Methodological manual

Foreign trade indices

$$I_{Laspeyres} = \sum_{i=1}^{m} g^i \frac{p_t^i}{p_0^i} =$$

$$\sum_{i=1}^{m} \frac{p_0^i q_0^i}{\sum_{i=1}^{m} p_0^i q_0^i} \frac{p_t^i}{p_0^i} = \frac{\sum_{i=1}^{m} p_t^i q_0^i}{\sum_{i=1}^{m} p_0^i q_0^i}$$

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The nominal index (value index) indicates the variation in absolute values between two periods.

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The unit value index measures the trend in prices on the basis of average values. A unit value corresponds to the value divided by quantity (see Chapter 2.1).

Real index
The real index (volume index) indicates the real trend (at constant prices or adjusted for price evolution) in foreign trade. It is a residual value resulting from the value index relative to the unit value index.

Tariff number
Goods of a comparable class, also known as customs tariff number or tariff heading.

International recommendations

IMTS 2010 – CM International Merchandise Trade Statistics: Compilers Manual, Revision 1, United Nations (2013): 329ff.

XMPI Manual - Export and Import Price Index Manual: Theory and Practice, International Monetary Fund (2009): S. 71ff.

OECD Progress Report on Calculation of UVIS, OECD (2012).

1 Introduction

This guide is the reference guide for Swiss foreign trade indices and is intended for all users who are interested in index calculation methodology. It contains numerous examples which allow the reader to get to know and understand the methodology used to calculate indices step by step.

It explains the available indices, the method used to calculate them on a moving basis, their subsequent chaining, opportunities for comparison and possible applications.

2 Foreign trade indices

Swiss foreign trade statistics not only provide the general public with absolute foreign trade figures (value in CHF and quantity in kg) but also indices. Foreign trade indices are calculated on the basis of information obtained from customs declarations. These split the nominal development into price and volume components. The following indices are published:

- nominal index
- real index
- unit value index

These indices are compiled for total trade, as well as for sub-groups, according to their nature (breakdown by branches), their broad economics categories (breakdown by basic categories of the national account) and the CPA classification ("Statistical classification of products by activity"). The indices are not available for individual countries or for customs tariff numbers. Total trade relates to the business cycle total (Total 1). This total does not include trade in precious metals, precious stones, works of art or antiques due to its uncertain and unpredictable nature.

The UN (IMTS 2010) recommends that official statistical offices publish foreign trade indices. The Swiss approach is based on the most important recommendations for calculating the unit value index as made by the UN, the International Monetary Fund and the OECD (see page 3).

The calculation of the unit value index, as well as the calculation used for value and real indices, are explained step by step. For better understanding, simple examples illustrate the various procedures and calculations.

The indices are available down to the lowest level of nature of goods, broad economic categories and CPA[1]. The indices are first calculated for these groups. The results obtained are then gradually aggregated in order to progressively establish the indices for higher levels, main groups and total trade.

[1] The aggregation by CPA can generate divergent results at the level of unit value indices and real indices for methodological reasons.

3 Nominal index

The nominal index (value index) indicates the variation in value between two periods. To illustrate the calculation, the December 2016 import data for the subgroup **socks, stockings and tights** (03.2.2.02) which is part of the **textiles, clothing, shoes** (03) main group will be used.

The example in brief

The subgroup socks, stockings and tights includes 16 products (tariff headings) (see Table 1) that can be distinguished by the type of fibre used (such as cotton or synthetic fibre).

The nominal index $I^k_{nominal}$ of the k subgroup with the i products is calculated using the formula:

$$I^k_{nominal} = \frac{P^k_t\, Q^k_t}{P^k_0\, Q^k_0} 100 = \frac{\sum_{i\epsilon k} p^i_t\, q^i_t}{\sum_{i\epsilon k} p^i_0\, q^i_0} 100 \qquad (1)$$

q_t	quantity at time t
p_t	unit value at time t
$p_t q_t$	value at time t
q_0	quantity at time 0
p_0	unit value at time 0
$p_0 q_0$	value at time 0

The indices are calculated on a moving basis. This procedure has advantages as opposed to a fixed basis (see box "Advantages of a moving base as opposed to a fixed base"). In the moving basis calculation, the reference period refers to the previous year average. This is illustrated as follows:

$q_0 = f * Q_0$ when Q_0 of total quantity for the previous year (2)

$p_0 q_0 = f * P_0 Q_0$ when $P_0 Q_0$ of total value for the previous year (3)

when f
- $\frac{1}{12}$ for the monthly data
- $\frac{1}{4}$ for the quarterly data
- $\frac{x}{12}$ for the cumulated data, e.g. x = 7 for the period from January to July

Advantages of a moving base as opposed to a fixed base

The composition of imports and exports changes from one period of time to another and variations can often be considerable. If the index is calculated on a moving base the weighting is determined by the current basket of goods exchanged. It is therefore not necessary to revise the contents of the basket at regular intervals since it will automatically change from one period to the next. This method serves to minimise the recurrent problems of price indices when the quality of the products changes. In the case of fixed base indices, the contents of the basket remains the same over time and changes in quality between the base period and the current period may distort price measurements.

Using the example of the subgroup socks, stockings, tights (03.2.2.02), the result of the nominal index in December 2016 was as follows (see Table 1):

$$I^{k}_{nominal} = \frac{11\ 251\ 551}{10\ 479\ 719} 100 = 107.4 \qquad \text{when k: subgroup 03.2.2.02}$$

Table 1: Calculation of the value index of the subgroup socks, stockings and tights

Tariff number	$p_t\, q_t$	$p_0\, q_0$	$I^{k}_{nominal}$
6115.1011	8 218	28 896	
6115.1019	166 458	192 906	
6115.1020	82 157	57 872	
6115.1031	382 396	417 220	
6115.1032	8 420	21 242	
6115.1039	110 593	89 346	
6115.2100	1 865 037	1 529 208	
6115.2200	393 738	288 617	
6115.2910	302 402	259 907	
6115.2990	239 263	159 312	
6115.3000	518 568	543 647	
6115.9400	587 078	497 906	
6115.9500	4 902 280	4 477 997	
6115.9610	782 550	664 487	
6115.9620	689 081	1 024 551	
6115.9900	213 312	226 604	
Total	**11 251 551**	**10 479 719**	**107.4**

Aggregation

Formula 1 is used for all aggregate levels. Let us take a look at the next biggest group of undergarments (03.2.2) which includes the four following subgroups:

- girdles, corsets, braces, etc. (03.2.2.01)
- socks, stockings, tights (03.2.2.02)
- other knitted undergarments such as pyjamas, T-shirts, briefs (03.2.2.03)
- other woven undergarments such as pyjamas, bathrobes, briefs (03.2.2.04)

For the undergarments group (03.2.2), the following breakdown emerges for the nominal index (see Table 2):

Table 2: Calculation of the value index of the undergarments group

Type of goods	Designation	$P_t\, Q_t$	$P_0\, Q_0$	$I^{k}_{nominal}$
03.2.2.01	Girdles, corsets, braces, etc.	9 953 662	9 795 019	101.6
03.2.2.02	Socks, stockings, tights	11 251 551	10 479 719	107.4
03.2.2.03	Other items of hosiery underwear such as pyjamas, T-shirts, briefs	40 863 624	40 140 015	101.8
03.2.2.04	Other items of fabric underwear such as pyjamas, bathrobes, briefs	2 765 711	1 796 716	153.9
03.2.2	**Undergarments**	**64 834 548**	**62 211 469**	**104.2**

$$I^{k}_{nominal} = \frac{64\ 834\ 548}{62\ 211\ 469} 100 = 104.2 \qquad \text{when k: group 03.2.2}$$

4 Unit value index

The unit value index measures the average variation in import and export prices. In order to interpret the estimated variation in prices correctly, it is necessary to understand the characteristics of unit values. This chapter describes the differences between real prices and unit values, as well as the difficulties that can arise. The second section describes the solutions applied to guarantee the quality and reliability of the published data. The third section concerns indexing.

Problem: unit values and prices

The Federal Office for Customs and Border Security does not record prices of imported and exported goods. Customs documents do, however, contain the type of goods, the quantity and the value. Variations in import and export prices are estimated for each tariff number on the basis of the unit values of all the goods it contains, which are defined as the ratio between value and quantity. This means the unit value is not a real price but rather an average value per kilo and customs tariff number. In the case of homogeneous tariff numbers, i.e. those which only contain one single product, the unit values tend to be similar to the real prices.

Over the long term, prices and unit values evolve in almost the same manner. In contrast, unit values show stronger short-term fluctuations. This is shown in a comparison of the price index and unit value index produced by the German Federal Statistical Office (Destatis) [2].

Using the unit value index in foreign trade offers the following **benefits**:

- No additional data collection:
  Unit values are calculated using the information provided in import and export customs declarations. Unlike a price index, there is no need to consult importers or exporters. This benefits both import and export companies (no additional administrative expenses) and customs administrations (no additional costs).
- Comprehensive picture of foreign trade (full census):
  All transactions included in the foreign trade statistics are used as the basis for calculating unit values.

Using unit values also has the following **disadvantages**:

- Variations in the unit value which arise from "non-price-related" factors:
  Unit values are generally more volatile than real prices. This means that the unit values of a tariff number can vary even if the prices of the products it contains remain constant. Unit values are influenced by many "non-price-related" factors, the most important of which are:
  - Changes in the range of goods within a heterogeneous customs tariff number:
    A heterogeneous tariff number includes different products with different prices (see "Change in range of goods and unit values" box). Just a change in composition of these products has an impact on the unit value.

[2] Method comparison between price and average value indices in foreign trade: Silke Gehle, in Wirtschaft und Statistik 10/2003: https://www.destatis.de/DE/Publikationen/Thematisch/Aussenhandel/Gesamtentwicklung/Aussenhandel-Welthandel5510006159004.pdf?__blob=publicationFile. (only in German)

- Changes in weight: technical developments allow ever smaller and lighter equipment to be produced. As a result, the price per kilogram (unit value) continually increases, even though the products become smaller but not more expensive. A change in packaging can also affect the unit value, e.g. when additional or different packaging material is used.

- Changes in quality: changes or, as in most cases, improvements to a product's properties influence its price trend. For instance, the price of a new smartphone model may increase but it will also include improved features (e.g. higher camera resolution, increased storage capacity, optimised operating system).This problem does not only influence the reliability of the unit value index, but also that of the traditional price indices.

Changes in range of goods and unit values

Unit values are more volatile than prices and do not necessarily reflect the real variation in price correctly. In extreme cases, unit values may suggest a price change when, in reality, prices remain stable.

Let us consider a tariff number that includes three products (A, B and C) for which the quantities are known, as well as, for illustrative purposes, the prices.

Table 3: Behaviour of the unit value

	Time 1			Time 2		
	kg	**CHF/kg**	**CHF**	**kg**	**CHF/kg**	**CHF**
Product A	300	30	9 000	100	30	3 000
Product B	200	20	4 000	200	20	4 000
Product C	100	20	2 000	100	20	2 000
Tariff number total	**600**	**-**	**15 000**	**400**	**-**	**9 000**

The prices of the imported products A, B and C remain unchanged, as do the quantity of products B and C. Only sales of product A have slumped.

Let us calculate the unit values of the tariff number:

$$p_t = \frac{p_1 q_1}{q_1} = \frac{15\,000}{600} = 25$$

$$p_2 = \frac{p_2 q_2}{q_2} = \frac{9\,000}{400} = 22.5$$

Between the first and second points in time, the unit value of the tariff number fell from CHF 25 to CHF 22.50, representing a drop of 10%. Without knowing the real prices, it would be assumed that the prices had dropped by 10%, even though they did not change. In this example, the unit value has dropped only as a result of a modification in the composition of the tariff number.

Solution to the problem of unit values

In order to optimise the use of unit values, a solution strategy is pursued which complements itself at three levels.

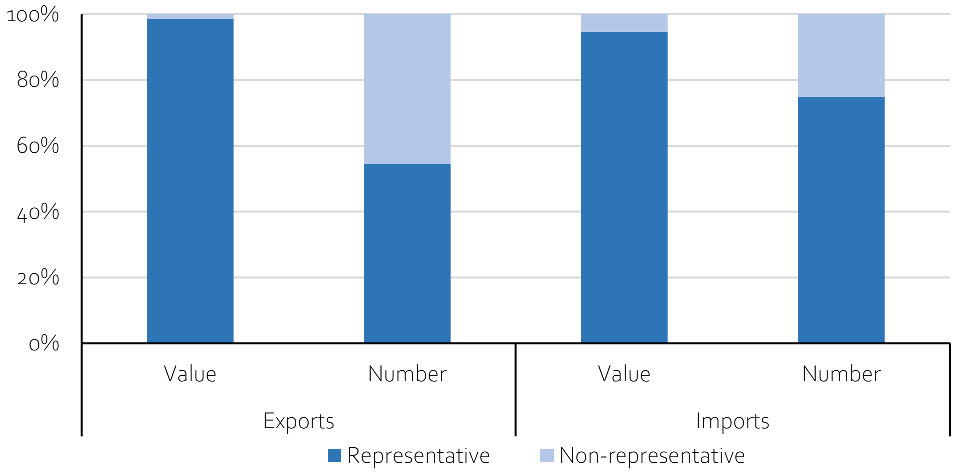
- Selection of representative tariff numbers
- Treatment of unit values
- Quality control

Selection of representative tariff numbers

In order to guarantee the quality and reliability of the unit value indices, the approximate 8,000 tariff numbers are split into two groups.

Representative tariff numbers: the unit values for these tariff numbers are sufficiently stable and it is assumed that their fluctuation corresponds more or less to that of real prices. The unit value index is based solely on these tariff numbers. In 2016, in value terms, 95% of imports and 99% of exports belonged to this group. These are tariff numbers with high trading volumes because, in the case of imports, their number only corresponds to a mere three quarters of all tariff numbers, and a mere 55% for exports.

Figure 1: 2016 tariff number breakdown
(share in %)



Non-representative tariff numbers: the unit values of these tariff numbers are subject to strong fluctuations and generally this volatility cannot be linked to the effective evolution of prices. This group primarily contains tariff numbers that are traded very little. The division of tariff headings into these two groups is subject to a detailed examination once a year. An automated discriminant analysis is carried out for this purpose. At tariff number level, various quality indicators (separation factors) are used, e.g. trend stability indicators. The discriminant analysis calculates the probability of a customs tariff number belonging to one group or the other. The calculated probability is then used as a basis for determining classification criteria. The final check, which is supplemented by an in-depth examination of individual customs tariff numbers, is used to accept or reject the suggestions of the discriminant analysis.

Treatment of unit values

Most of the original data undergoes a special treatment before the indices are calculated. This serves to minimise the volatility of unit values and responds to changes in the ranges of goods. One of the following processes is used:

- Outlier correction (standard method)
- Smoothing
- Median

If none of these processes produce satisfactory results, alternative data sources can also be used.

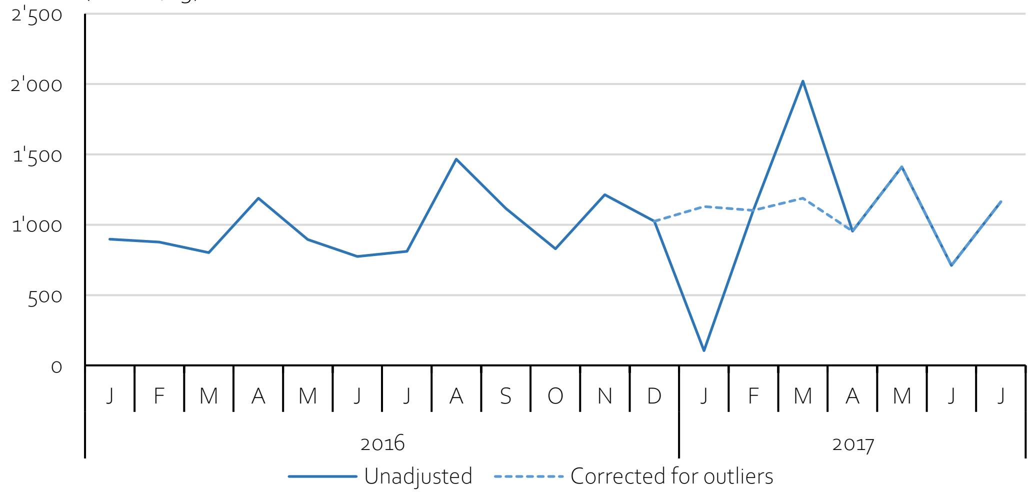
Outlier correction

Outlier correction is the standard method for eliminating outliers. Its aim is to recognise outliers which have no bearing on real price trends. In 2016, representative tariff numbers for 99.7% of imports and 99.8% of exports were processed using this procedure.

A fully automated procedure identifies outliers and replaces them with plausible estimated values. The basic tool is AUTOBOX.PLUS[3] which is specially designed for analysing time series. A version of AUTOBOX.PLUS has been implemented that is specially adapted to the requirements of Swiss foreign trade statistics.

Based on the monthly unit values of the current and previous six years, the programme identifies the ARIMA model which best describes the current data series. The programme simultaneously identifies any level shifts, seasonal factors, changes in trends and changes in variance. The programme then detects any extreme values; these are defined as any values which lie outside the confidence interval set by the model. The identified outliers are replaced by an estimated value. This is illustrated in Figure 2 below for the export unit values for polymers (tariff number 3913.9010). These were between CHF 800 and CHF 1500 CHF per kilogram - except in January and March 2017. Estimated values replaced the unit values for these two months.

Figure 2: Unit values for polymer exports
(in CHF/kg)



[3] www.autobox.com

While this process provides good results for the large majority of tariff numbers, it can result in undesired corrections or still unsatisfactory results for certain data constellations of the original series. Other options are examined in these cases.

Smoothing of time series

Two different smoothing methods are used. The first method is currently only used for aircraft. These tariff numbers cover trade of new and used aircraft as well as spare parts which means the unit value fluctuates substantially from month to month. In certain months no aircraft and only spare parts will be traded. These significant fluctuations are lessened by using the unit value over three months as this documents a more balanced ratio between spare parts and aircraft.

The second type of smoothing process is used for the trade of pharmaceutical products.
It is more difficult to determine price trends for such goods because they vary greatly. The same tariff number can contain medications for both headaches and cancer treatment. In such cases, the unit value can easily fluctuate between CHF 3 per kilogram and multiple hundreds of thousands of Swiss Francs per kilogram. Trade in chemicals and pharmaceuticals is of great importance to Swiss foreign trade and accounts for 45% of exports (2016). Excluding the most influential customs tariff numbers is therefore avoided where possible.

The method used depends on a two-phase process. Firstly, every month 3% of the highest and lowest unit values per customs declaration are set to the next lowest/highest value (winsorisation). The time series are then smoothed out, i.e. the fluctuations in the unit value over time are offset. This process is based on previous values. The further back in time a value lies, the less influence (weight) it has on the current smoothing. This process is called the exponentially weighted moving average (EWMA).

The original unit values are shown as $p_1, p_2, \ldots, p_n$. The smoothed values $p_1^*, p_2^*, \ldots, p_n^*$ are calculated as follows:

$$p_t^* = \sum_{n=0}^{q} \propto (1-\propto)^n \, p_{t-n} \quad \text{where } p_1^* = p_1 \qquad (4)$$

Factor $\propto$ corresponds to the smoothing parameter which has been set at 0.4 for this process. If this factor is used in the equation, it can be seen that the weight of the previous values decreases (40% for time t, 24% for t-1 etc.):

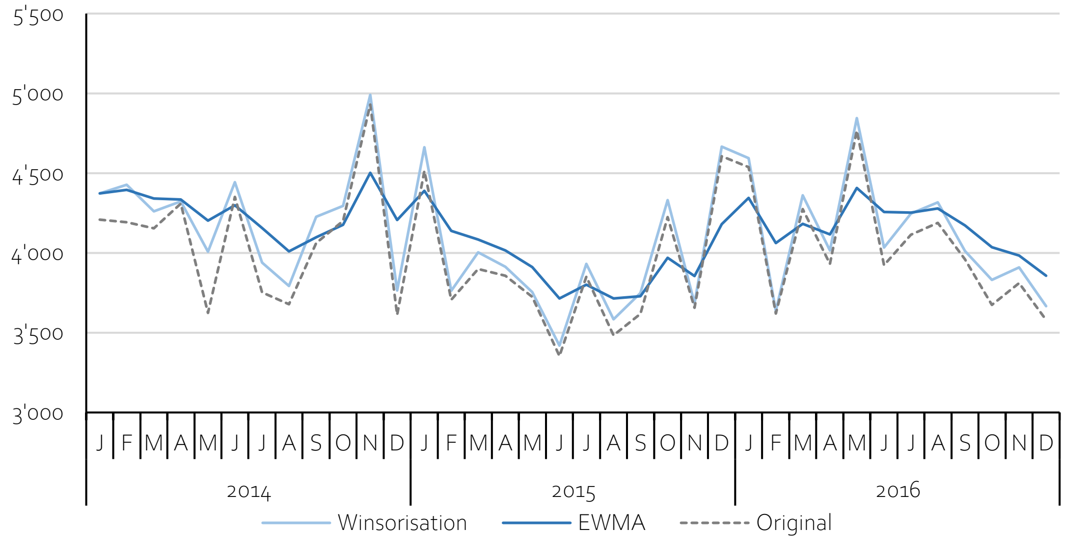
$$p_t^* = \sum_{n=0}^{q} 0.4\,(0.6)^n \, p_{t-n}$$

$$= 0.4\,(0.6)^0\, p_t + 0.4\,(0.6)^1\, p_{t-1} + 0.4\,(0.6)^2\, p_{t-2} + \ldots + 0.4\,(0.6)^n\, p_{t-q} \qquad \text{where } \propto = 0.4$$

$$= 0.4\, p_t + 0.24\, p_{t-1} + 0.144\, p_{t-2} + \ldots + 0.4\,(0.6)^q\, p_{t-q}$$

Figure 3 below illustrates the results according to both calculation levels for exports of antisera (tariff number 3002.1000).

Figure 3: Smoothed time series for exports under tariff number 3002.1000
(unit values in CHF/kg)



Median

The unit value of a tariff number can be replaced by the median price per kilogram of individual shipments. The median is also defined as the central value for one specific customs tariff number over the period of one month, dividing the price series into two equal halves: 50% of shipments with a price per kilogram above the median, 50% with a price per kilogram below the median.

This option is suitable for important tariff numbers with extremely variable unit values which can significantly distort results. This method is used in the watch sector.

Quality control

The annual classification decisions (representative vs. non-representative) can quickly become outdated because the representative character of a tariff heading can rapidly change. For this reason, as well as being checked annually, tariff numbers are also subject to a monthly quality check which tries to recognise unrealistic unit values before they are published. In addition, the leverage effect of all tariff numbers is measured on the higher aggregate levels into which they are divided. If necessary, tariff numbers with unrealistic unit values or an unrealistically high leverage effect are immediately transferred to the non-representative customs tariff numbers group. The index is then calculated again without this tariff heading. This check means that results can be actively leveraged therefore improving the quality and reliability of the foreign trade indices.

Indexing

Indexing is calculated using the Fisher method. Both the Laspeyres and Paasche indices are used to calculate the Fisher index. The stages in calculating the Lasypeyres, Paasche and Fisher indices are explained in the following.

This section considers the constellation where a group is composed solely of representative customs tariff numbers. The second scenario, where a group also contains non-representative customs tariff numbers, is described in the Annex.
The socks, stockings, tights group (03.2.2.02) will again be used by way of example. Their 16 tariff numbers are all representative for calculating the unit value.

Table 4: Values and quantities of the socks, stockings and tights group

Tariff	$p_t q_t$	q_t	$p_0 q_0$	q_0
6115.1011	8 218	131	28 896	440
6115.1019	166 458	3 159	192 906	3 604
6115.1020	82 157	1 453	57 872	3 466
6115.1031	382 396	4 404	417 220	5 233
6115.1032	8 420	129	21 242	278
6115.1039	110 593	2 115	89 346	1 366
6115.2100	1 865 037	40 147	1 529 208	33 306
6115.2200	393 738	9 538	288 617	10 616
6115.2910	302 402	16 353	259 907	12 767
6115.2990	239 263	6 348	159 312	4 401
6115.3000	518 568	12 173	543 647	13 631
6115.9400	587 078	7 086	497 906	7 035
6115.9500	4 902 280	216 508	4 477 997	194 263
6115.9610	782 550	18 009	664 487	17 682
6115.9620	689 081	22 060	1 024 551	20 404
6115.9900	213 312	6 617	226 604	7 196
Total	**11 251 551**		**10 479 719**	

Laspeyres index

In the first step, the unit values for periods t and 0 have to be determined for product i (p_t^i and p_0^i). In order to do this, the value for the current period $p_t^i\, q_t^i$ and that for the preceding year $p_0^i q_0^i$ are divided by the corresponding amounts q_t^i and q_0^i. By definition, the unit value equals the quotient of the value / quantity division. For the first tariff heading i (6115.1011) of the group the following is thus obtained:

$$p_t^i = \frac{p_t^i q_t^i}{q_t^i} = \frac{8\,218}{131} = 62.7$$ when product i: tariff number 6115.1011 (5)

$$p_0^i = \frac{p_0^i q_0^i}{q_0^i} = \frac{28\,896}{440} = 65.7$$ when product i: tariff number 6115.1011 (6)

Original and adjusted amounts

The corrections caused by the treatment of the unit values are taken into account when the index is calculated using q_0 und q_t. For each representative tariff number the quantities are adjusted in such a way that subsequently the result is always the unit value specified by the model. This operation guarantees that the value of each item corresponds to the original value "quantity multiplied by price" even after correction.

$$q_t^{adjusted} = \frac{p_t q_t}{p_t^{adjusted}} \quad \rightarrow \quad q_t^{adjusted} * p_t^{adjusted} = p_t q_t \qquad (7)$$

$$q_o^{adjusted} = \frac{p_o q_o}{p_o^{adjusted}} \quad \rightarrow \quad q_o^{adjusted} * p_o^{adjusted} = p_o q_o \qquad (8)$$

This can be seen from the example of tariff number 6115.1011. The price p_o was originally 77.5. It was reduced to $p_o^{adjusted} = 65.7$ (see Table 5). To keep the value $p_o q_o$ constant, the method corrects the quantity from 373kg to 440kg.

$$q_o^{adjusted} = \frac{28\,896}{65.7} = 440$$ for tariff number 6115.1011

Only the adjusted prices and quantities are used in this report.

Table 5: Values and adjusted quantities and prices of the socks, stockings and tights group

Tariff number	$p_t q_t$	q_t	p_t	$p_0 q_0$	q_0	p_0
6115.1011	8 218	131	62.7	28 896	440	65.7
6115.1019	166 458	3 159	52.7	192 906	3 604	53.5
6115.1020	82 157	1 453	56.5	57 872	3 466	16.7
6115.1031	382 396	4 404	86.8	417 220	5 233	79.7
6115.1032	8 420	129	65.3	21 242	278	76.3
6115.1039	110 593	2 115	52.3	89 346	1 366	65.4
6115.2100	1 865 037	40 147	46.5	1 529 208	33 306	45.9
6115.2200	393 738	9 538	41.3	288 617	10 616	27.2
6115.2910	302 402	16 353	18.5	259 907	12 767	20.4
6115.2990	239 263	6 348	37.7	159 312	4 401	36.2
6115.3000	518 568	12 173	42.6	543 647	13 631	39.9
6115.9400	587 078	7 086	82.9	497 906	7 035	70.8
6115.9500	4 902 280	216 508	22.6	4 477 997	194 263	23.1
6115.9610	782 550	18 009	43.5	664 487	17 682	37.6
6115.9620	689 081	22 060	31.2	1 024 551	20 404	50.2
6115.9900	213 312	6 617	32.2	226 604	7 196	31.5
Total	**11 251 551**			**10 479 719**		

Using estimated prices and quantities it is possible to reconstruct the values for the desired periods. In particular, this makes it possible to determine the (hypothetical) value of the original basket at current prices $p_t^i\, q_0^i$, from which the Laspeyres index can be calculated.

The Laspeyres index for basket k with products i is calculated using the following formula:

$$I^k_{Laspeyres} = \frac{P^k_t\, Q^k_0}{P^k_0\, Q^k_0} 100 = \frac{\sum_{i \in k} p^i_t\, q^i_0}{\sum_{i \in k} p^i_0\, q^i_0} 100 \qquad (9)$$

$P^k_0\, Q^k_0$	value of basket k for period 0
$P^k_t\, Q^k_0$	hypothetical value of basket k for reference period 0 expressed in current prices (period t).

$$I^k_{Laspeyres} = \frac{10\ 544\ 572}{10\ 479\ 719} 100 = 100.6$$

when k: subgroup 03.2.2.02

Table 6: Calculation of Laspeyres index for the socks, stockings and tights group

Tariff number	p_t	q_0	$p_t\, q_0$	$p_0\, q_0$	$I^k_{Laspeyres}$
6115.1011	62.7	440	27 593	28 896	
6115.1019	52.7	3 604	189 881	192 906	
6115.1020	56.5	3 466	195 984	57 872	
6115.1031	86.8	5 233	454 353	417 220	
6115.1032	65.3	278	18 158	21 242	
6115.1039	52.3	1 366	71 434	89 346	
6115.2100	46.5	33 306	1 547 229	1 529 208	
6115.2200	41.3	10 616	438 220	288 617	
6115.2910	18.5	12 767	236 086	259 907	
6115.2990	37.7	4 401	165 874	159 312	
6115.3000	42.6	13 631	580 661	543 647	
6115.9400	82.9	7 035	582 853	497 906	
6115.9500	22.6	194 263	4 398 599	4 477 997	
6115.9610	43.5	17 682	768 321	664 487	
6115.9620	31.2	20 404	637 357	1 024 551	
6115.9900	32.2	7 196	231 969	226 604	
Total			**10 544 572**	**10 479 719**	**100.6**

Laspeyres index

The Laspeyres price index shows the rate of variation in prices if the basket remains the same between the reference period and the current period.

The Laspeyres index is a weighted arithmetic mean of price ratios. The weighting is defined by the ratio of the value of item i to the total value for the reference period (period 0).

$$I_{Laspeyres} = \sum_i g^i \frac{p_t^i}{p_o^i} \qquad (10)$$

when $g^i = \frac{p_o^i q_o^i}{\sum_i p_o^i q_o^i}$ as the weighting of item i based on period 0 of Laspeyres: :

$$I_{Laspeyres} = \sum_i g^i \frac{p_t^i}{p_o^i} = \sum_i \underbrace{\frac{p_o^i\, q_o^i}{\sum_i p_o^i\, q_o^i}}_{g^i} \frac{p_t^i}{p_o^i} = \frac{\sum_i p_t^i\, q_o^i}{\sum_i p_o^i\, q_o^i} \qquad (11)$$

Replacing variable g^i by its expression in the index formula, we obtain the simplified formula. This expression is identical to formula (9) for the calculation of the unit value index. It should be noted that the simplified formula also uses the weighting of the basic formula.

Paasche index

The Paasche index is calculated alongside the Laspeyres index as a supplement. The hypothetical value of the current period basket has to be calculated first at initial period prices $p_0^i q_t^i$. This value is obtained by multiplying price p_0^i by quantity q_t^i.

The Paasche index is obtained using the following formula:

$$I_{Paasche}^k = \frac{P_t^k\, Q_t^k}{P_0^k\, Q_t^k} 100 = \frac{\sum_i p_t^i\, q_t^i}{\sum_i p_o^i\, q_t^i} 100 \qquad (12)$$

$$I_{Paasche}^k = \frac{11\,251\,551}{11\,337\,309} 100 = 99.2$$ when subgroup k: 03.2.2.02

Table 7: Calculation of Paasche index for the socks, stockings and tights group

Tariff number	$p_t\, q_t$	$p_0\, q_t$	$I^k_{Paasche}$
6115.1011	8 218	8 606	
6115.1019	166 458	169 111	
6115.1020	82 157	24 260	
6115.1031	382 396	351 143	
6115.1032	8 420	9 850	
6115.1039	110 593	138 325	
6115.2100	1 865 037	1 843 314	
6115.2200	393 738	259 321	
6115.2910	302 402	332 915	
6115.2990	239 263	229 798	
6115.3000	518 568	485 512	
6115.9400	587 078	501 516	
6115.9500	4 902 280	4 990 770	
6115.9610	782 550	676 793	
6115.9620	689 081	1 107 697	
6115.9900	213 312	208 378	
Total	**11 251 551**	**11 337 309**	**99.2**

Paasche index

The Paasche index measures the development in prices assuming that the basket for the current period was also valid for the initial period.
The Paasche index is a harmonious weighted mean of price ratios. The weighting is defined as the ratio of the value of item i to the total value for the current period (period t):

$$I_{Paasche} = \frac{1}{\sum_i g_i \frac{p_0^i}{p_t^i}} \quad \text{when } g^i = \frac{p_t^i q_t^i}{\sum_i p_t^i q_t^i} \text{ weighting of item i at period t} \qquad (13)$$

If the complete term is used in the formula instead of g^i, we obtain the simplified Paasche formula:

$$I_{Paasche} = \frac{1}{\sum_i g_i \frac{p_o^i}{p_t^i}} = \frac{1}{\sum_i \underbrace{\frac{p_t^i q_t^i}{\sum_i p_t^i q_t^i}}_{g^i} \frac{p_o^i}{p_t^i}} = \frac{\sum_i p_t^i q_t^i}{\sum_i p_o^i q_t^i} \qquad (14)$$

This is the expression of the formula (12) for calculating the Paasche unit value index. It should be noted that the simplified formula contains the weighting of the basic formula.

Fisher index

The published foreign trade indices are calculated using Fisher's formula. Fisher's index corresponds to the geometrical means of the Laspeyres and Paasche indices. It is based on the following formula:

$$I^k_{Fisher} = \sqrt{I^k_{Laspeyres} * I^k_{Paasche}} \qquad (15)$$

$I^k_{Fisher} = \sqrt{100.6 * 99.2} = 99.9$ when group k: 03.2.2.02

Fisher index

The Fisher index is preferred for the following reasons:

- It is an ideal index: if prices double and quantities triple within a given period of time, the product obtained must be multiplied by six. Out of the three indices considered here, only the Fisher index respects this axiom.
- The Fisher index is an intermediate alternative to the Laspeyres and the Paasche indices. From a practical point of view, the Fisher index compensates for the tendency of the Laspeyres index to overestimate the variation in prices and that of the Paasche index to underestimate it. Since, from a theoretical point of view, neither the Laspeyres nor the Paasche index prevail, it seems reasonable to opt for the intermediate solution.
- Unlike the other two indices, the Fisher index fulfils the desirable condition of reciprocity. According to this principle, the index for period t in relation to 0 is the inverse of the index for initial period 0 in relation to time period t.

Aggregation

The indices for the upper levels are calculated by aggregating the data for all their respective subgroups. The Laspeyres, Paasche and Fisher indices can be calculated from the aggregated values. This procedure is then repeated for each level up to the total index.

Let us look at the undergarments group (03.2.2) which consists of four subgroups:

Table 8: Calculation of Fischer index for undergarments group (03.2.2)

Type of goods	$P_0 Q_0$	$P_0 Q_t$	$P_t Q_0$	$P_t Q_t$	$I^k_{Paasche}$	$I^k_{Laspeyres}$	I^k_{Fisher}
03.2.2.01	9 795 019	10 428 156	9 386 258	9 953 662	95.5	95.8	95.6
03.2.2.02	10 479 719	11 337 309	10 544 571	11 251 551	99.2	100.6	99.9
03.2.2.03	40 140 015	39 626 060	41 999 357	40 863 624	103.1	104.6	103.9
03.2.2.04	1 796 716	2 765 106	1 933 342	2 765 711	100.0	107.6	103.7
03.2.2	**62 211 469**	**64 156 631**	**63 863 528**	**64 834 548**	**101.1**	**102.7**	**101.9**

All subgroups i of group k (here group 03.2.2) can be calculated as follows:

$$I^k_{Laspeyres} = \frac{P^k_t \, Q^k_0}{P^k_0 \, Q^k_0} 100 = \frac{\sum_i P^i_t \, Q^i_0}{\sum_i P^i_0 \, Q^i_0} 100 \quad = \frac{63\,863\,528}{62\,211\,469} 100 = 102.7 \qquad (16)$$

$$I^k_{Paasche} = \frac{P^k_t \, Q^k_t}{P^k_0 \, Q^k_t} 100 = \frac{\sum_i P^i_t \, Q^i_t}{\sum_i P^i_0 \, Q^i_t} 100 \quad = \frac{64\,834\,548}{64\,156\,631} 100 = 101.1 \qquad (17)$$

$$I^k_{Fisher} = \sqrt{I^k_{Laspeyres} * I^k_{Paasche}} \quad = \sqrt{102.7 * 101.1} = 101.9 \qquad (18)$$

The results are obtained for the upper levels of aggregation using the same principle.

5 Real index

The real index shows the real or inflation-adjusted trend of foreign trade. The real index is a residual value which is obtained from the ratio of the value index to the unit value index.

The real index of group k I^k_{real} is calculated using the formula:

$$I^k_{real} = \frac{I^k_{nominal}}{I^k_{Fisher}} 100 \qquad (19)$$

6 Chaining

All the indices for the different categories of goods and for the total are calculated on a moving base (see chapters 1 to 5). To make the results easier to use and interpret, the indices are then transformed into more practical bases (chain index, previous year=100, previous period=100).

Swiss foreign trade indices are published in the form of chain indices. The moving base results are thus linked in a multiplicative fashion with the previous year result. The 1997 data has been taken as the basis for the index.

In order to allow comparisons to be made between the various periods, the different moving base indices

$$I_{97}^{\text{moving base}}, I_{98}^{\text{moving base}}, I_{99}^{\text{moving base}}, \ldots$$

are then made into a chain, i.e. expressed in relation to a common basis (1997), using the following formula:

$$I_t^{\text{chain}} = \frac{I_t^{\text{moving base}} * I_{t-1}^{\text{chain}}}{100} \qquad (20)$$

when $I(\text{unit value})_{1997}^{\text{chain}} = I(\text{nominal})_{1997}^{\text{chain}} = I(\text{real})_{1997}^{\text{chain}} = I_{1997}^{\text{moving base}} = 100$

$$I(\text{unit value})_t^{\text{chain}} = \frac{I(\text{unit value})_t^{\text{moving base}} * I(\text{unit value})_{t-1}^{\text{chain}}}{100} \qquad (21)$$

$$I(\text{nominal})_t^{\text{chain}} = \frac{I(\text{nominal})_t^{\text{moving base}} * I(\text{nominal})_{t-1}^{\text{chain}}}{100} \qquad (22)$$

$$I(\text{real})_t^{\text{chain}} = \frac{I(\text{real})_t^{\text{moving base}} * I(\text{real})_{t-1}^{\text{chain}}}{100} \qquad (23)$$

These operations are called **chaining** and allow variations over two distinct periods of time to be linked to give the variation for the total period.

Chaining of annual data

The chaining process is illustrated using total exports as an example:

Table 9: Moving base index and chain index of the total exports, 2015 and 2016

	Moving basis			Chain index: 1997 = 100		
Year	**Nominal**	**Unit value**	**Real**	**Nominal**	**Unit value**	**Real**
2015	97.4	98.3	99.1	193.0	117.2	164.7
2016	103.7	104.6	99.1	200.2	122.6	163.3

$$I(\text{nominal})_{2016}^{\text{chain}} = \frac{I(\text{nominal})_{2016}^{\text{moving base}} * I(\text{nominal})_{2015}^{\text{chain}}}{100} \quad = \frac{103.7 * 193.0}{100} = 200.2 \qquad (24)$$

The chain index is interpreted as follows: 2016 exports have risen in value by 100.2% in relation to 1997.

$$I(\text{unit value})_{2016}^{\text{chain}} = \frac{I(\text{unit value})_{2016}^{\text{moving base}} * I(\text{unit value})_{2015}^{\text{chain}}}{100} \qquad (25)$$

$$= \frac{104.6*117.2}{100} = 122.6$$

$$I(\text{real})_{2016}^{\text{chain}} = \frac{I(\text{real})_{2016}^{\text{moving base}} * I(\text{real})_{2015}^{\text{chain}}}{100} \quad = \frac{99.1*164.7}{100} = 163.3 \qquad (26)$$

The real index can also be derived with the help of both of the first indices:

$$I(\text{real})_{2016}^{\text{chain}} = \frac{I(\text{nominal})_{2016}^{\text{chain}}}{I(\text{unit value})_{2016}^{\text{chain}}} 100 \quad = \frac{200.2}{122.6} = 163.3 \qquad (27)$$

Chaining of other periods

For procedural considerations, the monthly and quarterly times series are not chained with the index for the same period in the preceding year but with that for the preceding year. By definition, the moving base corresponds to the average period for the previous year (see formulas 2 and 3). It follows from this that this ratio can also be maintained for the linking of a partial period with the base year 1997 (in other words, with the chain index of the previous year).

Here is an example for the monthly export results:

Table 10: Moving base index and chain index of total exports, December 2016

	Moving basis			Chain index: 1997 = 100		
Period	**Nominal**	**Unit value**	**Real**	**Nominal**	**Unit value**	**Real**
December 2016	97.7	103.5	94.4	188.5	121.2	155.5

$$I(nominal)^{chain}_{December\ 2016} = \frac{I(nominal)^{moving\ base}_{December\ 2016} * I(nominal)^{chain}_{2015}}{100} = \frac{97.7*193.0}{100} = 188.5 \quad (28)$$

(Value for $I(nominal)^{chain}_{2015}$ see table 9)

7 Comparisons

Year-on-year comparison

The year-on-year comparison is calculated from the chain indices for the two periods. Since the chain index for each period shows the variation between that period and the mean period of 1997, the variation between period t of year j and period t of year j-1 is nothing other than the ratio between the two chain indices:

$$I_t^{year\text{-}on\text{-}year\ comparison} = \frac{I^{chain}_{t_j}}{I^{chain}_{t_{j-1}}} 100 \quad (29)$$

To understand this, let us return to our previous example:

Table 11: Moving base index and chain index of total exports, December 2015 and 2016

	Chain index: 1997 = 100			Year-on-year comparison		
Period	**Nominal**	**Unit value**	**Real**	**Nominal**	**Unit value**	**Real**
December 2015	184.3	120.1	153.4	101.9	99.5	102.4
December2016	188.5	121.2	155.5	102.3	100.9	101.4

$$I(nominal)^{year\text{-}on\text{-}year\ comparison}_{December\ 2016} = \frac{I^{chain}_{December\ 2016}}{I^{chain}_{December\ 2015}} 100 \quad = \frac{188.5}{184.3} 100 = 102.3$$

The result should be interpreted as follows: in December 2016 exports were 2.3% higher than in December 2015. As effects related to the number of working days play a role in the year-on-year comparisons, for the purposes of correct interpretation, they are adjusted to take account of these effects (see Seasonal and working day adjustment methodological manual). It is therefore recommended to use the working-day adjusted year-on-year comparisons.

Previous period comparison

The comparison with the previous period is calculated with the chain indices of the corresponding periods:

$$I_t^{\text{previous period comparison}} = \frac{I_t^{\text{chain}}}{I_{t-1}^{\text{chain}}} 100 \qquad (30)$$

To understand this, let us return to our previous example:

Table 12: Moving base index and chain index of total exports, November and December 2016

	Chain index: 1997 = 100			Year-on-year comparison		
Period	**Nominal**	**Unit value**	**Real**	**Nominal**	**Unit value**	**Real**
November 2016	213.2	123.2	173.1	104.7	99.0	105.9
December 2016	188.5	121.2	155.5	88.4	98.4	89.8

$$I(\text{nominal})_{\text{December 2016}}^{\text{previous period comparison}} = \frac{I(\text{nominal})_{\text{December 2016}}^{\text{chain}}}{I(\text{nominal})_{\text{November 2016}}^{\text{chain}}} 100 \quad = \frac{188.5}{213.2} 100 = 88.4$$

In December 2016, exports fell compared to November 2016 by 11.6% (100-88.4). As calendar constraints and seasonal effects play a role in the previous period comparisons of monthly and quarterly data, for the purposes of correct interpretation, they are adjusted to take account of these effects (see Seasonal and working day adjustment methodological manual). It is therefore recommended to use the seasonally adjusted previous period comparisons.

8 Areas of application

Foreign trade indices are an essential tool for any economic analyses of exports and imports and allow growth in trade for a given sector or product group or for all trade to be interpreted, be it in nominal or real terms. The indices can also be used as a basis for estimating trends in prices of imported or exported goods. This corresponds to the following areas of application:

- Measure import and export **price increases**
- Analyse **price elasticity** of imports or exports, i.e. determine how purchases or sales abroad react to a variation in price. The greater the price elasticity, the more sensitive imports and exports are to variations in price.
- Measure a **part of inflation**: the price of imported goods may play an important role in relation to the level of prices within a country. A rise in the price of imported goods generally leads to a rise in domestic prices, albeit with a slight delay.
- Analysis of the **terms of trade** (see box "Calculation and interpretation of the terms of trade")
- **Deflating time series**: foreign trade statistics data always corresponds to current prices (nominal index). Data at constant prices (real index) are often more appropriate for a long-term analysis, however. Unit value indices can be used to deflate series, i.e. to eliminate price variations.
- Analysing **competitiveness** in international markets.
- Analysis of the long-term development of foreign trade (real development).
- Analysis of the short-term (economic) development of foreign trade.

Calculation and interpretation of terms of trade

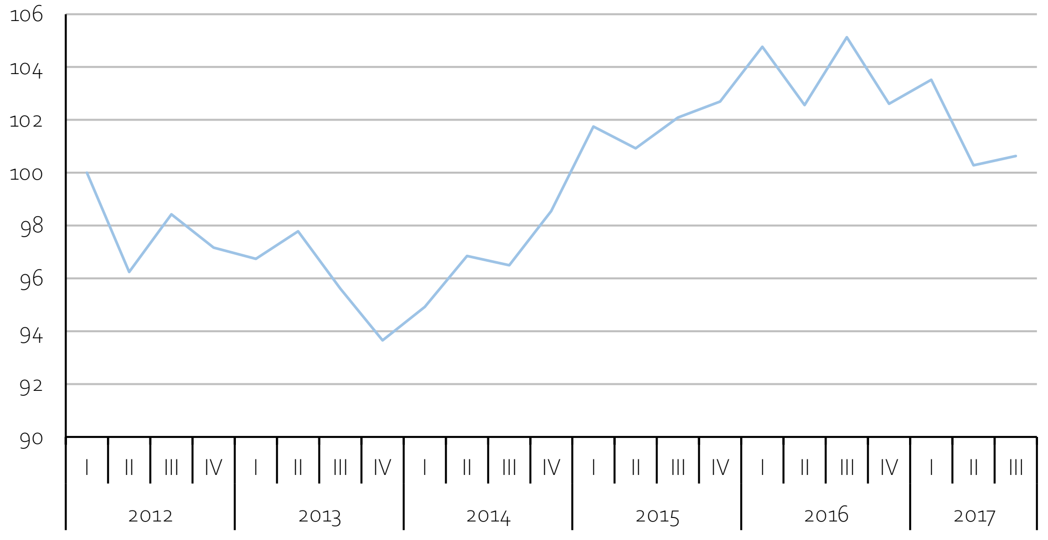
The terms of trade are an indicator which expresses the change in competitiveness between the domestic and foreign markets. It is a relative price index which is defined as the ratio between export and import goods prices. If this ratio drops, then one talks about a deterioration in the terms of trade. This means that an economy must export more goods to achieve the same import quantity. In the opposite case, there is an improvement in the terms of trade.

The unit value index serves as a basis for calculating the terms of trade.

$$\text{Terms of trade}_t^{chain} = \frac{I(\text{unit value})_t^{export}}{I(\text{unit value})_t^{import}} \qquad (31)$$

Example:

Figure 4: Swiss terms of trade, 2012 Q1 - 2017 Q3
(2012 Q1 = 100, business cycle total)



The terms of trade deteriorated by the end of 2013 and improved subsequently for two years. At the start of 2016, stagnation set in.

Interpretation of the terms of trade

The meaning of and the term terms of trade will be explained using a simple example. Assuming a country imports only one raw material and exports only one finished product. If the price of the raw material rises by 5% on the world market (over one year) and the price of the exported finished product remains unchanged, the terms of trade deteriorate by around 5% (105/100). As a result of this, the country must export more in order to be able to import the same amount.

Annex

Unit value index: groups with non-representative headings

The Laspeyres, Paasche and Fisher indices are only calculated on the basis of representative headings. However, at the lowest level, most goods groups also contain non-representative tariff numbers. As is generally known, these tariff numbers do not provide any useful price information. That is why they are assigned the index of their group, provided that it contains at least one index position.

If a subgroup j includes no representative items, it is omitted when the unit value indices (Laspeyres, Paasche and Fisher) for the group are calculated. This subgroup is then allotted the values of the unit value indices for the upper group to which it belongs, so that they are complete

$$P_t^j \, Q_0^j = \frac{P_0^j \, Q_0^j * I^k_{Laspeyres}}{100} \quad \text{when } \mathbf{j} \in \mathbf{k} \qquad (32)$$

$$P_0^j \, Q_t^j = \frac{P_t^j \, Q_t^j}{I^k_{Paasche} * 100} \quad \text{when } \mathbf{j} \in \mathbf{k} \qquad (33)$$

This procedure is applied at the lowest level of classification according to the type of goods. Non-representative tariff numbers, however, retain their hypothetical values $P_t^j \, Q_o^j$ and $P_o^j \, Q_t^j$ according to the classification of goods. In this way, all the tariff headings can then be considered as index headings. This procedure ensures that aggregation by classification of goods type and use results in the same results at the level of overall trade.