary policy announcements are often mentioned in the press as changes in market expectations about future economic conditions. Similarly, they are used in the literature to identify the nature of central bank announcements in large economies (see, for instance, Jarociński and Karadi, 2020 for the US and the euro area). Our results reveal instead that stock price responses are largely driven by the currency denomination hypothesis and that the response is further amplified by the cross-listing of stocks. The price reactions thus do not necessarily reflect the beliefs of market participants about future domestic economic conditions.

7 Conclusion

We have shown that the reaction of Swiss stock prices to exchange rate shocks reflects a currency denomination effect. Our analysis reveals that stocks with foreign-denominated cash flows are more sensitive to the exchange rate. Similarly, the sensitivity of domestic stock prices is amplified by the introduction of cross-listing via the law of one price.

Swiss stocks are useful in understanding this transmission mechanism because Swiss eco-

81% of the SPI. Multiplying our ATET by these fractions, we find that at least 35% of SMI returns and 29% of SPI returns following exchange rate shocks can be explained by cross-listing effects. This result is a lower bound since there might be some spillover effects to untreated stocks, which we do not measure.

nomic activity is highly sensitive to exchange rates and because Switzerland is home to a number of companies with extensive operations abroad. This conjunction has allowed us to identify whether stocks react to the exchange rate because of changes in economic conditions or simply because of the currency in which they are listed and in which their cash flows are denominated.

In terms of external validity, our findings can be extrapolated to other economies. Since currency denomination drives the stock price responses, economies with domestically denominated assets that are substitutable with foreign assets should be affected similarly to what we documented. Accordingly, the currency denomination effect should be more marked in small-open economies. Moreover, the increasingly large prevalence of cross-listed firms around the world[45] further enhances the role played by the currency denomination channel that we have uncovered.

References

Acemoglu, D., Carvalho, V. M., Ozdaglar, A., and Tahbaz-Salehi, A. (2012). The network origins of aggregate fluctuations. *Econometrica*, 80(5):1977–2016.

Adler, M. and Dumas, B. (1983). International portfolio choice and corporation finance: A synthesis. *Journal of Finance*, 38(3):925–984.

Adler, M. and Dumas, B. (1984). Exposure to currency risk: definition and measurement. *Financial Management*, pages 41–50.

Aguiar, M. (2005). Investment, devaluation, and foreign currency exposure: The case of mexico. *Journal of Development Economics*, 78(1):95–113.

Ajayi, R. A. and Mougouė, M. (1996). On the dynamic relation between stock prices and exchange rates. *Journal of Financial Research*, 19(2):193–207.

Alexander, G. J., Eun, C. S., and Janakiramanan, S. (1987). Asset pricing and dual listing on foreign capital markets: A note. *Journal of Finance*, 42(1):151–158.

Arkhangelsky, D., Athey, S., Hirshberg, D. A., Imbens, G. W., and Wager, S. (2021). Synthetic difference-in-differences. *American Economic Review*, 111(12):4088–4118.

Athey, S. and Imbens, G. W. (2022). Design-based analysis in difference-in-differences settings with staggered adoption. *Journal of Econometrics*, 226(1):62–79.

Auer, R., Burstein, A., and Lein, S. M. (2021). Exchange rates and prices: evidence from the 2015 Swiss franc appreciation. *American Economic Review*, 111(2):652–686.

Backus, D. K., Kehoe, P. J., and Kydland, F. E. (1992). International real business cycles. *Journal of Political Economy*, 100(4):745–775.

Bahmani-Oskooee, M. and Saha, S. (2015). On the relation between stock prices and exchange rates: a review article. *Journal of Economic Studies*, 42(4):707–732.

Baker, A. C., Larcker, D. F., and Wang, C. C. (2022). How much should we trust staggered difference-in-differences estimates? *Journal of Financial Economics*, 144(2):370–395.

Bartram, S. M., Brown, G. W., and Minton, B. A. (2010). Resolving the exposure puzzle: The many facets of exchange rate exposure. *Journal of Financial Economics*, 95(2):148–173.

Bilicka, K. A. (2019). Comparing UK tax returns of foreign multinationals to matched domestic firms. *American Economic Review*, 109(8):2921–2953.

Black, F. and Scholes, M. (1974). The effects of dividend yield and dividend policy on common stock prices and returns. *Journal of Financial Economics*, 1(1):1–22.

Bodnar, G. M. and Gentry, W. M. (1993). Exchange rate exposure and industry characteristics: evidence from canada, japan, and the usa. *Journal of international Money and Finance*, 12(1):29–45.

Brunnermeier, M., Farhi, E., Koijen, R. S. J., Krishnamurthy, A., Ludvigson, S. C., Lustig, H., Nagel, S., and Piazzesi, M. (2021). Review article: Perspectives on the future of asset pricing. *Review of Financial Studies*, 34(4):2126–2160.

Bu, C., Rogers, J., and Wu, W. (2021). A unified measure of Fed monetary policy shocks. *Journal of Monetary Economics*, 118:331–349.

Callaway, B. and Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics*, 225(2):200–230.

Camanho, N., Hau, H., and Rey, H. (2022). Global rebalancing and the exchange rate. *Review of Financial Studies*, 35(11):5228–5274.

Ciminelli, G., Rogers, J., and Wu, W. (2022). The effects of US monetary policy on international mutual fund investment. *Journal of International Money and Finance*, 127:102676.

De Chaisemartin, C. and d'Haultfoeuille, X. (2020). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review*, 110(9):2964–2996.

De Jong, A., Rosental, L., and Van Dijk, M. A. (2009). The risk and return of arbitrage in dual-listed companies. *Review of Finance*, 13(3):495–520.

Doidge, C., Karolyi, G., and Stulz, R. M. (2004). Why are foreign firms listed in the U.S. worth more? *Journal of Financial Economics*, 71(2):205–238.

Dominguez, K. M. and Tesar, L. L. (2006). Exchange rate exposure. *Journal of international Economics*, 68(1):188–218.

Dornbusch, R. and Fischer, S. (1980). Exchange rates and the current account. *American Economic Review*, 70(5):960–971.

Dumas, B. and Solnik, B. (1995). The world price of foreign exchange risk. *Journal of Finance*, 50(2):445–479.

Dunne, P., Hau, H., and Moore, M. (2010). International order flows: Explaining equity and exchange rate returns. *Journal of International Money and Finance*, 29(2):358–386.

Efing, M., Fahlenbrach, R., Herpfer, C., and Krüger, P. (2022). How do investors and firms react to a large, unexpected currency appreciation shock? *Review of Corporate Finance Studies*, forthcoming.

Engel, C. and West, K. D. (2005). Exchange rates and fundamentals. *Journal of Political Economy*, 113(3):485–517.

Eugster, J. and Donato, G. (2022). The exchange rate elasticity of the Swiss current account. *SNB Working Paper*, 14/2022.

Freitag, A. and Lein, S. M. (2023). Endogenous product adjustment and exchange rate pass-through. *Journal of International Economics*, 140:103706.

Fresard, L. and Foucault, T. (2012). Cross-listing, investment sensitivity to stock price and the learning hypothesis. *Review of Financial Studies*, 25:3305–3350.

Fung, J. K., Girardin, E., and Hua, J. (2022). How does the exchange-rate regime affect dual-listed share price parity? evidence from china's a- and h-share markets. *Journal of International Money and Finance*, 129:102738.

Gagnon, L. and Karolyi, G. A. (2010a). Do international cross-listings still matter? In Beck, T., Schmukler, S., and Claessens, S., editors, *Evidence on Financial Globalization and Crises*. Elsevier North-Holland Publishers.

Gagnon, L. and Karolyi, G. A. (2010b). Multi-market trading and arbitrage. *Journal of Financial Economics*, 97:53–80.

Gali, J. and Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *Review of Economic Studies*, 72(3):707–734.

Gavin, M. (1989). The stock market and exchange rate dynamics. *Journal of International Money and Finance*, 8(2):181–200.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2):254–277.

Griffin, J. and Stulz, R. (2001). International competition and exchange rate shocks: A cross-country industry analysis of stock returns. *Review of Financial Studies*, 14(1):215–241.

Grossmann, A., Ozuna, T., and Simpson, M. W. (2007). ADR mispricing: Do costly arbitrage and consumer sentiment explain the price deviation? *Journal of International Financial Markets, Institutions and Money*, 17(4):361–371.

Hau, H., Massa, M., and Peress, J. (2010). Do demand curves for currencies slope down? Evidence from the MSCI global index change. *Review of Financial Studies*, 23(4):1681–1717.

Hau, H. and Rey, H. (2004). Can portfolio rebalancing explain the dynamics of equity returns, equity flows, and exchange rates? *American Economic Review*, 94(2):126–133.

Hau, H. and Rey, H. (2006). Exchange rates, equity prices, and capital flows. *Review of Financial Studies*, 19(1):273–317.

Hodder, J. E. (1982). Exposure to exchange-rate movements. *Journal of International Economics*, 13(3-4):375–386.

Jarociński, M. and Karadi, P. (2020). Deconstructing monetary policy surprise: the role of information shocks. *American Economic Journal: Macroeconomics*, 12:1–43.

Jermann, U. J. (2017). Financial markets' views about the euro–Swiss franc floor. *Journal of Money, Credit and Banking*, 49(2-3):553–565.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review*, 95(1):161–182.

Karolyi, G. A. and Stulz, R. M. (2003). Are financial assets priced locally or globally? *Handbook of the Economics of Finance*, 1:975–1020.

Koeniger, W., Lennartz, B., and Ramelet, M.-A. (2022). On the transmission of monetary policy to the housing market. *European Economic Review*, 145:104107.

Lamont, O. A. and Thaler, R. H. (2002). Anomalies: The law of one price in financial markets. *Journal of Economic Perspectives*, 17(4):191–202.

Lane, P. R. and Shambaugh, J. C. (2010). Financial exchange rates and international currency exposures. *American Economic Review*, 100(1):518–40.

Ma, C. K. and Kao, G. W. (1990). On exchange rate changes and stock price reactions. *Journal of Business Finance & Accounting*, 17(3):441–449.

Miranda-Agrippino, S. and Ricco, G. (2021). The transmission of monetary policy shocks. *American Economic Journal: Macroeconomics*, 13(3):74–107.

Obstfeld, M. and Rogoff, K. (1995). Exchange rate dynamics redux. *Journal of Political Economy*, 103(3):624–660.

Oktay, A. (2022). Heterogeneity in the exchange rate pass-through to consumer prices: the Swiss franc appreciation of 2015. *Swiss Journal of Economics and Statistics*, 158(1):1–20.

Pavlova, A. and Rigobon, R. (2007). Asset prices and exchange rates. *Review of Financial Studies*, 20(4):1139–1180.

Phylaktis, K. and Ravazzolo, F. (2005). Stock prices and exchange rate dynamics. *Journal of International Money and Finance*, 24(7):1031–1053.

Ramey, V. A. (2016). Macroeconomic shocks and their propagation. *Handbook of macroeconomics*, 2:71–162.

Ranaldo, A. and Rossi, E. (2010). The reaction of asset markets to Swiss National Bank communication. *Journal of International Money and Finance*, 29(3):486–503.

Rosenthal, L. and Young, C. (1990). The seemingly anomalous price behavior of Royal Dutch/Shell and Unilever N.V./PLC. *Journal of Financial Economics*, 26(1):123–141.

Shleifer, A. and Vishny, R. W. (1997). The limits of arbitrage. *Journal of Finance*, 52(1):35–55.

Solnik, B. H. (1974). The international pricing of risk: An empirical investigation of the world capital market structure. *Journal of Finance*, 29(2):365–378.

Stulz, R. (1981). A model of international asset pricing. *Journal of Financial Economics*, 9(4):383–406.

Stulz, R. M. (1987). An equilibrium model of exchange rate determination and asset pricing with nontraded goods and imperfect information. *Journal of Political Economy*, 95(5):1024–1040.

Stulz, R. M. (1995). The cost of capital in internationally integrated markets: The case of Nestlé. *European Financial Management*, 1(1):11–22.

Sun, L. and Abraham, S. (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics*, 225(2):175–199.

Appendix

A Identification of information effects shocks

The identification of monetary policy shocks for Switzerland is described in Koeniger et al. (2022). However, a formal identification of information effects shocks for Switzerland has not yet been published and deserves a more thorough description.

The identification follows the identification through heteroskedasticity approach of Bu et al. (2021) and Ciminelli et al. (2022). That is, movements in the shape of the sovereign yield curve are used to estimate a joint set of monetary and information shocks. The general idea is that interest rate movements can be decomposed into a monetary and non-monetary component. Because the variance of the monetary component is higher on MPA days than on days during which no monetary policy decision is announced, one can exploit identification through heteroskedasticity to recover the monetary policy shocks. Unexplained interest rate movements are then interpreted as information effects.

The identification procedure is in three steps. First, an instrumental variable approach regresses the entire yield curve (from one to thirty years) on a reference maturity (two years) on pairs of monetary/non-monetary interest rate returns. The instrument has a negative sign restriction. Second, the coefficients of the first step are regressed on the entire yield curve on MPA days only, which yields a series of monetary policy shocks. These two steps correspond to the Fama-MacBeth two-step regression and are a common way to estimate unobserved price factors. Last, monetary policy shocks are regressed on the reference yield, the residuals being the information effects or unexplained interest rate shocks.[46]

Formally, the three steps are as follows. Using maturities $i = \{1, 2, ..., 30\}$, T monetary announcement days t, T non-monetary day $t-5$, and the daily changes in interest rates $\Delta r_{i,t}$, we denote the matrices:

$$R := \begin{bmatrix} \Delta r_{1,t} & \cdots & \Delta r_{30,t} \\ \Delta r_{1,t-5} & \cdots & \Delta r_{30,t-5} \end{bmatrix}, \quad X := \begin{bmatrix} \Delta r_{2,t} \\ \Delta r_{2,t-5} \end{bmatrix}, \quad Z := \begin{bmatrix} \Delta r_{2,t} \\ -\Delta r_{2,t-5} \end{bmatrix}$$

The first step is an instrumental variable regression using Z as an instrument. The relevance and exogeneity criteria are fulfilled based on the assumption that the variance of monetary policy shocks increase in t but not the non-monetary variance. With a 2SLS notation:

$$X = \alpha + Z\beta + \epsilon$$
$$R = \theta + \hat{X}\gamma + \eta$$

which yields a series of 30 estimated coefficients in vector $\hat{\gamma}$. The second step regresses $\hat{\gamma}$ on

[46] See online appendix B of Bu et al. (2021) for a more detailed description of this approach.

MPA interest rate differentials:

$$\begin{bmatrix} \Delta r_{1,t} & \cdots & \Delta r_{30,t} \end{bmatrix}' = \delta + \hat{\gamma}\phi + \xi$$

which yields a series of T estimated coefficients in vector $\hat{\phi}$. These coefficients denote the monetary policy shocks. The last step is to regress the shocks on the original reference yield:

$$\Delta r_{2,t} = \mu + \hat{\phi}\sigma + \omega$$

where the residuals $\hat{\omega}$ estimate the T information effects shocks.

B Computation of synthetic DID weights

Following Arkhangelsky et al. (2021), the synthetic control group weights $\hat{\omega}_{i,h}$ for each unit i are computed with the following minimization problem:

$$\{\hat{\alpha}_h, \hat{\omega}_{i,h}\}_{i\in I, h\in H} = \underset{\alpha_h\in\mathbb{R}, \omega\in\Omega}{\arg\min} \sum_{t\in M} \left(\alpha_h + \sum_{\text{untreated}} \omega_{i,h}\Delta p_{i,t+h} - \frac{1}{N_{\text{treated}}} \sum_{\text{treated}} \Delta p_{i,t+h} \right)^2 + \psi$$

where the synthetic control group is the average of all stock returns $\Delta p_{i,t+h}$ weighted by $\hat{\omega}_{i,h}$. The inclusion of a constant α_h in the problem allows for the control group to be parallel to the treated group instead of perfectly matching it. We compute these weights for cumulated stock returns up to 60 days since the SNB announcement days $t \in M$, that is $\forall h \in H = \{0, 1, ..., 60\}$. The regularization constant ψ increases the dispersion of the weights and ensures their uniqueness.[47] We divide the set of stocks $i \in I = \{1, 2, ..., 212\}$ into two mutually exclusive treated and untreated groups with size $\{N_{\text{treated}}, N_{\text{untreated}}\}$. The set of constraints Ω is such that the weights ω are positive $(\omega_{i,h} \in \mathbb{R}_+)$, sum to one $\left(\sum_{\text{untreated}} \omega_{i,h} = 1\right)$ and are constant for all treated units $\left(\omega_{i,h} = \frac{1}{N_{\text{treated}}} \text{ if } i \in \text{treated}\right)$ across all horizons h.

A similar minimization problem then computes the time weights $\hat{\lambda}_{t,h}$ for all announcement days t:

$$\{\hat{\gamma}_h, \hat{\lambda}_{t,h}\}_{t\in M, h\in H} = \underset{\gamma_h\in\mathbb{R}, \lambda\in\Lambda}{\arg\min} \sum_{i\in I} \left(\gamma_h + \sum_{\text{pre}} \lambda_{t,h}\Delta p_{i,t+h} - \frac{1}{T_{\text{post}}} \sum_{\text{post}} \Delta p_{i,t+h} \right)^2$$

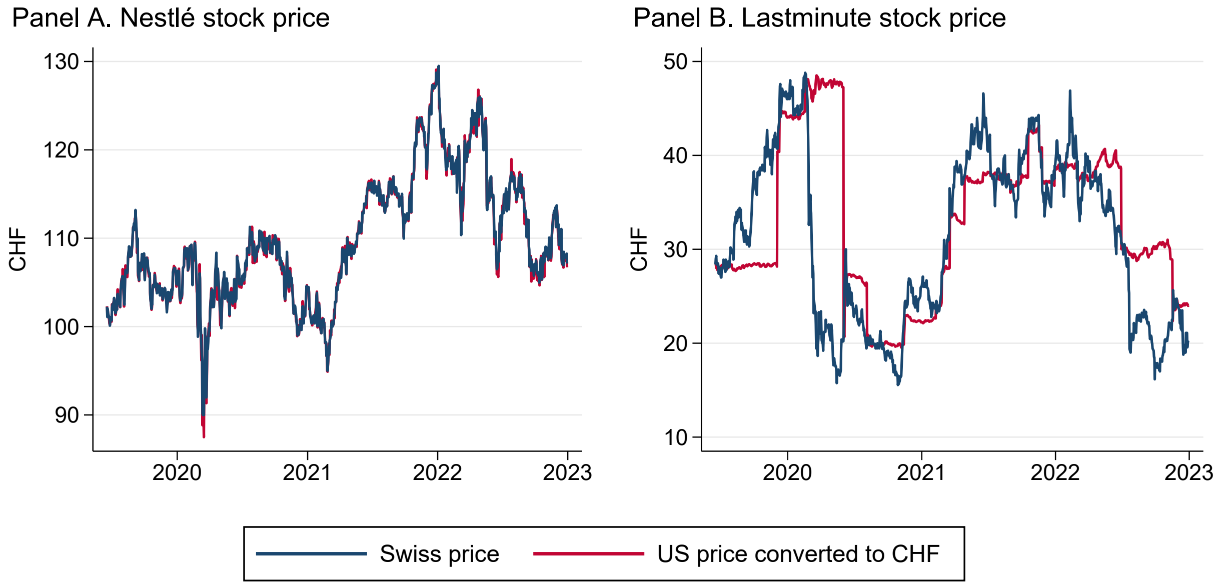
where the set of constraints Λ is such that the weights λ are positive $(\lambda_{t,h} \in \mathbb{R}_+)$, sum to one $\left(\sum_{\text{pre}} \lambda_{t,h} = 1\right)$ and are constant for all post-treatment periods $\left(\lambda_{t,h} = \frac{1}{T_{\text{post}}} \text{ if } t \in \text{post}\right)$ across all horizons h. These weights are such that the pre- and post-treatment exposures are balanced. The average pre-treatment stock return is thus equal to the average post-treatment stock return up to a constant. This weighting improves the precision of the SDID estimator by balancing extreme shocks, which is needed to counteract the two large shocks due to the introduction and

[47] Following Arkhangelsky et al. (2021), $\psi := \left(\left(N_{\text{treated}} T_{\text{post}} \right)^{1/4} \sqrt{\hat{\sigma}^2} \right)^2 T_{\text{pre}} \|\omega\|_2^2$, where announcement days are separated into pre- and post-treatment groups of size $T_{\text{pre}}, T_{\text{post}}$, and $\hat{\sigma}^2$ is the estimated variance of the pre-treatment $\Delta p_{i,t+h}$.

discontinuity of the minimum exchange rate (namely, in September 2011 and January 2015).

C Additional tables and figures

Figure A1: Two cross-listed Swiss stock prices



Notes: The sample start corresponds to the introduction of the Lastminute ADR in 2019. Source: Refinitiv Datastream

Table A1: Purging exchange rate shocks on monetary policy announcement days

	(1)	(2)	(3)
USD NEER	1.37***	1.37***	1.19***
	(0.24)	(0.24)	(0.24)
Monetary policy shock		0.00	-0.01
		(0.01)	(0.01)
Information effects shock			0.08***
			(0.03)
Constant	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
Observations	106	106	106
Adjusted R^2	0.23	0.23	0.27

Notes: Using specification 2. Purging daily USDCHF movements on SNB monetary policy announcement days from movements in the US dollar nominal effective exchange rate (NEER), Swiss monetary policy shocks from Koeniger et al. (2022), and Swiss information effects following the Bu et al. (2021) and Ciminelli et al. (2022) methodology. Significance levels: $*\ p < 0.10$, $**\ p < 0.05$, $***\ p < 0.01$. Standard errors in brackets.

Table A2: Regression outputs of Swiss asset class prices to exchange rate shocks

	Days after MPA					
	0	1	5	10	30	60
Sovereign bonds						
Exchange rate shock	-0.37	-3.73	-8.87*	-5.06	-5.23	-6.30
	(2.68)	(3.18)	(4.93)	(6.40)	(11.96)	(15.84)
USDCHF	Omitted	-0.17***	-0.12***	0.00	-0.14***	-0.06
		(0.05)	(0.04)	(0.06)	(0.05)	(0.07)
NEER USD	Omitted	0.23**	0.14*	-0.00	0.17**	0.08
		(0.10)	(0.08)	(0.09)	(0.09)	(0.10)
Constant	0.00	0.04	0.07	0.10	0.22	0.22
	(0.04)	(0.04)	(0.07)	(0.09)	(0.17)	(0.22)
Corporate bonds						
Exchange rate shock	-0.32	0.54	-2.69	-0.29	2.45	2.84
	(1.41)	(1.58)	(2.40)	(3.20)	(5.91)	(9.60)
USDCHF	Omitted	-0.03	-0.06***	-0.06**	-0.07***	-0.03
		(0.03)	(0.02)	(0.03)	(0.02)	(0.04)
NEER USD	Omitted	0.00	0.07*	0.03	-0.03	-0.10*
		(0.05)	(0.04)	(0.04)	(0.04)	(0.06)
Constant	-0.00	0.00	-0.00	-0.03	0.07	0.03
	(0.02)	(0.02)	(0.03)	(0.04)	(0.08)	(0.13)
Stocks						
Exchange rate shock	34.61***	56.58***	42.48***	56.19***	44.07***	29.20**
	(1.48)	(2.12)	(3.44)	(4.42)	(6.97)	(12.71)
USDCHF	Omitted	0.75***	1.09***	0.61***	0.47***	0.61***
		(0.03)	(0.03)	(0.04)	(0.03)	(0.05)
NEER USD	Omitted	-1.49***	-1.97***	-1.48***	-1.29***	-1.54***
		(0.07)	(0.05)	(0.06)	(0.05)	(0.08)
Constant	-0.16***	-0.12***	-0.27***	-0.02	0.87***	1.50***
	(0.02)	(0.03)	(0.05)	(0.06)	(0.10)	(0.18)
Gold						
Exchange rate shock	100.82***	78.85***	73.28***	83.02***	48.68	70.47
	(9.06)	(13.34)	(21.66)	(27.61)	(41.68)	(54.41)
USDCHF	Omitted	1.11***	0.92***	1.46***	0.88***	0.89***
		(0.19)	(0.18)	(0.19)	(0.15)	(0.21)
NEER USD	Omitted	-1.22***	-1.31***	-1.88***	-1.27***	-0.93***
		(0.38)	(0.31)	(0.31)	(0.27)	(0.32)
Constant	0.02	0.27	0.14	0.26	1.03*	2.55***
	(0.13)	(0.18)	(0.30)	(0.38)	(0.58)	(0.75)

Notes: Using specification 3. Local projections of purged Swiss franc shocks on Swiss asset prices. The controls on impact are omitted since they are already included in the purge of the exchange rate shocks. Significance levels: $* \ p < 0.10$, $** \ p < 0.05$, $*** \ p < 0.01$. Standard errors in brackets.

Table A3: Heterogenous sensitivity of Swiss stocks to exchange rate shocks

	By share of foreign sales		By cross-listing in the US		By market capitalization	
	FE	Interaction	FE	Interaction	FE	Interaction
Group 1	Omitted	0.12***	Omitted	0.25***	Omitted	0.15***
		(0.04)		(0.02)		(0.04)
Group 2	0.02	0.34***	-0.12***	0.62***	-0.06	0.26***
	(0.07)	(0.04)	(0.05)	(0.03)	(0.1)	(0.05)
Group 3	-0.05	0.46***			-0.10	0.23***
	(0.07)	(0.03)			(0.09)	(0.05)
Group 4	-0.09	0.47***			-0.14	0.22***
	(0.07)	(0.03)			(0.09)	(0.05)
Group 5	-0.12	0.56***			-0.10	0.41***
	(0.07)	(0.04)			(0.09)	(0.05)
Group 6					-0.10	0.30***
					(0.09)	(0.04)
Group 7					-0.19**	0.31***
					(0.09)	(0.05)
Group 8					-0.18**	0.38***
					(0.09)	(0.04)
Group 9					-0.16*	0.52***
					(0.09)	(0.05)
Group 10					-0.16*	0.64***
					(0.09)	(0.04)
Constant	-0.14***		-0.13***		-0.04	
	(0.05)		(0.02)		(0.06)	

Notes: Using specification 5. The firms are grouped based on their share of foreign sales / total sales, by whether they are cross-listed in the US, and by market capitalization, all in December 2022 (end of sample). See figures 6 and 7 for the composition of the groups. The table shows the fixed effects (FE) and interaction of group with exchange rate shocks (Interaction) coefficients. The first fixed effect groups are omitted due to colinearity. Significance levels: $* \ p < 0.10$, $** \ p < 0.05$, $*** \ p < 0.01$. Standard errors in brackets.

Table A4: Regression outputs of cross-listed Swiss asset class prices to exchange rate shocks

	Days after MPA					
	0	1	5	10	30	60
Stock CH - Stock US						
Exchange rate shock	104.59***	96.75***	87.63***	105.25***	96.04***	86.21***
	(3.88)	(5.21)	(6.79)	(9.45)	(10.59)	(12.69)
USDCHF	Omitted	1.15***	1.16***	1.04***	0.87***	0.99***
		(0.08)	(0.07)	(0.09)	(0.04)	(0.06)
NEER USD	Omitted	-1.47***	-0.97***	-0.30**	-0.20**	-0.34***
		(0.17)	(0.11)	(0.15)	(0.08)	(0.08)
Constant	-0.05	0.04	0.07	-0.05	0.33**	0.38**
	(0.06)	(0.07)	(0.10)	(0.14)	(0.16)	(0.19)
Gold CH - Gold US						
Exchange rate shock	91.87***	68.36***	88.30***	91.81***	83.29***	82.15***
	(12.46)	(13.09)	(15.71)	(12.53)	(10.93)	(11.83)
USDCHF	Omitted	1.52***	1.18***	1.24***	1.02***	1.02***
		(0.20)	(0.14)	(0.11)	(0.05)	(0.05)
NEER USD	Omitted	-1.18***	0.03	-0.31*	-0.32***	-0.09
		(0.41)	(0.25)	(0.17)	(0.08)	(0.07)
Constant	-0.17	0.04	-0.21	-0.12	-0.29*	-0.17
	(0.17)	(0.17)	(0.22)	(0.17)	(0.15)	(0.16)

Notes: Using specification 3. Local projections of purged Swiss franc shocks on the difference between Swiss asset prices and their US counterpart (the firm's American Depositary Reiceipt and the New York quotation of Gold). The controls on impact are omitted since they are already included in the purge of the exchange rate shocks. Significance levels: $* \ p < 0.10$, $** \ p < 0.05$, $*** \ p < 0.01$. Standard errors in brackets.

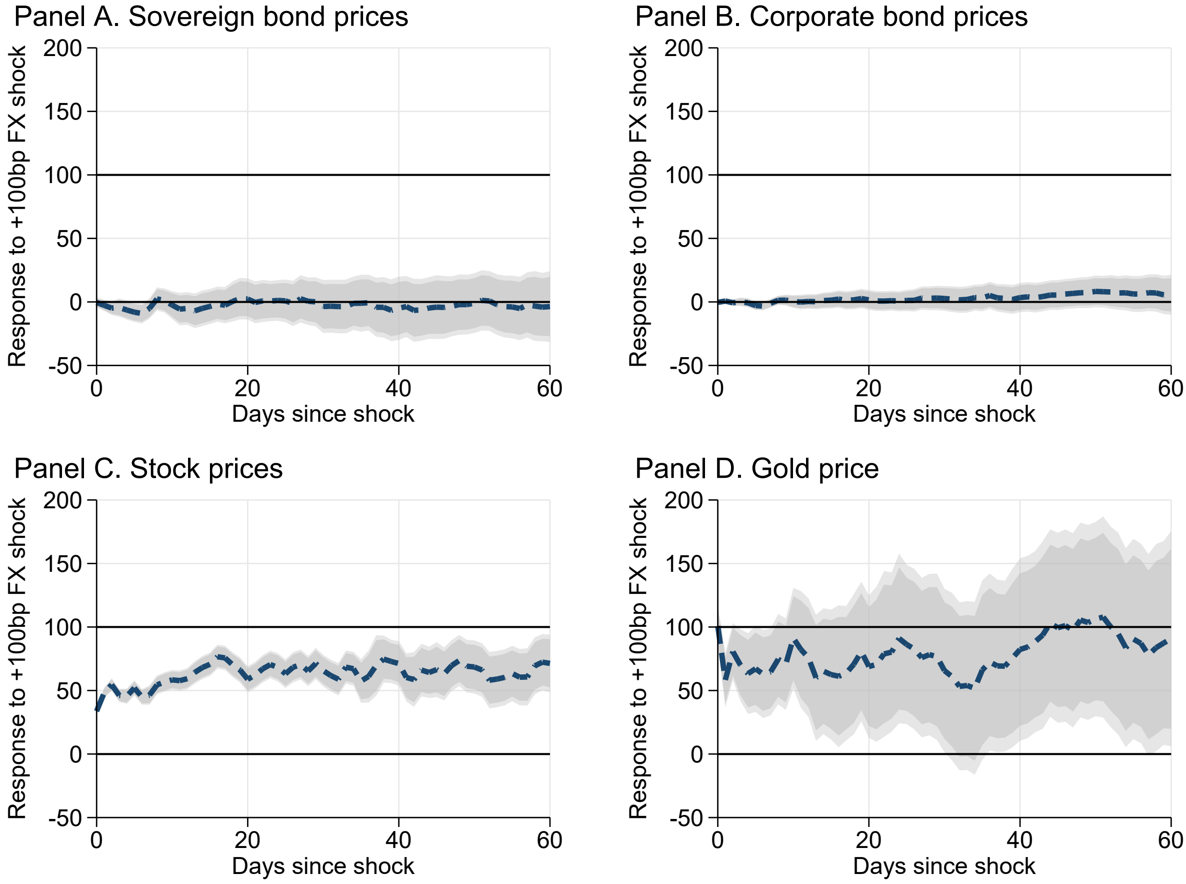
Table A5: Excess returns of Swiss stocks listed in the US

	Banks	Health	Industrial	Insurance	Pharma	Real estate	Retail	Services	Tech	Tourism	All sectors
Exchange rate shock	-0.45***	-0.69***	-0.30***	-0.33***	-0.29***	-0.36**	-0.42***	-0.60***	-0.81***	-0.35	-0.46***
	(0.09)	(0.09)	(0.1)	(0.09)	(0.1)	(0.14)	(0.06)	(0.08)	(0.25)	(0.29)	(0.03)
Constant	0.02	-0.56***	-0.29**	-0.03	-0.16	-0.15	-0.25**	-0.03	-0.51*	0.14	-0.23***
	(0.13)	(0.15)	(0.13)	(0.14)	(0.15)	(0.22)	(0.10)	(0.13)	(0.31)	(0.38)	(0.05)
Observations	325	280	411	352	284	142	517	183	163	66	2723

Notes: Using specification 6. Regressing excess returns of Swiss firms cross-listed in the US with respective to the relevant sectoral S%P500 index. The energy sector is omitted since none of these firms are cross-listed in the US. Significance levels: $* \ p < 0.10$, $** \ p < 0.05$, $*** \ p < 0.01$. Standard errors in brackets.

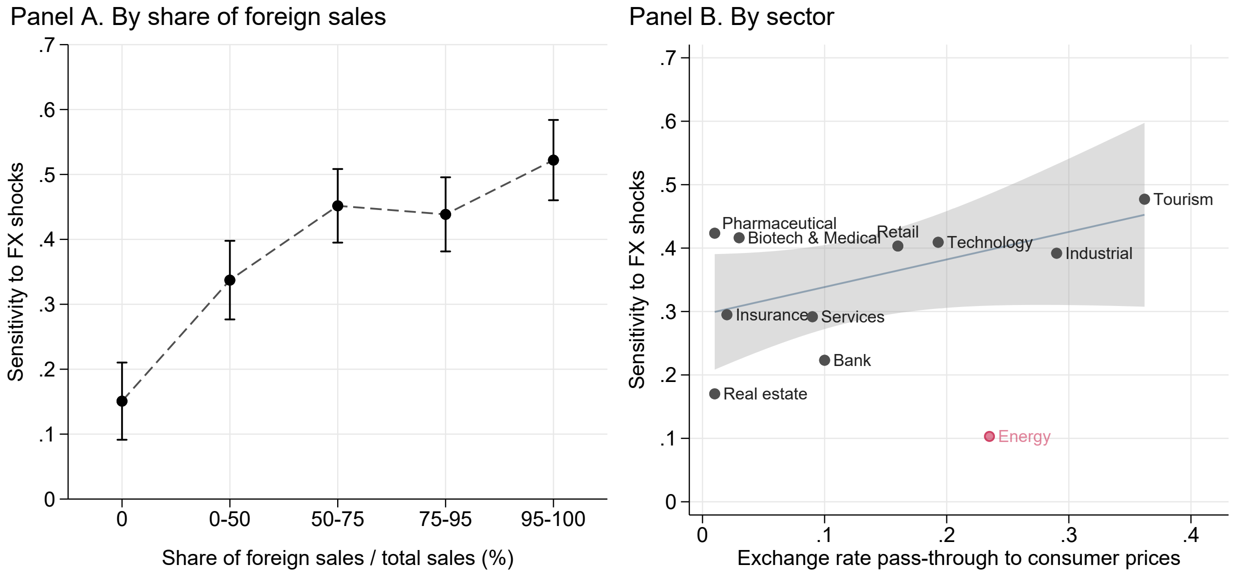
D Robustness: Using the observed instead of the purged shocks

Figure A2: Response of domestic asset prices to a 100 bp Swiss franc depreciation.



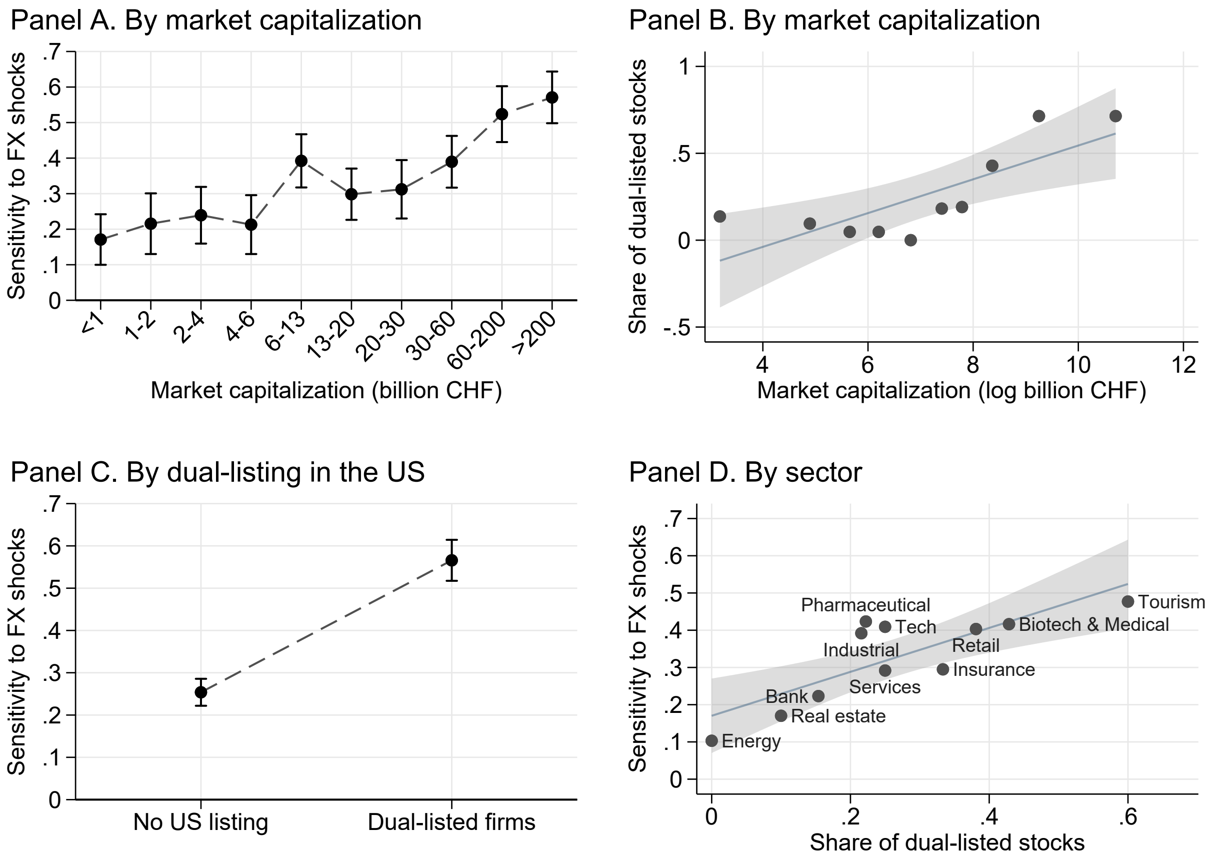
Notes: See the note of Figure 3. Using the observed shock series instead of the purged series. The controls used to purge the shocks are instead used as controls in the specification.

Figure A3: Heterogeneity in the cash flow denomination



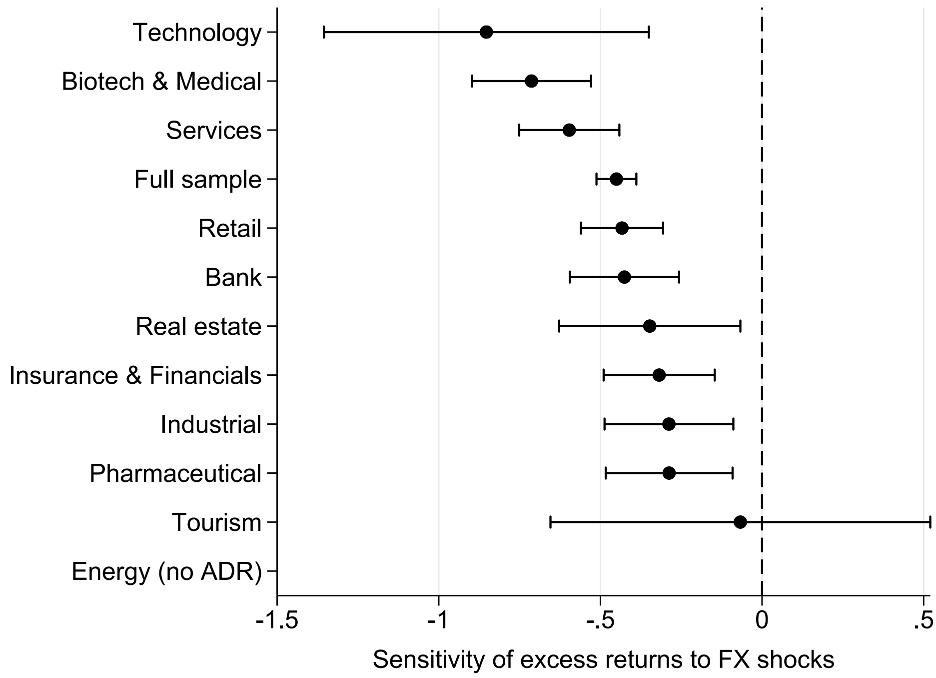
Notes: See the note of Figure 6. Using the observed shock series instead of the purged series. The controls used to purge the shocks are instead used as controls in the specification.

Figure A4: Heterogeneity of international substitution



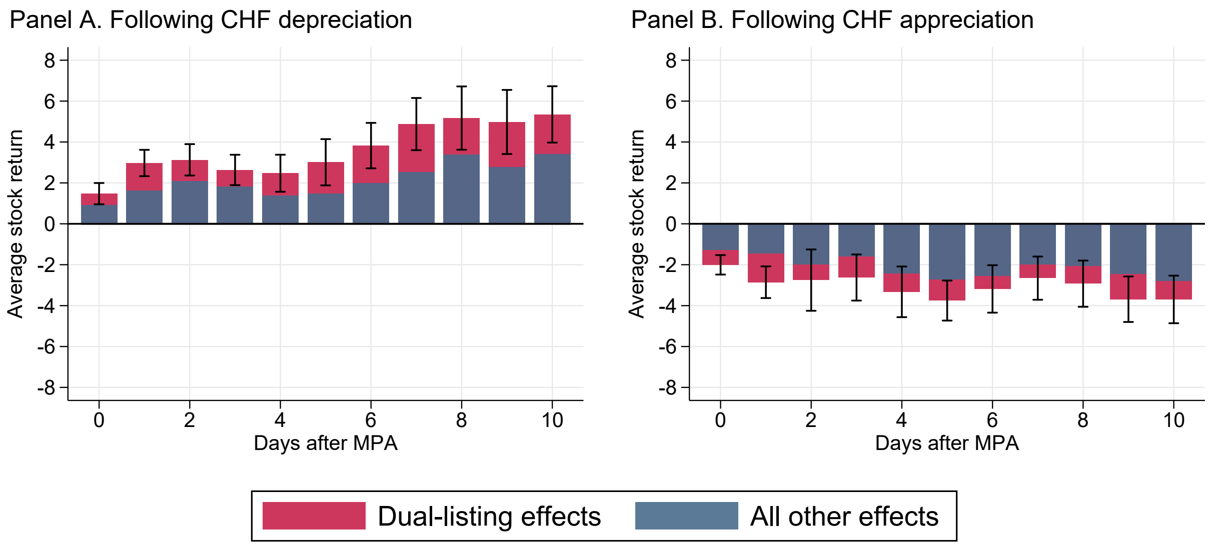
Notes: See the note of Figure 7. Using the observed shock series instead of the purged series. The controls used to purge the shocks are instead used as controls in the specification.

Figure A5: Excess returns of ADR listed in the US



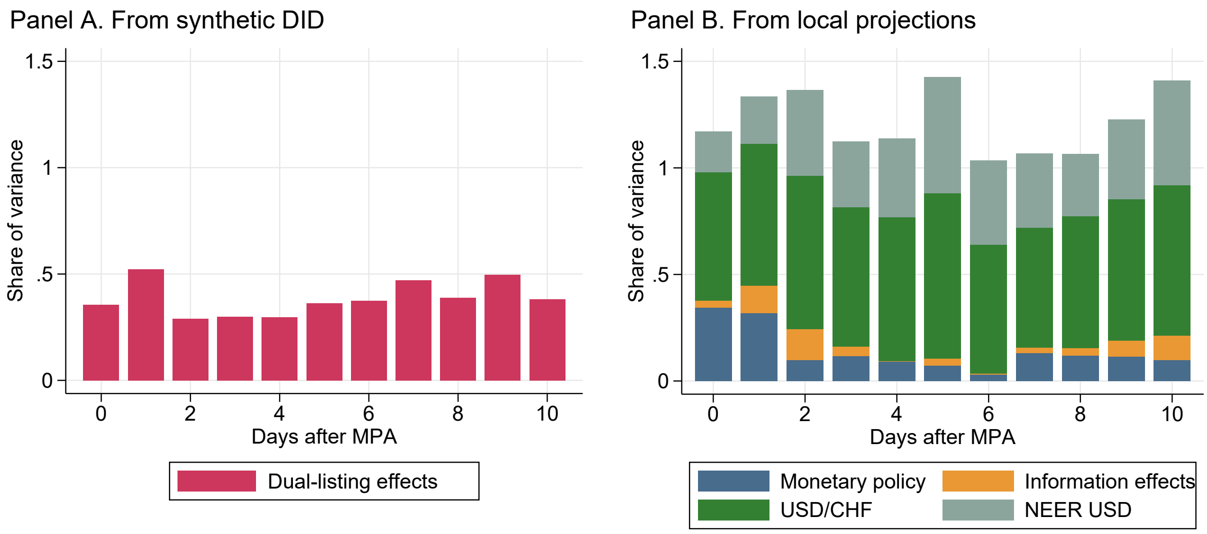
Notes: See the note of Figure 8. Using the observed shock series instead of the purged series. The controls used to purge the shocks are instead used as controls in the specification.

Figure A6: Effect of cross-listing on cumulated stock market returns



Notes: See the note of Figure 10. Using the observed shock series instead of the purged series. The controls used to purge the shocks are instead used as controls in the specification. Standard errors with 50 bootstrap replications.

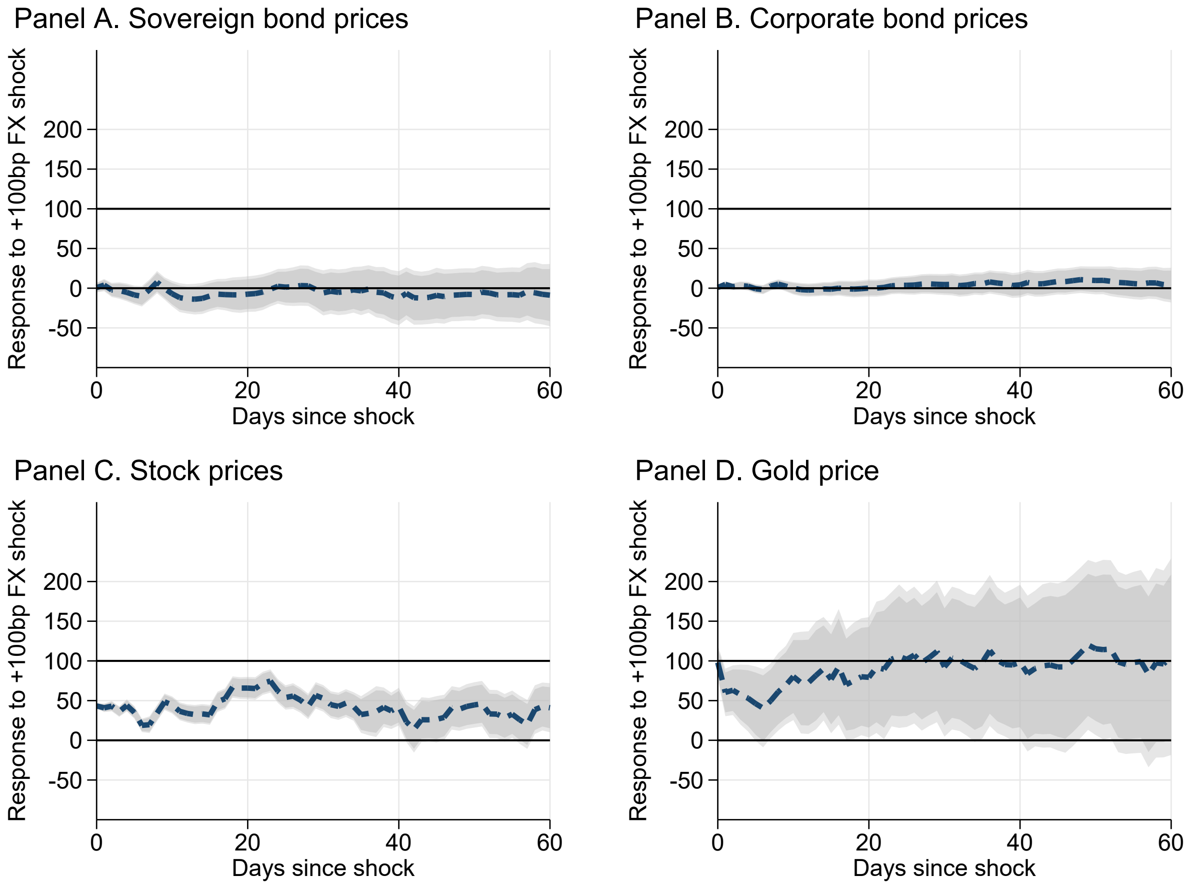
Figure A7: Variance decomposition of Swiss stock returns



Notes: See the note of Figure 11. Using the observed shock series instead of the purged series. The controls used to purge the shocks are instead used as controls in the specification.

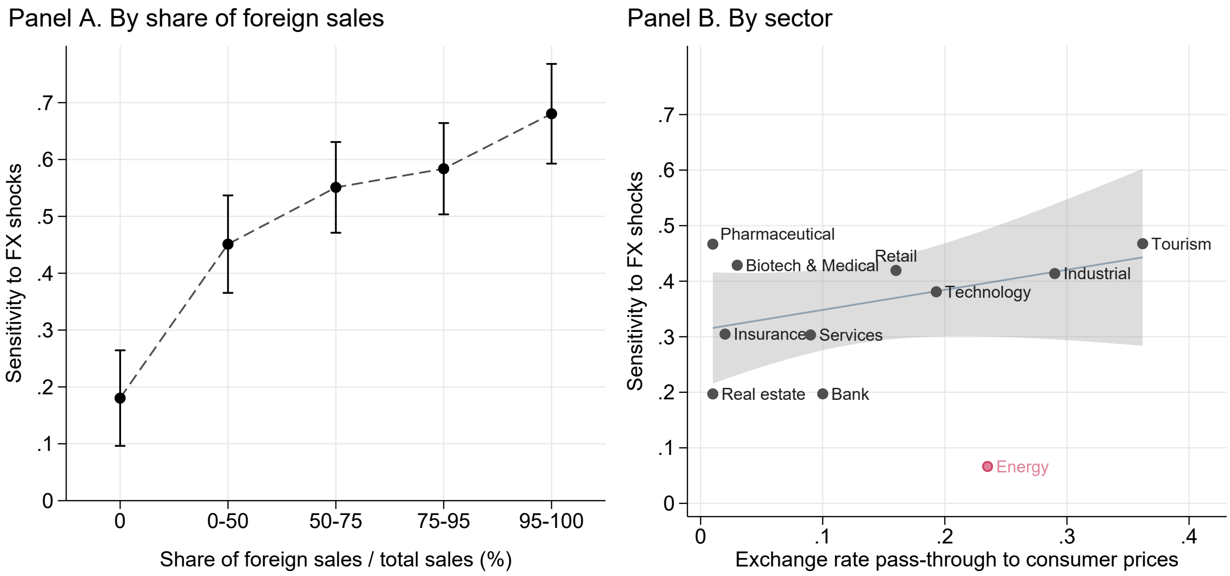
E Robustness: Omitting the introduction and discontinuation of the Swiss franc floor

Figure A8: Response of domestic asset prices to a 100 bp Swiss franc depreciation.



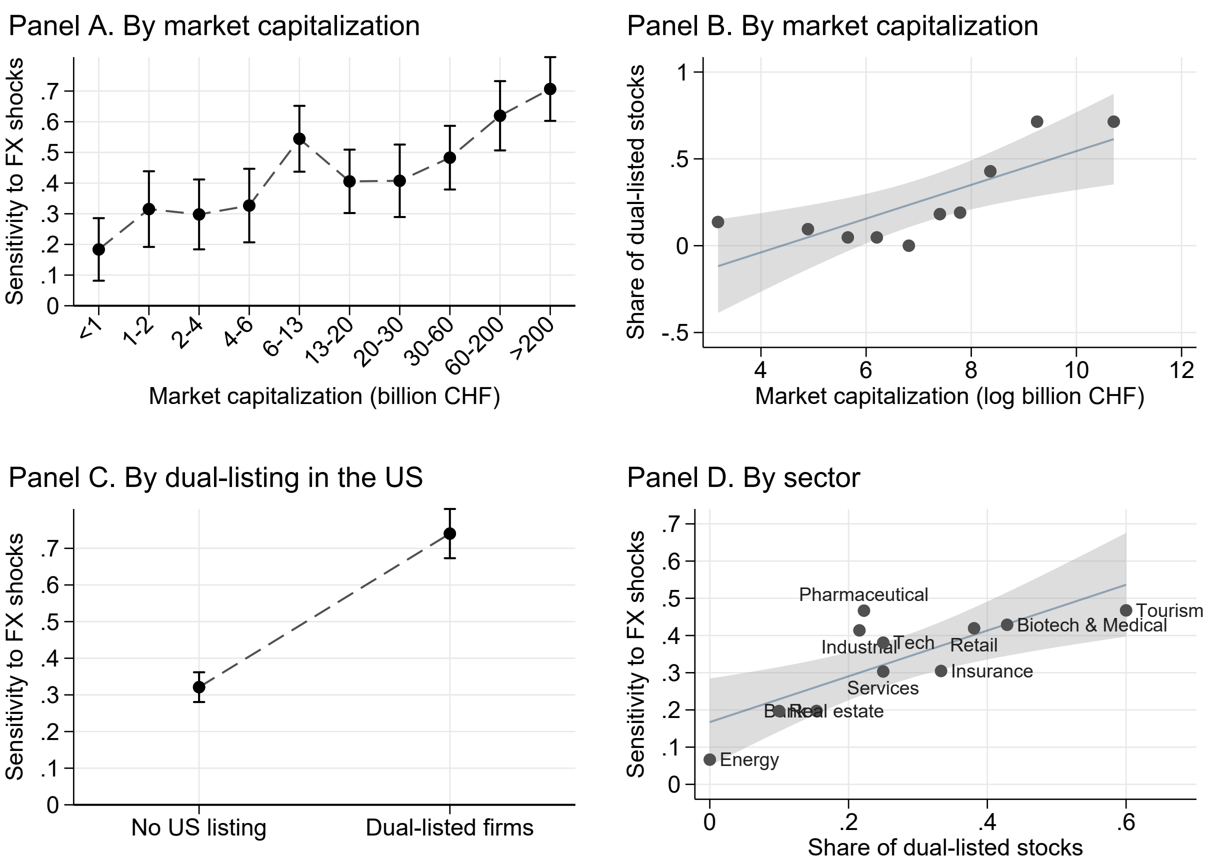
Notes: See the note of Figure 3. Omitting the shock of the Swiss franc floor introduction (in September 2011).

Figure A9: Heterogeneity in the cash flow denomination



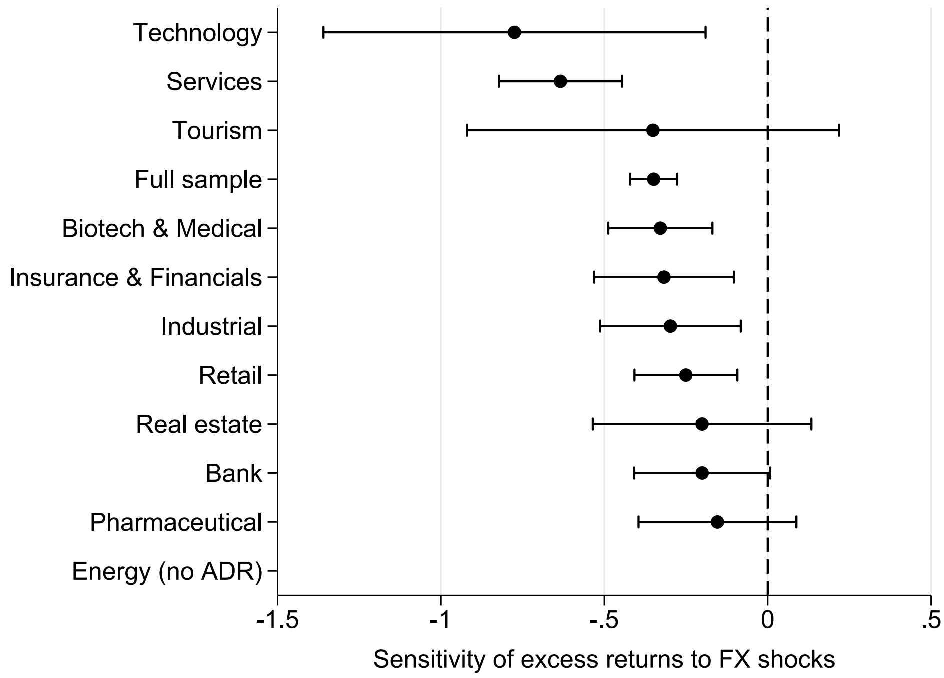
Notes: See the note of Figure 6. Omitting the shock of the Swiss franc floor introduction (in September 2011).

Figure A10: Heterogeneity of international substitution



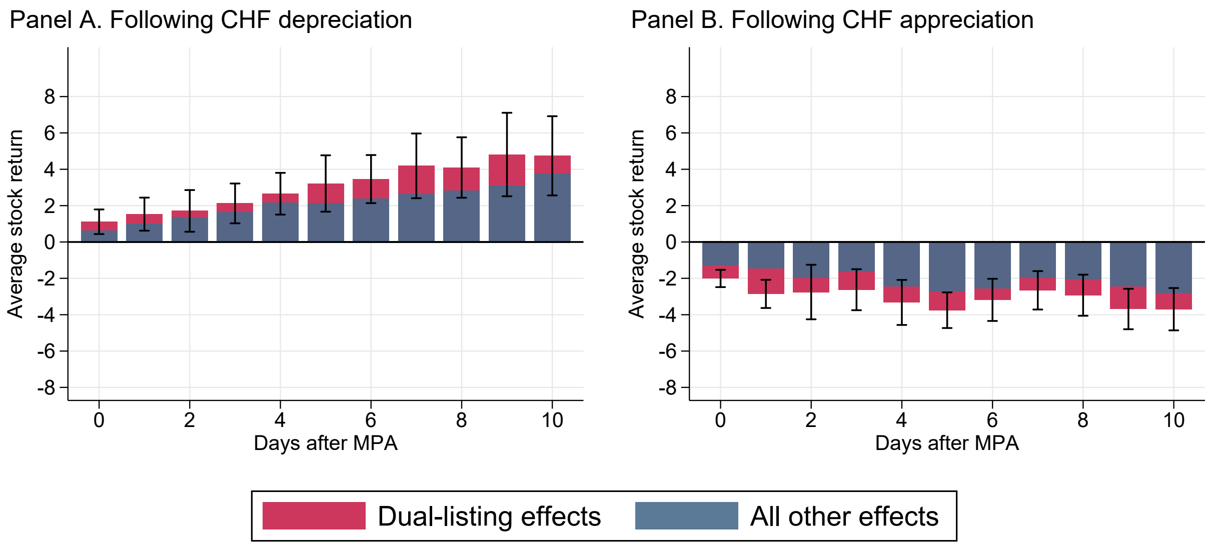
Notes: See the note of Figure 7. Omitting the shock of the Swiss franc floor introduction (in September 2011).

Figure A11: Excess returns of ADR listed in the US



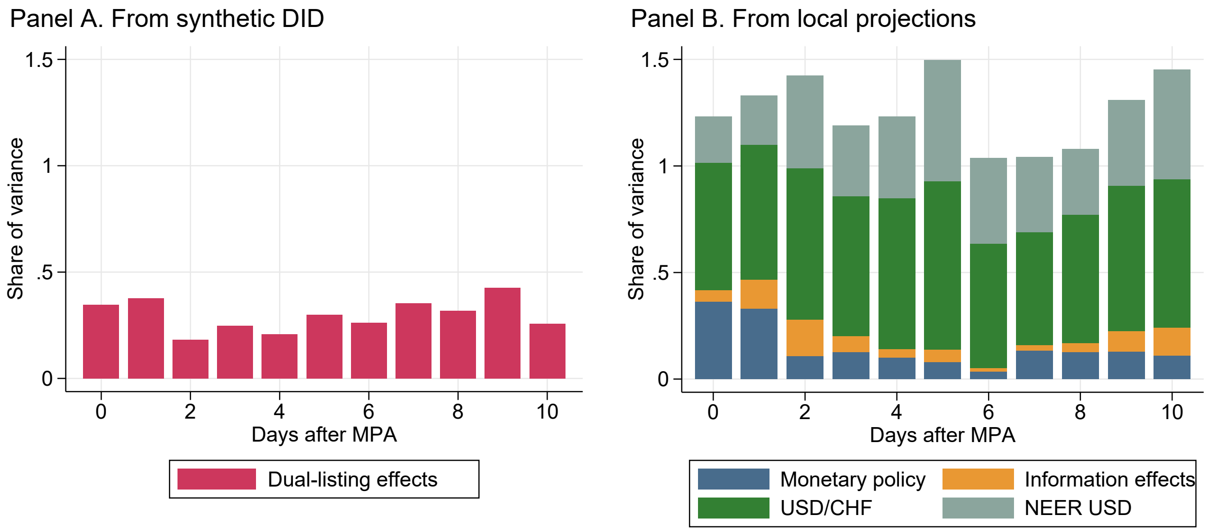
Notes: See the note of Figure 8. Omitting the shock of the Swiss franc floor introduction (in September 2011).

Figure A12: Effect of cross-listing on cumulated stock market returns



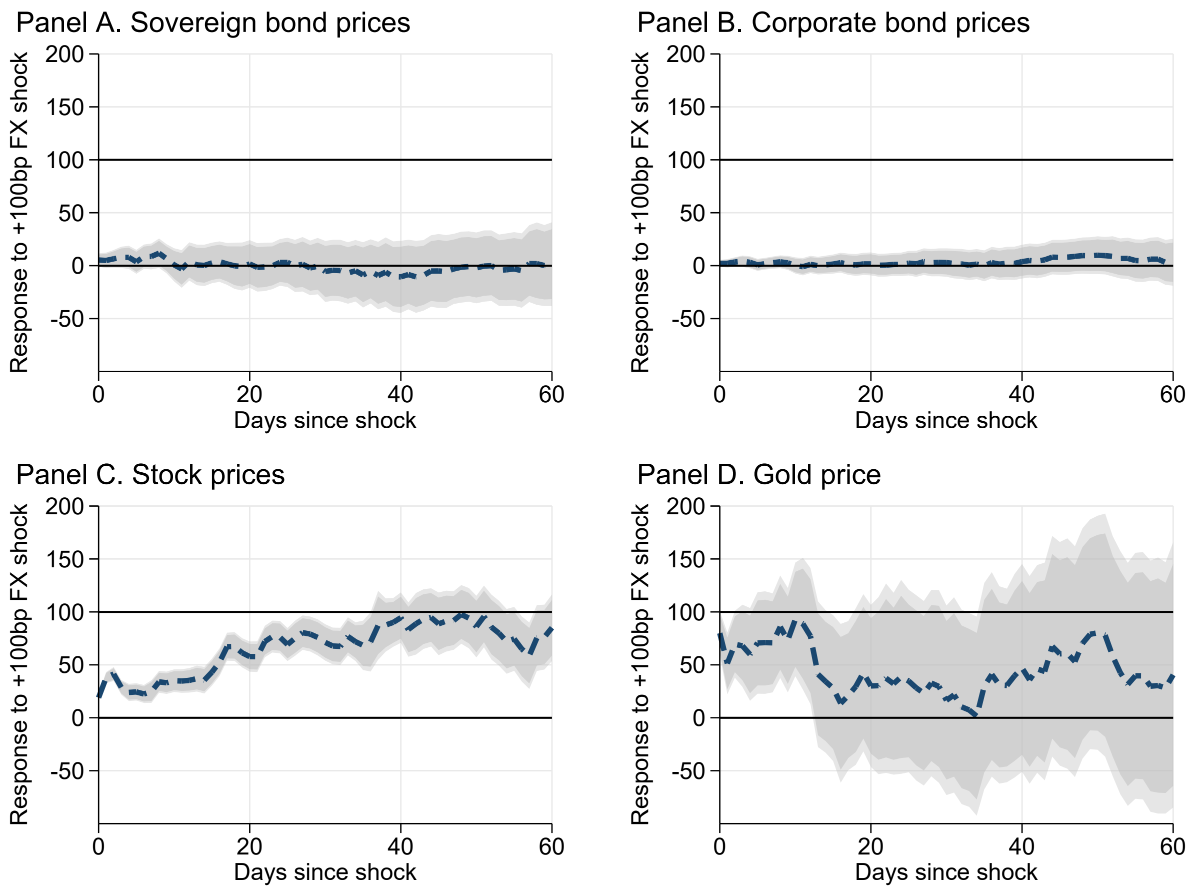
Notes: See the note of Figure 10. Omitting the shock of the Swiss franc floor introduction (in September 2011). Standard errors with 50 bootstrap replications.

Figure A13: Variance decomposition of Swiss stock returns



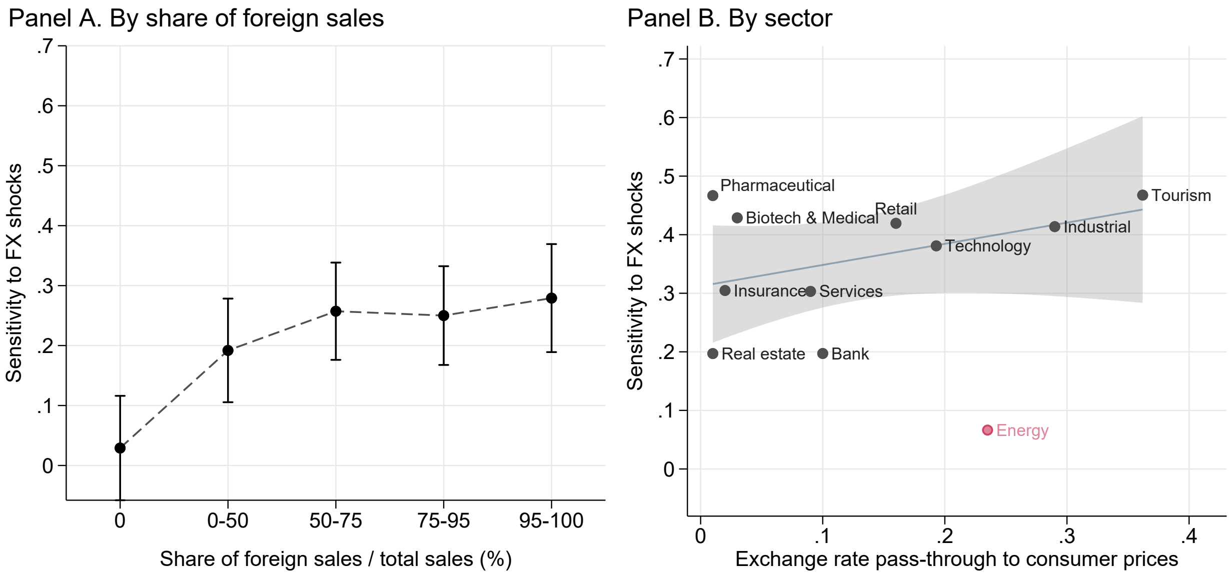
Notes: See the note of Figure 11. Omitting the shock of the Swiss franc floor introduction (in September 2011).

Figure A14: Response of domestic asset prices to a 100 bp Swiss franc depreciation.



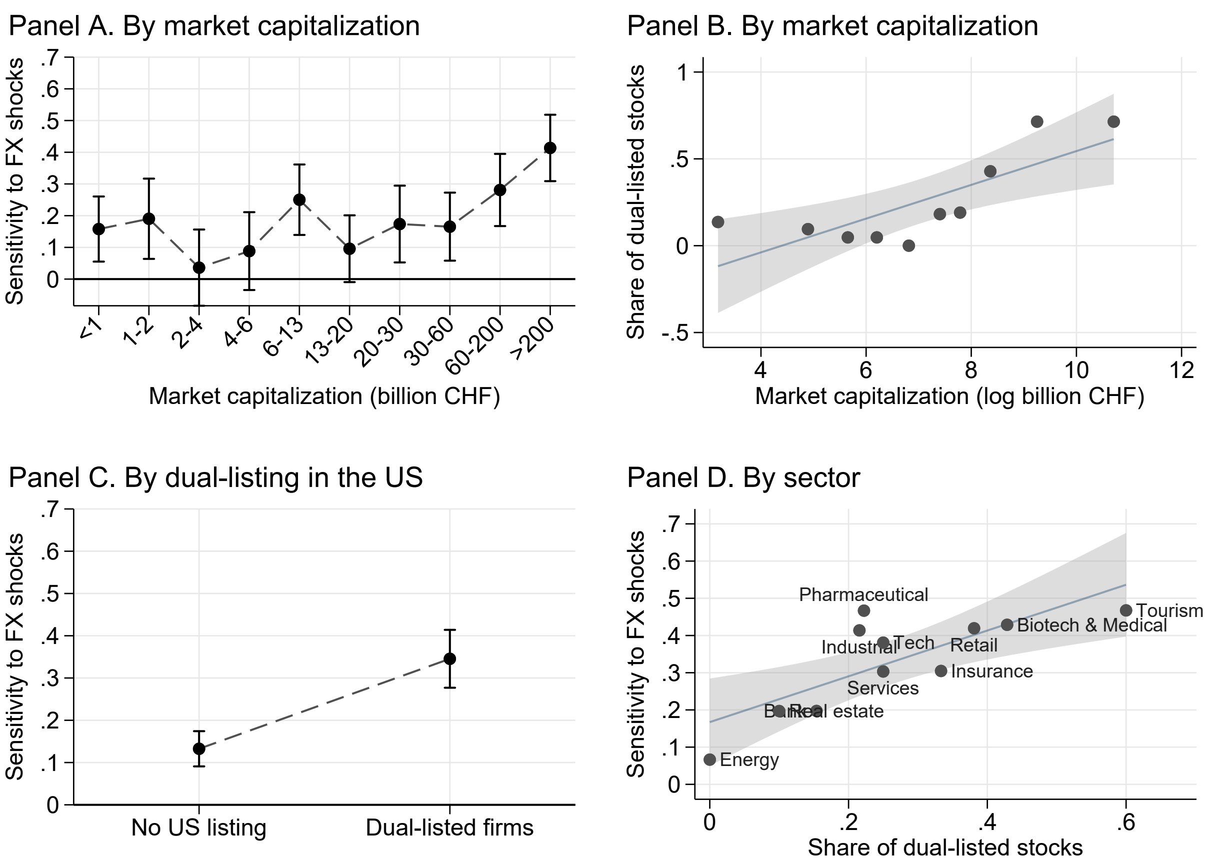
Notes: See the note of Figure 3. Omitting the shock of the Swiss franc floor introduction (in January 2015).

Figure A15: Heterogeneity in the cash flow denomination



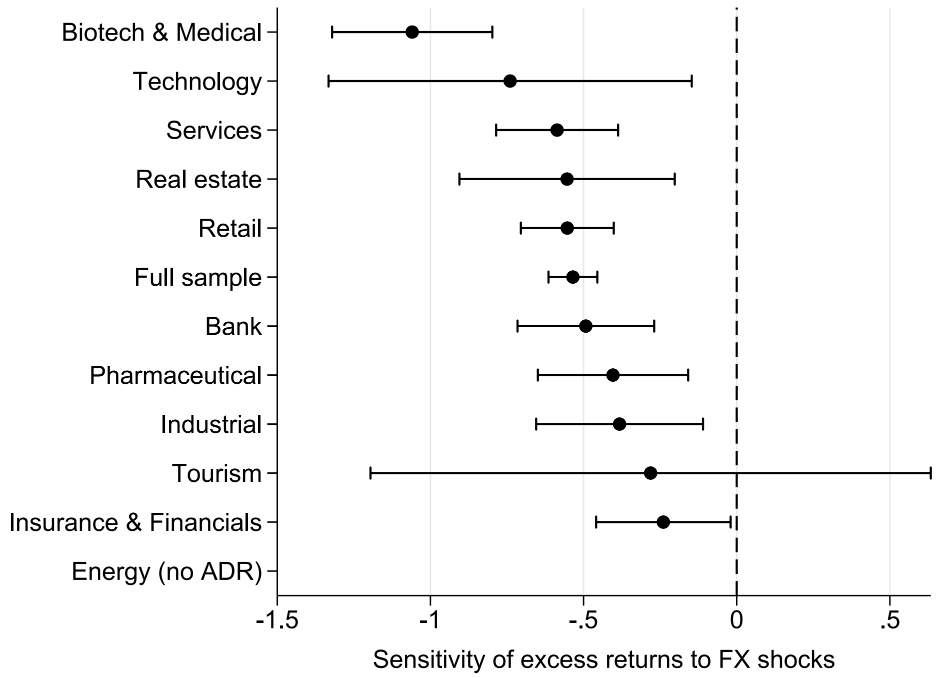
Notes: See the note of Figure 6. Omitting the shock of the Swiss franc floor introduction (in January 2015).

Figure A16: Heterogeneity of international substitution



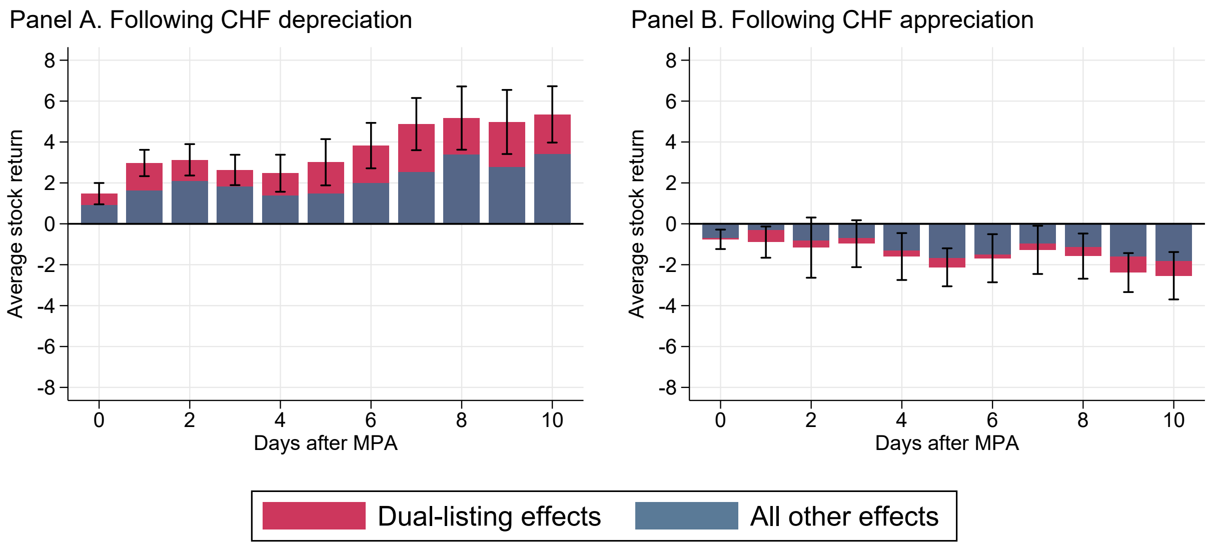
Notes: See the note of Figure 7. Omitting the shock of the Swiss franc floor introduction (in January 2015).

Figure A17: Excess returns of ADR listed in the US



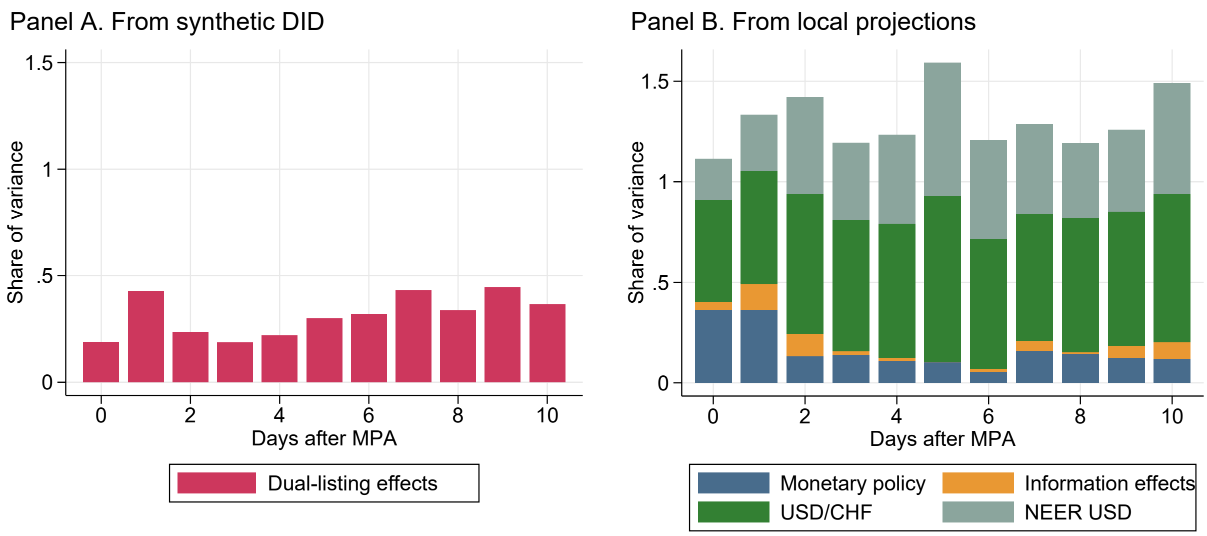
Notes: See the note of Figure 8. Omitting the shock of the Swiss franc floor introduction (in January 2015).

Figure A18: Effect of cross-listing on cumulated stock market returns



Notes: See the note of Figure 10. Omitting the shock of the Swiss franc floor introduction (in January 2015). Standard errors with 50 bootstrap replications.

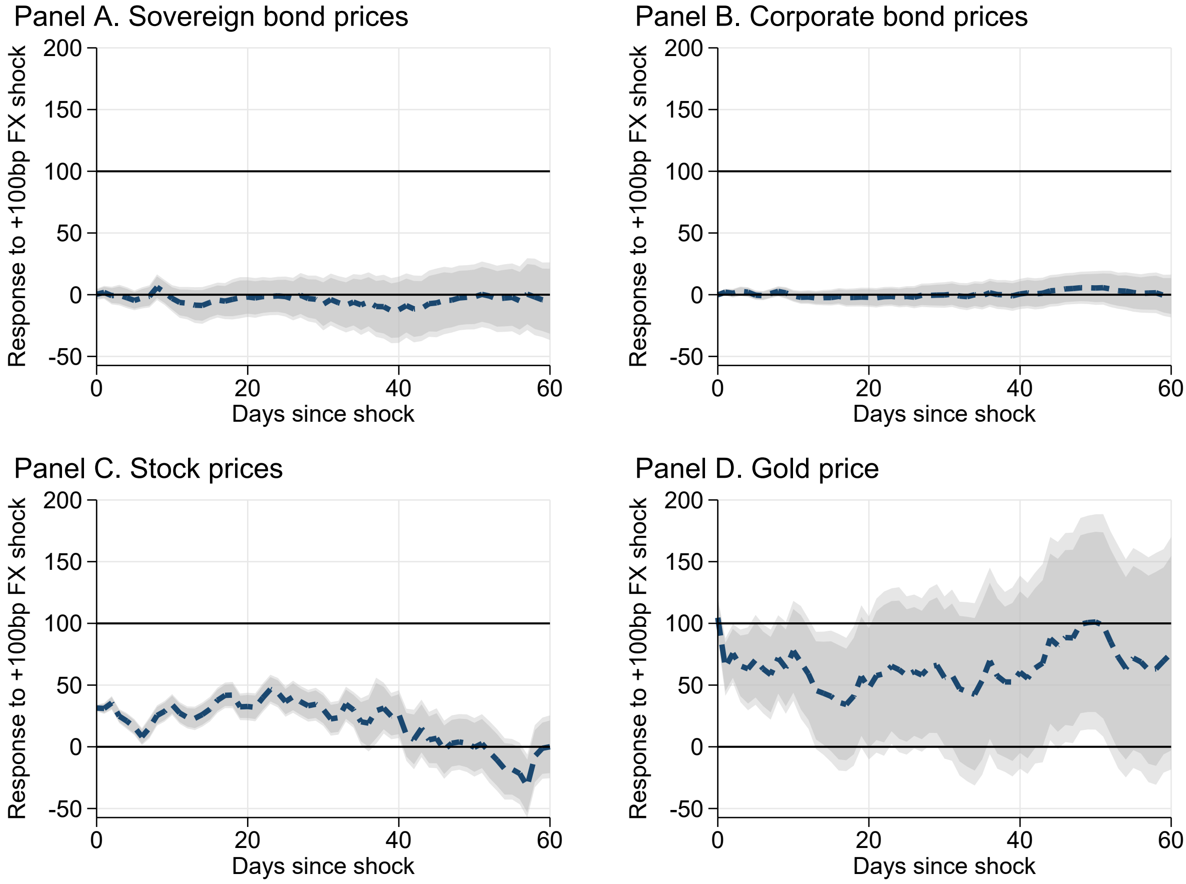
Figure A19: Variance decomposition of Swiss stock returns



Notes: See the note of Figure 11. Omitting the shock of the Swiss franc floor introduction (in January 2015).

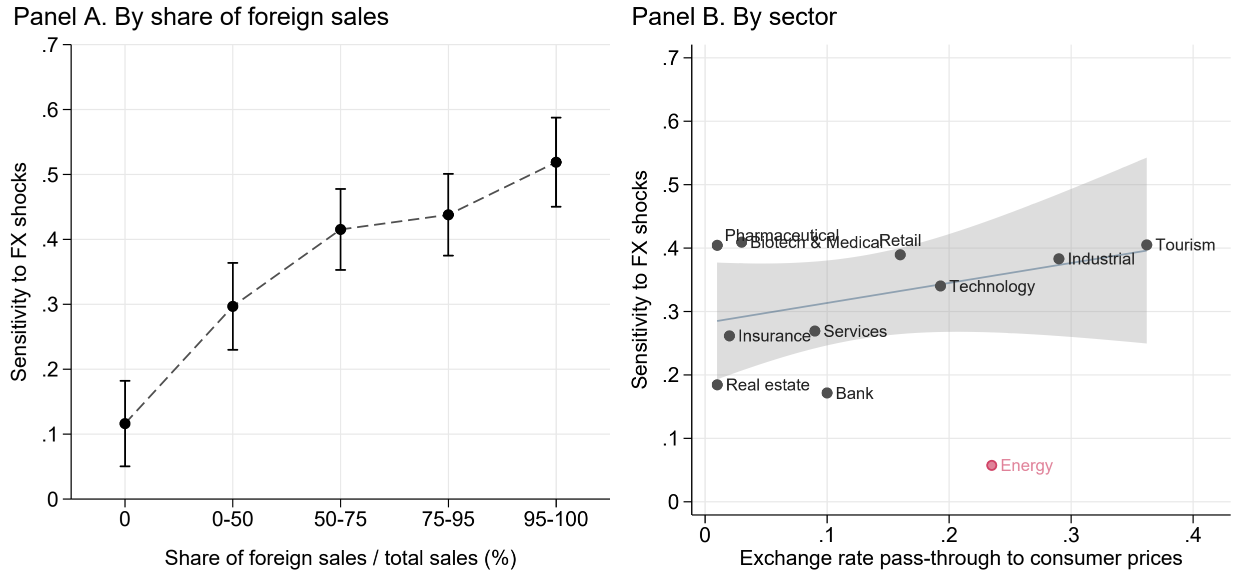
F Robustness: Using Bu et al. (2021) monetary policy shocks

Figure A20: Response of domestic asset prices to a 100 bp Swiss franc depreciation.



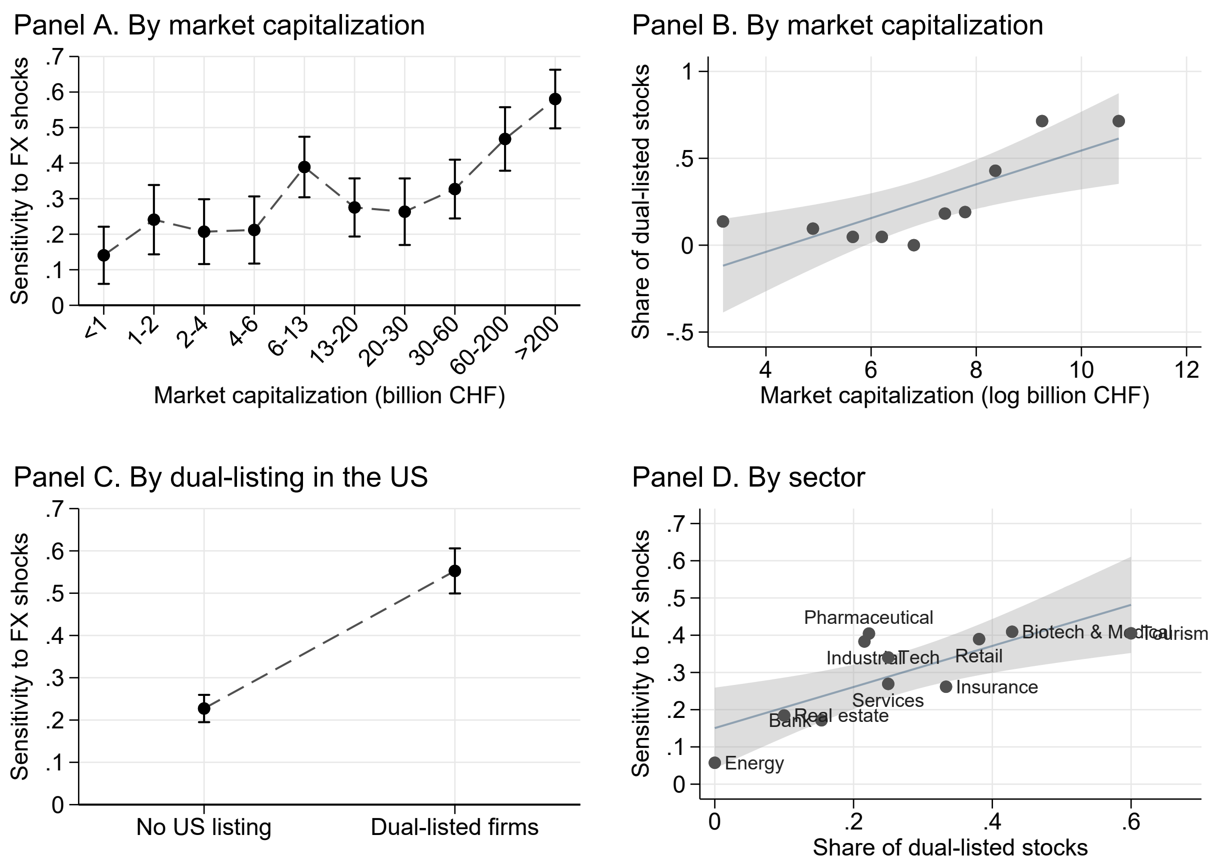
Notes: See the note of Figure 3. Replacing the monetary policy surprises of Koeniger et al. (2022) with the series of monetary policy shocks from the Bu et al. (2021) methodology to purge the shocks.

Figure A21: Heterogeneity in the cash flow denomination



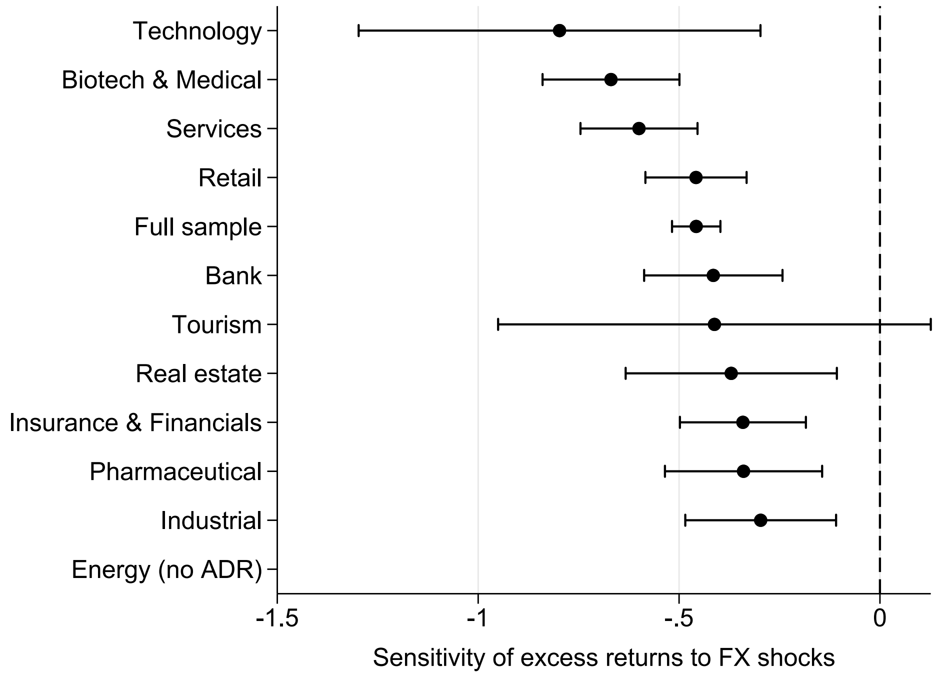
Notes: See the note of Figure 6. Replacing the monetary policy surprises of Koeniger et al. (2022) with the series of monetary policy shocks from the Bu et al. (2021) methodology to purge the shocks.

Figure A22: Heterogeneity of international substitution



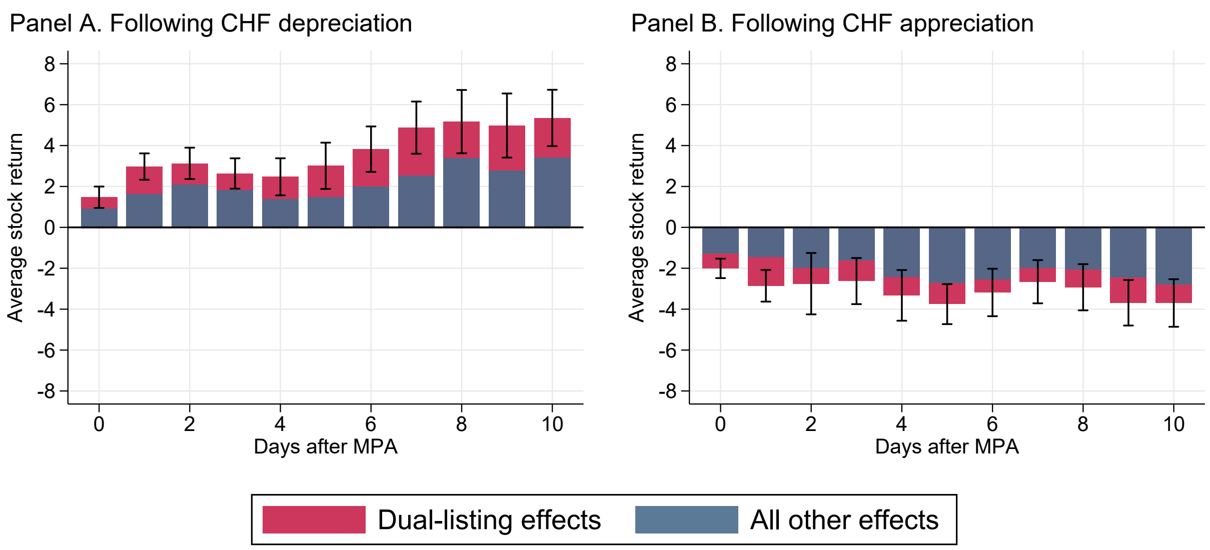
Notes: See the note of Figure 7. Replacing the monetary policy surprises of Koeniger et al. (2022) with the series of monetary policy shocks from the Bu et al. (2021) methodology to purge the shocks.

Figure A23: Excess returns of ADR listed in the US



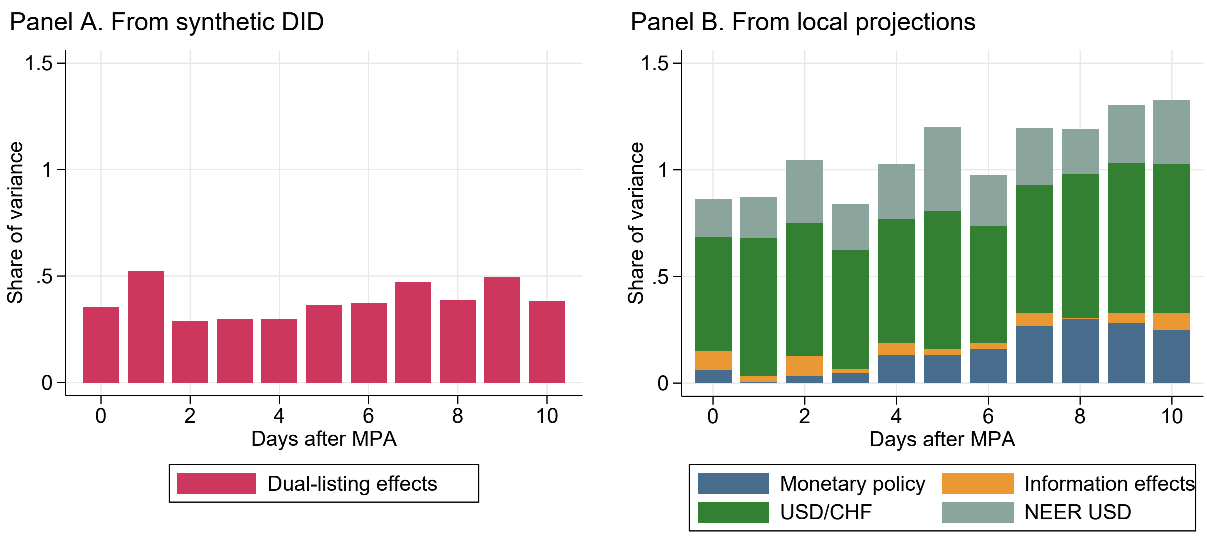
Notes: See the note of Figure 8. Replacing the monetary policy surprises of Koeniger et al. (2022) with the series of monetary policy shocks from the Bu et al. (2021) methodology to purge the shocks.

Figure A24: Effect of cross-listing on cumulated stock market returns



Notes: See the note of Figure 10. Replacing the monetary policy surprises of Koeniger et al. (2022) with the series of monetary policy shocks from the Bu et al. (2021) methodology to purge the shocks. Standard errors with 50 bootstrap replications.

Figure A25: Variance decomposition of Swiss stock returns



Notes: See the note of Figure 11. Replacing the monetary policy surprises of Koeniger et al. (2022) with the series of monetary policy shocks from the Bu et al. (2021) methodology to purge the shocks.

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