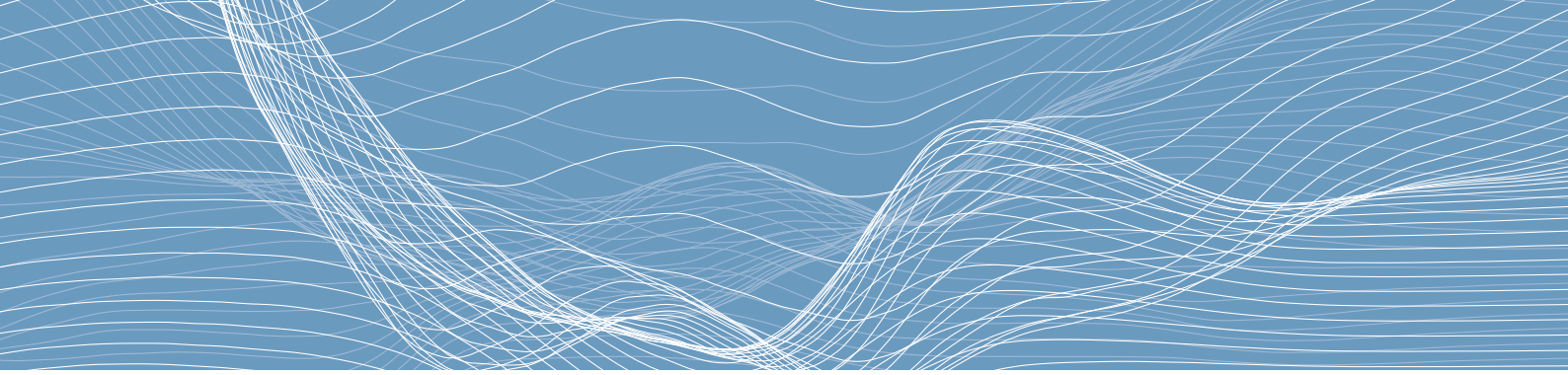

The new SNB exchange rate index

Robert Müller

SNB Economic Studies

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Abstract

The Swiss National Bank (SNB) is putting its calculated and published exchange rate indices on a new footing. This article describes the construction elements of the SNB's new exchange rate index, and presents the results of the new index calculation. The key aspects of the revision are: the application of the weighting method used by the IMF, which takes into account so-called third-market effects; continuous updating of the countries incorporated into the index; and calculation of a chained index. The methodological changes in the calculation of the new index have only a slight effect on the development of the nominal index. However, the difference between the nominal and real index (CPI-based) has increased with the new calculation. This is explained by the fact that countries with a greater weighting in the new index have higher average rates of inflation than those whose weighting has been reduced.

JEL classification: F31
Key words: Effective exchange rate index, weighting schemes, chained index

1. Introduction

Effective exchange rate indices serve as an indicator of the price competitiveness of a country. They are calculated on the basis of bilateral exchange rates, information on trade flows, and – in the case of real indices – information on price developments. The Swiss National Bank (SNB) has decided to put the exchange rate indices it publishes on a new footing, taking into account the improved data situation and the resulting new calculation methods. Here it is relying on methods that apply internationally and are viewed as the standard in the calculation of exchange rate indices. Where implementation is concerned, the SNB has sought to design the index in such a way that it is transparent and robust with regard to methodology and data sources, and can be calculated on a daily basis.

Three elements are relevant in the calculation of effective exchange rate indices:

1. The countries taken into account in the index together with the corresponding bilateral exchange rate indices.
2. The weighting method, i.e. how the bilateral exchange rate indices are weighted.
3. The index formula applied.

In the calculation of real exchange rate indices, the choice of deflators is another relevant aspect. Deflators are used to adjust the underlying nominal bilateral indices for relative price developments.

The effective exchange rate index calculated and published by the SNB up until now has encompassed a fixed group of countries. The weighting of the bilateral exchange rate indices has been done on the basis of export flows, while the Törnqvist index has been used as the index formula. Finally, in the calculation of the real effective exchange rate index, the consumer price index has been used as the deflator.

The new effective exchange rate index encompasses a group of countries that is updated on an ongoing basis. A key element in the revision is the application of an improved weighting method: the approach now adopted is that of the International Monetary Fund (IMF). This involves taking into consideration not just export flows, but also import flows and so-called third-market effects. In addition to the trading of goods, the trading of services is now also included when calculating the weightings. Furthermore, a ‘chained’ Törnqvist index is now used. Finally, in addition to consumer prices (in the form of CPIs), producer prices (in the form of PPIs) are now used as a deflator for calculating the real effective exchange rate indices. Table 1 provides an overview of the characteristics of the old and new effective exchange rate indices. The new exchange rate index will be published on the SNB’s data portal.

This article is broken down as follows. Section 2 contains a detailed description of the methodology and presents the results in brief. Section 3 compares the results of the new index with those of the indices calculated by the IMF and BIS, and shows how the methodological changes impact on the results.

Table 1: Comparison of old and new indices

	Old index	New index
Index formula		
Method	Törnqvist	Törnqvist
Chaining	No	Yes
Reference period (monthly index)	1999.01	2000.12
Available since:		
• Nominal index	1973.01	1973.01
• Real CPI	1973.01	1973.01
• Real PPI	–	1982.01
Available frequencies	Monthly, quarterly, yearly	Daily on working days, monthly, quarterly, yearly
Weighting method		
Update frequency	Updated annually	Updated annually
Method	Export-based	Import, export, and third-market-based (IMF approach)
Data considered	Goods exports	Goods and services exports and imports, as well as GDP data
Group of countries	Fixed (40 countries); until 1999: fixed (15 countries)	From 2000 variable (threshold: 0.2% imports or exports); until 1999: fixed (15 countries)
	Member states of euro currency area as per 1999; until 1999: fixed (8 countries)	Retrospectively 19 member states of euro currency area as per current point in time; until 1999: fixed (8 countries)
Deflators for bilateral indices	Consumer prices	Consumer and producer prices

2. Methodology of the new effective exchange rate index

The calculation of a nominal or real effective exchange rate index is based on the following three construction elements: the bilateral exchange rate indices (nominal or real) of the countries included in the index, the weighting method for amalgamating these bilateral indices, and the index formula applied. The following subsections describe these construction elements and present the results of the calculations.

2.1 Bilateral exchange rate indices

2.1.1 Nominal and real bilateral indices

A nominal bilateral exchange rate index represents the exchange relationship between the currency of a trading partner and the Swiss franc, with the price of the Swiss franc being expressed in units of the trading partner's currency. If this latter value rises, the Swiss franc appreciates. Due to the way the index is constructed, its movement over time – unlike a simple illustration of the exchange rate level – is shown against a base period. The index is based on the quotients of exchange rates of (current) reporting periods and the exchange rate at a fixed point in time (base period).

For the real bilateral exchange rate index of the Swiss franc against a trading partner, the nominal bilateral index is adjusted (deflated) to take account of price developments in the partner country and Switzerland. Here the deflator is defined by the ratio of the price index of the trading partner to Switzerland's price index. Under this definition, the real external value of the Swiss franc against a trading partner's currency rises if there is an increase in the value of the real bilateral index of the Swiss franc with respect to the trading partner in question. If the index falls, this means a real decline in the value of the Swiss franc.

2.1.2 Choice of deflators

The SNB calculates real bilateral exchange rate indices on the basis of both consumer price indices (CPIs) and producer price indices (PPIs). A CPI captures price developments in respect of goods and services consumed by private households. By contrast, a PPI measures price developments in domestic production at a product's first level of commercialisation, i.e. for producer sales ('ex-works prices').

The choice of deflators depends above all on the availability and international comparability of price indices. International institutions such as the IMF and the Bank for International Settlements (BIS) for the most part calculate real effective exchange rate indices on the basis of consumer prices. The CPI has the advantage of being internationally harmonised to a significant degree, and also available promptly in most cases. However, it will also include a significant proportion of goods and services that are either not traded or hardly traded internationally (e.g. those relating to living, energy, healthcare). Moreover, the CPI does not take into account capital goods. While the PPI does capture capital goods, it is only comparable internationally to a limited extent, as the underlying basket of goods is heavily determined by country-specific production structures, and in Switzerland in particular includes only a limited product group primarily relating to the manufacturing sector. Moreover, it is only available with a time lag. These advantages and disadvantages need to be weighed up when using a real exchange rate index.

2.1.3 Seasonal adjustments and deflator forecasting

Price indices are subject to seasonal fluctuations. As these can differ from country to country, the seasonal components of the consumer and producer prices of the individual countries are stripped out. This process of seasonal adjustment ensures that the real bilateral exchange rate index does not change on the basis of country-specific seasonal effects alone.

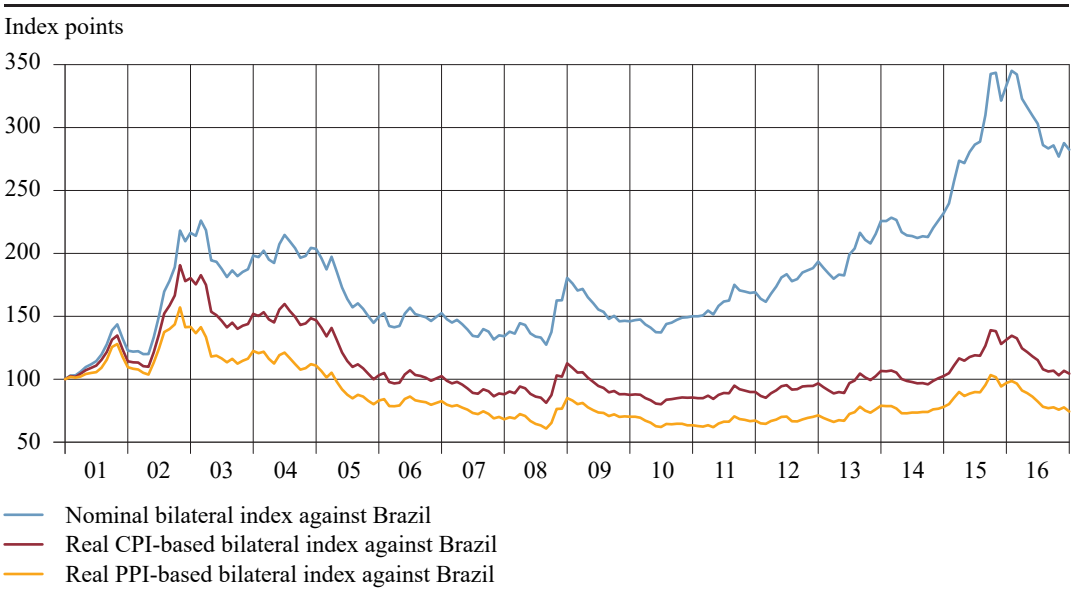
Price indices are not always up to date in all countries. The PPI in particular can be subject to a time lag of several months in some countries. For this reason, forecast values are used for the missing data, calculated on the basis of specific time series analysis models. As soon as definitive figures are available, the corresponding bilateral real indices are revised.

2.1.4 Comparison of nominal and real bilateral exchange rate indices

The course of nominal and real exchange rate indices can deviate considerably from one another. The key factor here is relative price developments in different countries. A good example of this can be found by comparing Switzerland with Brazil. In 2002, the Brazilian real depreciated significantly, and inflation picked up. However, the PPI increased more sharply than the CPI, as due to administrative regulations (among other things), the prices of consumer goods and services are often more rigid and therefore slower to adjust to a new currency environment.

Chart 1 shows the development of the nominal and real bilateral exchange rate indices of the Swiss franc against the Brazilian real. The much lower values of the two real indices compared to the nominal index are attributable to the significantly higher rates of inflation that prevailed in Brazil – compared to Switzerland – at that time. Furthermore, from 2002 onwards the index based on the PPI has a lower value than that based on the CPI. Unlike in Switzerland, the difference between the PPI-based rate of price increases (sharp rise) and the CPI-based rate was very pronounced in Brazil during that era. Accordingly, the real PPI-based bilateral index of the Swiss franc rose less strongly than the CPI-based equivalent.

Chart 1: Nominal and real bilateral indices of Swiss Franc against Brazil
Monthly basis; December 2000 = 100



Source: SNB

2.2 Weighting: method and group of countries

Effective exchange rate indices are calculated by weighting the bilateral exchange rate indices with effect to trading partners in keeping with their significance for the Swiss economy. A large number of weighting methods are described in academic literature relating to effective exchange rate indices. In this context the following questions arise:

1. How is the significance of countries measured and incorporated into the weighting (weighting method)?

2. What countries are relevant for weighting purposes (group of countries)?

The two following subsections explore these points in greater detail.

2.2.1 IMF weighting method

The new effective exchange rate index is calculated using the IMF weighting method,[1] which draws on the theoretical preparatory work undertaken by Armington (1969). In annex I ('IMF weighting method'), the calculation of the country weightings is illustrated using a three-country example.

The Armington model assumes a standardised goods item for which each country produces their own country-specific variant. This country-specific variant is offered in all country markets (including the domestic market) and can to a certain extent be substituted by the equivalent products of other countries. With elastic demand functions, the proportion of overall demand accounted for by the domestically produced product depends on the relative price of this product. The lower the relative price of the domestically produced product, the higher its share of overall demand. This demand then results in the corresponding imports and exports, as well as sales in the domestic market.

The Armington model is implemented in the IMF weighting method. Here a distinction is made between three competitive relationships in which domestic suppliers find themselves:

1. Competition with foreign suppliers in the Swiss domestic market (import competition).
2. Competition with foreign suppliers in those suppliers' domestic markets (bilateral export competition).
3. Competition with foreign suppliers in third markets (export competition in third markets).

Third markets are deemed to comprise all markets other than the Swiss domestic market and the domestic market of the partner country. Compared to a purely bilateral export weighting – such as that underlying the effective exchange rate index currently published by the SNB – the IMF weighting method has the advantage that the effective exchange rate index calculated on this basis provides a more comprehensive reflection of the forms of competition that are relevant to Swiss suppliers. However, the calculation of the corresponding weightings requires a much greater set of data. Whereas only Swiss export data are needed for the pure export weighting, the calculation of the IMF weightings requires export data, import data, and output data for all trading partners (cf. annex II 'Implementing the IMF weighting method').

The elements of the IMF weighting method can be illustrated using the example of the Netherlands as a competitor country. Swiss producers compete with Dutch exporters in the Swiss domestic market (import competition), while Swiss exporters compete with Dutch producers in the latter's domestic market (bilateral export competition). However, Dutch and Swiss producers compete with one another not just in their own markets, but also in all other third markets to which they export, e.g. Germany and France (export competition in third markets).

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1 The formal derivation of the weightings can be found in the IMF working papers by McGuirk (1986), and Zanello and Desruelle (1997).

With the IMF weighting method, these competitive relationships are described formally. Thus, the weighting assigned to a trading partner *j* of Switzerland is expressed in the following form (cf. also annex I):

$$W_{CH,j} = \lambda_{CH}^{M} MW_{CH,j} + \lambda_{CH}^{BX} BXW_{CH,j} + \lambda_{CH}^{TX} TXW_{CH,j} \quad (1)$$

Here $W_{CH,j}$ describes the weighting of the trading partner *j* used for the index. The term $\lambda_{CH}^{M} MW_{CH,j}$ indicates the import competition, $\lambda_{CH}^{BX} BXW_{CH,j}$ the bilateral export competition, and $\lambda_{CH}^{TX} TXW_{CH,j}$ the export competition in third markets. $MW_{CH,j}$, $BXW_{CH,j}$ and $TXW_{CH,j}$ reflect the relative importance of the corresponding competitive relationships with the trading partner *j* in comparison to the importance of these relationships with the other trading partners. The sum of $MW_{CH,j}$ for all trading partners *j* amounts to one. The sum of $BXW_{CH,j}$ and the sum of $TXW_{CH,j}$ for all trading partners *j* amounts to one in each case. The structural parameters λ_{CH}^{M}, λ_{CH}^{BX} and λ_{CH}^{TX} describe the relative weighting of the corresponding competitive relationships, i.e. they place the importance of the three competitive relationships to Switzerland overall in proportion to one another. They are fixed across all countries. In order for the sum of all $W_{CH,j}$ to result in one, the sum of λ_{CH}^{M}, λ_{CH}^{BX} and λ_{CH}^{TX} must likewise amount to one.

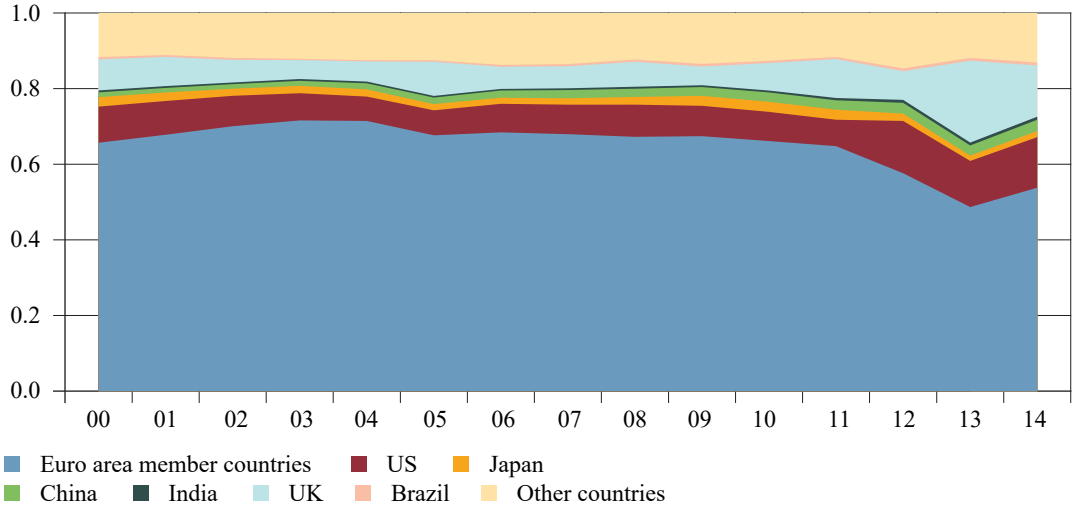
The individual components are described in greater detail below.

Import competition

The weighting $\lambda_{CH}^{M} MW_{CH,j}$ describes import competition and reflects the competition that Swiss products face from imports of the partner country *j*. The significance of a trading partner as a competitor in the Swiss domestic market increases in proportion to its share of overall sales in the Swiss market as well as to the share of Swiss output sold in the domestic market.

Chart 2 shows the development in country weightings of the component $MW_{CH,j}$ within import competition since 2000. The strong rise in the weighting of the United Kingdom (UK) in 2013 and subsequent decline in the following year are attributable to significant fluctuations in the import of precious metals.

Chart 2: Import competition



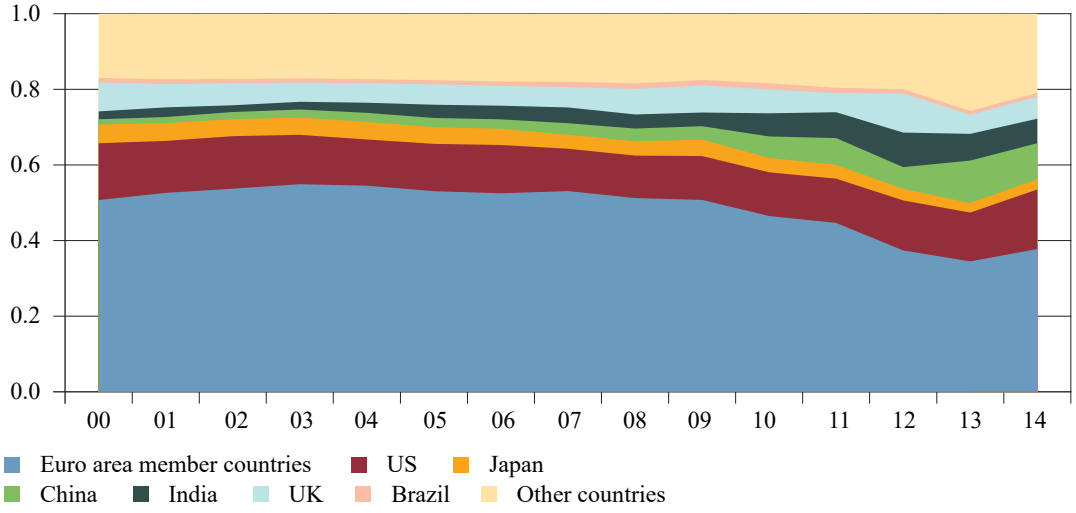
Source: SNB

Bilateral export competition

The weighting $\lambda_{CH}^{BX} BXW_{CH,j}$ reflects bilateral export competition and illustrates the degree of competition faced by Swiss suppliers in the domestic market of the partner country *j*. Two factors influence the intensity of bilateral export competition: the significance of the country for Swiss exports and the extent to which the economy of this partner country is closed. The former is captured through the proportion of output produced in Switzerland that is exported to the domestic market of the partner country, the latter through the market share of goods and services produced in the partner country as a proportion of overall sales (including imports from all other countries) in the domestic market of the partner country. The higher the second ratio, the more closed the economy. The higher the two factors, the more intense the competition faced by Swiss exporters from domestic suppliers in this market.

Chart 3 illustrates the development of the bilateral export component $BXW_{CH,j}$ since 2000.

Chart 3: Bilateral export competition



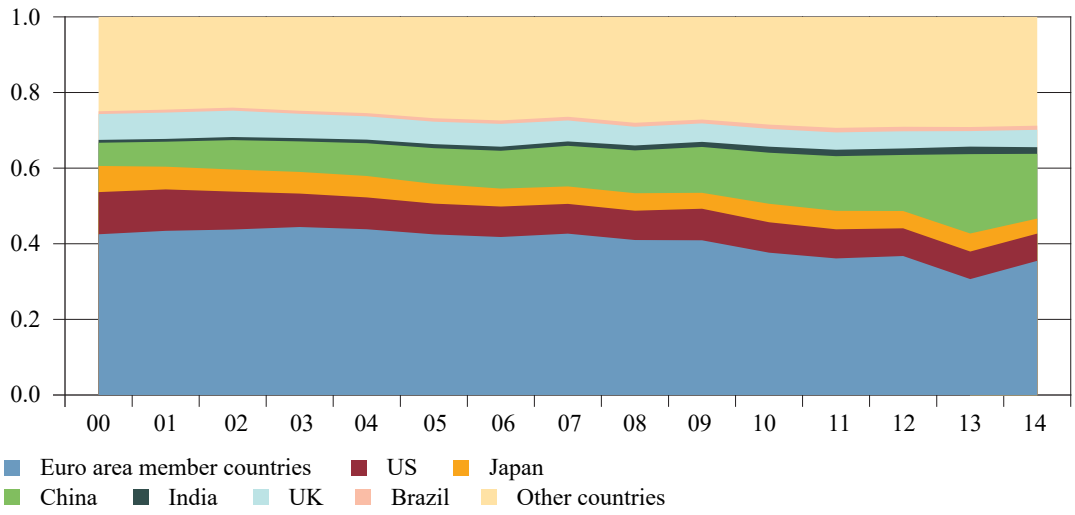
Source: SNB

Export competition in third markets

The weighting $\lambda_{CH}^{TX} TXW_{CH,j}$ reflects Switzerland's competitive relationships with the trading partner *j* in third markets. As explained in the previous subsection, bilateral export competition is particularly pronounced if the economy of the partner country is fairly closed. This competition tends to be less intense if the partner country in question has an open economy. By contrast, the competitive situation in third markets can be significant if the partner country is present in these markets (significant market share) and these third markets are also significant for Switzerland as export markets. To return to the example of the Netherlands as Switzerland's trading partner: the competition between the Netherlands and Switzerland is not very pronounced in the two countries' respective domestic markets. By contrast, the Netherlands and Switzerland have a more competitive relationship in the German market, as Germany is an important export market for Switzerland, and the Netherlands' share of the overall German market is not inconsiderable.

Chart 4 illustrates the movement in the country weightings $TXW_{CH,j}$ of export competition in third markets. The significance of other countries is greater for third-market weightings than it is for bilateral export weightings, as the group encompassed by the term 'other countries' is often made up of small open economies.

Chart 4: Export competition in third markets



Source: SNB

Significance of structural parameters

The structural parameters λ_{CH}^{M}, λ_{CH}^{BX} and λ_{CH}^{TX} in equation (1) place the relative importance of the three competitive relationships for Switzerland in relation to one another. λ_{CH}^{M}, λ_{CH}^{BX} and λ_{CH}^{TX} weight the three competitive weightings $MW_{CH,j}$, $BXW_{CH,j}$ and $TXW_{CH,j}$ of the individual countries so that the sum of the IMF country weightings is normalised to one.

λ_{CH}^{M} measures the relative importance of competition between domestically produced products and imports from the rest of the world in the Swiss domestic market (import competition). The higher the share of Swiss output accounted for by goods and services produced in Switzerland for the domestic market (and/or the higher the share of import goods and services in total sales in the Swiss domestic market), the greater λ_{CH}^{M}. The share of import goods in total sales in the domestic market can be interpreted as an indicator of the Swiss market's openness to foreign producers. The competitive pressure on Swiss producers increases with the opening up of the domestic market. This is particularly true if the domestic market is a significant market for Swiss suppliers.

λ_{CH}^{BX} measures the relative significance of competition between products of Swiss suppliers and products of suppliers from the rest of the world in the latter's domestic markets. Accordingly, λ_{CH}^{BX} is a measure of the relevance of bilateral export competition. This increases with the size of the export share of the Swiss economy and with the general level of the market shares of competitors in their own domestic markets. This parameter tends to become more pronounced as the general degree of closure of trading partners' economies increases.

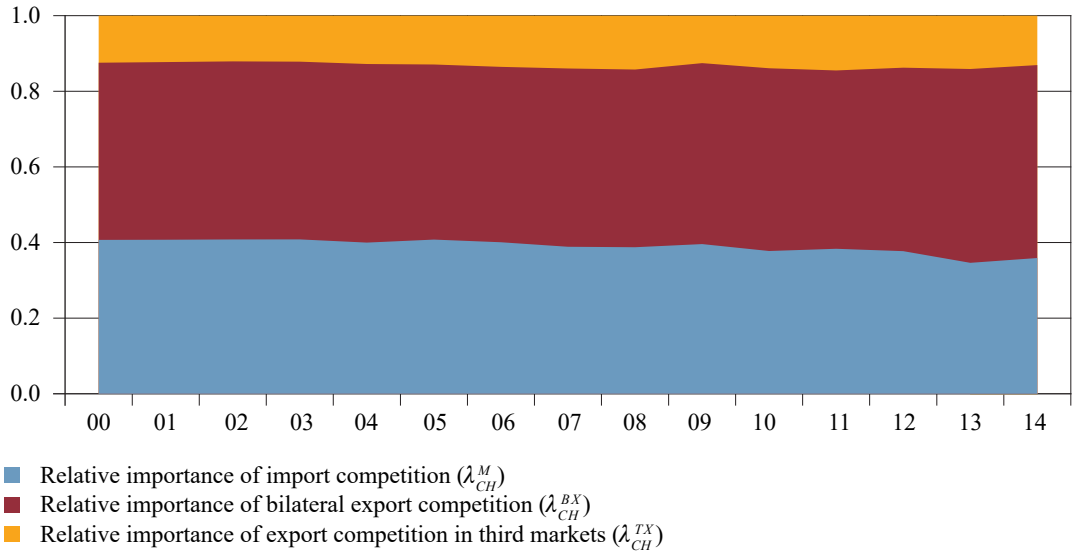
λ_{CH}^{TX} measures the relative significance of competition in third markets between products of Swiss suppliers and products of suppliers from the rest of the world. Accordingly, λ_{CH}^{TX} is a measure of the relevance of the export competition in third markets.

The component of export competition in third markets tends to increase in significance with the increasing market shares of foreign suppliers in the individual domestic markets (e.g. as a result of the international opening-up of markets). At the same time, the significance of bilateral export competition (λ_{CH}^{BX}) shrinks, as trade increases due to markets opening up and the degree to which economies are closed diminishes.

Chart 5 shows that the structure parameters λ_{CH}^{M}, λ_{CH}^{BX} and λ_{CH}^{TX} have barely changed since the year 2000. The average share of the third-market competition component from 2000 onwards amounts to some 13 %. Bilateral competitive relationships have a much greater significance for the Swiss economy.

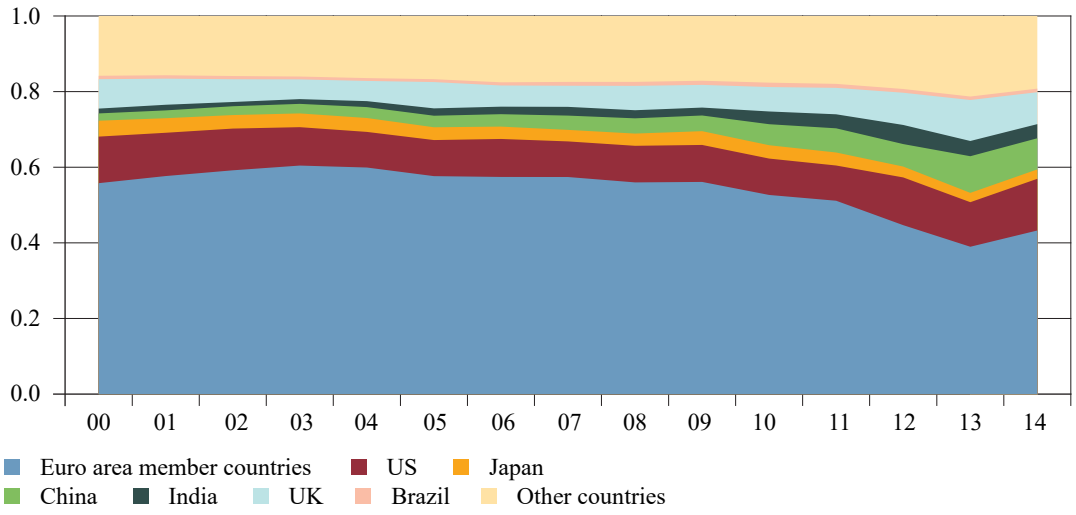
Chart 6 illustrates the development of the IMF weightings ($W_{CH,j}$) for Switzerland's key trading partners from 2000 onwards. The increasing importance of China is clearly discernible. The noticeable increase in the UK's weighting in 2013 is largely attributable to the aforementioned development in precious metal imports.

Chart 5: Structural parameters



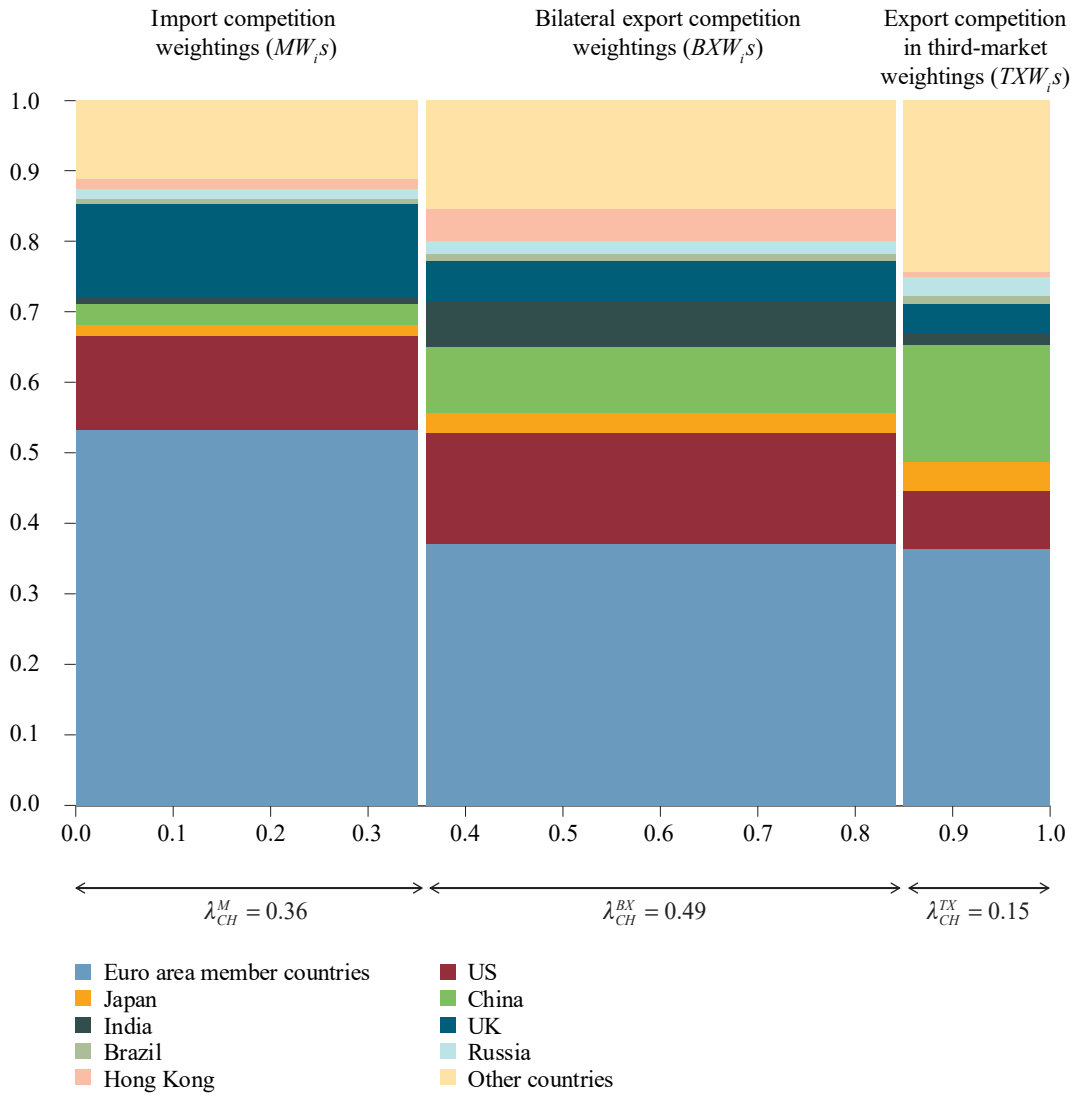
Source: SNB

Chart 6: Total weightings



Source: SNB

Chart 7[a]: Import, export and third-market weightings in 2014



Source: SNB

a Example: The weighting of the US ($W_{CH,US} = \lambda^{M}_{CH} MW_{CH,US} + \lambda^{BX}_{CH} BXW_{CH,US} + \lambda^{TX}_{CH} TXW_{CH,US}$) is expressed by the sum of the three red areas.

In summary, it can be said that a country receives a higher weighting in the index for Switzerland if

1. Imports from the partner country account for a significant proportion of total sales in the Swiss domestic market (import competition).
2. The partner country is an important market for Swiss exports and/or the partner country meets a large proportion of its demand for goods and services through domestic production (bilateral export competition).
3. Third markets are important markets for Swiss exports and/or the market shares of the exports of the partner country in these markets are high (export competition in third markets).

Chart 7 amalgamates the three components of the IMF weighting method with the corresponding country weightings for 2014. The three competitive components differ

with respect to their country structure. Whereas for the member states of the euro currency area and the UK, the import competition component tends to be important, the two components of export competition are the significant elements for China and 'other countries'. Significant countries in the 'other countries' group include South Korea, Singapore, Canada, Poland, Turkey, Australia, Saudi Arabia, Mexico, Malaysia and Thailand.

2.2.2 Group of countries

The global economy has experienced strong upheavals in recent decades. Countries that formerly played only a minor role in the international flow of services and goods have become important trading partners for Switzerland. The fixed group of countries that was previously used to calculate the effective exchange rate index failed to take sufficient account of this development. From now on, a variable group of countries will be used. Specifically, this will include all countries that account for either an export share or an import share of more than 0.2 % in the current or previous period. The threshold of 0.2 % ensures that all key countries are represented in this group of countries. If the threshold were to be set lower, problems would rapidly emerge with respect to the availability of data. This would run counter to the SNB's objective of being able to calculate an index on a daily basis that is robust from a data standpoint. On average, 43 countries are included in the new calculation, of which a core group of 39 has been permanently represented in the index ever since 2000.

In addition to the effective overall index, a real effective index will also be calculated (as it has up until now) for the euro currency area. This calculation will be undertaken on the basis of weighted bilateral real indices for the member states of the euro area. The group of countries corresponds to the latest composition of euro member states.[2] In other words, countries joining the currency union are treated as if they had already been member states of the euro currency area since the introduction of the euro. For the period prior to accession to the euro area, the corresponding bilateral exchange rates and price indices are used to compute real bilateral indices. Accordingly, the real effective euro index would be revised retrospectively in the event of any new country joining the euro area.

Consideration of trading partners outside the group of countries

Countries that do not fulfil the above-mentioned threshold criteria are not included in the index. However, in these third countries too, Switzerland is in competition with countries that lie above the threshold of 0.2 % and are therefore included in the index. In order to reflect these competitive relationships, the IMF weighting method has been adjusted so that countries that do not reach the threshold of 0.2 % are nonetheless taken into account as third markets for the purpose of calculating the components of export competition in third markets.

While the inclusion of countries not contained in the index for the calculation of third-market components has only a marginal impact on the overall index, it can nonetheless be significant in the calculation of subindices. For example, the index for

2 The euro group of countries consists of the following (as at 2017): Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, Spain.

the euro area takes into account not just competition between Switzerland and euro area countries in third markets also located in the euro area, but also competition in third markets outside the euro area – in countries such as the United States (US), Japan, and China.

2.3 Index formula

The effective exchange rate index amalgamates the bilateral indices of the individual countries on the basis of weightings, to produce a single figure. Like the previous version, the new index is a Törnqvist index. However, it is now calculated as a chained index. This subsection briefly explains the form and characteristics of the new index, the update frequency, and the chosen reference periods. Annex III ('Chained Törnqvist index') formally describes the index formula and the construction of the effective exchange rate index of the Swiss franc.

2.3.1 Törnqvist index

The Törnqvist index is a geometrically weighted index. It takes into account weighting changes between the base period and the comparison period, by applying the arithmetic mean of weightings of both periods for the weighting of the bilateral indices. By taking the mean of the weightings from the comparison and base periods, the definitive weightings are smoothed over time. On the basis of various criteria, the Törnqvist index can be classified as an optimal index form (cf., for example, Diewert and Nakamura, 1993).

2.3.2 Chaining of the Törnqvist index

Traditional (unchained) indices place the current observation value directly in relation to the observation value of a fixed base period, which in the case of the Törnqvist index means that the country weightings of the base period also influence the index values of the latest period. With a chained index, the current observation value is placed in relation to the observation value from the previous period. As the Törnqvist index is a geometric index, the chained (logarithmic) Törnqvist index weights the rates of change in the bilateral indices with respect to the previous period. The definitive index is then formed through multiplication of the resulting subindices (growth factors).

The selection of a chained index ensures that the group of countries can be variable and that current developments in the trading of goods and services can therefore be promptly replicated in the index. If the significance of a country for Swiss foreign trade rises sharply (e.g. in the case of China), the unchained (direct) Törnqvist index does not capture this development accurately. Now, however, the changes in the structure of international trade flows show up quickly in the index weightings, as the base period for the comparison of current observation values no longer lies far in the past.

2.3.3 Update frequency of the index

The effective exchange rate index is chained annually. This in turn requires annual updating of the weightings. For the overall index, the group of countries is re-determined afresh each year in keeping with the above-mentioned criteria. However, the full external trade and GDP data of all trading partners are only available after a time lag. Only in the first half of a calendar year do the data from two years previously become available. This delay in data availability means that a revision for the last two years takes place every year. Table 2 illustrates the update frequency of the index.[3]

Table 2: Update frequency

Stages in the calculation	Weightings used for index calculation				
		Year 2015	Year 2016	Year 2017	Year 2018
	Q2/2017	Definitive index with weightings from 2014 and 2015	Provisional update of index with weightings from 2015	Provisional update of index with weightings from 2015	
	Q2/2018		Definitive index with weightings from 2015 and 2016	Provisional update of index with weightings from 2016	Provisional update of index with weightings from 2016
	Q2/2019			Definitive index with weightings from 2016 and 2017	Provisional update of index with weightings from 2017
	Q2/2020				Definitive index with weightings from 2017 and 2018

2.3.4 Reference period

For purposes of illustration, the index relates to a reference period. December 2000 was determined as the reference period for the effective index on a monthly basis. The choice of this reference period is purely for technical reasons, and does not imply that the Swiss franc had a high or low valuation at that time. The reference period for the index on a quarterly basis is the fourth quarter of 2000, and the reference period

3 By way of an example to illustrate the table: in Q2/2017, data for 2015 will be complete. The external trade and GDP data are to be continued in a time series until 2015. The weightings of the index for 2015 can now be definitively revised (with data from both 2014 and 2015). Similarly, a (preliminary) revision/updating of the weightings for the index will be undertaken for 2016 and 2017. The determining factor for the establishment of the group of countries for these two years will be solely data from 2015. In Q2/2018, the index will become definitive for 2016 (taking into account data from 2015 and 2016). Only in Q2/2019, when the external trade data for 2017 are finally available, will the weightings be definitive for the 2017 index. This index includes the trading partners that met the threshold criteria in either 2016 or 2017. If a trading partner fulfils the threshold criterion in 2016 but not in 2017, the trading partner will be included in the (definitive) index for 2017. However, the second term in the Törnqvist weighting for 2017 will amount to zero. If a trading partner does not fulfil the threshold criterion in 2016 but does do so in 2017, the trading partner will still be included in the (definitive) index for 2017; in this case, however, its weighting for 2016 (first term of the Törnqvist weighting) will amount to zero.

for the index on an annual basis the year 2000. December 2000 is the reference period for the index on a daily basis.

2.4 Design of the SNB's effective exchange rate index

The SNB calculates an overall index and a subindex for the euro area. The SNB's overall index comprises the countries selected by means of the threshold criteria with the corresponding nominal and real bilateral indices on the basis of the CPI/PPI, weighted according to the IMF approach. Using the same method, the subindex for the euro area weights the bilateral indices of the 19 member states of the euro area, likewise on the basis of the CPI/PPI.

In order to calculate the IMF weightings, trade in goods and services is taken into account (including precious metals trading, as per current practice). Whereas a country breakdown of data is widely available for the trade in goods, this does not extend to trade in services. The figures for trade in services of the partner countries are therefore assigned in keeping with the breakdown for the country-specific trade in goods. For the weighting calculation until 2012, the total of Swiss trade in services is assigned to the individual countries using the same method. Thereafter, however, a country structure is available for Swiss trade in services, and this is applied accordingly (cf. also table 3 'Trade in services'). Only in the case of Switzerland's tourism industry does no country breakdown exist at the current time. Here it is assumed that the country structure of Switzerland's tourism business corresponds to that of other trade in services.

The SNB's previous CPI-based effective overall index, which stretches back to 1973, comprised an index made up of the old 15 countries until 1999 and then an index of 40 countries from 1999 onwards. For reasons of data availability, the new index likewise involves a restricted group of 15 countries for the period 1973–1999. However, the countries are now weighted as per the IMF approach. The index values from 1973 to 1999 for the CPI-based 'euro area subindex' are calculated from the bilateral indices of eight countries, likewise weighted according to the IMF approach.

Both the overall index and the PPI-based euro area subindex are only available from 1982 onwards, as prior to 1982 there were major gaps in the data relating to producer prices. As in the case of the CPI-based index, until 1999 a group of 15 countries is taken into account for the overall index, and a group of 8 countries for the 'euro area subindex'.

Table 3 provides a summary of the data used for the new SNB index and the respective sources, as well as the corresponding structural breaks.

Table 3: Data basis for the new index

	Nominal and real CPI index		
	1973–1999	2000–2011	2012 to now
	Real PPI index		
	1982–1999	2000–2011	2012 to now
Group of countries – overall index	**Fixed for the following countries:** Austria, Belgium/Luxembourg, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, UK, US.	**Variable for the following potential countries:** Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Croatia, Czech Republic, Cyprus, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Ireland, Israel, Italy, Japan, Jordan, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Singapore, Slovakian Republic, Slovenia, South Africa, South Korea, Spain, Sweden, Thailand, Turkey, UK, US.	
Criterion for inclusion in group of countries	–	Export or import share > 0.2% in current or year-back period	
Group of countries – euro area subindex	Austria, Belgium/Luxembourg, France, Germany, Italy, Netherlands, Portugal, Spain.	Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, Spain. New members are integrated and the real index retrospectively revised accordingly.	
Trade in goods	Matrix of export and import data of countries included in the index. Source: UN-COMTRADE (total of all HS commodities)	Matrix of export and import data of all potential countries envisaged for inclusion in the index. Source: UN-COMTRADE (total of all HS commodities)	
Re-exports[a]	Unadjusted	Adjusted Sources: *Annual Review of Hong Kong External Merchandise Trade* and UN-COMTRADE	

a Re-exports are exported goods that were previously imported in the same condition. Adjustments are made insofar as possible for trade data distortions in individual countries as a result of re-exports.

(→)

Table 3 continued

	Nominal and real CPI index		
	1973–1999	2000–2011	2012 to now
	Real PPI index		
	1982–1999	2000–2011	2012 to now
Trade in services	Here it is assumed that the country structure of trade in services corresponds to that of trade in goods. Calculation of total exports of country *i* to country *j*: $X^j_{TOT,i} = \frac{X_{TOT,i}}{X_{W,i}} * X^j_{W,i}$ $X^j_{TOT,i}$: total exports of country *i* to country *j* $X_{TOT,i}$: total exports (incl. services) country *i* $X_{W,i}$: total goods exports country *i* $X^j_{W,i}$: goods exports of country *i* to country *j* The same formula is used for imports. Sources: IFS and UN-COMTRADE		**Switzerland:** Country breakdown of Switzerland's trade in services. In the case of Switzerland's tourist industry, no country breakdown currently exists. Here it is assumed that the country structure of the tourism business corresponds to that of other trade in services. Calculation of total service exports of CH to country *j*: $X^j_{TOT\_D,CH} = \frac{X_{TOT\_D,CH}}{X_{D,CH}} * X^j_{D,CH}$ $X^j_{TOT\_D,CH}$: service exports (incl. tourism) of CH to country *j* $X_{TOT\_D,CH}$: total service exports (incl. tourism) of CH $X_{D,CH}$: total service exports (excl. tourism) of CH $X^j_{D,CH}$: service exports (excl. tourism) of CH to country *j* The same formula is used for imports. Source: SNB **Other countries**: Here it is assumed that the country structure of trade in services corresponds to that of trade in goods. Calculation of total exports of country $i \neq$ CH to country *j*: $X^j_{TOT,i} = \frac{X_{TOT,i}}{X_{W,i}} * X^j_{W,i}$ $X^j_{TOT,i}$: total exports of country *i* to country *j* $X_{TOT,i}$: total exports (incl. services) country *i* $X_{W,i}$: total goods exports country *i* $X^j_{W,i}$: goods exports of country *i* to country *j* The same formula is used for imports. Sources: IFS and UN-COMTRADE
GDP	Source: IFS	Source: IFS	Source: IFS
Deflators	Source CPI: IFS (from 1973) Sources PPI: IFS and OECD (from 1982)	Source CPI: IFS Sources PPI: IFS and OECD	Source CPI: IFS Sources PPI: IFS and OECD

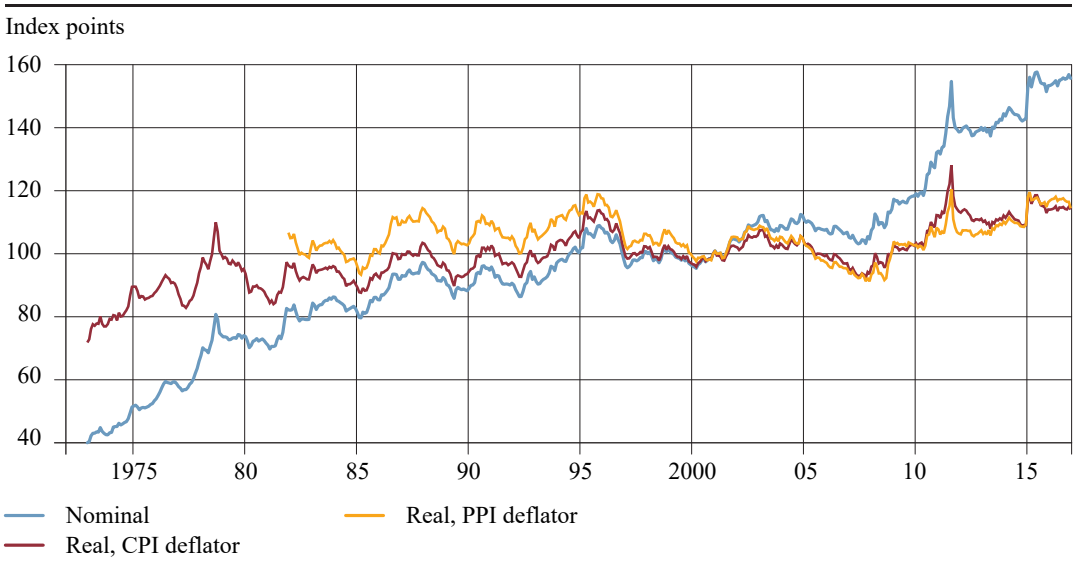
3. The new exchange rate index – results and comparisons

3.1 Results

The nominal and real effective exchange rate indices calculated with the new methodology are illustrated in chart 8. A rise corresponds to an appreciation of the Swiss franc. In the short term, there is a strong correlation between nominal and real franc exchange rates. As the price indices (and therefore the deflators) used barely change in the short term, monthly changes in real exchange rates are above all determined by nominal price developments. Over the long term, by contrast, it is evident that the Swiss franc has appreciated much more strongly in nominal terms than in real terms. This reflects the fact that inflation has, on average, been lower in Switzerland than in other countries.

Chart 8 also contrasts the new real exchange rate indices on the basis of consumer prices (CPI-based) with those of the basis of producer prices (PPI-based). The real PPI-based effective index was higher in 2016 than that calculated with the CPI, as in recent years the differences in inflation between Switzerland and other countries have, on average, been greater at consumer level than at producer level.

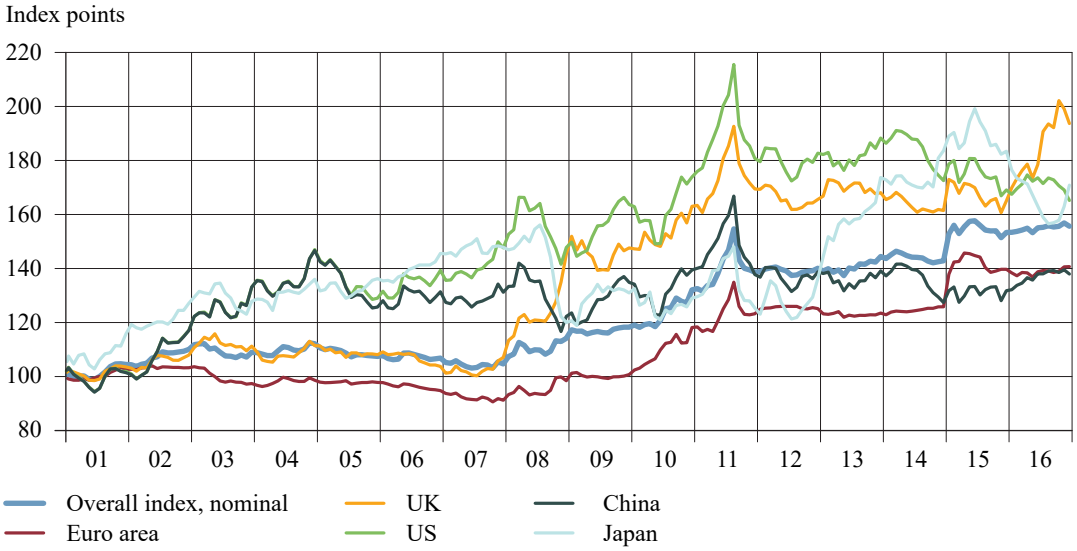
Chart 8: Nominal and real effective exchange rate indices of Swiss Franc
Monthly basis; December 2000 = 100



Source: SNB

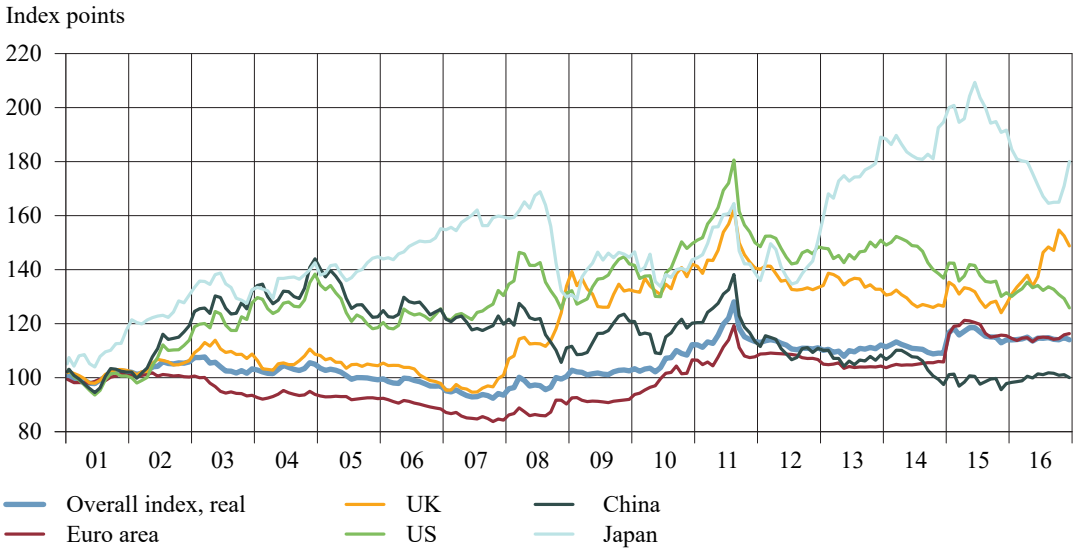
Charts 9 and 10 show movements in various bilateral indices of the Swiss franc and the effective overall index (chart 9 nominal, chart 10 real). The powerful influence of the euro on the overall index is very apparent. The introduction of the minimum EUR/CHF exchange rate in September 2011 and its discontinuation in January 2015 can be seen clearly in the corresponding extreme movements.

Chart 9: Nominal bilateral indices and nominal effective overall index
Monthly basis; December 2000 = 100



Source: SNB

Chart 10: Real bilateral indices and real effective overall index (CPI-based)
Monthly basis; December 2000 = 100

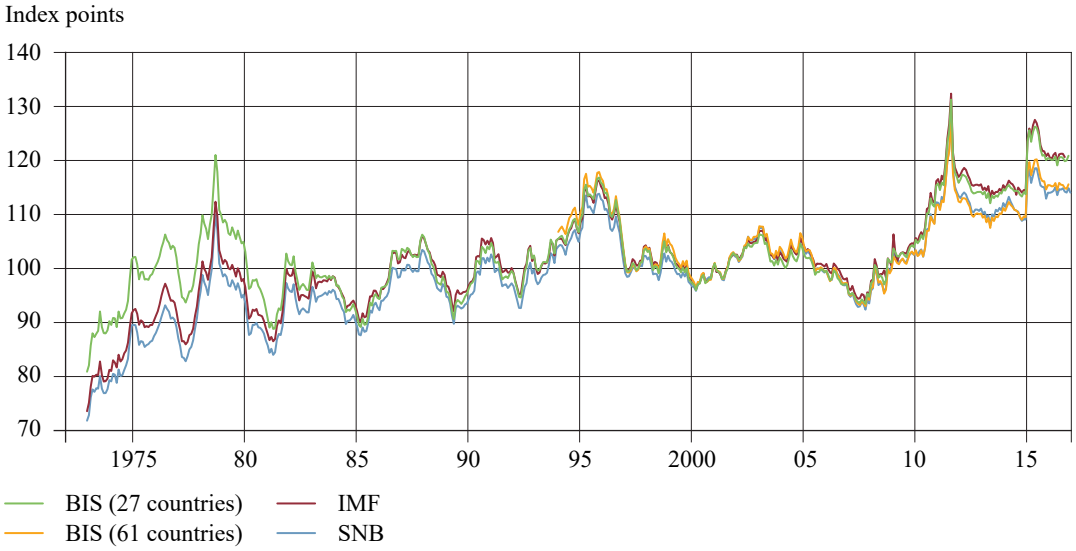


Source: SNB

3.2 Comparison with indices of the BIS and IMF

The BIS and the IMF also calculate effective exchange rate indices for the Swiss franc. Chart 11 compares the SNB's new CPI-based real effective exchange rate index for the Swiss franc with indices published by the BIS and the IMF. All three indices use CPIs as their deflator and calculate weightings which take into account exports, imports, and third-market competition. Overall, all indices show a very similar picture of the real external value of the Swiss franc, whereby the BIS index, with 61 countries, correlates most closely with the new SNB index. The difference

Chart 11: Comparison of real CPI-based exchange rate indices
Monthly basis; December 2000 = 100



Sources: BIS, IMF, SNB

between the new SNB index and the IMF index is primarily attributable to the fact that the latter index uses a fixed weighting scheme (which is updated only every ten years) in order to weight the bilateral indices.

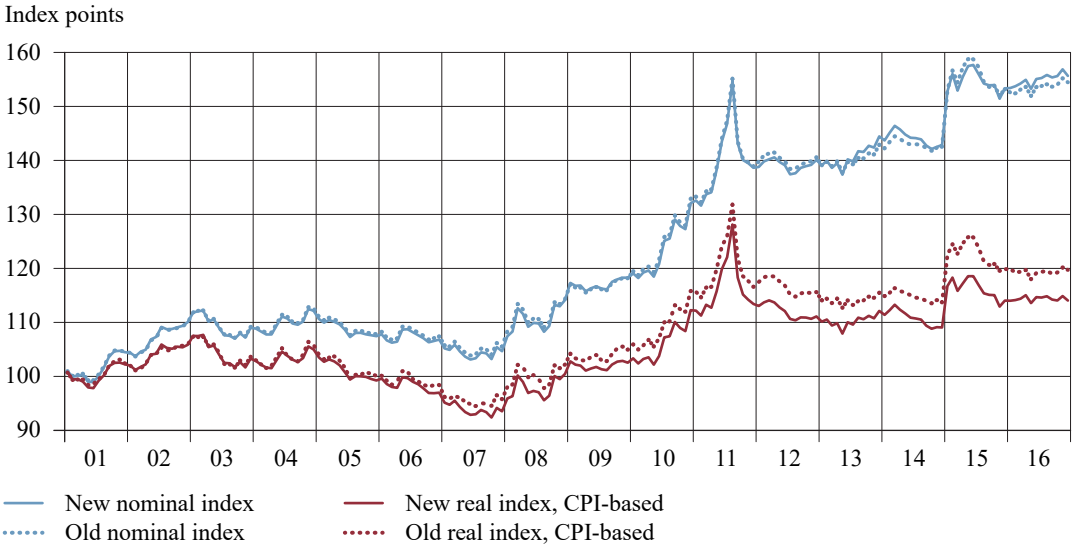
3.3 Effect of methodological changes

The methodological changes in the calculation of the effective index have barely any impact on movements in the new nominal index. By contrast, as chart 12 shows, the level of the new CPI-based real index is below that of the old real index. The difference between the nominal and the real indices has increased with the new calculation. This is explained by the fact that countries with a greater weighting in the new index have higher average rates of inflation than those whose weightings have been reduced.

As table 4 shows, a shift in country weightings has taken place. This is primarily attributable to two factors:

- The new index uses the IMF weighting method, whereas the weightings of the previous index were exclusively export-based. The additional incorporation of import and third-market components has an impact on the country weightings.
- As the new index is a chained index, any change in the foreign trade importance of a trade partner feeds into the new index more quickly than in the previous version.

Chart 12: Comparison of old and new effective exchange rate index
December 2000 = 100



Source: SNB

Table 4: Weightings of key trading partners in the old and new overall indices for 2016

	Germany	France	Italy	Euro area	UK
Old index	22.0%	8.9%	7.6%	52.9%	10.1%
New index	17.2%	6.6%	6.1%	42.7%	8.3%

	US	Hong Kong	China	Japan	India
Old index	14.8%	2.2%	2.6%	3.9%	0.6%
New index	13.8%	2.9%	8.1%	2.5%	3.7%

4. Further reading

Armington, P. (1969), A theory of demand for products distinguished by place of production, *International Monetary Fund Staff Papers*, XVI (1969), pp. 159–178.

Diewert, W. E., and A. Nakamura (1993), *Essays in index number theory, Volume I*, Science Publishers B.V., 1993.

McGuirk, K. A. (1986), Measuring price competitiveness for industrial country trade in manufactures, *IMF Working Paper*, 87 (34).

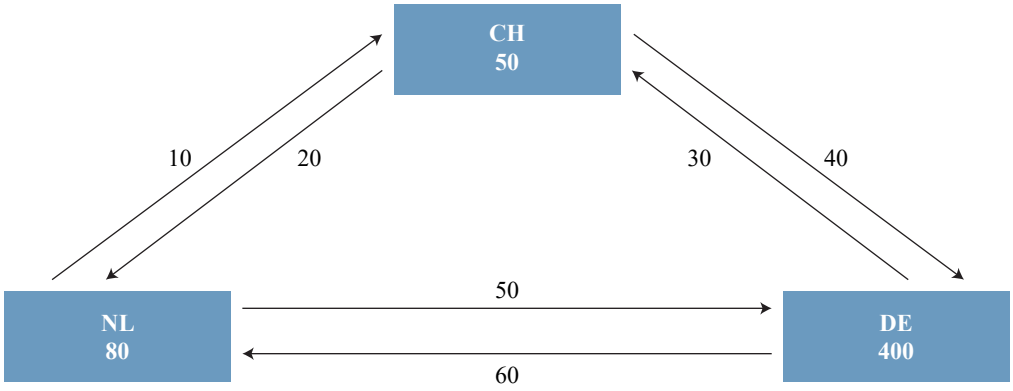
Turner, P., and J. Van 't dack (1993), Measuring international price and cost competitiveness, *BIS Economic Papers*, 39, November 1993.

Zanello, A., and D. Desruelle (1997), A primer on the IMF's information notice system, *IMF Working Paper*, 97 (71), May 1997.

5. Annex I: IMF weighting method

The calculation of weightings as per the IMF method is explained using the example of the three-country model, Switzerland-Germany-Netherlands (CH, DE, NL). Chart A1 maps the fictitious trade flows (expressed in a common currency) between the three countries (arrows) and the end sales of domestically produced goods (and services) in each individual domestic market.

Chart A1: Goods flow in the three-country model



The goods flows and sales by domestic suppliers in the domestic market can be illustrated in a table, whereby the end sales of domestically produced goods in the domestic market are shown in the diagonals:

Table A1: Goods flows in the three-country model

	Imports			
	CH	DE	NL	Total output
Exports CH	50(T_{CH}^{CH})	40(T_{CH}^{DE})	20(T_{CH}^{NL})	CH: 110
Exports DE	30(T_{DE}^{CH})	400(T_{DE}^{DE})	60(T_{DE}^{NL})	DE: 490
Exports NL	10(T_{NL}^{CH})	50(T_{NL}^{DE})	80(T_{NL}^{NL})	NL: 140
Total sales	CH: 90	DE: 490	NL: 160	740

The data from the table can be used to calculate the weightings according to the IMF method. Two figures are important in this context:

1. The export shares of Swiss output in the other countries together with the share of domestically produced goods for the Swiss domestic market.
2. The German market share in the Swiss and Dutch markets as well as the Dutch market share in the Swiss and German markets.

The export shares of Swiss output result from the first-row entries (CH, DE, NL) of table A1 divided by the row total (total output).

The market shares of Switzerland, Germany and the Netherlands result from the table A1 column entries (CH, DE, NL) divided by the corresponding column totals, which capture total sales for the country in question.

Using a matrix **T**,

$$\mathbf{T} = \begin{pmatrix} 50 & 40 & 20 \\ 30 & 400 & 60 \\ 10 & 50 & 80 \end{pmatrix} = \begin{pmatrix} T_{CH}^{CH} & T_{CH}^{DE} & T_{CH}^{NL} \\ T_{DE}^{CH} & T_{DE}^{DE} & T_{DE}^{NL} \\ T_{NL}^{CH} & T_{NL}^{DE} & T_{NL}^{NL} \end{pmatrix},$$

which represents the flows from the table, the first figure can be calculated by the vector

$$w = (w_{CH}^{CH} \quad w_{CH}^{DE} \quad w_{CH}^{NL}) = (50/110 \quad 40/110 \quad 20/110)$$

$$\text{with } w_{CH}^{k} = \frac{T_{CH}^{k}}{\sum_k T_{CH}^{k}} \text{ and } \sum_k w_{CH}^{k} = 1 \text{ for } k \in \{CH, DE, NL\}$$

and the second figure by the matrix **S**

$$\mathbf{S} = \begin{pmatrix} s_{CH}^{CH} & s_{CH}^{DE} & s_{CH}^{NL} \\ s_{DE}^{CH} & s_{DE}^{DE} & s_{DE}^{NL} \\ s_{NL}^{CH} & s_{NL}^{DE} & s_{NL}^{NL} \end{pmatrix} = \begin{pmatrix} 50/90 & 40/490 & 20/160 \\ 30/90 & 400/490 & 60/160 \\ 10/90 & 50/490 & 80/160 \end{pmatrix}$$

$$\text{with } s_j^k = \frac{T_j^k}{\sum_l T_l^k} \text{ and } \sum_j s_j^k = 1 \text{ for } j,k,l \in \{CH, DE, NL\}.$$

The factor w_{CH}^{CH} gives the proportion of Swiss output sold in the Swiss market. The other elements w_{CH}^{k} ($k \neq CH$) give the proportion of Swiss output exported to Germany and the Netherlands. The matrix *S* with the elements s_j^k consists of the diagonal elements s_k^k, which illustrate the market share of the local supplier of country *k* in its domestic market in country *k*, and the other elements s_j^k ($j \neq k$), which describe the market shares of suppliers from country *j* in the sales markets of the other two countries.

Using the system devised by Armington (1969), McGuirk (1987) derives the gross weightings for the index, which in this specific example take the following form:

$$GW_{CH,j} = \sum_k \{w_{CH}^k s_j^k\} \text{ with } j,k \in \{CH, DE, NL\}. \tag{A1}$$

The gross weightings can be computed by applying the dataset of the matrix *T*. The gross weighting of Switzerland vs. Germany in this example therefore works out as follows:

$$GW_{CH,DE} = \sum_k \{w_{CH}^k s_{DE}^k\} = w_{CH}^{CH} s_{DE}^{CH} + w_{CH}^{DE} s_{DE}^{DE} + w_{CH}^{NL} s_{DE}^{NL},$$
$$\text{with } k \in \{CH, DE, NL\}. \tag{A2}$$

The gross weighting in this example consists of three summands. The first summand describes the import competition. Here s_{DE}^{CH} represents the share of total Swiss imports accounted for by German imports (including sales from Swiss output in the Swiss domestic market), while w_{CH}^{CH} represents the proportion of Swiss output sold in the Swiss domestic market. The second summand illustrates bilateral export competition. Here w_{CH}^{DE} represents the share of Swiss output exported to Germany and s_{DE}^{DE} the market share of German-produced goods in the domestic German market. The third summand describes export competition in the third market, the Netherlands, between Germany and Switzerland, whereby w_{CH}^{NL} expresses the proportion of Swiss output exported to the Netherlands, and s_{DE}^{NL} the market share of Germany in the Dutch domestic market. The gross weighting

$$GW_{CH,NL} = \sum_k \{w_{CH}^k s_{NL}^k\} = w_{CH}^{CH} s_{NL}^{CH} + w_{CH}^{DE} s_{NL}^{DE} + w_{CH}^{NL} s_{NL}^{NL} \tag{A3}$$

can be calculated analagously. The factors for $GW_{CH,DE}$ are summarised in table A2.

Table A2: German weighting components as per IMF approach

	1st factor Export share of CH	2nd factor Market share of DE	Intensity of competition Matrix element (row, column) in chart A2
1st summand Import competition with DE	'Export share' of CH goods for CH market $w_{CH}^{CH} = \frac{T_{CH}^{CH}}{T_{CH}^{CH} + T_{CH}^{DE} + T_{CH}^{NL}} = \frac{50}{50+40+20} = \frac{50}{110}$	Market share of DE goods in CH market $s_{DE}^{CH} = \frac{T_{DE}^{CH}}{T_{CH}^{CH} + T_{DE}^{CH} + T_{NL}^{CH}} = \frac{30}{50+30+10} = \frac{30}{90}$	The greater $\boldsymbol{w_{CH}^{CH} s_{DE}^{CH}}$, the higher this figure Matrix element in chart A2 (2,1)
2nd summand Bilateral export competition with DE	Export share of CH goods for DE market $w_{CH}^{DE} = \frac{T_{CH}^{DE}}{T_{CH}^{CH} + T_{CH}^{DE} + T_{CH}^{NL}} = \frac{40}{50+40+20} = \frac{40}{110}$	Market share of DE goods in DE market $s_{DE}^{DE} = \frac{T_{DE}^{DE}}{T_{CH}^{DE} + T_{DE}^{DE} + T_{NL}^{DE}} = \frac{400}{40+400+50} = \frac{400}{490}$	The greater $\boldsymbol{w_{CH}^{DE} s_{DE}^{DE}}$, the higher this figure Matrix element in chart A2 (2,2)
3rd summand Export competition with DE in third market NL	Export share of CH goods for NL market $w_{CH}^{NL} = \frac{T_{CH}^{NL}}{T_{CH}^{CH} + T_{CH}^{DE} + T_{CH}^{NL}} = \frac{20}{50+40+20} = \frac{20}{110}$	Market share of DE goods in NL market $s_{DE}^{NL} = \frac{T_{DE}^{NL}}{T_{CH}^{NL} + T_{DE}^{NL} + T_{NL}^{NL}} = \frac{60}{20+60+80} = \frac{60}{160}$	The greater $\boldsymbol{w_{CH}^{NL} s_{DE}^{NL}}$, the higher this figure Matrix element in chart A2 (2,3)
Total	$w_{CH}^{CH} + w_{CH}^{DE} + w_{CH}^{NL} = 1$		$w_{CH}^{CH} s_{DE}^{CH} + w_{CH}^{DE} s_{DE}^{DE} + w_{CH}^{NL} s_{DE}^{NL} = \boldsymbol{GW_{CH,DE}}$

In chart A2 the gross weightings $GW_{CH,DE}$ and $GW_{CH,NL}$ are expressed by the sum of the areas of the matrix elements – defined by (row, column) – (2,1), (2,2) and (2,3) or the matrix elements (3,1), (3,2) and (3,3). The three columns of chart A2 represent the locations (CH, DE, NL) where competition takes place. For the calculations of the net weightings $W_{CH,DE}$ and $W_{CH,NL}$ the 'own weighting'

$$GW_{CH,CH} = \sum_k \{w_{CH}^k s_{CH}^k\} = w_{CH}^{CH} s_{CH}^{CH} + w_{CH}^{DE} s_{CH}^{DE} + w_{CH}^{NL} s_{CH}^{NL} \tag{A4}$$

(white matrix elements (1,1), (1,2) and (1,3)) is not taken into account, as the index is constructed as a measure of the competitiveness of Swiss products in the global market. Accordingly, the totality of the coloured areas in chart A2 is normalised to one. This is done by dividing $GW_{CH,DE}$ and $GW_{CH,NL}$ by the term

$$(1 - GW_{CH,CH}) = \sum_k w_{CH}^k (1 - s_{CH}^k) \text{ for } k \in \{CH, DE, NL\}. \tag{A5}$$

In chart A2 the expression $\Sigma_k w_{CH}^k (1 - s_{CH}^k)$ is expressed by the sum of the six coloured areas of the matrix elements (2,1) and (3,1); (2,2) and (3,2); and (2,3) and (3,3) – the 1st, 2nd and 3rd summands respectively. If the Swiss economy were entirely self-sufficient, then $GW_{CH,CH} = w_{CH}^{CH} s_{CH}^{CH} = 1$.

Chart A2: IMF WEIGHTINGS

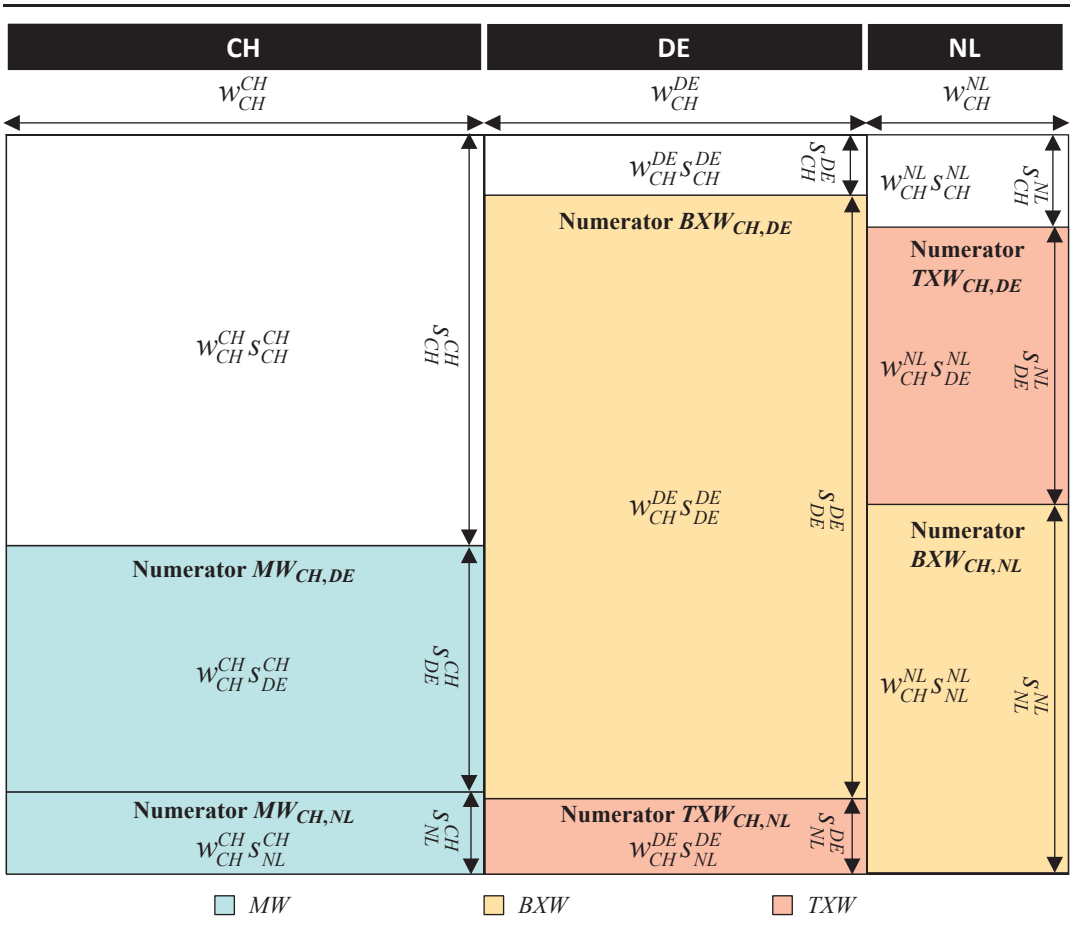


Chart A2 shows how the weighting formula (1) used in the text

$$\boldsymbol{W_{CH,j} = \lambda_{CH}^{M} MW_{CH,j} + \lambda_{CH}^{BX} BXW_{CH,j} + \lambda_{CH}^{TX} TXW_{CH,j}} \quad \text{(A6)}$$

is arrived at. The same rule always applies: the greater the corresponding area, the more intense the competition. The following mathematical terms illustrate the three competitive relationships in graphic form.

Numerator $\boldsymbol{MW_{CH,j}}$ (blue background shading) reflects the intensity of the competition between Switzerland and the trading partners Germany and the Netherlands in the local Swiss market (import competition). The weighting $\boldsymbol{MW_{CH,DE}}$ can accordingly be illustrated by the blue area, labelled with 'numerator $MW_{CH,DE}$', divided by the total blue area (denominator of $MW_{CH,DE}$), which corresponds to the ratio of s_{DE}^{CH} to $(s_{DE}^{CH} + s_{NL}^{CH})$, as w_{CH}^{CH} is cancelled out in the calculation of $MW_{CH,j}$. The weighting $MW_{CH,NL}$ is illustrated analogously. The key factors are the import shares $s_{DE}^{CH} / (s_{DE}^{CH} + s_{NL}^{CH})$ and $s_{NL}^{CH} / (s_{DE}^{CH} + s_{NL}^{CH})$ of the trading partners DE and NL in the local Swiss market.

Numerator $\boldsymbol{BXW_{CH,j}}$ (yellow background shading) reflects the intensity of the bilateral competition between Switzerland and its trading partners Germany and the Netherlands. This depends on the proportion of Swiss output exported to the partner countries (w_{CH}^{DE} or w_{CH}^{NL}) and the market share of trading partner j in its own domestic market (s_{DE}^{DE} or s_{NL}^{NL}). The weighting $\boldsymbol{BXW_{CH,DE}}$ can accordingly be illustrated by the yellow area, labelled 'numerator $BXW_{CH,DE}$', divided by the total yellow area (denominator of $BXW_{CH,DE}$). $BXW_{CH,DE}$ illustrates the significance of the component of bilateral export competition with Germany in relation to the significance of this component with the Netherlands. The weighting $BXW_{CH,NL}$ is illustrated analogously.

Numerator $\boldsymbol{TXW_{CH,j}}$ (red background shading) shows the export competition in third markets between Switzerland and its trading partners Germany and the Netherlands. This depends on the proportion of Swiss output exported to a third market of trading partner j (w_{CH}^{NL} or w_{CH}^{DE}), and the market share of trading partner j in the third market (s_{DE}^{NL} or s_{NL}^{DE}). The weighting $\boldsymbol{TXW_{CH,DE}}$ can accordingly be illustrated by the red area, labelled 'numerator $TXW_{CH,DE}$', divided by the total red area (denominator of $TXW_{CH,DE}$). $TXW_{CH,DE}$ illustrates the significance of the component of export competition with Germany in the third market, the Netherlands, in relation to the significance of this component with the Netherlands in the third market Germany. The weighting $TXW_{CH,NL}$ is illustrated analogously.

The term $\boldsymbol{\lambda_{CH}^{M}}$ (relative weighting of import competition in Switzerland) may be described as the ratio of the blue areas to the entire coloured area. It indicates what proportion of total competition between Swiss and foreign products across all markets is attributable to competition located in the Swiss domestic market. It depends on the extent to which the Swiss domestic market is supplied by foreign suppliers and the share of Swiss output accounted for by goods produced in Switzerland for the domestic market. The term $\boldsymbol{\lambda_{CH}^{BX}}$ (relative weighting of bilateral export competition) may be expressed as the ratio of the yellow areas to the entire coloured area. This term indicates what proportion of total contacts between Swiss and foreign suppliers takes place in the partner countries' domestic markets and depends on the extent to which they are supplied by their own producers and the share of Swiss output sold in foreign markets. The term $\boldsymbol{\lambda_{CH}^{TX}}$ (relative weighting of export competition in third

markets) can be described as the ratio of the red areas to the entire coloured area. It depends on the average extent to which Swiss trading partners' domestic markets are supplied by third countries.

In annex I (cf. p. 29) of the IMF working paper by Zanello and Desruelle (1997), the formula $W_{CH,j} = \lambda_{CH}^{M} MW_{CH,j} + \lambda_{CH}^{BX} BXW_{CH,j} + \lambda_{CH}^{TX} TXW_{CH,j}$ is presented in general form with the factors 'export and market shares'. In our example, the individual components can be expressed as follows:

$$MW_{CH,j} = \frac{s_j^{CH}}{\sum_{l \neq CH} s_l^{CH}} \tag{A7}$$

$$BXW_{CH,j} = \frac{w_{CH}^{j} s_J^{j}}{\sum_{k \neq CH} w_{CH}^{k} s_k^{k}} \tag{A8}$$

$$TXW_{CH,j} = \frac{\sum_{k \neq CH,j} w_{CH}^{k} s_j^{k}}{\sum_{k \neq CH} w_{CH}^{k} (1 - s_{CH}^{k} - s_k^{k})} \tag{A9}$$

and

$$\lambda_{CH}^{M} = \frac{w_{CH}^{CH} (1 - s_{CH}^{CH})}{\sum_{k} w_{CH}^{k} (1 - s_{CH}^{k})} \tag{A10}$$

$$\lambda_{CH}^{BX} = \frac{\sum_{k \neq CH} w_{CH}^{k} s_k^{k}}{\sum_{k} w_{CH}^{k} (1 - s_{CH}^{k})} \tag{A11}$$

$$\lambda_{CH}^{TX} = \frac{\sum_{k \neq CH} w_{CH}^{k} (1 - s_{CH}^{k} - s_k^{k})}{\sum_{k} w_{CH}^{k} (1 - s_{CH}^{k})} \tag{A12}$$

for $j,k,l \in \{CH, DE, NL\}$. The expression $\sum_k w_{CH}^{k} (1 - s_{CH}^{k})$ in the denominator of λ_{CH}^{M}, λ_{CH}^{BX} and λ_{CH}^{TX} represents the entirety of the coloured area in chart A2.

In a three-country model such as our example, the numerator of $TXW_{CH,j}$ has just one summand. In a multi-country model, the numerator of $TXW_{CH,j}$ has $(n-1)$ summands, whereby n represents the number of countries included in the index. In the above example, $n = 2$.

6. Annex II: Implementation of the IMF weighting method

This annex explains the specific calculation of the various factors of the IMF weighting method and the data used for this purpose (cf. formulae (A4) – (A9) from annex I). For the calculation of the weightings, trade in services as well as trade in goods is taken into account, as is the gross value of goods and services produced domestically. The latter is calculated from the sum of GDP and imports (including services). This figure provides an approximation of the gross value of sales of domestically produced goods and services to end users both domestically and abroad. By distinguishing the products according to their place of production, the original Armington system assumes that the

entire value-added process of products takes place domestically. In open economies, however, a substantial share of export value is accounted for by preliminary work undertaken abroad. The latter is stripped out of GDP. Accordingly, GDP would not be a suitable measure for the gross value of goods and services produced domestically. With the method applied, exports will be compared to a gross figure (including preliminary work abroad), a conceptually more appropriate value than GDP, which is a net figure (excluding preliminary work abroad). Under this approach, preliminary work procured domestically is not taken into consideration, which turns out to be advantageous in connection with the calculation of domestic output, as this ensures that multiple countings of sales in the domestic market are avoided.[4]

The paragraphs below show the national account data used to ascertain the factors of export shares w_{CH}^{j} and market shares s_{j}^{k} in the formulae (A4)–(A9) for the calculation of the weightings according to the IMF weighting method.

1. The export shares of production in Switzerland

– In the case of import competition with the Swiss market as the competitive market, the significance of the goods and services produced in Switzerland for the domestic market as a share of domestic output is observed. This factor is calculated as follows:

$$w_{CH}^{CH} = \frac{(BIP_{CH} + M_{CH}) - X_{CH}}{(BIP_{CH} + M_{CH})}, \tag{A13}$$

whereby w_{CH}^{CH} describes the share of Swiss output sold in the domestic market. M_{CH} and X_{CH} describe the totality of Swiss imports and exports respectively. $(BIP_{CH} + M_{CH})$ is used as an approximation for the gross value of goods and services produced domestically (or output).

– In the case of bilateral export competition with the market of the trading partner as the competitive market, the focus is on the significance of the domestic market of the trading partner for Swiss suppliers. The calculation is as follows:

$$w_{CH}^{j} = \frac{X_{CH}^{j}}{(BIP_{CH} + M_{CH})}, \tag{A14}$$

whereby w_{CH}^{j} describes the share of Swiss output exported to the trading partner *j*. X_{CH}^{j} describes Swiss exports to country *j*.

– In the case of third-market competition with the market of the third country as the competitive market, the focus is on the significance of the third market for Swiss exports. This factor is calculated analogously to that of bilateral export competition:

$$w_{CH}^{k} = \frac{X_{CH}^{k}}{(BIP_{CH} + M_{CH})}, \tag{A15}$$

whereby w_{CH}^{k} represents the share of Swiss output exported to the market of the trading partner *k*.

4 This issue is discussed in detail in appendix I of the the BIS paper by Turner and Van ’t dack (1993).

2. *The market shares of a trading partner in a competitive market*
   - In the case of import competition with the Swiss market as the competitive market, the focus is on the significance of the goods and services of the trading partner as a proportion of overall sales in Switzerland. This factor is calculated as follows:

$$s_j^{CH} = \frac{M_j^{CH}}{(BIP_{CH} + M_{CH}) - X_{CH} + M_{CH}}, \tag{A16}$$

   whereby s_j^{CH} represents the proportion of sales in the Swiss domestic market accounted for by the imports of trading partner *j*. M_j^{CH} describes the imports from country *j* into Switzerland. The denominator represents the total value of all sales in the Swiss domestic market.
   - In the case of bilateral export competition with the market of the trading partner as the competitive market, the focus is on the significance of the goods and services of the trading partner as a proportion of overall sales in the domestic market of the trading partner itself. This factor is calculated as follows:

$$s_j^j = \frac{(BIP_j + M_j) - X_j}{(BIP_j + M_j) - X_j + M_j}, \tag{A17}$$

   whereby s_j^j represents the market share of goods and services produced in country *j* in its own domestic market *j* and X_j and M_j the overall exports and overall imports respectively of country *j*. The denominator represents the total value of all sales in the domestic market of the partner country *j*, whereby $(BIP_j + M_j)$ is used as an approximation to describe the gross value of goods and services produced in the partner country *j*.
   - In the case of third-market competition with the third country as the competitive market, the focus is on the significance of the trading partner for sales in the third country. This factor is calculated as follows:

$$s_j^k = \frac{X_j^k}{(BIP_k + M_k) - X_k + M_k}, \tag{A18}$$

   whereby s_j^k $(k \neq j)$ represents the market share of exports from the country *j* in the market *k*. M_k and X_k describe the totality of imports and exports from country *k* respectively. The denominator represents the total value of all sales in the third market *k*, whereby $(BIP_k + M_k)$ describes, as above, the gross value of goods and services produced in the partner country *k*.

The factors calculated in this way are used in the formulae (A4)–(A9) in annex I, in order to ascertain for each trading partner *j* the weightings $MW_{CH,j}$, $BXW_{CH,j}$ and $TXW_{CH,j}$ as well as the corresponding structural parameters λ_{CH}^{M}, λ_{CH}^{BX} and λ_{CH}^{TX}.

7. Annex III: Chained Törnqvist index

The SNB exchange rate index is a chained Törnqvist index. A Törnqvist index is a geometrically balanced index that takes into consideration weighting changes between the base period and the comparison period, namely by applying the arithmetic mean of the weightings of both periods for the weighting of the relative prices.

A chained index is the result of the linking of consecutive indices whose base period is the prior period in each case. As a result of this linking, the weightings of a chained index will change on a regular basis. The defining characteristic is that any two-period comparison (between periods 0 und T) is produced indirectly, namely as the product of the corresponding subindices, and not directly, i.e. just through the use of the data of periods 0 und T, as would be the case with a direct index. For illustration purposes, the chained index refers to a specific reference year (e.g. the year 2000 = 100).

Nominal effective exchange rate index

A chained nominal effective exchange rate index in the Törnqvist (NEER) mould is defined as follows:

$$NEER^{T}_{Chained\ Törnqvist} = \prod_{j=1}^{J_1}(e_{j,1})^{\frac{1}{2}(w_{j,0}+w_{j,1})} \cdots \prod_{j=1}^{J_{T-1}}(e_{j,T-1})^{\frac{1}{2}(w_{j,T-2}+w_{j,T-1})} \prod_{j=1}^{J_T}(e_{j,T})^{\frac{1}{2}(w_{j,T-1}+w_{j,T})}$$

$$\text{with } e_{j,t} = \frac{wk_{j,t}}{wk_{j,t-1}}, \tag{A19}$$

whereby $e_{j,t}$ describes the nominal bilateral exchange rate index of the domestic currency against the currency of trading partner j, with the prior period as the base. The expression $e_{j,t}$ is obtained by dividing the exchange rate of the comparison period $wk_{j,t}$ by the exchange rate of the prior period $wk_{j,t-1}$ (with respect to the currency of the partner country j, expressed in the indirect quotation as the number of units of foreign currency per unit of domestic currency) in the period $t = 1,\ldots,T$. An increase in $e_{j,t}$ indicates a nominal appreciation of the Swiss franc. The weightings $w_{j,t}$ are ascertained on the basis of international trade in goods and services (cf. annex I). J_t describes the number of countries included in the index at point in time t.

Real effective exchange rate index

The real effective exchange rate index (REER) defines:

$$REER^{T}_{Chained\ Törnqvist} = \prod_{j=1}^{J_1}(v_{j,1})^{\frac{1}{2}(w_{j,0}+w_{j,1})} \cdots \prod_{j=1}^{J_{T-1}}(v_{j,T-1})^{\frac{1}{2}(w_{j,T-2}+w_{j,T-1})} \prod_{j=1}^{J_T}(v_{j,T})^{\frac{1}{2}(w_{j,T-1}+w_{j,T})}. \tag{A20}$$

The index formula is identical to the formula for the nominal effective index. The only difference is that the nominal bilateral indices $e_{j,t}$ are replaced by the real bilateral indices $v_{j,t}$. The expression $v_{j,t}$ describes the real bilateral exchange rate index against the currency of partner country j in the period $t = 1,\ldots,T$ and is defined as follows:

$$v_{j,t} = e_{j,t} \cdot \frac{p_{j,t-1}}{p_{j,t}} \cdot \frac{p_{0,t}}{p_{0,t-1}}, \tag{A21}$$

whereby $e_{j,t}$ describes the nominal exchange rate index, $p_{j,t}$ and $p_{j,t-1}$ the index level of the deflator of the country with the currency n at points in time t and $t-1$ respectively. The expressions $p_{0,t}$ and $p_{0,t-1}$ describe the corresponding index levels for Switzerland. A rise of $v_{j,t}$ signifies a real appreciation of the Swiss franc against the currency of country j. As with the nominal index, the weightings $w_{j,t}$ are ascertained on the basis of international trade in goods and services (cf. annex I).

Differing frequencies of trade and exchange rate data

The new chained Törnqvist index weights (geometrically) the annual rates of change in bilateral indices. The weightings for the exchange rate index are calculated using annual trade data. By contrast, the bilateral indices, which also need to be weighted, are ascertained on the basis of daily, monthly, quarterly, and annual data. In order to correctly link the corresponding mathematical terms of different frequencies, the above formula needs to be adjusted for the chained Törnqvist index. For bilateral indices on a monthly basis, the index formula for the nominal effective index is as follows:

$$\begin{aligned} NEER^{T,m}_{Chained\ Törnqvist} = & \prod_{j=1}^{J_1} (e_{j,1,12})^{\frac{1}{2}(w_{j,0}+w_{j,1})} \\ & \ldots \prod_{j=1}^{J_{T-1}} (e_{j,T-1,12})^{\frac{1}{2}(w_{j,T-2}+w_{j,T-1})} \prod_{j=1}^{J_T} (e_{j,T,m})^{\frac{1}{2}(w_{j,T-1}+w_{j,T})} \\ \text{with } e_{j,t,m} = & \frac{wk_{j,t,m}}{wk_{j,t-1,12}}, \end{aligned} \tag{A22}$$

whereby the periods $t = 1,\ldots,T$ describe the annual periods ($t = 1$: year 2001) and m the corresponding monthly observations. For example, $wk_{US,15,11}$ describes the exchange rate with respect to the US dollar in November 2015. An analogous approach is used in respect of the exchange rate data on a quarterly and daily basis. The calculation of the real effective index on the basis of monthly data follows the same pattern:

$$\begin{aligned} REER^{T,m}_{Chained\ Törnqvist} = & \prod_{j=1}^{J_1} (v_{j,1,12})^{\frac{1}{2}(w_{j,0}+w_{w,1})} \\ & \ldots \prod_{j=1}^{J_{T-1}} (v_{j,T-1,12})^{\frac{1}{2}(w_{j,T-2}+w_{j,T-1})} \prod_{j=1}^{J_T} (v_{j,T,m})^{\frac{1}{2}(w_{j,T-1}+w_{j,T})} \end{aligned}$$

$$\text{with } v_{j,t,m} = e_{j,t,m} \cdot \frac{p_{j,t-1,12}}{p_{j,t,m}} \cdot \frac{p_{0,t,m}}{p_{0,t-1,12}}. \tag{A23}$$

No adjustment of the index formula is required to calculate the index with exchange rates on the basis of annual data.

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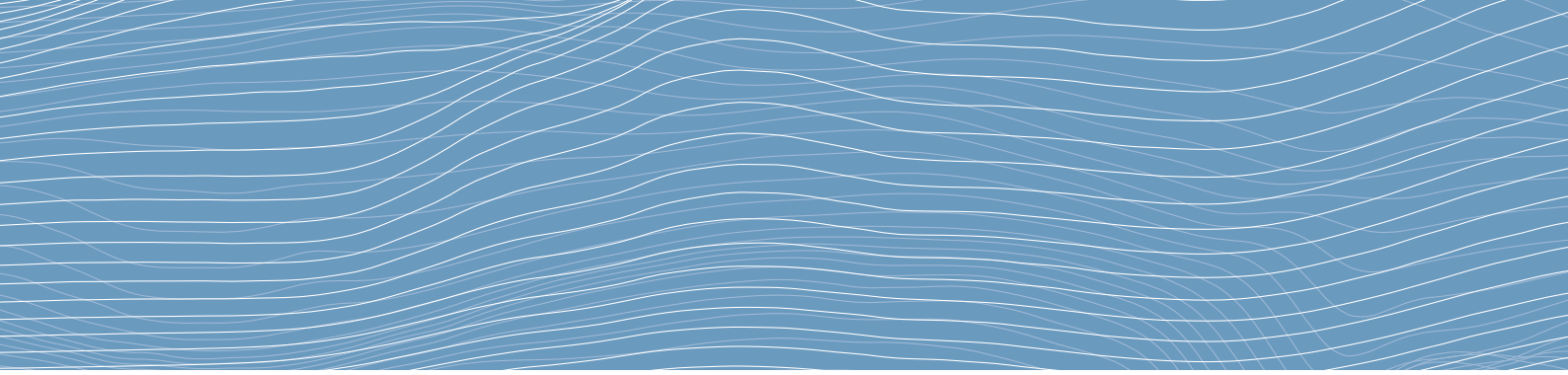

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