Irving Fisher Committee on
Central Bank Statistics

BANK FOR INTERNATIONAL SETTLEMENTS

Ninth IFC Conference on "Are post-crisis statistical initiatives completed?"

Basel, 30-31 August 2018

Exchange rate effects in the international investment position - methods, tools and applications for Germany[1]

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[1] This paper was prepared for the meeting. The views expressed are those of the authors and do not necessarily reflect the views of the BIS, the IFC or the central banks and other institutions represented at the meeting.

Exchange Rate Effects in the International Investment Position – Methods, Tools and Applications for Germany

Stephanus Arz[1], Stefan Hopp[2] and Ulf von Kalckreuth[3]

Abstract

Exchange rate movements play an important role in explaining the dynamics of national and sectoral gross and net wealth and the rate of return on foreign investments. The German international investment position (IIP) statistics have long since provided and published data on assets and liabilities with foreign counterparties by sector and by financial instrument. For the period since 2012, all the items can additionally be broken down by seven currencies: euro and six non-euro denominations. Ex post, this allows the effect of exchange rate changes on the euro value of assets and liabilities to be calculated, enabling a wide range of analytical work. These exchange rate changes are now collected in an index of exchange rate effects in the IIP, which depicts the influence of individual exchange rate movements on all non-derivative assets and liabilities in the external position on an aggregated level as well as on various disaggregated levels. Ex ante, it is possible to conduct sensitivity analyses concerning exchange rate shocks in terms of gradients and in terms of volatility measures. The extended IIP approach can be used to indicate potential currency mismatches and imbalances and as a basis for delving deeper into sectoral currency risk exposure and vulnerabilities on the aggregate level.

Keywords: IIP, external position, currency composition, exchange rate sensitivity.

JEL classification: C43, F31, F36

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1. Introduction

International spill-overs of financial shocks can be transmitted by a variety of channels, among them direct financial interlinkages and demand effects. Since the days of Keynes and Mundell, one focus in monetary macroeconomics has been the exchange rate. The exchange rate is a summary relative price for traded goods and services as well as for real and financial assets. Thus, the exchange rate will determine the values of all of these items in terms of other currencies, steer trade and financial flows, and determine the relative wealth of people, sectors and nations, including their state of solvency. The Asian crisis started out as a series of currency devaluations that triggered stock market declines and made the foreign debt positions of a number of countries unsustainable.

The IIP is to national wealth what the current account is to GNP: national wealth is the sum of real capital plus the net foreign position of a country. Thus, in order to categorize and analyse wealth effects of exchange rate fluctuations, the IIP is the notional point of departure. Obviously, wealth effects of exchange rate movements on countries, sectors and individuals depend on their overall gross and net financial positions as well as on the currency composition of their portfolio. In terms of macroeconomic effects, these portfolio effects may even more than offset the trade channel.[4] For investors holding unhedged net positions denominated in a foreign currency, exchange rate movements will translate directly, without any further intermediation, into changes in the market value of their net wealth. This is why the new Balance of Payments and International Investment Position Manual, BPM6,[5] asks for a standardized breakdown of changes of IIP positions into transactions, revaluations – exchange rate changes among the latter – and other changes:

Beginning of period position

+ Transactions during the period

+ Revaluations during the period:

of which due to

◦ exchange rate changes

◦ other price changes

+ Other changes in volume during the period (reclassifications etc.)

= End of period position

This accounting identity for the "law of motion" holds at all levels – countries, sectors, economic agents – and for single financial instruments as well as for aggregate assets, liabilities or net positions.

To identify the effect of exchange rate changes, there needs to be a system of bookkeeping for currency denominations. For each position, each instrument of each entity that is covered, consistent and updated information on the currency

[4] Kearns and Patel (2016).

[5] International Monetary Fund (2009).

composition is required.[6] This is why the currency composition of IIP positions figures explicitly in the recommendations of the G 20 Data Gaps Initiative, Phase II.[7] The information is not easy to come by – in many instances, hard data from mandatory reports or surveys have to be complemented by reliable estimates. But once the matrix of currency compositions is in place, it is quite straightforward to use it for depicting exchange rate effects on many levels, both ex post as well as ex ante, for forecasting and policy and scenario analyses.

It is important to understand that, in principle, IIP positions are valued at market prices in the home currency, and if market prices are not available, close substitutes are used. The IIP positions are changed by flows from the current account – trade in goods and services, primary and secondary income, and by stock adjustments. Looking at the consequences of exchange rate changes for the IIP of a country, we can thus distinguish between the effects on stocks and on flows as two broad levels of analysis. Regarding stocks, there are first of all instantaneous revaluation effects given the portfolio composition and denomination structure. Gross assets and liabilities denominated in foreign currencies enter the balance sheets of individuals or sectors at a new rate of exchange. Second, depending on how economic agents respond, and with some lag, there may be portfolio rebalancing effects resulting from an attempt to restore portfolio equilibrium. These lead to direct purchases or sales of financial assets, with an effect on prices and the asset and liability structure. Concerning the current account, we can make the same distinction. The flows of trade in goods and services, of primary income from labour or as a return on assets, and of secondary income are revalued. In addition, there is an economic adjustment of quantities, as a result of re-optimisation given the new relative prices. While the effects of flows on the IIP may be important in the long run, the effects on stocks are "fast" or even instantaneous.

This paper takes a look at the instantaneous effect that revaluations have on stocks. The valuation effects are mechanical, but depending on the currency denomination of external positions, they can be very strong. The elasticity approach of Marshall, Lerner and Robinson, as it is known, looks at the conditions under which the trade balance reacts "normally" to an exchange rate movement despite the translation effects. Similarly, we may ask ourselves, with respect to the IIP, whether and when in a given situation the portfolio rebalancing effects and the effects on the current account can possibly override the immediate revaluation effects of an exchange rate change. Think, for example, of a country with a currency mismatch, where liabilities denominated in foreign currency are much larger than the corresponding assets. As usual, a devaluation of the home currency may help this country's export sector, but the valuation effect makes the foreign net position deteriorate instantaneously. Even worse, the interest or dividend payments on the liabilities denominated in foreign currency also become more of a burden.

[6] See Lane and Shambough (2010), who construct a database of currency compositions for aggregate IIP positions of 127 countries. See also Bénetrix, Lane and Shambough (2015).

[7] Recommendation 10 on the International Investment Position in DGI II. An overview of progress on currency breakdowns is given by IMF (2015).

This paper gives a methodological exposition with a focus on the German IIP.[8] Section 2 introduces the basic ideas. Section 3 outlines the dimensions of the set of statistical information that is available for analysing exchange rate effects for Germany. As the compilation of statistical data in Germany is guided by the methodologies set out in the IMF BPM6 directives, which apply worldwide, it can be expected that this type of analysis is feasible in many other countries. Section 4 introduces the IIE, a system of indices of exchange rate valuation effects. Section 5 investigates some measures of sensitivity and volatility with respect to exchange rate valuation effects that can be readily calculated on the basis of available information. Section 6 concludes by discussing the relationship between these sensitivity measures and currency risk exposure, taking into account the role of hedging.

2. Exchange rate effects: using stocks as a weighting matrix for relative changes

Consider any vector a_t of *K* different IIP stocks at the end of period *t* on any level of aggregation – different instruments in the balance sheet of a sector, or aggregates across multiple classes of instruments:

$$\mathrm{a}_t = \begin{pmatrix} a_t^1 \\ \vdots \\ a_t^K \end{pmatrix}.$$

Note that *K* is not fixed but depends on the analytical question at hand. There is an associated composition matrix A_t. For each entry a_t^k of the stocks vector, line *k* of the composition matrix gives the currency composition. Let *N* be the number of currency denominations and *n* a running index, with 1 indicating the home currency:

$$\mathrm{A}_t = \begin{pmatrix} a_t^{11} & \cdots & a_t^{1N} \\ \vdots & \ddots & \vdots \\ a_t^{K1} & \cdots & a_t^{KN} \end{pmatrix}, \text{ with } \sum_{n=1}^{N} a_t^{kn} = a_t^k .$$

All elements in a_t and A_t are denominated in units of home currency. Let $\hat{\mathrm{E}}_t$ be the vector of relative exchange rate changes for the *N* currencies with respect to period *t*, the first element being an entry for the home currency which is identically equal to zero. The exchange rates indices are given in price notation, i.e. in units of home currency per unit of foreign currency:

$$\hat{\mathrm{E}}_t = \begin{pmatrix} 0 \\ \Delta E_t^2 / E_{t-1}^2 \\ \vdots \\ \Delta E_t^N / E_{t-1}^N \end{pmatrix}.$$

[8] For an introduction to the new German IIP statistics, also concerning exchange rate effects, see Schipper and Jäcker (2016), as well as Deutsche Bundesbank (2018).

To indicate the exchange rate effect in the changes of positions from *t-1* to *t*, we condition on the asset structure in *t-1*. Then the *vector of exchange rate effects* for all positions in A_t is given by the matrix product

$$EE_t = \mathrm{A}_{t-1} \cdot \hat{\mathrm{E}}_t \ .$$

It is useful to rephrase this in terms of rates of change, using weights. Define a weighting matrix for the currency composition of assets, where the elements in each line add up to one:

$$\mathrm{W}_t = \begin{pmatrix} a_t^{11}/a_t^1 & \cdots & a_t^{1N}/a_t^1 \\ \vdots & \ddots & \vdots \\ a_t^{K1}/a_t^K & \cdots & a_t^{KN}/a_t^K \end{pmatrix}, \qquad (1)$$

and, accordingly, a *vector of IIP weighted exchange rate changes:*

$$\eta_t = \mathrm{W}_{t-1} \cdot \hat{\mathrm{E}}_t \ .$$

The term η_t is a vector of growth rates. One can look at it in two ways. First, by weighting the exchange rate changes on the basis of IIP positions, they are "translated" into effects on wealth stocks. Second, from the perspective of these stocks, the elements of η_t denote the relative change in the positions of a_t induced by exchange rate variations. The absolute value of effects can be recovered by simply multiplying the weighted changes η_t back into the stocks a_{t-1}.

$$EE_t = \begin{pmatrix} a_{t-1}^1 \eta_t^1 \\ \vdots \\ a_{t-1}^K \eta_t^K \end{pmatrix} .$$

By suitably choosing components of interest in a_{t-1}, one can compute exchange rate effects by instrument, by sector or by any combination of the two. And obviously, the same set of computations is possible for any matrix L_t of liability positions according to currency denominations, leading to corresponding weighted exchange rate changes η_t for liabilities. Exchange rate effects are being calculated as part of the current publication programme of DG Statistics at the Deutsche Bundesbank.

At this point, an important caveat is in order. The exchange rate effects that can be computed on the basis of the currency composition of IIP positions do not necessarily translate fully into wealth effects for the respective creditor or debtor, i.e. into capital gains or losses. Economic agents may be hedged, either by holding derivatives or by currency diversification in multinational enterprises (natural hedge). Other parties may be affected. The IIP does not deliver sufficient information on these hedging activities, and, when analysing the distribution of wealth effects, this information has to be added separately. This issue will be addressed in Section 6.

3. The extended information set for Germany

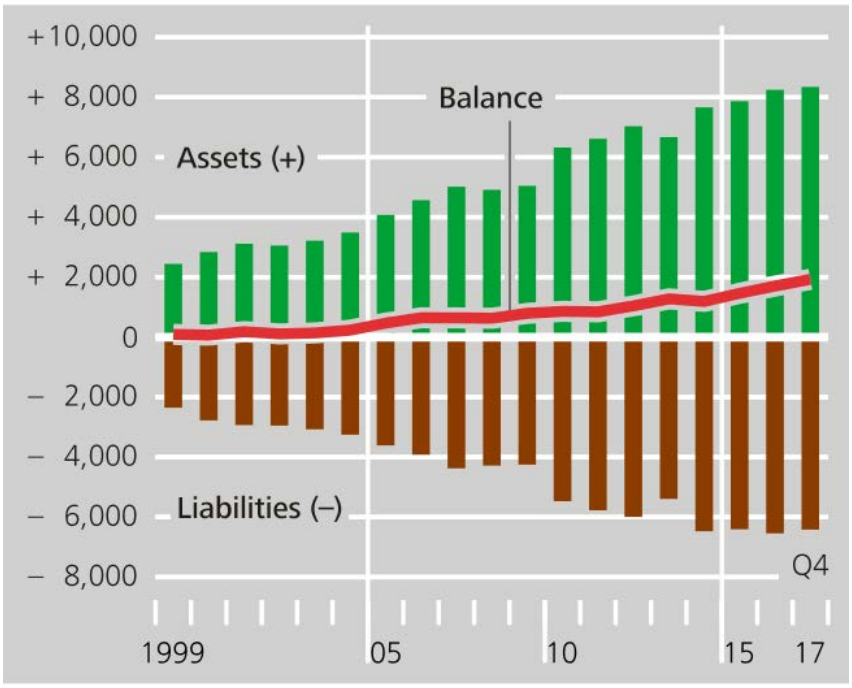
German IIP positions, including the net balances, have been increasing dramatically in recent years. Graph 1 depicts the dynamics of this development. The net external position of Germany – ie external assets minus external liabilities as a percentage of nominal GDP – has increased from almost 20% to around 60% in the eleven years between 2007 and 2017.[9] At the end of 2017, external assets reached a volume of € 8,346 bn and external liabilities amounted to € 6,417 bn. A large share of these positions is denominated in foreign currencies: 34% of all assets and 20% of all liabilities. This equates to € 1.5 trillion of net IIP at the end of Q3/2017, or around 50% of GDP. For such a portfolio, even small exchange rate changes may have a high impact.

Consider, for example, a devaluation of the euro against the other currencies. The euro value of Germany's debt positions denominated in foreign currencies will increase, as will the asset positions. The absolute value of foreign-currency-denominated positions on the asset side is larger – both the total size and the share of foreign-currency-denominated positions are larger for assets than for liabilities. Combine this with the conjecture that the currency composition of income flows from assets and liabilities will be similar to the composition of the stocks. Disregarding hedging, there will be a systematic positive effect on the IIP in home currency, also concerning income flows, at least for the aggregate economy.[10] These structural effects will be quite different from the effects that the same depreciation may have on a net debtor country with a large reliance on foreign-currency-denominated liabilities; see e.g. the analysis by the IMF Spillover Task Force (2015). The situation at the level of sectors or individuals may be rather diverse in both countries, of course, depending on the underlying financing structure. Gross positions are important, as the holders of financial liabilities will not coincide with the holders of foreign assets.

[9] See Deutsche Bundesbank (2018).

[10] Indeed, in 2017 an appreciation by the euro against the US dollar and other currencies led to a negative exchange rate effect on Germany's net position in the order of € 123 bn, which is the balance of a decrease of the euro value of assets by € 207 bn and of liabilities by € 84 bn; see Bundesbank (2018), pp 33.

Graph 1: The international investment position of Germany.
€ bn, end of year



3.1 Institutional sectors in German IIP

Following the directives of the BPM6, German IIP statistics provide quarterly information on international investment positions for a rich set of institutional sectors and financial instruments. In this section, we show how the elements of A_t and L_t can be chosen based on the information infrastructure of German IIP statistics. The institutional classification used in German IIP statistics is given below in Table 1. Economic agents are grouped into six sectors. Compared to the earlier standard, the sector "Monetary Financial Institutions (MFIs) excluding central banks" has been split further into "Deposit taking institutions" and "Money market funds". Furthermore, "Financial corporations" have been separated out from the old residual category "Other sectors", to give a more complete picture of financial institutions.

3.2 Financial instruments in German IIP

For each of the sectors listed above, IIP statistics provide data on assets or liabilities with an external counterparty, according to a rather detailed set of 20 instruments (within functional categories) at the deepest level of disaggregation, which is listed in Table 2.

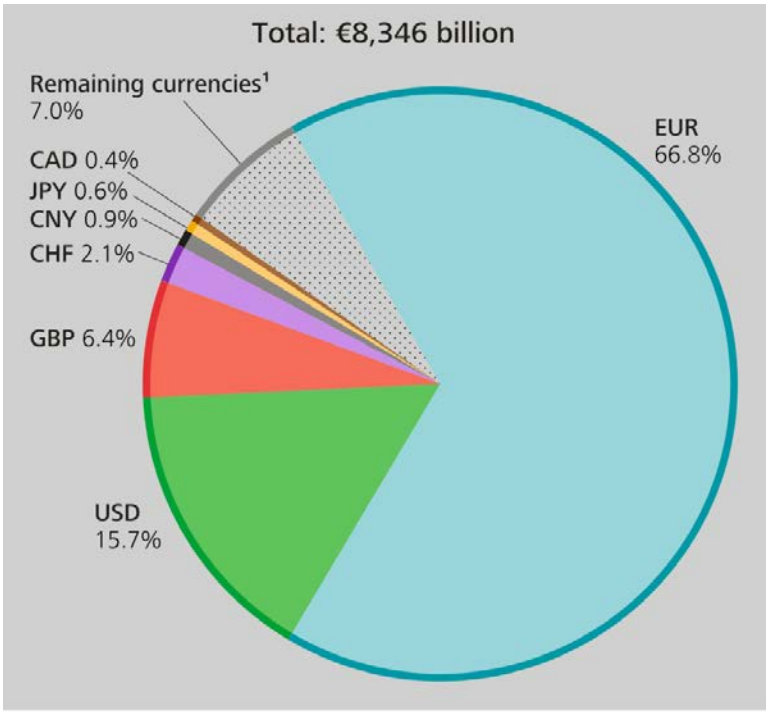
Table 2: Financial instruments in German IIP
I. Direct investment
1. Equity capital
1.1. Listed
1.2. Unlisted
1.3. Other equity
2. Debt instruments
2.1. In direct investment enterprise
2.2. In direct investor (reverse investment)
2.3. Between fellow enterprises
II. Portfolio investment
1. Shares
2. Investment fund shares
3. Short-term debt securities
4. Long-term debt securities
III. Financial derivatives and employee stock options
IV. Other investment
1. Loans
1.1. Short-term debts
1.2. Long-term debts
2. Currency and deposits
2.1. Currency and short-term deposits
2.2. Long-term deposits
3. Trade credits and advances
4. Insurance, pension and standardised guarantee schemes
5. Other equity
6. Other accounts receivable / payable
7. Special drawing rights (only liabilities)
V. Reserve assets

3.3 Currency denominations in German IIP

Combining sectors and instruments will lead to a system of balance sheets concerning external assets and liabilities, and data on currency denominations need to be produced for the respective positions. At present, this bookkeeping is being carried out for a set of six major foreign currencies (US dollar, pound sterling, Japanese yen, Swiss franc, Chinese renminbi and Canadian dollar), plus the euro, and plus gold and special drawing rights in the context of central banking. This approach will depict the currency composition of most of the assets and liabilities of German residents and their financial linkages with the outside world.

Table 3: Currency denominations in German IIP
I. Foreign currencies
- US dollar
- Pound sterling
- Japanese yen
- Swiss franc
- Chinese renminbi
- Canadian dollar
II. Special drawing rights (in the reserve position of the Deutsche Bundesbank)
III. Euro

Graph 2: IIP assets by currency in Germany
Percentage share, end of 2017



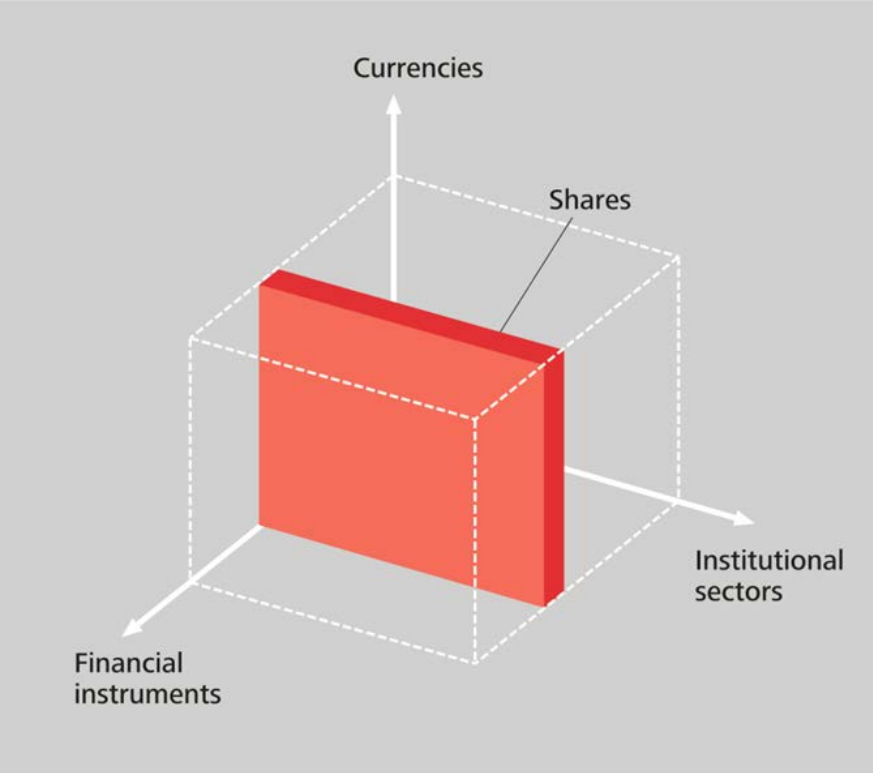
1 Including special drawing rights (XDR) and monetary gold.
Deutsche Bundesbank S3PR0326.Chart

Around 93% of assets and 96% of liabilities in Germany are being held in euro, gold or one of the six currency denominations named above; see Graph 2 above.[11] There are some more major currencies for international finance in Germany, such as the Indian rupee, the Swedish krona, the Danish krone and the Brazilian real. These

[11] In this graph, the gold reserves of the Deutsche Bundesbank are part of the external assets, and they are considered to be denominated in euro. With a view on monetary history, one might have also thought of treating gold as a currency in its own right, with the gold price serving as the exchange rate.

are almost exclusively being used in financial positions with the counterparty resident in the country where the respective currency is legal tender. At the current stage, these currencies do not enter the analysis.

Graph 3: Dimensions of analysis for exchange rate effects



3.4 The cube of statistical information for exchange rate analysis in German IIP

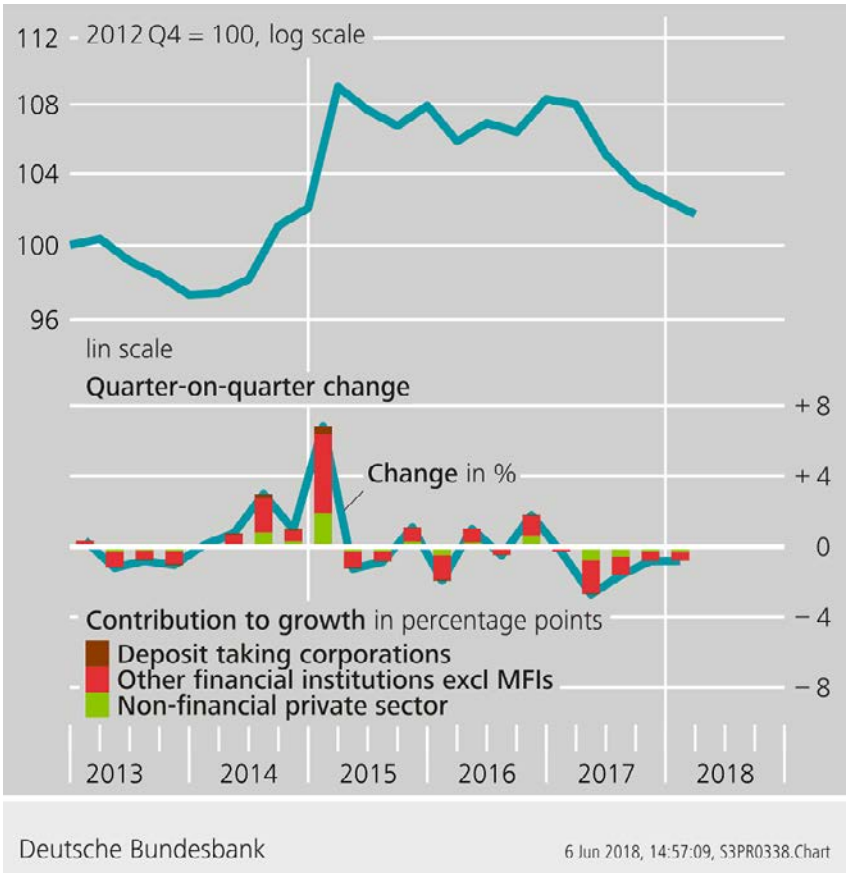
The preceding paragraph shows that the elements of the composition matrices A_t and L_t can be chosen along three dimensions: sectors, instruments, and currency denominations. At the lowest level of disaggregation, this encompasses a number of 960 elements in the composition matrices, both for assets and for liabilities, each of which will yield separate low-level exchange rate effects. Not all the combinations are filled, though. Households do not issue currency and deposits. There are assets denominated in special drawing rights only for the Deutsche Bundesbank. On the other hand, the Deutsche Bundesbank does not hold any foreign direct investments. Of course, all sorts of aggregations are also possible and meaningful. Statisticians are accustomed to visualizing this type of information structure in terms of a cube; see Graph 3 above.

4. An index of IIP-weighted exchange rate effects

Given a time series of η_t^k for any asset or liability position, it is straightforward to construct Laspeyres-type indices of exchange rate effects, upon which analytical work can be based. Chain-linking the growth factors associated with η_t^k while setting some base period equal to 100 yields an index for the capital gains and losses caused by exchange rate changes in the respective IIP positions. For any asset or liability position *k*, we obtain IIE_t^k, the **I**ndex of **I**IP-weighted **E**xchange rate effects:

$$IIE_t^k = 100 \cdot \left(1+\eta_1^k\right) \cdot \left(1+\eta_2^k\right) \cdot \ldots \cdot \left(1+\eta_t^k\right) = IIE_{t-1}^k \cdot \left(1+\eta_t^k\right) \ .$$

Graph 4: IIE for shares in portfolio investment (asset side)

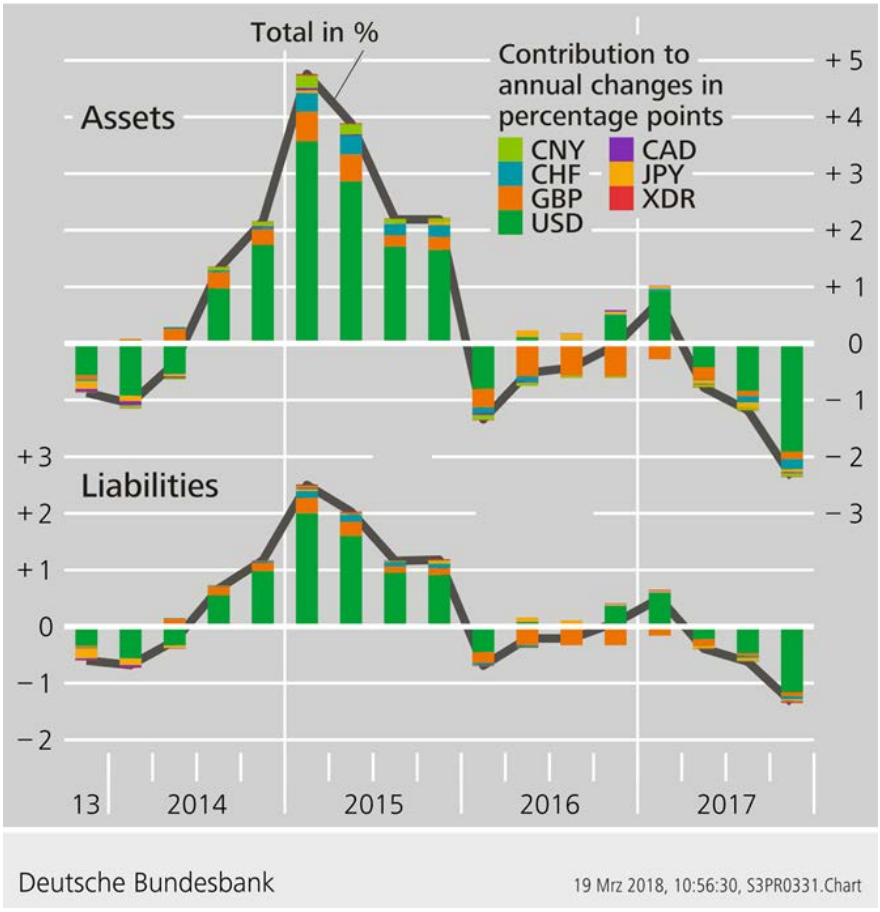


For aggregate gross positions, IIP-weighted effective exchange rates have been proposed and evaluated, in slightly different ways, by Lane and Shambough (2010) and Patel and Kearns (2016). At the Deutsche Bundesbank, in a joint effort by the General Statistics and External Statistics divisions, the IIE are being computed and stored, item by item, for the baseline combinations of sectors, instruments and currency denominations, as well as for many meaningful aggregates, ready for analytical use.

As an example, Graph 4 shows how the index of IIP-weighted exchange rate effects on the value of foreign shareholdings has evolved in both aggregated terms and disaggregated by sector. The top panel shows the IIE for aggregate holdings,

the panel below, the associated quarter-on-quarter changes by sector. One can readily observe the depressing effects of the euro appreciation in 2013 and the strong positive effect that the depreciation in 2014 had on the euro value of foreign shareholdings, and the deflating effect of the re-appreciation in 2017. The panel below shows that the brunt of the effects is borne not by MFIs but by other financial institutions and, to a lesser degree, by private households as well. This sort of information, facilitated by the breakdown of positions by currency and the calculations of exchange rate effects, can be of high analytical value for financial stability analysis.

Graph 5: Currency decomposition of IIE changes in percentage points
Total assets and liabilities



Graph 5 above decomposes the annual percentage change of IIE by currency, in percentage points. For liabilities, the total effects are clearly smaller, due to a lower share of positions denominated in foreign currencies, compared to assets. Concerning magnitudes, the dynamics are clearly dominated by the US dollar – the percentage change of the dollar's exchange rate is highly indicative of the total exchange rate effect.

It is instructive to see the absolute values behind this decomposition. The IIE year-on-year change of -2.4% on the asset side in Q4/2017 corresponds to an absolute decrease of € 207 bn, whereas the decrease of 1.3% on the liability side translates into € 84 bn in absolute terms!

5. Sensitivity and volatility of aggregates and specific positions

For financial stability purposes, it can be useful to calculate the sensitivity of aggregates or sub-categories to exchange rate changes.

5.1. Sensitivity-related results

As a starting point for quantitative analysis, we may be interested in the partial revaluation effect of a one-percentage-point change of a given currency, eg the US dollar, on the value of some or all asset or liability positions. This is the kind of question which proved to be highly relevant in the Latin American debt crisis of the early eighties or the Asian Crisis in the late nineties. For currency *n*, for example, the effect on η_t in percentage points is simply given by the vector w_{t-1}^{n} of weights for currency *n*, i.e. column *n* of the weighting matrix W_{t-1} in (1). As a sensitivity measure in absolute terms, we obtain – as a gradient with respect to relative changes in the rate of currency *n* – the *n*'th column of the composition matrix A_{t-1}:

$$\frac{\mathrm{da}}{\mathrm{d}\hat{E}_t^n} = \begin{pmatrix} a_{t-1}^1 \cdot w_{t-1}^{1n} \\ \vdots \\ a_{t-1}^K \cdot w_{t-1}^{Kn} \end{pmatrix} = \begin{pmatrix} a_{t-1}^{1n} \\ \vdots \\ a_{t-1}^{Kn} \end{pmatrix} = \mathrm{a}_{t-1}^n \ .$$

There is an interesting extension to this exercise. Exchange rate changes often do not happen in isolation. Changes for different currencies are typically highly correlated – for an illustration of this, see Graph 5. If one considers a hypothetical change of exchange rate *n* as a structural stochastic shock, one might be interested in how the values of IIP positions respond to an increase of exchange rate *n* by one standard deviation, additionally taking into account the correlation structure regarding the other currencies. Let Ω be the covariance matrix of the exchange rates of our analytical system – including the euro, entering with zeroes for the variance and all covariances:

$$\Omega = \mathrm{cov}\,\hat{\mathrm{E}}_t = \begin{pmatrix} 0 & 0 & \dots & 0 \\ 0 & \mathrm{var}\,\hat{E}_t^2 & \dots & \mathrm{cov}\left(\hat{E}_t^2, \hat{E}_t^K\right) \\ \vdots & \vdots & \ddots & \vdots \\ 0 & \mathrm{cov}\left(\hat{E}_t^2, \hat{E}_t^K\right) & \dots & \mathrm{var}\,\hat{E}_t^K \end{pmatrix} .$$

The estimated effect of a *one-standard-deviation shock* to currency *n* on the asset positions a_t in absolute values, taking into account the correlation structure, will then be:

$$\mathrm{s}\left(\mathrm{a}_{t-1}, E_t^n\right)_\Omega = \sqrt{\mathrm{a}_{t-1}^n \cdot \Omega \cdot 1(\mathrm{n})} \ ,$$

where $1(\mathrm{n})$ is a column vector that has 1 as its *n*'th element and zeroes elsewhere.

5.2. Volatility aspects

To understand the volatility induced in the IIP by exchange rate movements, it is straightforward to first consider the historical/ex post volatility of the IIE. Table 4 shows the volatility of portfolio investment assets, computed on the basis of Q4/2012 to Q4/2017 data.

Table 4: Std dev of portfolio investment assets: quarter-on-quarter changes of IIE

	All sectors	Banks	MM funds	Fin. corp. w/o MFIs	Gov	Others*
All instruments	0.6	0.9	0.1	0.8	1.7	0.4
Long-term debt securities	0.6	0.3	0.0	0.6	1.5	0.3
Short-term debt securities	0.8	1.2	3.3	0.8	0.0	0.6
Shares	2.0	1.5	0.0	2.0	0.0	2.4
Investment fund shares	0.6	0.9	0.1	0.8	1.7	0.4

*Non-financial corporations, households and non-profit institutions serving households

This volatility measure implicitly comprises the historic volatility both of exchange rates and the currency composition of assets. In a forward-looking type of analysis, it may be more interesting to consider the volatility of *IIP*, given the current structure of assets and liabilities. Consider any asset or liability position a_t^k. Let the row vector $\mathrm{g}_t^k{}'$ be the currency weights for this position – row *k* in the general weighting matrix in equation (1) – and η_t^k be the associated weighted exchange rate change. Then

$$\mathrm{std}\left(\eta_t^k\right) = \sqrt{\mathrm{var}\left(\mathrm{g}_{t-1}^k{}' \cdot \hat{E}_t\right)} = \sqrt{\mathrm{g}_{t-1}^k{}' \cdot \Omega \cdot \mathrm{g}_{t-1}^k}$$

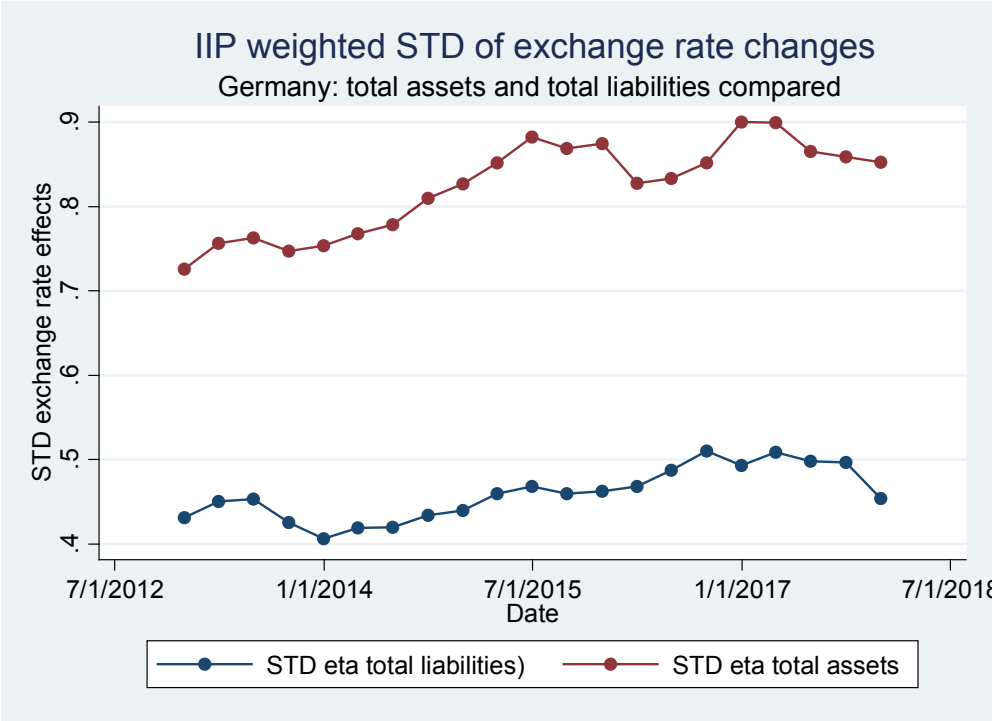
is the standard deviation of *IIE* for a_t^k on the basis of the current exchange rate composition and the correlation structure for exchange rates. The elements of Ω can be estimated on the basis of time series observation.

To also take into account the absolute value of the position, which may change quite strongly over time, we can instead consider the exchange-rate-induced standard deviation of position a_t^k:

$$\mathrm{std}\left(a_t^k \eta_t^k\right) = a_t^k \,\mathrm{std}\left(\eta_t^k\right) = a_t^k \sqrt{\mathrm{g}_{t-1}^k{}' \cdot \Omega \cdot \mathrm{g}_{t-1}^k} \qquad (2)$$

For the overall exchange-rate-induced variance in the German IIP, the massive increase in assets and – to a lesser degree – in liabilities denominated in foreign currencies will be an important driver.

Graph 6: Standard deviations of exchange-rate effects in percentage points. Total assets and total liabilities in Germany

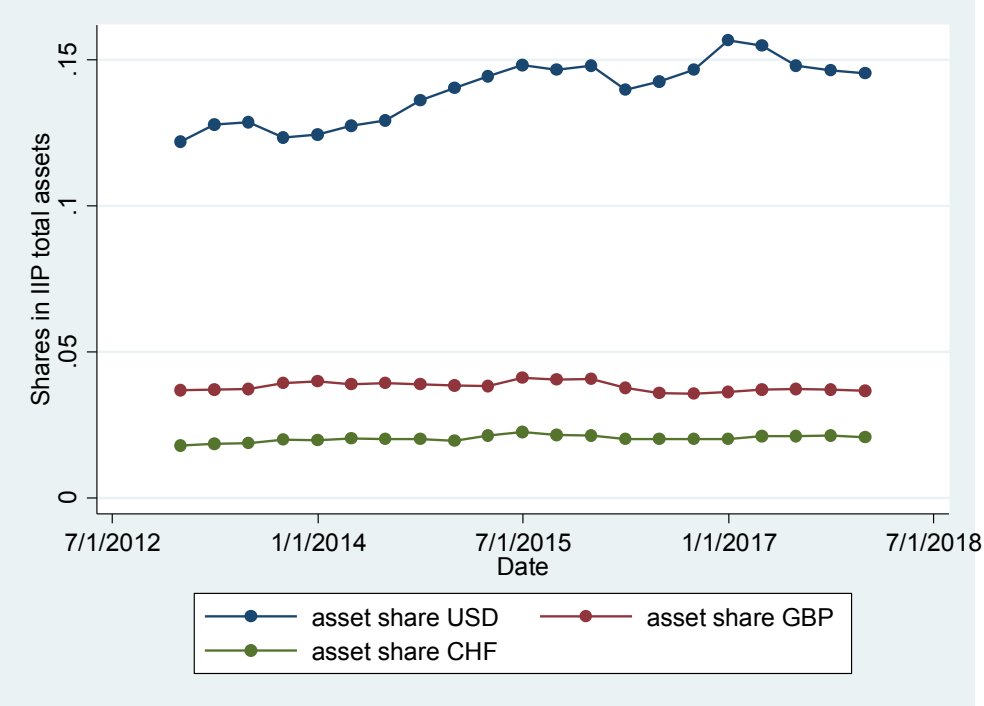


Let us now consider, as an example, the standard deviations for the η_t^k concerning total assets and liabilities. Graph 6 plots the standard deviations in percentage points for the five years between Q4/2012 and Q4/2017. The standard deviations have been calculated using the covariance matrix generated from the deviations of exchange rate indices in the time between Q4/2012 and Q1/2018. The value is given in percentage points: i.e. the quarterly standard deviation of total assets in Germany in Q4/2017 was 0.85 percentage point of its absolute value. Whereas the standard deviation for assets has increased noticeably, the standard deviation for total liabilities is lower and rather stationary.

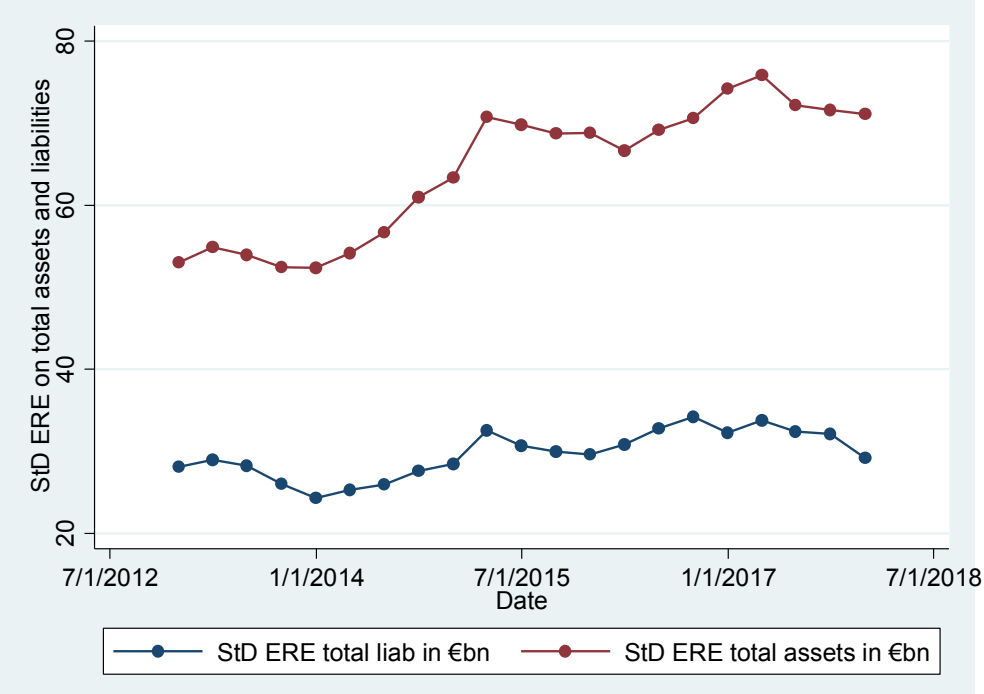
Graph 7 gives an explanation of why the standard deviation of assets has grown: the share of dollar assets increased over that time. While the standard deviation of exchange-rate-induced valuation changes does not seem to be impressive, Graph 8 shows how this translates into absolute values. The units are now shown in billions of euro. As both assets and liabilities have been increasing over this time, the rise in the standard deviations of absolute values is steeper than the increase of their etas.

Although these numbers are large in absolute terms, they are a more or less mechanical outcome for a large economy that is closely integrated into the worldwide financial system, both on the asset and the liability side. Of course, the standard deviation of Germany's net position (not shown) is much lower, and – as has already pointed out – we are not yet in a position to trace the important consequences of hedging activities.

Graph 7: Exchange rate weights in total assets in Germany.
The largest three: USD, GBP and CHF



Graph 8: Standard deviations of exchange rate effects for totals
Total assets and total liabilities in Germany



6. An outlook: IIP information and currency risk exposure

So far, we have been careful to avoid using the words "risk" and "exposure". The exchange rate effects η_t^k and the associated indices IIE^k are the result of a mechanical decomposition of the corresponding changes in IIP positions. By itself, they are not necessarily informative about the ultimate distribution of capital gains and losses.[12] The economic agents may be hedged (although this may be costly or incomplete), either by forward markets or derivatives or by holding natural hedges, such as FX gains from export business or being part of a multinational enterprise group. Derivatives are reported at market values among the IIP securities where they constitute a relationship with the outside world, but even then there is no additional information on whether the items are hedging exchange rate risk or something quite different, or whether they are in fact being used as speculative instruments to take on currency risk.

Thus, in order to construct indicators for currency risk exposure, one has to combine the information from the IIP with information on hedging activity. Let g^{*k}_t be the currency shares with respect to the unhedged portions of position a_t^k, not summing up to 1 but to the total unhedged position as a fraction of a_t^k. Corresponding to (2), a macro-statistical indicator for the wealth risk from currency exposure concerning IIP item a_t^k may be given by:

$$WR\left(a_t^k\right)\big|_{FX} = a_t^k \sqrt{g^{*k}{}_t' \cdot \Omega \cdot g^{*k}_t} \quad .$$

Finding useful representations of g^{*k}_t is easy in some cases. Households do not usually hold derivatives to hedge their currency risks. In this case, one may safely assume $g^{*k}_t = g^k_t$. Regarding direct investment activity, the currency risk activities could be hedged using revolving derivatives positions, but this is expensive, and given the many other sources of risk in direct investment, it is not likely to happen. Deposit taking institutions usually do not hold open foreign currency positions concerning their short-run credit or portfolio investment. In terms of statistical aggregates, these positions could be regarded as mostly hedged, and $g^{*k}_t = 0$.

For other combinations of sectors, functional categories and instruments, the relationship between wealth effects and exchange rate changes is less clear-cut. In these cases, one may interpret the $\mathrm{std}\left(a_t^k \eta_t^k\right)$ in (2) as being indicators for the need to hedge. Specific research is needed on the unhedged portion of the IIP position in question and, if possible, its currency composition. Two caveats are in order. First, the results will typically involve an element of educated guessing.[13] Second, if currency-related derivatives are traded between domestic residents, the aggregate

[12] Information on the currency composition of assets and liabilities has been repeatedly used to compute the "balance sheet effects" of exchange rate changes for a cross-section of countries, e.g. IMF Spillover Group (2015), Lane and Shambough (2010), and Bénetrix, Lane and Shambough (2015). This is perfectly legitimate and informative as long as one keeps in mind that an interpretation in terms of wealth effects and currency risk exposure needs additional information and assumptions regarding hedging activities.

[13] When considering the FX exposure of the corporate sector in emerging market economies and developing countries, the IMF Spillover Group summarily assumes that half of FX liabilities are hedged.

exposure will not change, though the resulting systemic risk may well diminish if the currency risk of diverse agents is netted out or the residual risk is borne by agents better able to deal with it. And derivatives contracts between residents and non-residents may both increase and diminish aggregate exposure.

A better understanding of the relationship between the exchange rate effects and sensitivity measures in the IIP on the one hand, and revaluation-induced wealth effects on the other, is the subject of ongoing research.

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Ninth IFC Conference on "Are post-crisis statistical initiatives completed?"

Basel, 30-31 August 2018

Exchange rate effects in the international investment position - methods, tools and applications for Germany[1]

Stephanus Arz, Stefan Hopp and Ulf von Kalckreuth,
Deutsche Bundesbank

[1] This presentation was prepared for the meeting. The views expressed are those of the authors and do not necessarily reflect the views of the BIS, the IFC or the central banks and other institutions represented at the meeting.

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Exchange Rate Effects in the IIP

Methods, Tools and Applications for Germany

Ulf von Kalckreuth, Principal Economist-Statistician, DG Statistics, Deutsche Bundesbank*

9th biennial IFC Conference “Are post-crisis statistical initiatives completed?”
BIS, Basel, 30-31 August 2018

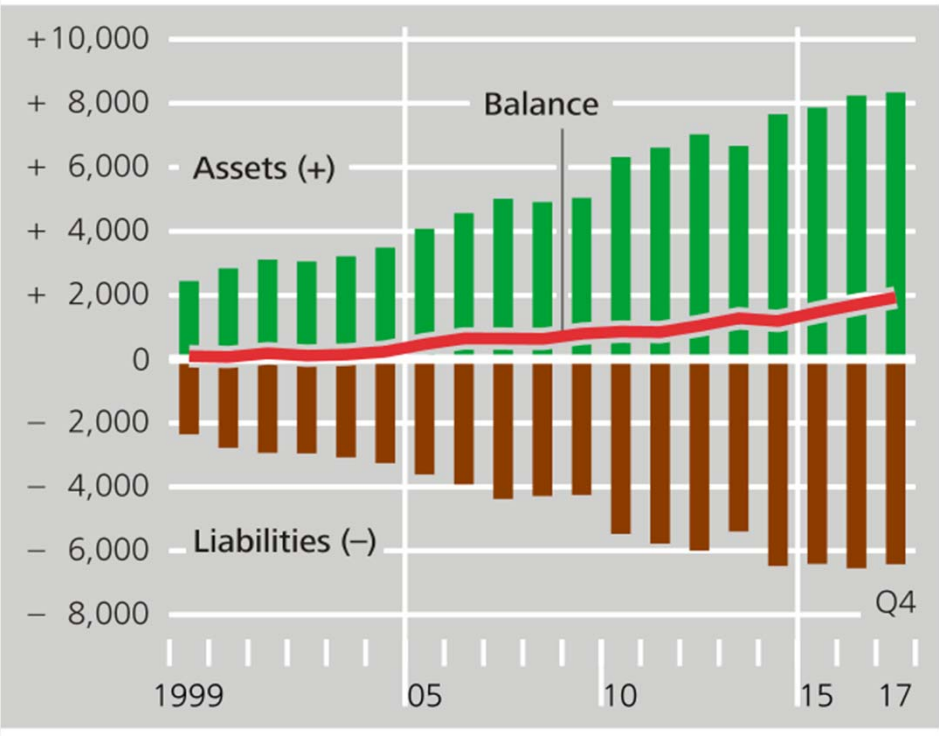
*The paper is joint work with Stephanus Arz and Stefan Hopp. It represents the authors' personal opinion and does not necessarily reflect the views of the Deutsche Bundesbank or the Eurosystem..

Outline

- Introduction: The significance of exchange rate fluctuations on the IIP for wealth and financial stability
- Basic concepts: the matrix of currency compositions
- An index of IIP weighted exchange-rate effects
- Sensitivity analysis
- Outlook: taking hedging into account

Introduction

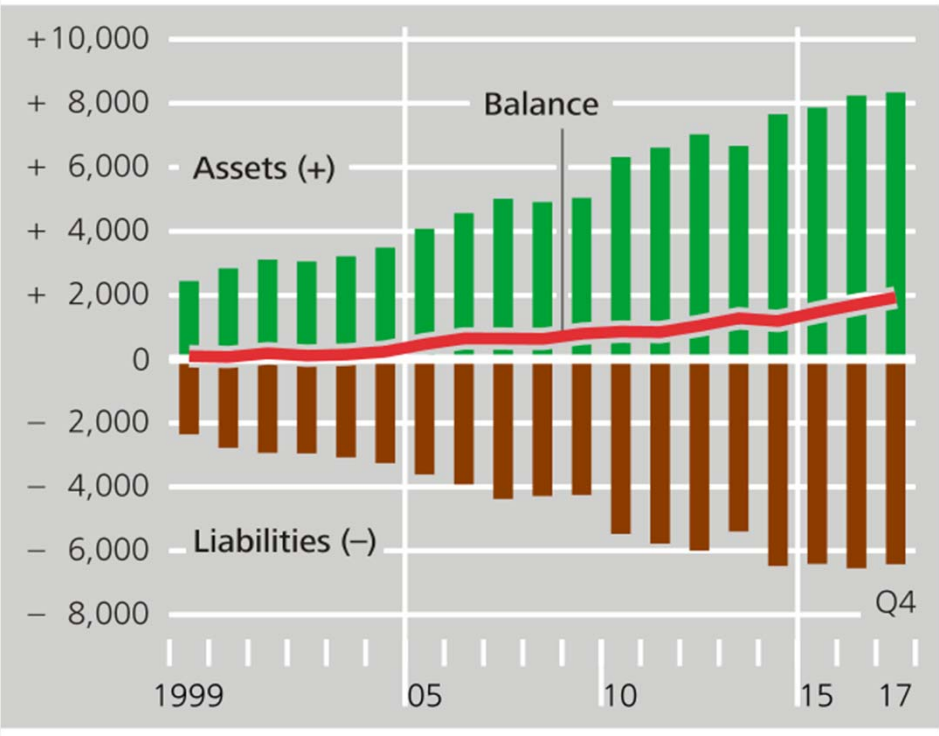
German IIP, all sectors, 1999 to end of 2017



The net external position of Germany has **increased from almost 20% to around 60% of GDP** in the years between 2007 and 2017. At the end of 2017, **external assets have reached a volume of € 8,346 bn** € and **external liabilities amount to € 6,417 bn €.**

Introduction

German IIP, all sectors, 1999 to end of 2017



A large share of IIP is denominated in foreign currencies: 34% of all assets and 20% of all liabilities – **net exposure is equivalent to € 1.5 trillion**, around 50% of GDP. For such a portfolio, even small exchange rate changes may have a high impact.

Introduction

- **National wealth** is **sum of real capital** plus **net foreign position**
- For wealth effects of exchange rate changes, IIP is the point of departure.
- Wealth effects on countries, sectors and individuals **depend on the currency composition of their portfolio**
- For investors holding **unhedged net positions** in a foreign currency, **exchange rate changes will directly affect net wealth.**
- **BPM6** asks for **breakdown** of changes of IIP positions into **transactions, revaluations** – exchange rate changes among them – and **other changes.**

- To identify effects of exchange rate changes, a **system of bookkeeping for currency denominations is needed** -- for each position, each instrument of each entity!

→ **Matrix of currency compositions needed!**

Basic concepts

Euro value of *N* currency positions in IIP stock *k*, the first being €

Exchange rate change for home currency, identically = 0

$$\mathrm{a}_t = \begin{pmatrix} a_t^1 \\ \vdots \\ a_t^K \end{pmatrix} \qquad \mathrm{A}_t = \begin{pmatrix} a_t^{11} & \cdots & a_t^{1N} \\ \vdots & \ddots & \vdots \\ a_t^{K1} & \cdots & a_t^{KN} \end{pmatrix} \qquad \hat{\mathrm{E}}_t = \begin{pmatrix} 0 \\ \Delta E_t^2 \,/\, E_{t-1}^2 \\ \vdots \\ \Delta E_t^N \,/\, E_{t-1}^N \end{pmatrix}$$

Vector of *K* different IIP stocks, in €

Matrix of currency compositions of stocks in a_t

Vector of exchange rate changes w.r. to €, for currencies 1 to *N*

Basic concepts

The **vector of exchange rate effects** is given by:

$$EE_t = \mathrm{A}_{t-1} \cdot \hat{\mathrm{E}}_t$$

Share of currency *N* in the Euro value of item 1

Consider the matrix of weights

$$\mathrm{G}_t = \begin{pmatrix} a_t^{11} / a_t^1 & \cdots & a_t^{1N} / a_t^1 \\ \vdots & \ddots & \vdots \\ a_t^{K1} / a_t^K & \cdots & a_t^{KN} / a_t^K \end{pmatrix}$$

and accordingly a **vector of IIP weighted exchange rate changes:**

$$\eta_t = \mathrm{G}_{t-1} \cdot \hat{\mathrm{E}}_t$$

Basic concepts

Formally, η_t is a **vector of growth rates.** One can look at it in two ways:

- By **weighting the exchange rate changes on the basis of IIP positions**, η_t "translates" these changes into effects on wealth stocks.
- Regarding the stocks, the elements of η_t denote the **relative changes of IIP positions** induced by exchange rate variations.

Absolute value of exchange rate effects can be **recovered** by simply **multiplying the weighted changes back into the stocks.**

An index of IIP weighted exchange rate effects

Chain-linking the growth factors associated with asset *k* while setting some base period equal to 100 yields an index for the capital gains and losses due to exchange rate changes in the respective IIP positions.

For any asset or liability position *k*, we obtain the **I**ndex of **I**IP-weighted **E**xchange rate effects:

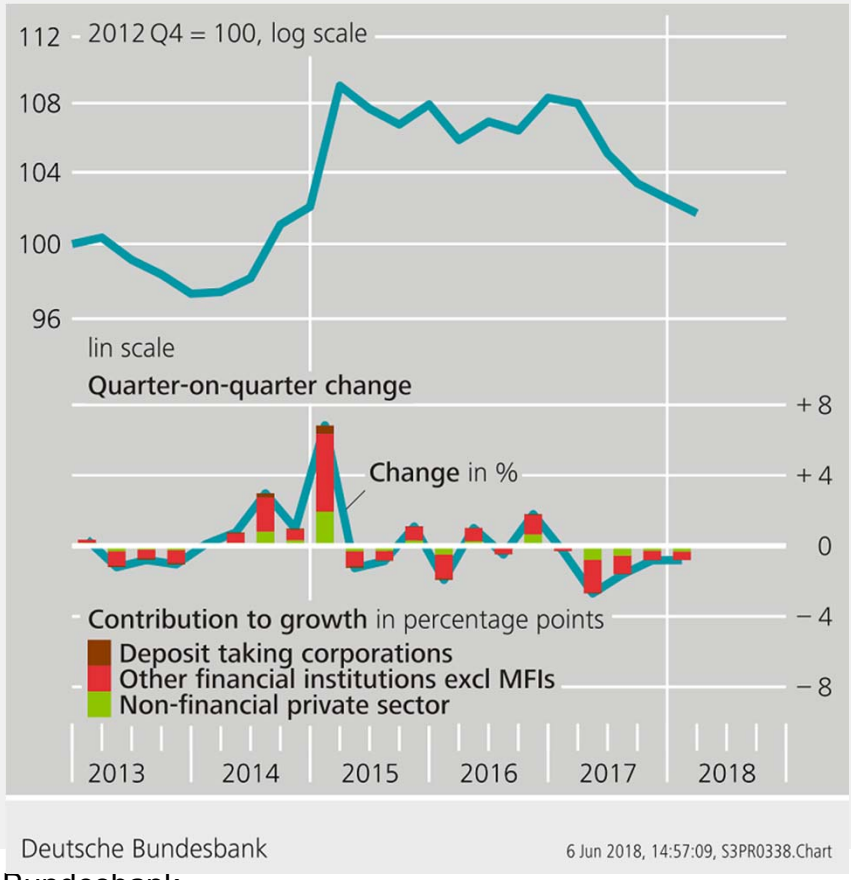
$$IIE_t^k = 100 \cdot \left(1+\mathfrak{n}_1^k\right) \cdot \left(1+\mathfrak{n}_2^k\right) \cdot \ldots \cdot \left(1+\mathfrak{n}_t^k\right) = IIE_{t-1}^k \cdot \left(1+\mathfrak{n}_t^k\right)$$

See Lane and Shambough (2010), Bénétrix, Lane and Shambough (2015) and Kearns and Patel (2016) for similarly constructed aggregate indices!

At the Bundesbank, as a service to analysts, the *IIE* are being computed and stored **for the baseline combinations of sectors, instruments and currency denominations, as well as for many meaningful aggregates!**

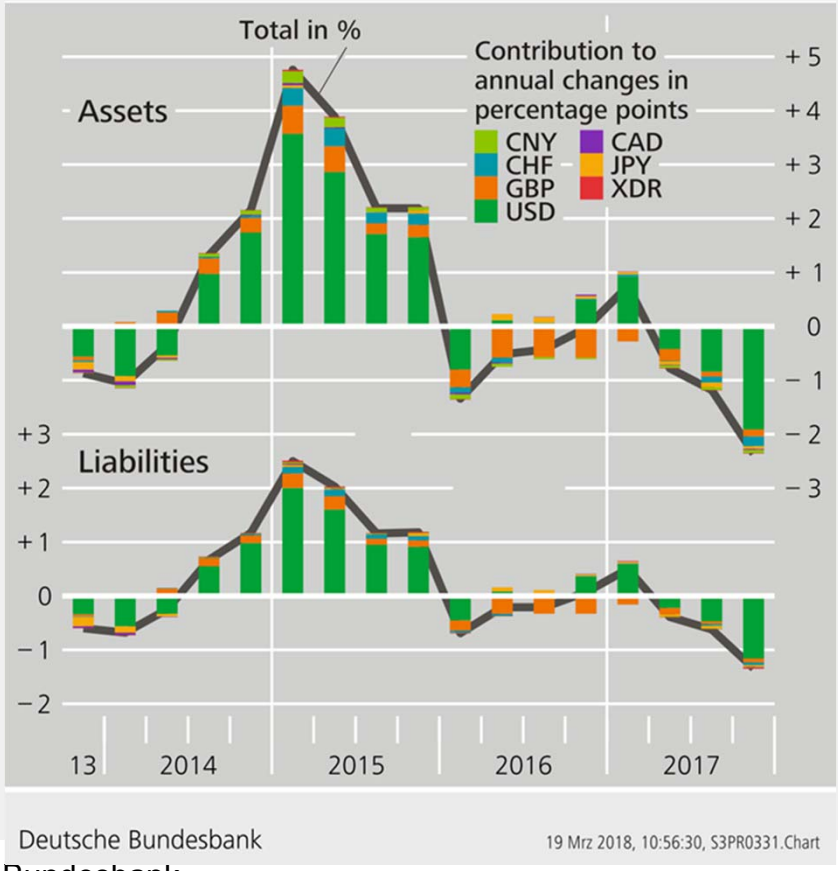
An index of IIP weighted exchange rate effects

IIE for shares in portfolio investment (asset side)



An index of IIP weighted exchange rate effects

Currency decomposition of IIE changes in percentage points
Total assets and liabilities



Sensitivity: ex post analysis

We may start by looking at time series **variability of IIP weighted exchange rate changes**, for certain asset positions or an aggregate portfolio, using historic currency compositions and ER-changes.

Std dev of portfolio inv. assets: q-on-q changes of IIE

	All sectors	Banks	MM funds	Fin. corp. w/o MFIs	Gov	Others*
All instruments	0.6	0.9	0.1	0.8	1.7	0.4
Long term debt securities	0.6	0.3	0.0	0.6	1.5	0.3
Short term debt securities	0.8	1.2	3.3	0.8	0.0	0.6
Shares	2.0	1.5	0.0	2.0	0.0	2.4
Investment fund shares	0.6	0.9	0.1	0.8	1.7	0.4

However, the currency compositions of asset or liability positions evolve over time, as does the covariance structure of exchange rate volatility.

Sensitivity: the effect of a 1 pp exchange-rate change

More informative to study **current IIP and currency composition.**

The effect of an isolated 1 percentage point change in currency *n*…

$$\frac{\mathrm{da}}{\mathrm{d}\hat{E}_t^n} = \begin{pmatrix} a_{t-1}^1 \cdot g_{t-1}^{1n} \\ \vdots \\ a_{t-1}^K \cdot g_{t-1}^{Kn} \end{pmatrix} = \begin{pmatrix} a_{t-1}^{1n} \\ \vdots \\ a_{t-1}^{Kn} \end{pmatrix} = \mathrm{a}_{t-1}^n$$

… is given by the respective **column of the currency composition matrix**

Sensitivity: considering correlation

However, exchange rate changes **do not happen in isolation.**

Covariance matrix of exchange-rate fluctuations:

Exchange rate change for home currency identically 0

$$\Omega = \operatorname{cov} \hat{\mathrm{E}}_t = \begin{pmatrix} 0 & 0 & \dots & 0 \\ 0 & \operatorname{var} \hat{E}_t^2 & \dots & \operatorname{cov}\left(\hat{E}_t^2, \hat{E}_t^K\right) \\ \vdots & \vdots & \ddots & \vdots \\ 0 & \operatorname{cov}\left(\hat{E}_t^2, \hat{E}_t^K\right) & \dots & \operatorname{var} \hat{E}_t^K \end{pmatrix}$$

We obtain

$$\left.\frac{\mathrm{da}}{\mathrm{d}\hat{E}_t^n}\right|_{\Omega} = \sqrt{\mathrm{a}_{t-1}^n \cdot \Omega \cdot 1(\mathrm{n})}$$

as the effect of a one standard deviations shock to currency n on the asset positions in absolute values, taking into account the correlation structure.

Sensitivity: standard deviation for rates of change

Total volatility given **current currency composition** and **current covariance structure** of exchange rate changes

Std. dev. of asset or liability position *k* resulting from ER volatility:

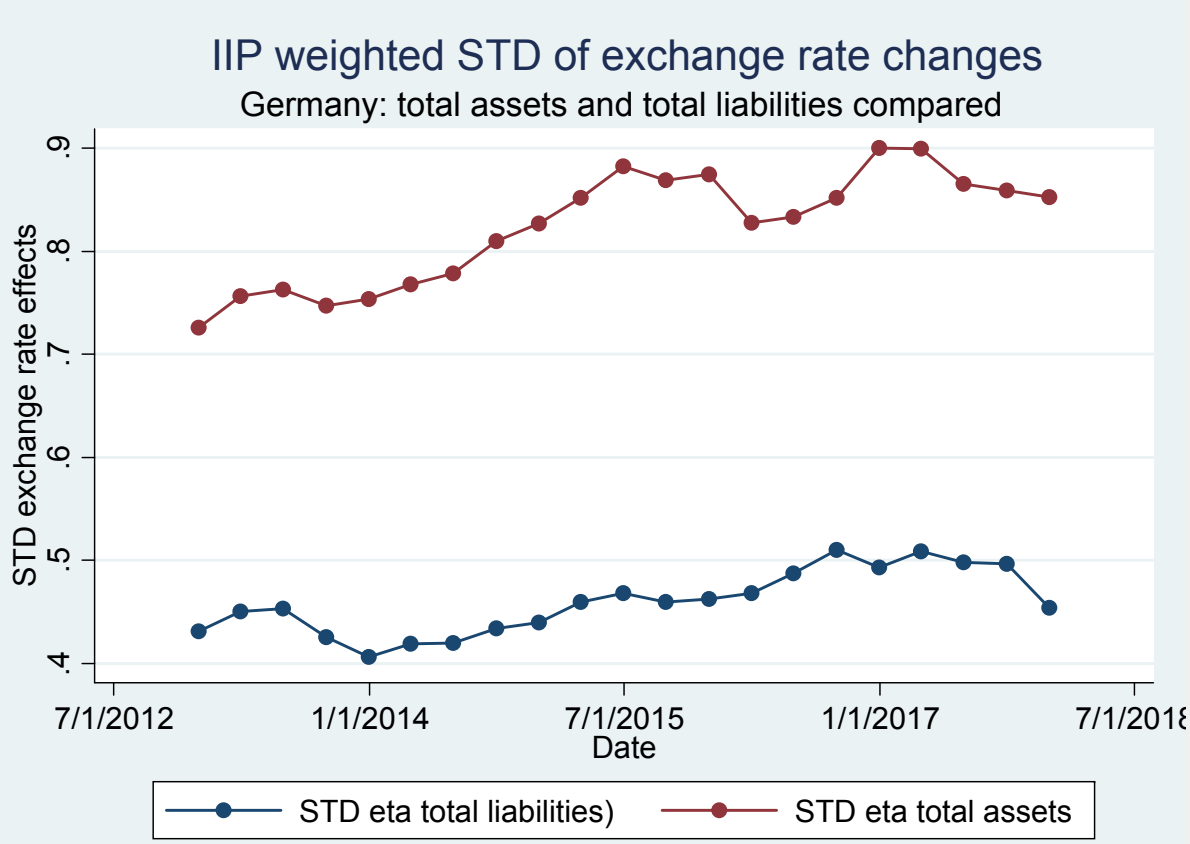
$$\operatorname{std}\left(\eta_t^k\right) = \sqrt{\operatorname{var}\left(g_t^{k\,\prime} \cdot \hat{E}_t\right)} = \sqrt{g_t^{k\,\prime} \cdot \Omega \cdot g_t^k}$$

Exchange-rate induced r.o.c. in IIP position *k*

Currency weights for IIP position *k*

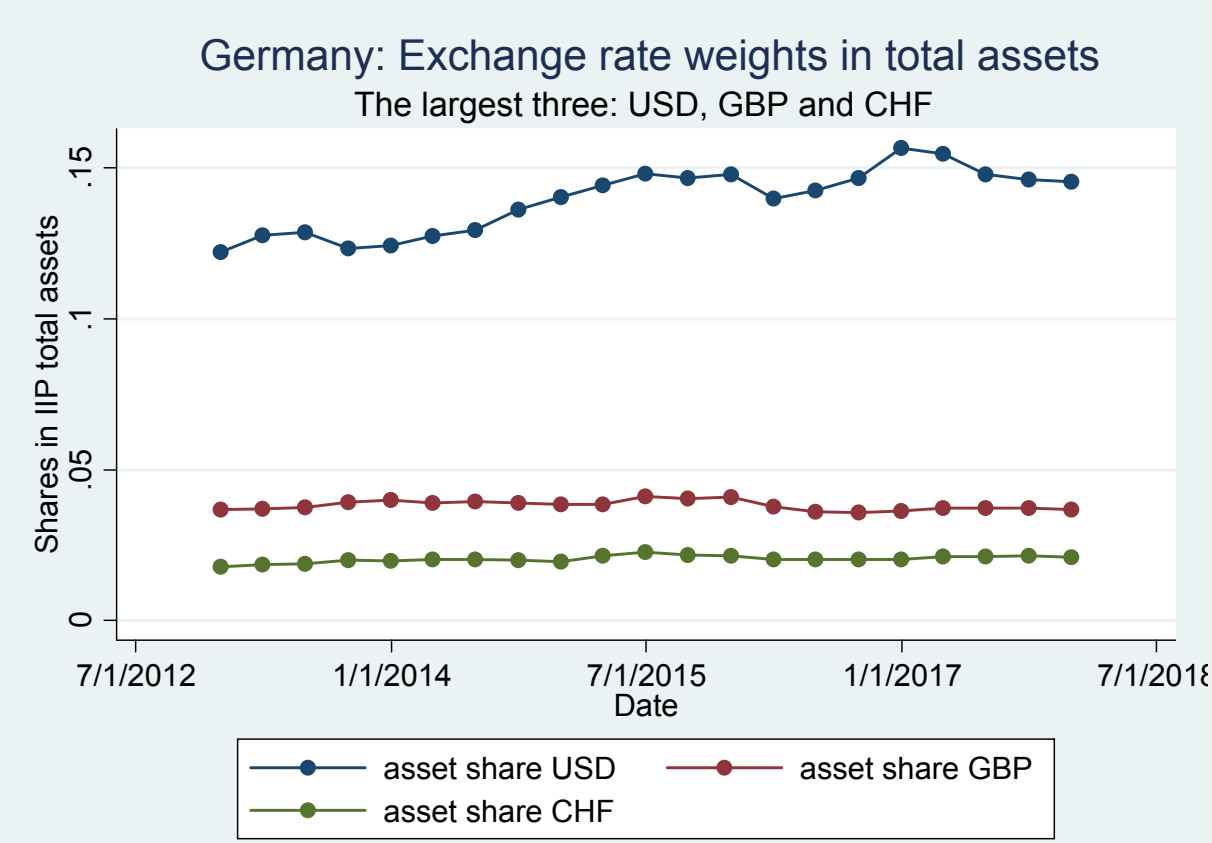
Sensitivity: standard deviation for rates of change

Growing exchange rate sensitivity of total assets…



Sensitivity: standard deviation for rates of change

… due to rising share of US Dollar



Sensitivity: standard deviation for absolute changes

Looking at absolute values

The **absolute value** of position *k* may be changing quite strongly over time.
→ look at the **scaled standard deviation:**

$$\mathrm{std}\left(a_t^k \eta_t^k\right) = a_t^k \,\mathrm{std}\left(\eta_t^k\right) = a_t^k \sqrt{\mathrm{g}_t^{k\,\prime} \cdot \Omega \cdot \mathrm{g}_t^k}$$

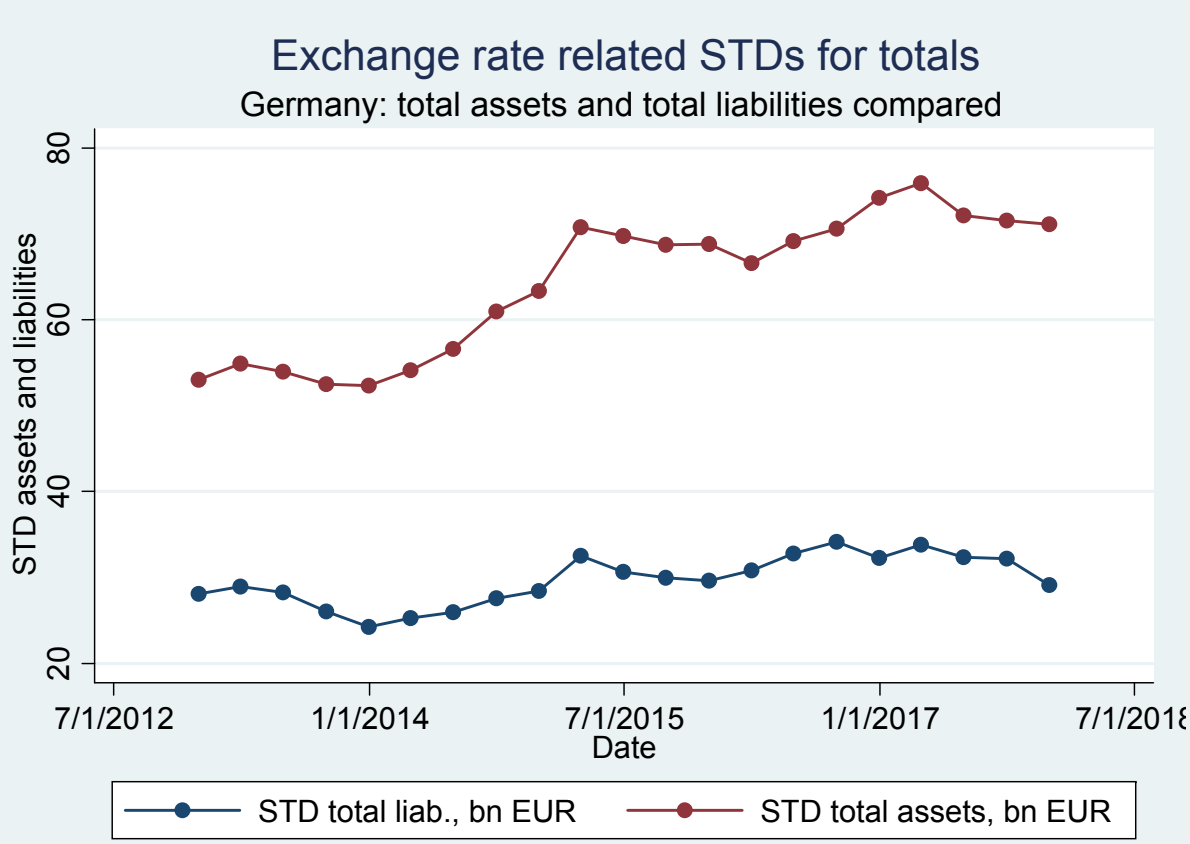
Absolute value of change in IIP position *k*

Currency weights for IIP position *k*

This is a **measure for potential currency risk** in position *k*

Sensitivity: standard deviation for absolute changes

Strongly increasing volatility of total assets



Outlook: taking hedging into account

Taking hedging into account – a way towards useful macro-statistical risk measures?

Part of IIP positions are hedged (forward contracts, derivatives or holding counter positions within the group). No direct information in IIP!

If there is exogenous information on hedging, we may construct **modified weights g*** to be used instead of g**:**

$$WR\left(a_t^k\right)\Big|_{FX} = a_t^k \sqrt{g^{*k\prime}_t \cdot \Omega \cdot g^{*k}_t}$$

Std dev of exchange rate induced changes in unhedged part of IIP position *k*

Currency weights of **unhedged assets or liabilities** in IIP position *k*

Outlook: taking hedging into account

This may **delineate the path** towards **operational macro-statistical risk measures** of foreign currency exposure associated with IIP.

But:

- Empirical values for g* are not to be had without estimates and approximations.
- Derivative contracts between agents that are both domestic residents will not reduce the aggregate exposure of the country – although it can still reduce systemic risk if currency risk in different positions is annihilated or ultimately rests with agents that are able to deal with it.
- Trading in derivatives with non-residents may increase or reduce aggregate open positions, thereby affecting aggregate exposure outside the IIP.

A better understanding of sectoral hedging activities is needed.

This is the end…

Thank you!