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**Sample Size and Number of Observations as a  
Balance between Quality and Producibility**

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## 1. Introduction

Beginning in 2007, Germany started to successively publish newly developed producer price indices (SPPIs) for around 20 service industries. As required by EU regulations<sup>1</sup> the weighting system and base year of the indices have to be adjusted regularly. Currently, Germany pursues the necessary steps for rebasing all SPPIs to the year 2010. The rebasing gives an opportunity to incorporate methodological and substantive improvements in the index calculation. However, the resources for price index improvements are limited.

EU member states were obliged to develop and produce SPPIs for 17 service industries or aggregations of industries successively by August 2008. In Germany this work was done from 2003 onwards – by staff members experienced in price statistics with support of scientific staff in fixed term contracts – in form of projects for every service sector. Therefore, parts of the concepts have been developed partially independently and thus the methodology is not completely harmonized.

Every improvement has to be weighed against the amount of work it incorporates when implemented. Generally, the effort statistical offices have to carry out for a price index can be measured by the sample size they address and by the amount of observations they collect to calculate the index. Therefore, we see an important issue in analyzing the efficiency of both sample size and number of observations in advance to methodological and other index refinements.

First, it should be emphasized that the quality of a price index improves with the number of collected price observations. An additional price monitoring, however, has less and less additional benefit, so that it can be weighed against the additional collection costs. As costs we should not only consider the amount of work in the statistical office, but also the burden on respondents. The difficulty in assessing the benefit of an additional price observation lies in the unknown distribution of price data. However, since price variations usually follow patterns, the price variation history gives information about the degree of heterogeneity of certain goods. Based on the analysis of our collected survey data we hope to assess the accuracy loss for reduced sample sizes or price observations. Moreover, we want to use the following considerations to

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<sup>1</sup> Regulation (EC) No 1158/2005 of the European Parliament and of the Council of 6 July 2005 amending Council Regulation (EC) No 1165/98 concerning short-term statistics (Official Journal of the EU No. L 191, p. 1).

standardize the assignment of sample size (both on a whole and for turnover strata) and amount of observations to our different indices.

The following analysis has two aims. First, we intend to come up with a standardization process for sample size allocation that account for the needs of SPPI calculation. Second, the mathematical and statistical analysis of the number of price observations is intended to provide our staff decision support for index revisions.

Here in this paper, the primary focus is on the allocation of sample size to the different industries in accordance to their importance in the service sector and with the requirements of high quality indices. While there are several different guidelines for the distribution of the sample across strata, one finds very little assistance to determine the necessary sample size for an industry. Some general advice is given in the “Producer Price Index Manual” published by the international monetary fund.

## **2. Preliminary considerations**

### **2.1 What are the determining factors for sample size?**

The following table for base year 2006 shows the sample size for each SPPI Germany is publishing. The total sample size for base year 2006 is 2,489 respondents. According to the EU-regulation on short term statistics Germany is required to publish 3 more SPPIs (ISIC<sup>2</sup> 62, 631 and 639). These are collected regularly from 2012 onwards and will be published in late 2012. As there was no sample drawn in 2006 they are not included in the table above. Taking into account the sample size for these 3 industries the total sample size increases to about 2,800 companies.

We see in some sectors a striking discrepancy between the market significance, the observed number of activity types and the number of respondents during the first base period. The sample size to turnover ratio varies from 0.39 (ISIC 61) to 43.77 (ISIC 5210).

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<sup>2</sup> ISIC, Rev. 4 (2008)

**Table 1 Overview on turnover, sample size and CPA products**

ISIC	Title	Turnover in 2006 Mill. € <sup>1</sup>	Sample size in 2006	Sample size / Turnover (bn €)	Number of CPA-Products	Sample size / # of products
4912	Freight rail transport	5,526	62	11.22	7	8.86
4923	Freight transport by road <sup>2</sup>	28,580	350	12.25	10	35.00
5011 5012	Sea and coastal water transport	24,817	30	1.21	12	2.50
51	Air transport	15,123	8	0.53	11 (13) <sup>3</sup>	0.73
5210	Storage and warehousing	2,856	125	43.77	4	31.25
5224	Cargo handling	2,309	80	34.65	4	20.00
53	Post and courier services	25,736	350	13.60	3 (9) <sup>4</sup>	116.67
61	Telecommunications	77,375	30	0.39	24	1.25
6910	Legal activities	16,735	360	21.51	9	40.00
6920	Accounting, bookkeeping and auditing activities; tax consultancy	20,574	150	7.29	9	16.67
7020	Management consultancy activities	20,437	150	7.34	11	13.64
7110	Architectural and engineering activities	35,864	143	3.99	25	5.72
7120	Technical testing and analysis	4,982	65	13.05	5	13.00
7310	Advertising	18,623	110	5.91	10	11.00
7320	Market research and opinion polling	2,176	60	27.57	6	10.00
78	Employment activities	16,085	170	10.57	16	10.63
80	Security and investigation activities	3,959	90	22.73	5	18.00
812	Cleaning activities	12,560	156	12.42	8	19.50
	Total or average	334,317	2,489	7.45	179	20.80

<sup>1</sup> Turnover in 2006 was surveyed in the structure of NACE rev1.1. In some of the industries the turnover stated above slightly differs from the "real" turnover.

<sup>2</sup> In NACE rev 1.1 rail transport was not divided in freight and passenger transport. Turnover in 2006 was estimated by relations in the years 2008, 2009 and 2010.

<sup>3</sup> Space transport services need not to be counted.

<sup>4</sup> Postal services under universal service obligation need not to be counted.

The ratio sample size to number of activities varies from 0.73 (ISIC 51) to 116.67 (ISIC 53). For the latter some reasons are obvious. Here, the structure of the product classification itself has to be mentioned first. For the different sectors the breakdown in products varies in its differentiation. While the differentiation of architectural and engineering services are very fine, the level of detail of postal and courier services not under universal service obligation is very rough. For the collection and calculation of a meaningful SPPI, postal and courier services must be structured much deeper than

specified by the CPA. Another reason arises from the respective weighting schemes. Although for some activities the CPA distinguishes a large number of products, not all of them have a significant market share in Germany. Because of capacity reasons services that would have only a very small weight (because of their market share) are not considered in the German SPPIs.

The variation of sample size – turnover – ratio is lower. In section 2.2 we discuss to what extent these variations are desirable (because of special market conditions or frame conditions of the collection) and to which extent sample sizes in relation to significance of the industries should be harmonized.

Since SPPIs were developed successively from 2007 onwards and only limited experience could be transferred from CPI index calculation, the sample sizes for each ISIC group were assigned according to the individual market characteristics with an upper limit derived from national regulation on price statistics<sup>3</sup> for services. In the light of 5 years of experience in production of SPPIs we have now the opportunity to review the configuration of these surveys.

The starting point for determining the sample size should be the significance of the ISIC group in relation to the covered markets. The larger the size of the industry, the more establishments should be included in the survey. The size of the industry and, thus, its significance can be measured by the share of turnover the industry contributes to the covered service turnover.

As the sole criterion for determining the sample size, this seems inadequate. The reason for the relatively low number of reporting units in the SPPI for telecommunications is the high concentration of the market.

In markets dominated by a few market leaders, small and medium-sized enterprises are supposed to have little influence on price developments. Under this assumption, in addition to the importance of the individual markets for the value creation of the service sector, the concentration of the markets is an important determining factor for the required number of reporting units. If a small number of enterprises make up the major share of turnover, the number of enterprises questioned can also be small as long as the market players are included in the survey<sup>4</sup>. The degree of industry concentration

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<sup>3</sup> Gesetz über die Preisstatistik vom 9. August 1958 in der im Bundesgesetzblatt Teil III, Gliederungsnummer 720-9, veröffentlichten bereinigten Fassung (685).

<sup>4</sup> Similar considerations are treated in section 5.E paragraph 5.64 of the PPI Manual published by the IMF in 2004.

may be measured by Gini-coefficient or other concentration measures. It has to be discussed in which way the knowledge of any concentration indicator can be transformed into a decision rule.

Finally, we must take account of the respondents' burden. The more differentiated products a market offers the more variation of prices we expect in this industry. In service sectors with a greater variety of service products the collection should be based on a larger number of companies in order not to overload the ones, which were sampled. Since surveys are generally not based on a product register, statistical offices have to ensure to capture the main product catalogue by enhancing the sample size. As we have already seen in Table 1, the number of CPA 6-digits is not always an adequate indicator for product variety. The service products are chosen by FSO experts in much greater detail to ensure homogeneous categories. In section 3.2.2, we discuss how to refine these product categories.

In order to standardize the sample size attribution to ISIC groups, we identify three major factors determining the sample size:

- Size of the industry
- Concentration of the industry
- Diversification of service products in the industry

A special case is the index calculation based on other data sources than price collection like catalogues of fees or price databases made available by industry associations. Since they count as only one observation, such cases should not be considered for the standard procedure of sample size allocation.

Which parts of turnover have to be considered in the calculation of sample size?

To find a reasonable distribution of the total sample on the various service sectors we have to disregard the components of turnover for which prices may be collected without questioning of companies. In Germany e.g. this is the case for the most important price components of air freight and for advertising space in television and radio broadcasting. Also in sectors in which all or part of the prices are regulated by scales of fees sample size needs not to correspond to the share of turnover of the respective sectors. For the determination of sample size only the parts of turnover resulting from

activities not regulated by scales of fees should be regarded. For this the activities of law firms should be mentioned.

Lawyers have a legal scale of fees, but they are also allowed to negotiate their charges with their clients. In particular larger firms often negotiate fees for their services. For the measuring of regulated fees the percentage fee method is used. The cases on which the percentage fees are applied have been defined together with the chamber. Their values are extrapolated with help of other statistics. The share of negotiated fees is about X % of the turnover of NACE 69.1. The list of examples for parts of turnover for which prices may be collected without questioning of companies could continue.

Furthermore in paragraph 2.1 we have seen that the relation of sample size and number of CPA-products of an industry is not a meaningful figure. Thus the table below describes the relation of sample size and first level aggregates instead of CPA-products. In paragraph 3.2.2, however, we will also attend to adjust the number of first aggregates according to past price data.



**Table 2 Relation of “corrected” Turnover, Sample size and number of first level aggregates**

ISIC	Title	Turnover in 2006 Mill. € <sup>1</sup>	TO covered by SPPI-survey <sup>2</sup>	Sample size in 2006	Sample size / Turnover (bn €)	Number of Els surveyed	Sample size / # of Els
4912	Freight rail transport <sup>3</sup>	5,526	5,526	62	11.22	45	1.38
4923	Freight transport by road	28,580	28,580	350	12.25	147	2.38
5011 5012	Sea and coastal water transport	24,817	11,519	30	2.60	135	0.22
51	Air transport	15,123	3,351	8	2.39	77	0.10
5210	Storage and warehousing	2,856	2,856	125	43.77	59	2.12
5224	Cargo handling	2,309	2,309	80	34.65	49	1.63
53	Post and courier services	25,736	25,736	350	13.60	143	2.45
61	Telecommunications	77,375	77,254	30	0.39	19	1.58
6910	Legal activities	16,735	4,717	360	76.32	16	22.50
6920	Accounting, bookkeeping, auditing activities; Tax consultancy	20,574	6,399	150	23.44	38	3.95
7020	Management consultancy activities	20,437	18,794	150	7.98	33	4.55
7110	Architectural and engineering activities	35,864	24,148	143	5.92	44	3.25
7120	Technical testing and analysis	4,982	3,176	65	20.47	18	3.61
7310	Advertising	18,623	4,974	110	22.11	57	1.93
7320	Market research, opinion polling	2,176	2,176	60	27.57	19	3.16
78	Employment activities	16,085	16,085	170	10.57	11	15.45
80	Security and investigation activities	3,959	3,834	90	23.47	12	7.50
812	Cleaning activities	12,560	10,865	156	14.36	11	14.18
	Total or average	334,317	252,299	2489	9.87	933	2.67

<sup>1</sup> Turnover in 2006 was surveyed in the structure of NACE rev1.1. In some of the industries the turnover stated above slightly differs from the “real” turnover.

<sup>2</sup> Tramp- and tankshipping is not represented the SPPI for 5012;

Price observations for ¾ of the turnover of ISIC 51 are covered by external data sources. Only security and fuel surcharges have to be reported by companies;

Parts of 6910, 6920, 7020, 7110, 7120 and 812 are regulated by scales of fees;

Prices for advertising space are collected from trade associations

<sup>3</sup> see table 1

We see that the ratio of the products to be observed and required reporting units already looks much more harmonious. On the other hand, the correction of turnover to the parts that play a role in the allocation of sample size provided no explanation for the discrepancy between sectors. On the contrary, partially the imbalances have become even more serious. Especially in the field of legal activities the large sample only represents a relatively small part of sales. The number of observed products provides no justification for the size of the sample. This raises the question of whether a

redistribution of the collection effort to other sectors, with the same effort better results could be achieved.

## 2.2 How many price observations are necessary to produce a high-quality SPPI?

We start our considerations about the necessary number of price observations for the production of SPPIs with an overview on the current German SPPIs. As can be seen from the following table, Germany collects 13.419 prices for the 18 indices presented here.

To highlight the different coverage of indices with price information, we compare three NACE groups with turnover around 25 billion € in 2006. 3.328 prices, about 25% of the collected total, enter the production of the indices for "Freight transport by road" and "Post and courier services". However, only 586 prices (4 %) are collected for "Architectural and engineering activities". Taking the overall number of prices, 13,419, as a given and distributing the number of price observations according to turnover size, one billion € turnover could be matched with 53 prices. We see that "Freight transport by road" (51.43 prices/billion €) comes close to this average, while "Post and courier services" is above average (68.70 prices/billion €) and "Architectural and engineering activities" under average (24.27 prices /billion €).

The difference in the number of price observations is due to the number of products price information is collected for. "Freight transport by road" and "Post and courier services" are divided into 143 and 147 respectively first aggregates. They can be interpreted as the number of differentiated products FSO Germany identified for these industries. The product range of "Architectural and engineering activities", however, is assumed to be much smaller: the price information is summarized into 44 first aggregates.

When the indices were constructed, first aggregates were constructed to minimize heterogeneity of price movements within elementary indices by using market information. The actual volatility of past collected prices within an ISIC group might be a first justification for the performed breakdown. However, we do not see a straight forward correlation between the standard deviation of prices and number of first aggregates.

Table 3 Overview on turnover, sample size, number of prices, first aggregates and price volatility

	Title	Corrected turnover in mill. €	Sample size in 2006	# of prices in 2006	# of prices / turnover in billion €	# prices / sample size	Number of first aggregates	# prices / # of first aggregates	Standard deviation
4912	Freight rail transport	5,526	62	834	150.92	13.45	45	18.53	1.04
4923	Freight transport by road	28,580	350	1,470	51.43	4.20	147	10.00	1.03
5011	Sea and coastal water transport	11,519	30	883	76.66	29.43	135	6.54	1.07
5012									
51	Air transport	3,351	8	231	68.93	28.88	77	3.00	1.05
5210	Storage and warehousing	2,856	125	390	136.55	3.12	59	6.61	1.02
5224	Cargo handling	2,309	80	351	152.01	4.39	49	7.16	1.02
53	Post and courier services	25,736	350	1,768	68.70	5.05	143	12.36	1.02
61	Telecommunications	77,254	30	286	3.70	9.53	19	15.05	NA
6910	Legal activities	4,717	360	662	140.34	1.84	16	41.38	1.02
6920	Accounting, bookkeeping and auditing activities; tax consultancy	6,399	150	1,352	211.28	9.01	38	35.58	1.02
7020	Management consultancy activities	18,794	150	1,008	53.63	6.72	33	30.55	1.02
7110	Architectural and engineering activities	24,148	143	586	24.27	4.10	44	13.32	1.03
7120	Technical testing and analysis	3,176	65	239	75.25	3.68	18	13.28	1.02
7310	Advertising	4,974	110	782	157.22	7.11	57	13.72	1.03
7320	Market research and opinion polling	2,176	60	468	215.07	7.80	19	24.63	1.02
78	Employment activities	16,085	170	870	54.09	5.12	11	79.09	1.02
80	Security and investigation activities	3,834	90	518	135.11	5.76	12	43.17	1.02
812	Cleaning activities	10,865	156	721	66.36	4.62	11	65.55	1.01
	<b>Total or average</b>	<b>252,299</b>	<b>2,489</b>	<b>13,419</b>	<b>53.19</b>	<b>5.39</b>	<b>938</b>	<b>14.38</b>	

The number of collected price information also depends on the sample size and the kind of price collected to restrict the burden on respondents. According to our experiences it is easier for respondents to report charge-out rates and prices of repeated services than contract prices. Therefore, indices that use price information from charge-out rate or prices of repeated services might need a smaller sample size than indices that rely on contract prices.

To sum up, we see four factors influencing the number of price observations:

- Weight of the service products
- Complexity of service (number of products)
- Heterogeneity of service products (Volatility of price observations within service products)
- Burden on respondents (prices collected per respondent; kind of price collected)

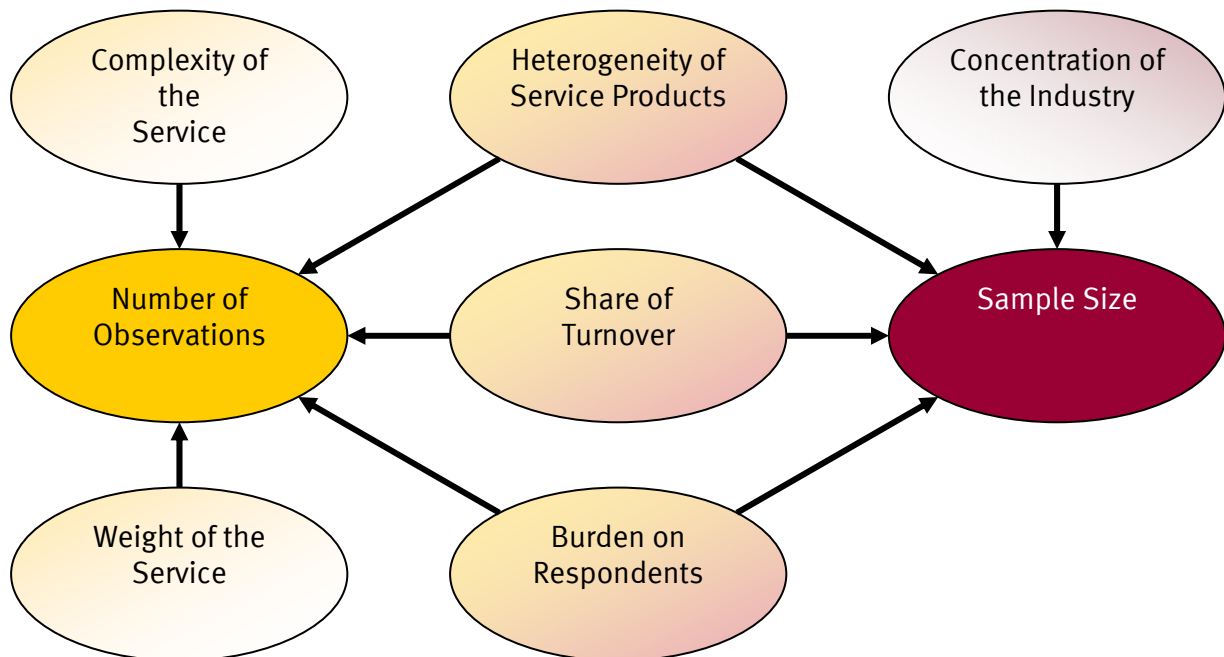
The question how many prices are necessary for SPPI production is hardly dealt with in manuals that focus more on the sample size. The PPI Manual (IMF, p. 27, 1.137) states that the “degree of heterogeneity of the sampled products must be explicitly taken into account in the calculation of an elementary index”. It does not give practical advice for implementation. Concerning the interdependence of sample size and number of price observations, it refers to the sample size as the major restraint, but warns that increasing the number of collected prices might not add to accuracy if intra-establishment variance is low<sup>5</sup>. The manual also mentions how the number of prices collected from each establishment can be restricted. As an example, it gives a general rule like 4 to 5 prices on average per establishment with an upper limit of 15 to 20.<sup>6</sup>

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<sup>5</sup> PPI Manual, p. 111, 5.55.

<sup>6</sup> PPI Manual, p. 112/113, 5.62.

### 2.3 Dependencies between sample size and number of price observations



In paragraphs 2.1 and 2.2 we identified the factors influencing the number of price observations and the sample size. Both variables are – as one might expect – not entirely independent of each other. Sample size is largely determined by the turnover of the industries and their concentrations. The concentration of the industry has no immediate impact on the required number of price observations.

This is different for the number of services that need to be considered in the index. The variety of products directly affects the number of price observations and thus simultaneously also affects the number of required reporting units. For both variables the burden on respondents should also be taken into account. Neither should the number of reporting units be chosen larger than necessary for the "correct" picture of price development, nor should the individual reporting unit be asked for too many price reports.

Other factors that influence the number of prices to be observed are: the weights of the observed products measured by share of turnover and the complexity of the services. The higher the weight of a product within the overall index the more important it is that the price trend reproduced is complete and correct. Neither should be disregarded divergent developments in parts of the market, nor should individual outliers affect the development of the index.

The complexity of a product – in sense of price statistics – is expressed by the number of price-determining characteristics. The more manifold these features are, the more difficult it is to compare and evaluate the price reports. Therefore, for a reliable picture of the price development of such products and the knowledge about the causes more price series are needed than for less complex services.

Thus sample size and number of price observations cannot be examined independent of each other. In the following section 3.1 we turn first to the sample size. Subsequently, the studies on the number of the required price observations are shown, in order to derive the necessary adjustments of the sample sizes.

### **3. Results**

#### **3.1 Approaches to determination of sample size**

##### **3.1.1 Sample size by Neyman-allocation**

It is foreseeable that different criteria for the determination of sample size lead to different results for every industry. The discrepancies between sample size chosen in 2006 and sample size by share of turnover may be due to special conditions for the observation of price developments (fee scales, few number of actors, use of other sources). But even after taking into account all these special conditions, the samples of industries that seemed to be comparable still look unbalanced.

In a first step the application of Neyman allocation method to the services industries was tested. Neyman allocation is known as a sample allocation method that may be used with stratified samples. The purpose of the method is to maximize survey precision, given a fixed sample size. If we consider the companies of the service sector as the population, the different industries may be treated as strata of this population. As mentioned before, the number of companies in the service sector that may be surveyed for different price statistics (SPPIs, construction costs indices, CPI) is limited by German price statistics regulation. For SPPIs production a maximum of 2,800 respondents is supposed to be sufficient.

With Neyman allocation, the "best" sample size for stratum h would be:

$$n_h = \frac{n^*(N_h * \sigma_h)}{\sum_i N_i * \sigma_i}$$

where  $n_h$  is the sample size for stratum  $h$ ,  $n$  is total sample size,  $N_h$  is the population size for stratum  $h$ , and  $\sigma_h$  is the standard deviation of stratum  $h$ . This leads to the sample sizes represented in the table below:

**Table 4 Comparison of Sample size depth by share of turnover and Neyman allocation**

ISIC	Title	Turnover 2010 covered by SPPI-survey <sup>1</sup>	Sample size in 2006 <sup>2</sup>	Sample size by share of Turnover (2010)	Sample size by Neymann-Allocation	Sample size by Neymann / Turnover (bn €)
4912	Freight rail transport	6,031	62	46	12	2.03
4923	Freight transport by road	33,498	350	255	172	5.13
5011 5012	Sea and coastal water transport	12,168	30	93	70	5.78
51	Air transport	5,442	8	41	60	11.03
5210	Storage and warehousing	7,488	125	57	35	4.62
5224	Cargo handling	2,834	80	22	2	0.85
53	Post and courier services	27,473	350	209	591	21.52
61	Telecommunications	72,235	30	549	313	4.33
62	Computer programming, consultancy and related activities	80,800	298	615	586	7.25
631	Data processing, hosting and related activities; web portals	3,804	26	29	2	0.59
639	Other information service activities <sup>3</sup>	250	25	2	2	7.46
6910	Legal activities	5,046	360	38	43	8.54
6920	Accounting, bookkeeping, auditing activities; Tax consultancy	7,110	150	54	15	2.17
7020	Management consultancy activities	19,588	150	149	399	20.37
7110	Architectural and engineering activities	30,373	143	231	262	8.62
7120	Technical testing and analysis	5,706	65	43	44	7.78
7310	Advertising	5,403	110	41	79	14.61
7320	Market research, opinion polling	2,199	60	17	6	2.69
78	Employment activities	23,594	170	179	52	2.18
80	Security and investigation activities	4,242	90	32	9	2.17
812	Cleaning activities	12,832	156	98	46	3.56
	Total or average	368,116	2,489	2,800	2,800	7.61

<sup>1</sup> see table 2

<sup>2</sup> Samples for ISIC 62, 631 and 639 were drawn later, while building up the surveys

<sup>3</sup> In German SPPI only prices of “News agency activities” are represented.

On the one hand we see that the number of enterprises per billion € of turnover would be less unbalanced than it was in the past. On the other hand we find some industries

where the sample size would have to be extended although it was already rather high – in relation to the importance of the industry measured by share of turnover (Post and courier services, Management consultancy activities). Furthermore this allocation method leads to very small samples in industries with only few companies and low standard deviation of turnover (“Cargo handling”, “Data processing, hosting and related activities”, “Other information services”). For confidentiality and quality reasons a sample of only two enterprises is not feasible.

The weaknesses of this allocation method in the light of price statistics are obvious. Its purpose is to reduce the variance of the estimator. Thus the division of the population into strata should account for the deviation of the variable to be measured – the “price”. This is not applicable to collection of prices. If we misuse the standard deviation of turnover instead, this leads to oversized samples in industries that are highly concentrated.

### **3.1.2 Comparison of sample size by share of turnover and census with coverage rate of 80% of turnover**

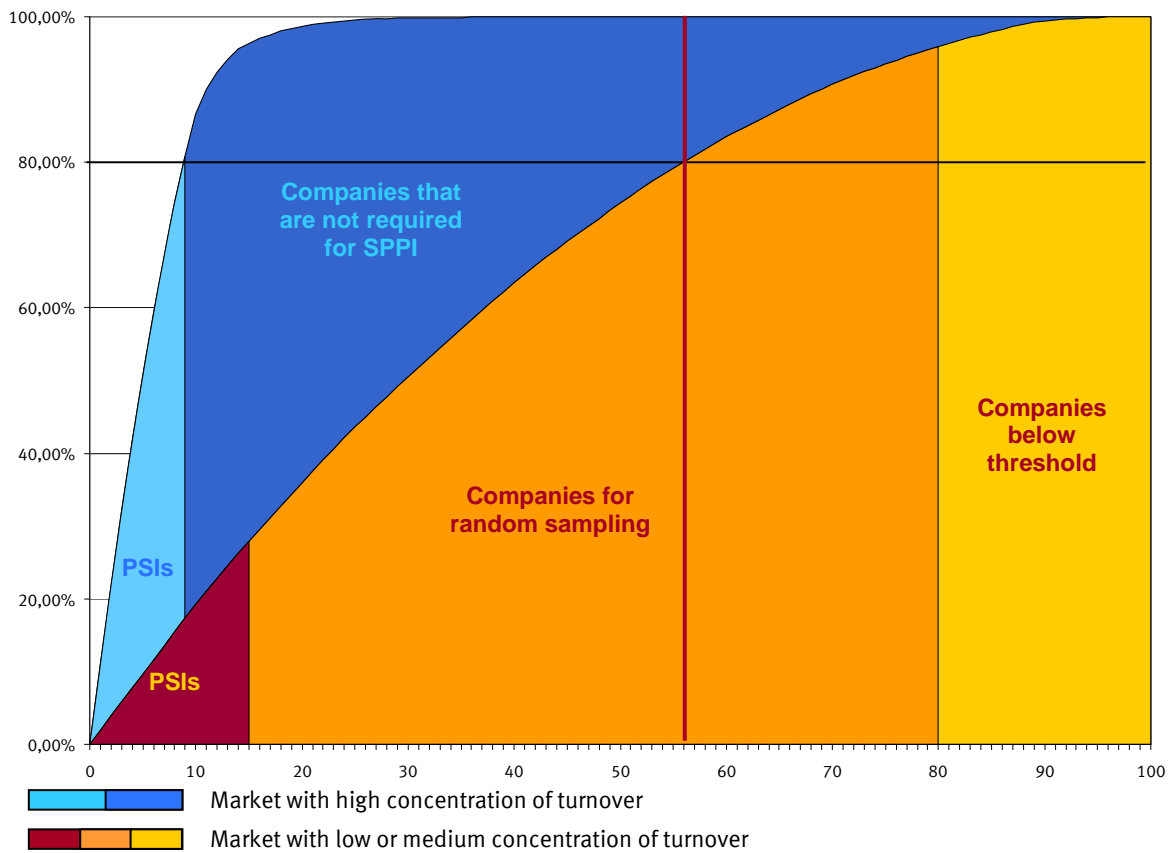
In the past, samples in industries with high inequality of turnover were particularly small (“Air transport”, “Telecommunications”). It was assumed that in industries with few market leaders, representing a very high share of turnover of the industry, smaller companies have almost no influence on price development. Their prices could only deviate from the prices fetched by the market leaders, if they offer some kind of niche products. But in this case these niche products would have such small weights in the index that they would not influence the development of the index.

This leads to the general idea to apply different sampling methods depending on the concentration of the service industry. Following the assumption that in sectors dominated by few market leaders the prices of small and medium sized enterprises may be disregarded, a random sampling is only necessary if the share of turnover of the most important enterprises does not exceed a certain threshold.

The idea of the below presented graphic chart is to determine for each German 5-digit subcategory of the European NACE-classification, if coverage of 80% of turnover can be reached with less companies than assigned by calculation of sample size by share of turnover. It has to be mentioned that even in the case of random sampling a stratum with selection probability = 1 is inevitable. In the graphic chart this stratum is named



“PSIs” (providers of statistical information), which comprises all companies which should not be replaced.



This basic approach leads to Table 5. On basis of the business register and turnover submitted by the tax authorities for the year 2009 a simulation test was executed. What sample size would be required for each industry if we would change over from random sampling to a census with coverage rate of 80% of turnover? For most of the service sectors the simulation leads to a number of respondents that is much too high in relation to the share of turnover of the sector. Nevertheless, the practice of price collection in the air transport and telecommunications sector is attested.

**Table 5 Comparison of sample size by share of turnover and census with coverage rate of 80%<sup>7</sup>**

ISIC	Title	Turnover 2010 covered by SPPI-survey <sup>1</sup>	Sample size by share of Turnover (2010)	Companies required to cover 80% of turnover	Portion of all companies in the industry In %	Gini-Coefficient
4912	Freight rail transport	6,031	46	5	5.56	0.91
4923	Freight transport by road	33,498	255	6627	8.80	0.80
5011 5012	Sea and coastal water transport	12,168	93	415	21.40	0.79
51	Air transport	5,442	41	8	1.36	0.98
5210	Storage and warehousing	7,488	57	80	6.64	0.90
5224	Cargo handling	2,834	22	48	15.34	0.81
53	Post and courier services	27,473	209	14	0.11	0.97
61	Telecommunications	72,235	549	29	1.13	0.98
62	Computer programming, consultancy and related activities	80,800	615	3097	5.81	0.90
631	Data processing, hosting and related activities; web portals	3,804	29	105	8.03	0.85
639	Other information service activities	250	2	147	11.70	0.83
6910	Legal activities	5,046	38	15460	26.19	0.74
6920	Accounting, bookkeeping, auditing activities; Tax consultancy	7,110	54	15040	32.62	0.91
7020	Management consultancy activities	19,588	149	8566	12.25	0.82
7110	Architectural and engineering activities	30,373	231	11194	12.71	0.82
7120	Technical testing and analysis	5,706	43	522	7.06	0.88
7310	Advertising	5,403	41	5170	13.56	0.82
7320	Market research, opinion polling	2,199	17	202	8.52	0.87
78	Employment activities	23,594	179	1453	17.40	0.81
80	Security and investigation activities	4,242	32	350	9.88	0.86
812	Cleaning activities	12,832	98	2494	7.71	0.84
	Total	368,116	2800	71026		

<sup>1</sup> see table 2

Further service sectors for which the change from random sampling to a census should be considered are “Freight rail transport” and “Post and courier services”. We see that mainly the sectors that had been regulated in the past are dominated by very few market leaders. Also for the 4-digit NACE-position 62.03 “Computer facilities management activities” and the German 5-digit subcategory “Auditing” (69.20.1) of

<sup>7</sup> Columns “Companies required to cover 80% of turnover”, “Portion of all companies in the industry” and “Gini-coefficient” are based on the content of the business register for the year 2009.

69.2 noticeable small shares of enterprises (1.78% and 3.47%) are computed to cover 80% of turnover. Despite that, the number of enterprises required to cover 80% of turnover in the subcategory of auditing is higher than the sample size calculated by share of turnover for the whole 3-digit NACE-position 69.2. Only in the industry of information technology a mixed model for determination of sample size seems sensible.

Here it should be mentioned that the number of 2800 companies for all SPPIs is only representing 0.63% of all companies in the service industries covered by German SPPIs. Nevertheless the portion of companies included in the surveys of these industries is very uneven. The sample of 62 reporting units for freight rail transport represents about 70% of all companies in the respective service sector, whereas the 143 companies selected for the price collection of architectural and engineering activities represent only 0.16% of the population.

### **3.1.3 Mixture of sample size by share of turnover and census**

To obtain an optimal allocation of the maximum number of 2800 companies supposed to be sufficient for the production of German SPPIs to the different service sectors a mixture of sample size determination methods seems to be suitable. Thus,

- as first step, an allocation of sample size by share of turnover is calculated.
- As second step for every 5-digit subcategory of NACE-positions for which prices are surveyed the number of companies to cover 80% of turnover has to be determined.
- If the number of “market leaders” that cover 80% of turnover is smaller than the sample size calculated by share of turnover, the sample should be restricted to these market leaders.

After this third step only 2011 companies are allocated to the different service sectors. To exploit the maximum sample size permitted by German price statistics regulation we reallocate the surplus companies by share of turnover. For this fourth reallocation step we only regard the turnover of industries for which “census with threshold” - method seems not reasonable.

This leads to Table 6 shown below. Comparing sample sizes in 2006, sample size by share of turnover in 2010 and sample sizes calculated by the “mixed model”, we easily identify some industries for which a reduction of sample size seems to be indicated. From this point on purely mathematical methods cannot help to further improve

allocation of sample size. Here, “Storage and warehousing”, “Cargo handling”, “Post and courier activities”, “Legal activities”, “Auditing activities”, “Advertising” and “Security and investigation” are to mention.

On the other hand the purely mathematical approach can sometimes return undesirable results – as we see in the sector of “Other information services”. In the light of confidentiality and quality a sample of 3 companies is unfeasible.

**Table 6 Mixture of sample size by share of turnover and census**

ISIC	Title	Sample Size in 2006	Sample size by share of Turnover (2010)	Mixture of random sample and census	Sample size after reallocation of surplus companies
4912	Freight rail transport	62	46	5	5
4923	Freight transport by road	350	255	255	358
5011 5012	Sea and coastal water transport	30	93	93	130
51	Air transport	8	41	8	8
5210	Storage and warehousing	125	57	57	80
5224	Cargo handling	80	22	22	30
53	Post and courier services	350	209	14	14
61	Telecommunications	30	549	29	29
62	Computer programming, consultancy and related activities	298	615	615	863
631	Data processing, hosting and related activities; web portals	26	29	29	41
639	Other information service activities	25	2	2	3
6910	Legal activities	360	38	38	54
6920	Accounting, bookkeeping, auditing activities; Tax consultancy	150	54	54	76
7020	Management consultancy activities	150	149	149	209
7110	Architectural and engineering activities	143	231	231	324
7120	Technical testing and analysis	65	43	43	61
7310	Advertising	110	41	41	58
7320	Market research, opinion polling	60	17	17	23
78	Employment activities	170	179	179	252
80	Security and investigation activities	90	32	32	45
812	Cleaning activities	156	98	98	137
	Total	2833	2800	2011	2800

Also some of the other smaller sectors suggested for reduction of sample size are worth a closer look. What would be the impacts on quality of the individual indices if sample sizes for “Cargo handling” and “Security and investigation” were reduced to half or less

than half? At the same time the algorithm proposes a significant expansion of sample sizes for “Computer programming and consultancy”, “Architectural and engineering activities” and “Employment activities” because of their importance in the service sector. In these cases, the question of the value added by such an expansion has to be answered.

PPI-Manual suggests to increase the number of sampling units for the smaller firms if the concentration ratio (percentage of industry output by large firms) becomes smaller. This proposal is in contrast to Neyman allocation, in which the sample size increases with increasing standard deviation of a stratum.

The concentration of markets is positively correlated with the standard deviation of sales. A second attempt was made to allocate the surplus companies by calculating a correction factor that was greater, the smaller the concentration was. By considering the concentration, we had hoped for a convergence of sample sizes to the proposal of the PPI Manual and a reduction of the influence of the revenue shares. This attempt failed. The imbalance in the allocation of sample size for the industries chosen for random sampling was caused by the imbalance of turnover. A correction factor derived from concentration of the industry can only work, if the important industries would be more concentrated than the less important.

Thus we now turn to the relation between sample size and number of required observations. How many elementary indices and how many price observations are required to produce a high quality SPPI? Table 6 is a starting point for further examinations on this question in order to decide to what extent the expansions suggested should be implemented.

## 3.2 Determining the number of price observations

### 3.2.1 Assessing the weight of service products

Analogously to the considerations on sample size and turnover, the number of price observations should also depend on the turnover the service generates. Although the turnover of the product associated with the industry might not be the same due to extra-industry production or side-production of the product's industry, it is still the best indicator for the product's importance.

Recently, Germany can increasingly rely on intra-industry turnover data for services (Dienstleistungsstatistik nach Arten<sup>8</sup>). This makes it possible to assign turnover data to detailed CPA groups. As already mentioned in section 2.1, the CPA differentiation is not suitable for product differentiation necessary for SPPI calculations.

Therefore, our first step to determine the number of price observations for each industry follows the industry's turnover. Table 7 shows the results if Germany's 13.419 price observations were distributed by turnover weights.<sup>9</sup> This approach follows the way the number of prices is assigned in FSO Germany for producer price index for industrial products<sup>10</sup>.

According to turnover, we see that the index for "Auditing activities" (prices in 2006: 1,352) exceeds its turnover generated value (340) by large. On the other hand, "Architectural and engineering activities" only need 586 prices in our current index calculation while the turnover weight had given the industry 1,284 price observations.

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<sup>8</sup> Supplementary survey to the structural statistics on business services "Turnover by product type and residence of client".

<sup>9</sup> This step is redundant to the turnover weights for sample size on the aggregated level, but differs on product levels.

<sup>10</sup> In this case, an absolute number of 10 price observations is given for every 0.1 percent of turnover share the product contributes to overall turnover.

**Table 7 Price distribution methods according to turnover weight and number of products**

ISIC	Title	# of prices in 2006	# of 1 <sup>st</sup> aggregates	Distr. by turnover weight	Dev. from actual # of prices	Distr. by # of 1 <sup>st</sup> aggregates	Dev. from actual # of prices
4912	Freight rail transport	834	45	294	540	647	187
4923	Freight transport by road	1,470	147	1,520	-50	2,114	-644
5011 5012	Sea and coastal water transport	883	135	613	270	1,942	-1,059
51	Air transport	231	77	178	53	1,107	-876
5210	Storage and warehousing	390	59	152	238	849	-459
5224	Cargo handling	351	49	123	228	705	-354
53	Post and courier services	1,768	143	1,369	399	2,057	-289
61	Telecommunications	286	19	4,109	-3,823	273	13
6910	Legal activities	662	16	251	411	230	432
6920	Accounting, bookkeeping and auditing activities; tax consultancy	1,352	38	340	1,012	547	805
7020	Management consultancy activities	1,008	33	1,000	8	475	533
7110	Architectural and engineering activities	586	44	1,284	-698	633	-47
7120	Technical testing and analysis	239	18	169	70	259	-20
7310	Advertising	782	57	265	517	820	-38
7320	Market research and opinion polling	468	19	116	352	273	195
78	Employment activities	870	11	856	14	158	712
80	Security and investigation activities	518	12	204	314	173	345
812	Cleaning activities	721	11	578	143	158	563
	<b>Total</b>	<b>13,419</b>	<b>933</b>	<b>13,419</b>		<b>13,419</b>	

### 3.2.2 Assessing the complexity of the service/number of products

Obviously, the number of price observations depends also on the variety of sub-services the overall service can be broken down. Table 7 gives the number of elementary indices or first aggregates for the current index calculation.

On average, every first aggregation for the index calculation is filled with 14.38 price observations. If we assign the price observations equally across all first aggregates, the main fields for price selection shift to “Freight transport by road”, “Post and courier services”, “Sea and coastal water transport” and “Air transport” which are subdivided into a broad range of sub-services. On the other hand, “Employment activities” and “Legal activities” lose price observations.

When SPPIs were developed, the definition of basic products was based merely on the assessment on market experts. Whether the chosen groups were actually homogeneous can only be determined in retrospect. We discuss possible ways of analysis later.

Before that, Table 8 highlights another important aspect of first aggregates. In the development process it is often unknown whether an elementary index can be filled with enough observations of the same kind (no product based register). So over time or even from the start, some (originally assumed) representative elementary indices are thin with price observations.

**Table 8 Price observations and elementary indices by ISIC sectors (small)**

ISIC	Title	Collected Price Observations	First aggregates	FA with less than 20 Price Obs	FA with less than 15 Price Obs	FA with less than 10 Price Obs
4912	Freight rail transport	834	45	34	28	23
4923	Freight transport by road	1,470	147	134	128	110
5011 5012	Sea and coastal water transport	883	135	134	127	98
51	Air transport	231	77	77	77	73
5210	Storage and warehousing	390	59	58	55	50
5224	Cargo handling	351	49	48	44	39
53	Post and courier services	1,768	143	111	100	81
61	Telecommunications	286	19	14	12	7
6910	Legal activities	662	16	0	0	0
6920	Accounting, bookkeeping and auditing activities; tax consultancy	1,352	38	14	14	8
7020	Management consultancy activities	1,008	33	11	9	8
7110	Architectural and engineering activities	586	44	27	17	11
7120	Technical testing and analysis	239	18	11	8	2
7310	Advertising	782	57	50	28	12
7320	Market research and opinion polling	468	19	11	8	6
78	Employment activities	870	11	3	3	2
80	Security and investigation activities	518	12	2	0	0
812	Cleaning activities	721	11	0	0	0
	<b>Total</b>	<b>13,419</b>	<b>933</b>	<b>739</b>	<b>658</b>	<b>530</b>

*Note: The number of price observations does not contain price information obtained from other sources. However, the number of elementary indices is not corrected for other price information.*



The table indicates that the number of first aggregates might be inflated in the industries "Freight transport by road" and "Advertising".

On the other hand, first aggregates can also be very large. If the price developments within the elementary indices are divers, an important price determining factor indicating its own product group might have been neglected.

The following table shows that especially "Auditing" and less so "Management consultancy" and "Cleaning" have elementary indices that contain many price observations.

**Table 9 Price observations and elementary indices by ISIC sectors (large)**

ISIC	Title	Collected Price Observations	First aggregates	FA with more than 50 Price Obs	FA with more than 40 Price Obs	FA with more than 30 Price Obs
4912	Freight rail transport	834	45	4	5	7
4923	Freight transport by road	1,470	147	5	7	8
5011 5012	Sea and coastal water transport	883	135	0	0	0
51	Air transport	231	77	0	0	0
5210	Storage and warehousing	390	59	0	0	0
5224	Cargo handling	351	49	0	0	0
53	Post and courier services	1,768	143	6	12	18
61	Telecommunications	286	19	0	0	1
6910	Legal activities	662	16	3	7	13
6920	Accounting, bookkeeping and auditing activities; tax consultancy	1,352	38	13	23	24
7020	Management consultancy activities	1,008	33	9	9	16
7110	Architectural and engineering activities	586	44	0	1	3
7120	Technical testing and analysis	239	18	0	2	2
7310	Advertising	782	57	0	0	0
7320	Market research and opinion polling	468	19	3	3	4
78	Employment activities	870	11	5	5	5
80	Security and investigation activities	518	12	2	6	8
812	Cleaning activities	721	11	7	9	11
	<b>Total</b>	<b>13,419</b>	<b>933</b>	<b>57</b>	<b>89</b>	<b>120</b>

*Note: The number of price observations does not contain price information obtained from other sources. However, the number of elementary indices is not corrected for other price information.*

Contrary to the sample size that can be adjusted more easily, recommendations on the number of price observations (i.e. during re-basing) is more complex since it usually involves an analysis of both the number of price observations per first aggregate and of the number of first aggregates itself. Decision support is given in both cases by the analysis of the past price movements within an index. If the above mentioned general methods, for instance, imply a reduction or expansion of the number of product services, the previous price development might give insights which service products were defined too narrow or too broad in the first place. A homogeneous or heterogeneous price development also indicates a situation where a first aggregate is filled with too many price observations or too few (although not necessarily). However, assessing the homogeneity of price movements has to deal with two dimensions: the distribution of price changes over time and the distribution across observations or elementary indices. As basis for the following indicators we chose to use the size of the area around the geometric means of the first aggregates that includes 95% of observations over all time periods.

As said previously, the variety of service products determines the number of price observations necessary to conduct an index. Supplementary to experts drawing product categories, we might use past price information to assess the number of products. Generally, the heterogeneity of prices within service products (inter-aggregate heterogeneity) should determine the optimal number of service products. Table 10 contains indicators for inter-aggregate heterogeneity based on existing product categories for each presented ISIC class. We could not define an absolute value for the desired heterogeneity for a product, so we set our measure for heterogeneity within a ISIC group relative to the average heterogeneity we observed for all industries (see table notes on calculation procedure). Inter-aggregate heterogeneity was derived from the overlap of first aggregate confidence intervals.

Significant above average heterogeneity within product categories can be observed for “Air transport”, “Freight transport by road”, “Sea and coastal water transport” and “Storage and warehousing”. Significant under average heterogeneity is seen in “Cleaning”, “Security and investigation” and “Management consultancy”. Assigning the average heterogeneity value our current product average per presented ISIC class, we can use the inter-aggregate heterogeneity factors to calculate heterogeneity adjusted number of products.

In our current index calculations, we have about 54 service products per given ISIC class. Using the inter-aggregate heterogeneity factors to distribute service products across classes, we can give heterogeneity adjusted target values of product breakdowns. We see the least variety of products measured this way for “Cleaning” and the highest variety of products for “Air transport”.

**Table 10 Inter- and intra-heterogeneity adjusted number of prices**

ISIC	Title	# of prices in 2006	Inter aggregate heterogeneity	InterAH adjusted # of products	Intra aggregate heterogeneity	IntraAH adjusted # of prices/product	Inter- and IntraAH adjusted # of prices
4912	Freight rail transport	834	1.3	67	1.3	19	1,279
4923	Freight transport by road	1,470	1.7	93	1.3	19	1,783
5011 5012	Sea and coastal water transport	883	1.7	90	0.3	5	422
51	Air transport	231	1.9	102	0.4	5	551
5210	Storage and warehousing	390	1.6	86	0.7	10	867
5224	Cargo handling	351	1.0	55	0.5	7	384
53	Post and courier services	1,768	1.2	65	0.5	7	449
61	Telecommunications	286	NA	NA	NA	NA	NA
6910	Legal activities	662	0.6	31	1.6	22	705
6920	Accounting, bookkeeping and auditing activities; tax consultancy	1,352	0.6	31	1.2	17	520
7020	Management consultancy activities	1,008	0.5	28	1.0	14	401
7110	Architectural and engineering activities	586	1.0	54	1.2	18	948
7120	Technical testing and analysis	239	0.7	39	0.9	12	486
7310	Advertising	782	1.2	65	1.6	22	1,441
7320	Market research and opinion polling	468	0.8	43	1.2	17	712
78	Employment activities	870	0.6	30	1.7	24	719
80	Security and investigation activities	518	0.4	22	1.1	16	357
812	Cleaning activities	721	0.2	11	0.7	10	113
	<b>Total or average</b>	<b>13,419</b>	<b>1</b>	<b>914/54</b>	<b>1</b>	<b>14</b>	<b>12,138</b>

### 3.2.3 Assessing the heterogeneity of service products

As for the question on how to measure the complexity of service products, the way to measure heterogeneity of service products is difficult.

The best empirical insight how divers prices within a product category are can be derived from looking at the dynamics within current first aggregates (intra-aggregate heterogeneity). Analogously to the previous section, we present in Table 10 the factors

that give the derivation of intra-aggregate heterogeneity from the average. The factors were derived from the first aggregates' confidence intervals. The smaller the size the more homogeneous is the index. The large the size, the more heterogeneous is the index.

Since we believe these figures give estimations for price volatility within product groups, we derive from these factors the targeted depth of each first aggregate. For instance, prices within the first aggregates of "Sea and coastal water transport" have an inter-aggregate heterogeneity of 30% of the average. Taking our current average number of prices per first aggregate as standard depth for the first aggregate (which is voluntarily) yields a target depth of 5 prices per service category. "Employment activities" that are very volatile get a depth for the first aggregate of 24.

By summarizing the results from section 3.2.2 and 3.2.3 new target values for the number of price observations can be derived. The given results in Table 10 illustrate major shifts of price observations between industries. For example "Technical testing and analysis" now get 486 price observations instead of 239. This assignment is explained by the advice to further segregate the industry's products since price volatility across existing categories was especially strong.

Since, turnover weights were not included we also see a striking imbalance between the number of price observations and the importance of the industry. "Cleaning" is assigned 110 price observations, while "Freight rail transport" gets 1,279. However, the turnover of cleaning is double the turnover of "Freight rail transport". The turnover weights could be inserted into a standardized assessment of price observations by introducing an upper bound derived from the industries' turnover weight and a total of price observations. Table 7, for instance, gives a potential upper bound for the number of price observations for "Freight rail transport" of 286. Thinking further along upper bounds, we consequently may lower the target number of products to 20, so that still 19 prices per product can be reached.

Since the given considerations assign price observations only to relative figures, we are aware that this procedure is not stringent. It comprises an attempt to standardize this assessment along observable variables that are intended to give broad target values for the experts that decide on the actual service categories and depth of first aggregates. In practice, the experts need more tools to identify aggregates that could be summarized or further broken down. One of these tools could be a bootstrap procedure that

illustrates alternative index developments if past decisions on service categories were taken differently. The idea is that a change for the coming base period should only be done if the estimated effect on the past index is lower than a certain threshold.

### **3.2.4 Assessing the burden on respondents**

The final consideration regarding price observations and sample size is the burden on the single respondent. As mentioned before, we found that the burden depends on the kind of price that has to be reported. Prices for timely methods like hourly or daily charge out rates have a low burden, however, are restricted by the amount of professional groups and skill levels employed by the respondent. The average number of prices per respondent in Germany is 4.8. Also less burdensome is the collection of transaction prices of repeated services or component prices like service level agreements. Respondents currently report 6.0 prices on average. More time consuming is the reporting of contract prices, since respondents have to look up contracts and usually do not have a sufficient amount of running contracts to report. We ask for only 4.0 prices on average per respondent.

If an index is build on model price information and the average price to be collected exceeds a certain value, say 4 prices, the sample size has to be adjusted.

### 3.1. Evaluation

With this paper we want to share the considerations on sample size and number of observations we made in advance of the restructuring and rebasing of our SPPIs. The described approaches try to close the gap the PPI manual leaves in assessing sample size and number of observations in the praxis.

We want to close this paper with some caveats. In the industry “Post and courier activities” neither NACE nor the WZ divides the corresponding services into further sub-categories. Therefore, it becomes even more difficult to find enough suppliers of the necessary price information (no information of service statistics on product portfolio). The presented way to assemble the sample size according to industry concentration leads to a sample size of 14 from the exhaustive strata. It is to be questioned whether this sample size really captures all services offered in this sector. This information gap has to be considered for all service industries. The random sample can never be of the same size as the number of required reporting units. The sample has to be chosen larger in order to be able to refuse units that proved to be unsuited for the price collection of specific service products. Thus the sampling will never be completely random. With the information available we have to practice a mixture of random sampling and purposive sampling.

The ways to determine price observations depends on past data and may not give a good projection of future price movements. Therefore, the results should be interpreted as broad guidelines for the depth of elementary indices and have to be checked against market information. This is especially the case for the analysis of scarcely filled elementary indices with less than 15 price indices. In this case, the bootstrap method inflates the heterogeneity of collected price information that might not be representative of the actual price development (however, the approach will in most of these cases (unnecessarily) advise to collect more prices, thus leading to a less-efficient, but accurate price index).

As already mentioned before, the results of the examinations presented in this paper should be regarded as indicators for areas in the field of SPPIs in which either operational efficiency or quality of the index might be increased. The next step is to discuss the indicators within the price statistics division with the persons in charge with

the production in order to acknowledge or reject the suggestions obtained by mathematical methods.

## **References**

IMF (2004): PPI Manual – Theory and Practice. Washington, D.C.