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Methodology of the Icelandic Wage Index

Greinargerð um aðferðarfræði launavísitölu Hagstofu Íslands

Statistics Iceland

Icelandic summary

Tilgangur greinargerðarinnar er að lýsa launavísitölu Hagstofu Íslands, ásamt gögnum og tölfræðiaðferðum sem lögð eru til grundvallar útreikningum. Aðferðir launavísitölu eru settar í samhengi við almenna aðferðafræði verðvísitalna og lagt mat á þekktar skekkjur við útreikninga á vísitölum, rek (e. chaining drift) og líftíma mælieininga (e. life-cycle errors), í tilviki launavísitölu.

Helstu atriði greinargerðarinnar:

- Þær aðferðir sem Hagstofan notar við útreikning á launavísitölu eru í samræmi við viðurkenndar aðferðir verðvísitalna þar sem hagnýtt eru yfirgripsmikil gögn með skipulögðum hætti. Helstu áskoranir tengjast skorti á þekju og endurnýjun úrtaks.
- Launavísitala er *verðvísitala* sem byggir á gögnum úr launarannsókn Hagstofu Íslands en einnig eru notuð staðgreiðslugögn.
- Við útreikning á verðbreytingum í grunni er notast við *Törnqvist afburðavísitölu* sem byggir á pöruðum breytingum (e. matched sample model) reglulegs tímakaups milli tveggja samliggjandi mánaða þar sem miðað er við fasta einingu ráðningarsambands (launagreiðandi, launamaður, starf og atvinnugrein). Við útreikning í efra lagi, þar sem grunnliðir eru vegnir saman, er notast við *keðjutengda Laspeyres fastgrunnsvísitölu*.
- Mat á skekkjum vegna reks bendir til þess að slíkar skekkjur séu ekki vandamál í tilviki launavísitölu.
- Mat á skekkjum vegna líftíma mælieininga bendir til lágmarks áhrifa á undirvísitölur.

Greinargerðin er fyrsta skrefið í endurskoðun gagna og aðferða við útreikning launavísitölu. Stefnt er að frekari þróunarvinnu á næstu misserum í samstarfi við notendur og sérfræðinga.

Contents

Introduction

The main goals of this paper are to describe the Icelandic Wage Index (*launavísitala*), the data used for its calculation and to provide information on the statistical methods used by Statistics Iceland for the construction of the index. Furthermore, some of the most relevant errors and biases known to affect general price index numbers are analysed and assessed for the case of the Icelandic Wage Index, i.e. the chaining effect and the influence of life cycles.

Definition of the Icelandic Wage Index

The Icelandic Wage Index is a price index, hereafter referred to as *IWPI, the Icelandic Wage Price Index*. The IWPI is based on (weighted) changes between two successive points in time of hourly wages paid to an employee for fixed working hours within the same occupation (ISTARF95; Statistics Iceland 2009a), the same economic activity (ISAT2008; Hagstofa Íslands 2009b) by the same employer. These changes are combined in accordance to the price index theory into a unique measure, which is a population estimate based on sample data.

Statistics Iceland compiles its wage index based on a Törnqvist index formula at lower aggregation levels and a matched sample model with the smallest aggregate being the item itself, i.e. the hourly wage. At top-level the sub-indices are aggregated according to Laspeyres' formula since weights at this level are updated once a year.

This approach makes use of detailed survey data on wages and paid hours collected by Statistics Iceland (SI) as well as administrative data from the tax authorities. The time series of index values are built based on chaining of bilateral index numbers.

The wages used in the calculation of IWPI are regular hourly wages, i.e. all basic wages paid for both day-time and shift-work hours as well as fixed wage contract hours, including additional payments like fixed overtime and bonuses settled regularly in each wage period. Overtime and other irregular payments are excluded as well as employers' social contributions and taxes[1].

Users of the index

The IWPI is commonly used for indexation of contracts, and for economic and labour market analyses (Appendix 1). The main users of the index are individuals, private business enterprises, national and international organisations, employees' organisations and employers' associations, ministries and public institutions.

[1] https://statice.is/publications/metadata?fileId=19576

Conclusions from the general price index theory

Review of index number methodology can be found in Diewert 1976, 1987, 1993, Selvanatan and Rao 1994, Balk 2008, Feenstra and Reinsdorf 2007, which all lead to several important conclusions:

- the index number formula, elementary aggregate, method of defining the time evolution of the index (from bilateral/multilateral index numbers), sampling and data structures have all important roles in the performance of a price index number
- there is no single index number formula which exactly fulfils all the conditions of the axiomatic, economic and/or stochastic approaches but several superlative index numbers, like Fisher or Törnqvist, fulfil with a high degree of approximation an optimum combination of such conditions
- for describing long term evolution of price variation, neither direct nor chained index numbers are free of errors, mainly due to dynamic effects, base degradation or path dependence and the size of these errors is data dependent[2]
- superlative index numbers, like Törnqvist, Fisher and Walsh, are less susceptible to chain drift for longer time periods than others, with the former having the smallest drift of all, especially for monotonous trends in price variations and weights and/or low correlations between these quantities
- more recent methods, like multilateral index numbers or optimally linked index methods, minimize the errors due to price oscillations/path dependency at the cost of higher complexity in construction and analysis

A harmonized price index for wages has not yet been established at international level and different approaches for measuring wage changes are used in countries where a wage price index exists. For example, in Australia, a Laspeyres type of index is used to calculate the Australian wage price index on a quarterly basis, covering wage and salary costs (ABS, 2012). In France, a matched model structure is employed to calculate changes in payment per hour ("l'indice de salaire horaire de base", DARES, 2012). In the United States, a Laspeyres index is used to calculate the American employment cost index (Ruser, 2001).

Main findings of the analysis

The main findings of the present analysis of the IWPI are the following:

- SI uses standard methods of price index theory for compiling the IWPI
- the direction of the chain drift is indeterminate for the IWPI and its formula contains pairs of terms which neutralize each other (for smoothly trending prices and weights) at any chain length
- the drift effect depends on the covariance between relative price changes (sub-index numbers) and weights' variations. In the case of IWPI, for a chaining period of 3, 12,

[2] "Data dependent errors": the analytical expressions of the errors cannot be bound by values which are valid on any data set.

24 and 36 months, it is found to be of the same order of magnitude as the rounding errors
- there exists a weak effect of the items' life cycle on the distributions of relative price variation and on the distributions of weights, therefore on sub-index values

Purpose, background and publications of the IWPI

Purpose and content of IWPI

As a wage price index, the IWPI measures *changes in wages* paid by employers *for one hour of work*, between two successive points in time. These changes should *not* depend on structural changes of the market or on the quality and quantity of the labour. Different measures, designed to incorporate these effects are provided by SI's average Earnings[3] and Quarterly Total Wage Index[4], the latter based on the same methods as Eurostat's Labour Cost Index (LCI; Eurostat, 15.06.2018).

Each measure reflects different aspects of the expected changes in wages. Thus, if an analysis is focused on the changes of average wages that reflect structural change in the labour market, then average Earnings or the Quarterly Total Wage Index should be the preferred measure. On the other hand, if an analysis is concerned with the price change of wages then users should consider using the IWPI.

This is further discussed in an internal communication presented in Appendix 1, where it is shown that the differences observed when comparing changes of IWPI with the average Earnings changes do not reflect errors of either of these two measures but mainly the fact that they are calculated according to different formulae, different assumptions and describe different phenomena. For example, the average wage may change if the availability of cheap workflow changes, where only changes in wages may affect the results of the index calculations.

[3] https://statice.is/statistics/society/wages-and-income/wages/
[4] https://statice.is/statistics/society/wages-and-income/wage-index/

Historical background

The publication of the IWPI started in 1989 and was based on the Act on the Wage Index No 89/1989 which states in Art.2:

> The wage index pursuant to this Act shall insofar as possible show changes in the total wages of all wage earners *for fixed number of working hours*. This refers to changes in the wages paid for daytime, overtime and night-time work, including all job- and pay-related surcharges and bonuses. (Statistics Iceland n.d., italics added by the authors)

The historical roots of the IWPI are connected to the indexation of financial obligations in Iceland. From year 1979 indexation was based on a composite index (*lánskjaravísitala*) based on 2/3 of changes in consumer prices and 1/3 of changes in building costs. This was changed in early 1989 to 1/3 of changes in consumer prices, 1/3 of changes of building costs and 1/3 of changes in wages. As a consequence each part needed to be calculated on a monthly basis. This led to the need for a legal basis for the IWPI and in longer terms a renewal of the existing data collection on wages. The legal base for the indexation of financial obligations was changed in 1995 to rely solely on the Consumer Price Index. From that time the IWPI has been commonly used for indexation of contracts and for economic and labour market analyses (Appendix 1).

Publications

Indices of the IWPI are released both monthly and quarterly[5], as a total index according to the legal act and as sub-indices to better serve users' needs. While the IWPI is a legal requirement, Statistics Iceland is not obliged to publish any sub-indices. The main publications are as follows:

1. The total index of IWPI is published monthly about 20 days after the end of the reference month. The time series published are *Wage index from 1989*.
2. The sub-indices, i.e. the breakdown of the IWPI by sectors (including level of administration for the public sector) and by occupational group and economic activity sections for the private sector, are published monthly about 90 days after the end of the reference month. The time series published are *Monthly wage index by sector from 2015*, *Monthly wage index in private sector by occupational group from 2015* and *Monthly wage index in private sector by economic activity from 2015*.
3. Older tables with quarterly breakdown are maintained. The time series published are *Quarterly wage index by sector from 2005* and *Quarterly wage index in private sector by occupational group from 2005*.

[5] https://statice.is/statistics/society/wages-and-income/wage-index/

Statistics Iceland publishes four other indices based on the IWPI; the index for mortgage payment adjustment from 2008[6] (*Greiðslujöfnunarvísitala*), the Wage Index for mortgage payment adjustments from 1979[7] (*Launavísitala til greiðslujöfnunar*), the Index for Real Wages from 1989[8] (*Vísitala kaupmáttar*) and the Index for the State's Pension obligations[9] (*Vísitala lífeyrisskuldbindinga*).

Structure of the IWPI

In this section a description of the structure of the IWPI is given, in the context of the general price index theory, which is briefly reviewed in what follows.

Short formulation of the general price index number

In order to present the wage index compilation, the general price index structure is used. Prices (p_i) and price-change distributions for a set of items ($i = 1, \ldots N$), such as the hourly wages, evolve with time. In order to compare all hourly wages, each one corresponding to different quantities (q_i), i.e. employee working hours, at two different points in time, the (bilateral) index number solution is to *decompose the change of the total value* of all hourly wages ($\delta\ V$) *into a product* of two (price and quantity) index numbers:

$$\delta(V) \ = \delta\ (\sum_i p_i\ q_i) \ = \ I_P\ I_Q$$

Here, the finite change of a the total value V between two points in time is defined as relative change or as the ratio: $\delta V = \ (V(t) - V(t_0))/V(t_0) = \ V(t)/V(t_0) \ - 1$, (Balk, 2008).[10]

Various conditions in the axiomatic approach to index theory, various choices for integrating factors or different discrete approximations of Divisia's integral (Divisia, 1926) lead to well-known index number formulae (Forsyth, 1981). For instance, constant weights (between two points in time) approximation gives the geometric mean index number, constant quantities equal to the ones measured at initial time give the Laspeyres price index number, constant

[6] The index is calculated in accordance with Act No 133/2008 on adjusting mortgage payments of housing mortgages for individuals. Base November 2008 = 100.
[7] The index is calculated in accordance with Act No 63/1985 with changes in Act No 108/1989 and in Act No 133/2008. Base 1979=100.
[8] The index reflects the change in the IWPI deflated by the Icelandic CPI. Base 2000=100.
[9] The index for the State's Pension obligations is calculated in accordance with Act No 1/1997. Base December 1996 = 100.
[10] For infinitesimally small variations (as firstly proposed by Divisia, 1926), the same problem is formulated as:$d(ln(V)) = \ \sum_i w_i\ d\ln(p_i) \ + \ \sum_i w_i\ dln(q_i)$, where $w_i \ = \ p_i\ q_i/(\sum_j p_j\ q_j\ )$.This is not an exact (total) differential in general, but only if written as such, i.e. as $d(ln(I_P)) + d(ln(I_Q))$ does one obtain a path independent result for a finite variation between two time points t, t_0.

quantities equal to the final ones give the Paasche index number, the trapezoidal rule of discrete approximation of a continuous integral gives the Törnqvist index number.

In general, index numbers may be regarded as weighted or non-weighted averages of prices or quantities.

The most desirable properties of an index number are consistency in aggregation (index of an aggregate is the same as the aggregate of the indices of its components), path independence and time reversal but the list of tests or conditions which one may define is long. No formula satisfies all conditions defined by the axiomatic, economic or stochastic approaches (Clements, 2006) although some have a better record than others (Balk, 2008, Diewert, 1993). On the other hand, a set of index numbers gives very similar results. Diewert (1976, 2002) and Hill (2006) established that all of the commonly used superlative index number formulae (including the Fisher, the Törnqvist and implicit Törnqvist functional forms) approximate each other to the second order when evaluated at an equal price and quantity point.

Components of the IWPI

By definition, the ***item*** used in constructing the IWPI is the hourly wage.

The ***elementary aggregate***[11] is the *ideal elementary aggregate* (ILO, IMF, 2004), i.e. the item itself - hourly wages paid to an employee for fixed working hours within the same occupation[12] the same economic activity[13] and the same employer. The main motivation for using the 'matched models' structure is its ability to control for quality changes especially when used in conjunction with a well-designed sample refresh.

The ***bilateral index formula*** is a Törnqvist index, for the *lower levels of the index hierarchy* (elementary aggregates up to cell levels, where cells are defined in the paragraph below):

$I_a(t_0,t) = \prod_i \left(\frac{p_i(t)}{p_i(t_0)}\right)^{\frac{1}{2}(w_i(t)+w_i(t_0))}$, where $w_i(\tau) = p_i(\tau)q_i(\tau)/(\sum_j p_j(\tau)\, q_j(\tau))$,
$\tau = t, t_0$ and i, j are denoting items in any cell a.

This gives equal importance to the weights at the initial and final time points and its most useful characteristics are as follows (Balk and Diewert, 2001):

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[11] An elementary aggregate is the lowest level of aggregation for which value data are available and used in the calculation of the price index. It consists of relatively homogeneous sets of items. Their values are used as weights when averaging the elementary price indices associated with them to obtain indices for higher-level aggregates.

[12] A four digit number according to the Ístarf95 occupation classifications of Statistics Iceland (based on ISCO-88). In addition there is a 5th digit in the occupational code to distinguish status of the employee, i.e. general workers, foreman and craft worker.

[13] A five digit number according to on Ísat2008 economic activity classification of Statistics Iceland (based on NACE2008 rev.2.).

1. it is exact, in terms of translog utility function, i.e. it has a "Divisia nature" (Divisia, 1926), and a microeconomic justification
2. it is superlative, i.e. it converges, like Fisher and Walsh index numbers, to same values, for smoothly trending times series data
3. it passes the 20 tests of the axiomatic approach (Diewert, 1993) with a very high degree of approximation, including *approximate* consistency in aggregation
4. it gives the smallest weight to outliers, out of all superlative numbers, since it belongs to the class of indices called quadratic-mean-of-order-r, with $r = 0$
5. it has a symmetric formula and minimises the index spread

The ***hierarchical structure*** of the IWPI contains three more levels, apart from the elementary aggregates: 1) the so-called *cell aggregation level*, defined by occupational groups[14] and economic activity sections[15] in the private sector and federation of trade unions[16] in the public sector 2) economic sectors level 3) and the whole economy.

The *higher level* index numbers are calculated according to the Laspeyres' formula:

$$I(t_0, t) = \sum_a w_a(t_0) I_a(t_0, t)$$

Here $w_a(t_0)$ are the expenditure weights[17] of the sub-aggregates a which have indices I_a, calculated at time t_0, and in the IWPI case these are the cell (and higher level) weights, updated once a year. This type of formula has the main advantage of being consistent in aggregation as well as giving results approximately equal to the superlative index when prices (i.e. hourly wages in this case) and weights are reasonably monotonic with time.

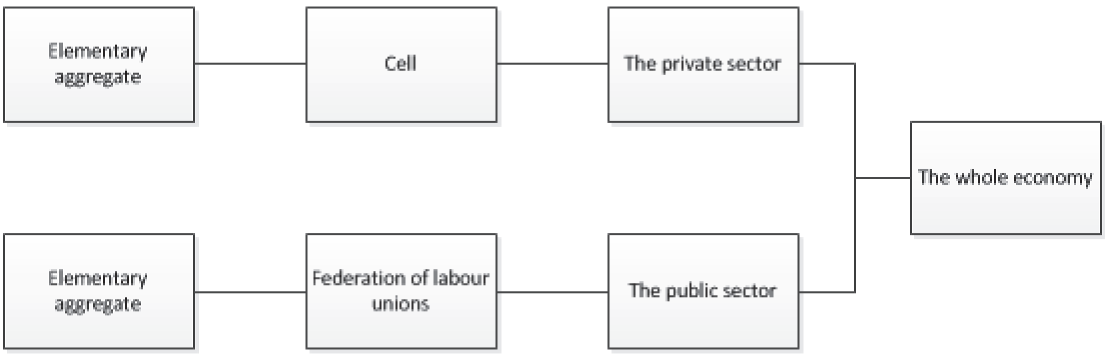

Figure 1. The hierarchical structure of the IWPI.

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[14] Occupational groups follow the Ístarf95 classification (based on ISCO-88). In addition there are two occupational groups: Craft workers, defined as those belonging to occupational groups 7, 8 and 9 and having 5th digit (Icelandic addition) 2 and 3 (skilled craft workers and skilled foremen); general, machine and specialized workers, defined as those belonging to occupational groups 7, 8 and 9 and having the 5th digit 0 and 1 (general workers, and foremen).
[15] Economic activity sections are the level one of the Ísat2008 classification of economic activity (based on NACE2008 rev.2.), identified with alphabetical letters.
[16] Trade unions are grouped together if they belong to the same federations or have common interest in federations.
[17] An expenditure weight for any sub-aggregate is the ratio between the value of the sub-aggregate and the value of the aggregate at the next higher level. The value is defined as the product between price and quantity, i.e. hourly wages and number of employee hours.

Figure 1 shows the hierarchical structure of the aggregation levels in the IWPI and the difference between the public and private sectors. In both sectors the elementary aggregation unit is the same. On the next level the aggregation method differs between the sectors. In the private sector the aggregation is done at the cell level (occupational group x economic activity section) but at the level of the federation of labour unions in local and central governments in the public sectors. The final aggregation step is the same for both sectors.

The ***time evolution*** of the index is defined by linking the short term bilateral index values, calculated for each two successive months, at the higher levels of the hierarchy, i.e. for cells, economic sectors and the whole economy.

Data structure and methods

Data

The IWPI is mainly based on data collected through the Icelandic Survey on Wages, Earnings and Labour Costs (*ISWEL; Launarannsókn Hagstofu Íslands*) conducted by SI. Data are collected directly from employer's wage software systems monthly and contain information on all labour cost and paid hours for all employees, as well as background information on employees and employers (for detailed description of the data file see Appendix 5). Validations checks are performed in accordance to predefined rules in order to eliminate or fix data items that are incorrect. The ISWEL is designed to accommodate demands in regulations on surveys on earnings and labour costs in the European Economic Area and is the main source for public wage statistics by Statistics Iceland.

The ISWEL data are aimed at adequately representing the population on the private market, municipalities and central government. For each employer in the ISWEL, pay-roll items have been categorised in a harmonised way in order to minimise measurement errors. Great effort is also put into harmonised classification of background information, e.g. occupations[18].

Although the use of electronic data collection offers many advantages, like simplicity, consistency and efficiency, the experience has shown that data are sensitive to alterations in business' demography as well as in their internal management. Merging or splitting of businesses and exchanges of the type of wage software are known risk factors for introduction of errors in data. In such cases information linked to the survey can be lost and data has to be re-harmonised.

Administrative data are also utilised in the calculations of the IWPI, primarily PAYE (Pay as your Earn) data. The monthly PAYE data reflects for example the sum of the taxable income

[18] http://www.dst.dk/extranet/staticsites/Nordic2010/pdf/d792814f-968a-4b2d-9e80-b311b24957d6.pd

of workers for the entire labour market, irrespective of economic sector or employer's size, but does not contain information on working hours[19]. Henceforth, the use of PAYE data is primarily on constructing a sample frame for ISWEL and weights for various statistical products in the wage statistics such as the IWPI.

Sample

The ISWEL sample is a stratified cluster sample, where the sample unit is the employer and the observation unit is the employee. Within the private sector the target pool contains all companies with 10 or more employees. The pool of companies is stratified in sections and subsections according to ISAT2008 (Hagstofa Íslands, 2009b) and size. As the small size of the Icelandic economy does not allow partition into harmonized size categories across sections a general selection rule was created. The number (m) of companies in each stratum is 10% of the total number (N) of companies in the stratum, but can never be fewer than 4. Automatically selected companies (n) are companies in which the number of employees is greater than the average number of employees within the stratum, i.e. the inclusion of those companies is not based on probability, but on their relative size. The rest of the pool of companies is split into two pools (medium size and small) based on their number of employees such that the covariance is minimal. In each stratum there can be companies from all the pools (big, medium and small). The selection probability of other than the big companies within the stratum are computed in the following manner: $p = (m–n)/(N–n)$ where *m* is the number of companies that is to be selected, *n* is the number of the automatically selected companies and *N* is the total number of companies in the strata. In the public sector full coverage data are received for all employees working for the central government and the biggest local government. Furthermore, a sample is drawn from the local governments in such a way as to achieve representativeness over regions. As in the private sector, the population is defined as all wage earners working for local government that have 10 or more employees.

In praxis, most companies in the sample, irrespective of size, are present in the sample for long periods of time. The main reason for big companies remaining in the sample is the fact that they are quite few in each economic activity section and therefore necessary to have them all in the sample for representativeness purposes. Other companies are constantly part of the sample as it is costly and very time consuming to make the necessary preparation for inclusion of new companies. The main emphasis of Statistics Iceland is on increasing the coverage of the survey rather than refreshing the sample as the coverage is still not fully complete. Nevertheless, the sample is revised yearly in order to adjust it to changes in companies' environment from the last revision. A systematic sample refresh is not yet implemented.

[19] https://www.istat.it/en/archive/155782

Coverage

According to SI[20] there were 197,600 employees on the labour market in 2017. Some of those employees might be part time workers while other might be counted twice because they might be working within more than one economic activity. The data in the ISWEL survey are collected from the following economic activities (ISAT2008; Hagstofa Íslands 2009b): C, D, E, F, G, H, J (only economic divisions 58–61), K, M (only economic division 71), O, P and Q. Within these economic activities there are approximately 145 thousand employees or ≈ 74% of the total number of employees. The size of the sample in the year 2017 was approximately 100 thousand employees or ≈ 50% of the total number of employees in the labour market.

Weights

The calculation of the IWPI involves a standard structure of expenditure[21] weights which are calculated for all sub-levels of the IWPI hierarchy: elementary aggregates, cell – aggregates (for occupation + economic activity cells/federation of trade unions) and economic sectors.

In particular, weights on the level of the elementary aggregates are based on the expenditure weight of an employee within a cell where the expenditure for each employee is computed each time when the IWPI is computed but the employer expenditure is fixed yearly. Expenditure weights for cell aggregates and economic sectors are fixed yearly. Weights are based on ISWEL data and PAYE-data[22].

Re-adjustments

No preliminary data are published for the total index of IWPI and an already published value of the index is not subjected to revision. Nevertheless, in light of the strict demand for timeliness some retrospective corrections or necessary readjustments are made each month in order to compensate for data delays and data errors. After the first calculation for a given month (T), that given month is revised twice (in months T+1 and T+2) and those revisions contribute to the index value for latest months (T+2). For example, the chained index value of June 2018 includes wage changes in June 2018 but also readjusted values of the changes in April and May 2018[23].

Readjustments have to be made due to data delivery delays. Although the IWPI is based on an electronic data collection directly from the administrative records of employers, data delays can occur when the employers make management decisions such as to change the administrative software or due to changes in the demographics of businesses, e.g. when the business units are changing, splitting up or merging with a new one. In addition, many

[20] https://px.hagstofa.is/pxen/pxweb/en/Efnahagur/Efnahagur__vinnumagnogframleidni__vinnumagn/THJ11002.px/?rxid=52272a61-0b7e-4c19-826f-ff496f61f1a5
[21] An expenditure weight for any sub-aggregate is the ratio between the value of the sub-aggregate and the value of the aggregate at the next higher level. The value is defined as the product between price and quantity, i.e. hourly wages and number of hours.
[22] https://statice.is/publications/metadata?fileId=19576
[23] https://statice.is/publications/metadata?fileId=19576

business units do not close their wage processing for a current month until delivering a report and payment of the deducted wage tax to the Icelandic Directorate of Internal Revenue - which is due the 15th of each month.

Readjustments due to data errors can have multiple causes. Despite SI's strategy to give continuous feedback to data providers in the ISWEL survey, it is not realistic to address every uncertainty or imperfection that comes up in data validations performed each month. Abnormal measurements can be due to errors in paid hours, e.g. when contracts change from measured overtime to fixed overtime hours. In that case the measurement is validated in the next month by comparing the new value to the previous one. If the abnormal measurement only occurs in one month of many, the usual value overwrites the abnormal value in the recalculations. Data errors can also be the result of a neglect to update classifications in the administrative systems of an employer leading to wrong conclusions when pay rises are considered in the data. Therefore, changes are evaluated for each of the three calculations and adjustment made if necessary.

When dealing with outliers no fixed cut-offs are implemented but predefined rules are used to handle and examine the outliers. The only cut-offs used in the calculation of the IWPI regard the first three and the last three incidents (months) of measure for each item and when working hours are either under 10 or over 340 per month. The reason for excluding the first three months and the last three months of each item is the likelihood of extreme values or errors when employment starts or is terminated[24].

Sources and estimates of main bias and errors

A price index has a hierarchical structure and it may be viewed as a generalized weighted average of sub-indices, at any level of this hierarchy. At its lowest level one finds the changes in prices of items, i.e. of hourly wages for the IWPI. It is therefore a summary measure, since it reflects only the means and nothing more of the probability distributions of the relative price variations. It is also based on sample data and calculated for successive points in time which then have to be used to describe the time evolution of the "true" index. Due to all these causes, a price index number is prone to errors and bias irrespective of the index formula.

Sources of errors and bias

The main types of errors and bias for any price index (Balk, 2008) are due to:

1. Sampling errors
   Index numbers are in general not calculated on census data. Sampling from a population of items, e.g. hourly wages, needs to be random, i.e. a probability

[24] https://statice.is/publications/metadata?fileId=19576

sampling and ensure a good coverage and representativeness, including rare patterns if possible. Any deviation from these conditions may induce errors and instabilities in index estimates.

2. Dynamic effects

   Since the population of items evolves over time, the price and weight distributions are affected and may introduce errors if the assumptions or methods for calculating the index do not accommodate this dynamics.

   Examples of changes over time and counter measures which could be employed are:

   2.1 quality changes, which may be corrected for by using matched models structures

   2.2 newly appearing, missing or disappearing products, which may be compensated for by adequate sample refresh and using large samples

   2.3 influences of life cycle evolution or the effect of persistent products, which may be addressed by modelling and choice of elementary aggregate

   2.4 seasonality effects, which may be corrected by appropriate adjustments when needed

3. Combining bilateral index information into time series of multiple time points

   This may be done by using direct, chained or multilateral index numbers. This problem is addressed in some detail, in the following section

The following conclusions are made by considering these main types of errors and bias in the context of the IWPI:

- IPWI is based on a matched sample model which is considered to be suitable to control for quality changes
- as the ISWEL data are comprehensive and based on an extensive sample this should compensate well for product changes but a systematic sample refresh should be considered
- the existence of bias due to life cycle evolution is explored further in the following sections
- the choice of elementary aggregate is in accordance with the general index theory, i.e. the lowest level of aggregation for which value data are available and consists of relatively homogeneous sets of items
- the existence of a drift in the IWPI due to a chaining effect is explored in the following sections

Estimating the chaining drift and life cycle errors

An index is said to “drift” if it does not return to unity when prices in the current period return to their levels in the base period.

To chain or not to chain

The choice between a fixed base and a chained index number used for describing the time evolution of price changes is defined as a choice between transitivity and representativeness (Forsyth and Fowler 1981, Lent 2000), i.e. between the following requirements: i) the index should return to its initial value if prices go through symmetric changes (transitivity), and ii) the index structure should reflect the price and weight structure at current time points (representativeness).

A chained index (which combines successive bilateral direct index numbers as: $I_{\{0,n\}} = I_{0,1}I_{1,2} \dots I_{n-1,n}$) is a cumulative measure of long term price changes but, since path dependent, it gives better description of the *process* than of the difference between the initial and final states. It is most appropriate for real time measurements due to the index' and weights' structures which are always mirroring the current period prices at any point in time. A direct index $I_{0,n}$ measures price changes between a fixed base period and the current period, its structure becoming less representative over time.

The main *advantages* of using chained index numbers are the following (Diewert, 1987):

- they can be used for medium and long term economic comparisons
- the amount of information used in calculating the chained indices is maximised
- the effects of new and disappearing products and of quality changes are minimised
- all superlative indices will closely approximate each other if the chain principle is used, since changes in prices and quantities tend to be small for adjacent time periods
- no single period is singled out to play an asymmetric role in its calculation

The main *disadvantage* of using chained index numbers is that the more prices and quantities fluctuate *simultaneously*, the more a chained index will diverge from the corresponding direct index. This is the so-called drifting effect and chained indices should be avoided when a high proportion of the prices and weights are volatile. High frequency chaining can also induce drift accumulation in the presence of strong price, more than quantity oscillations (Ehemman, 2005). For example, sub-annual chaining of data with seasonal character is not desirable, but it is not a problem when an annual link is used. The IWPI data does not show seasonality, but one should continuously monitor the extent and influence of simultaneous price spikes and weight oscillations at chaining levels.

It has been shown that, in special cases, the drift becomes zero or very small in comparison to the index values, for instance:

- when the index formula is of a particular type (such as unweighted index numbers or multilateral index numbers like GEKS (Invacic, Diewert and Fox, 2009) or
- when the distribution of prices and of expenditure weights meet certain conditions (Alterman, Diewert and Feenstra, 1999), in particular if the logarithmic price ratios

trend linearly with time and the expenditure shares also trend linearly with time, then the Törnqvist index will satisfy the circularity test *exactly*.

It is also important to note that the difference between direct and chained index values includes several effects and it does not only show the influence of chaining. Such effects are: the influence of the index formula of choice, the sample degradation (for the direct index) and effects due to the elementary aggregates (Clews, 2014).

The analytical formula for the (log) chain drift of the IWPI index number, for any k, k', k'' time points between t_0 and t (at *each chaining step*) and for $J = 1, \dots, n$ sub-aggregates $l_j(k,k') = \prod_{a \in j} \left(\frac{p_a(t)}{p_a(t_0)}\right)^{\frac{1}{2}(w_a(k)+w_a(k'))}$, reads:

$$(I_{\{k,k''\}}) - ((I_{\{k,k'\}}) + (I_{\{k',k''\}})) = \sum_j w_j(k,k'')l_j(k,k'') - \sum_j w_j(k,k')l_j(k,k') - \sum_j w_j(k',k'')l_j(k',k'')$$

The chaining drift for an elementary aggregate is given in Appendix 2, but in real life applications chaining is done at higher aggregate level, as derived in Appendix 3, for any level of the hierarchy. Since calculation of a direct index over long time periods is meaningless, unless the sample is unchanged during that period (and then one would not need to use chained index numbers in the first place), in order to estimate the size of the accumulated drift over multiple chaining steps the equivalent drift formula was used based on the covariance between the relative price variations (or sub-indices) and the weight variations (see Appendix 3 which uses the results in Forsyth and Fowler 1981, and Lent 2000 and our additional calculations):

$$ln(I_{\{t_0,t\}}) - \sum_{\{k,k' \; in \; t_0,\dots,t\}} ln(I_{\{k,k'\}})$$

$$= \frac{N}{2}\sum_{k=t_0+1}^{t-1} c\left(l_{k-1,k}, d_{t,k}\right) - \frac{N}{2}\sum_{k=t_0+2}^{t} c\left(l_{k-1,k}, d_{k-1,t_0}\right) \qquad (1)$$

Here $l_{k,k'} = \left(\ln\left(\frac{p_1(k)}{p_1(k')}\right), \dots, \ln\left(\frac{p_N(k)}{p_N(k')}\right)\right)$, $d_{k,k'} = (w_1(k) - w_1(k'), \dots, \; w_N(k) - w_N(k'))$, N is the number of sub-aggregates in the chained aggregate, $l_j(k,k')$ are the (log) sub-index values calculated for any time points k, k' and $c(x,y)$ is the notation for covariance terms. In Appendix 3, the following form is derived of the drift term, used for computations since involves mostly terms measured at successive points in time:

$$\sum_{k=t_0+2}^{t-1} l_{k-1,k} \cdot (\widetilde{w}_{0t} - \widetilde{w}_{k,k-1}) - \frac{1}{N}\sum_{k=t_0+2}^{t-1} (\sum l_{k-1,k}) \cdot \left(\sum(\widetilde{w}_{0t} - \widetilde{w}_{k,k-1})\right)$$

$$+\frac{1}{2}(l_{t_0,t_0+1} \cdot d_{t,t_0+1} - l_{t-1,t} \cdot d_{t-1,t_0})$$

$$\frac{1}{2N}(\sum l_{t-1,t}) \cdot (\sum d_{t-1,t_0}) - \frac{1}{2N}(\sum l_{t_0,t_0+1}) \cdot (\sum d_{t,t_0+1}) \qquad (2)$$

This formula is valid at any level, for both a general superlative Törnqvist aggregate (lower levels) and for linear combinations like a Laspeyres index at higher levels, where weights are kept constant across each year, as is the case for the higher levels of the IWPI. Many of the differences in first terms of relation (2) are zero and $l_{k,k'}$ denote sub-index values. It shows (with tilde weights denoting averages, as in the definition of the index) more clearly how terms may compensate each other for smoothly trending data. However, when there are frequent oscillations in data, drift may become significant. For example, high frequency chaining of scanner data (de Haan, 2013) has been proven to show higher drift than lower frequency, smoother data.

The formula above proves mainly that the size of the accumulated drift is indeterminate and data dependent. Its size is estimated on the real IWPI data in the following section.

Persistent products/life cycle effects

Matched samples method for calculating price index numbers may introduce bias if the products (hourly wages of employer-employee transactions, in the case of IWPI) have systematic price or weight trends at different points in their life cycle and if the age distribution of the products in the sample does not mirror consistently the one in the whole population.

For the components of the IWPI index number, cf. Appendix 4, that the bias can be written (for each successive time points t_0, t_1) as:

$$\delta I = E(I_{sample}) - I_{population} =$$

$$= \sum_{\widehat{M}_{01}} \left(\hat{g}_j(t_0, t_1)\right) (\mathrm{f}(\mathrm{l_j}(\mathrm{t_1}) - \mathrm{f}(\mathrm{l_j}(\mathrm{t_0})) - \sum_{M_{01}} \left(g_j(t_0, t_1)\right) (\mathrm{f}(\mathrm{l_j}(\mathrm{t_1}) - \mathrm{f}(\mathrm{l_j}(\mathrm{t_0}))$$

Here M_{01} is the set of matched items during the period (t_0, t_1) on the whole population of items (hourly wages) and $\widehat{M}_{01}$ is the set of matched items on the sample. The functions $g(t_0, t_1)$, $\hat{g}(t_0, t_1)$ describe the life cycle dependency of weights (on population and sample) and $\mathrm{f}(\mathrm{l_j}(\mathrm{t_1}))$ the dependency of (log-) prices. The formula above is derived in Appendix 4, by using a generalization of the model in Melser and Syed (2014) which in turn is related to the hedonic time-dummy approach of de Haan and Hendriks (2013).

This means that the bias depends on the extent of life cycle pricing and on the difference between the life cycle effect on the sample and on the total population of hourly wages. If this difference is small or if the sample represents the population in a correct manner, then the bias is very small. Whether the IWPI prices and weights depend on life cycle is tested in the next section.

Data analysis for IWPI

The IWPI data for all economic sectors over a 40 months period between 2015 and 2018 was used in order to perform statistical tests and estimates of typical errors and biases described in the previous section. The chaining of the index is done at the level of occupation, economic activity, federation of trade unions, economical sector and total economy. The issue of aggregation versus chaining *order* is not investigated here. In this paper, the analyses are based on the effects of chaining at sector level as an illustrative example.

Chaining effects

1. Short term chaining

Numerical calculations of the drift size on main economic sectors were performed, by comparing chained index numbers with direct ones for a linking period of only three months, in order to illustrate the short term drift.

The relative differences between chained and direct index numbers for all available time points of the type$(t, t+3)$, by economic sector, were calculated and t-tests were used to decide whether these differences were significant. For the central and local government sectors, the differences between direct and chained numbers were not statistically significant (t(14)=2.8, p>.001, 95% CI: (.00015, .001), with a mean of 0.0006 and standard deviation of 0.0008 for the central government sector and t(29)=-0.14, p>.001, 95% CI: (-.002, .002), with a mean of -0.0001 and standard deviation of 0.005 for the local government sector) while for the private economic sector a significant but trivial value was obtained (t(28)=5.1, p < .001; 95% CI: (0.001, 0.003), with a mean 0.002 and standard deviation of 0.002).

Figure 2 shows that the values of the direct and chained index changes between two time points are close to each other but the direct index variation is smaller than the chained one, especially for high values of both index changes. These higher values are however much fewer as well.

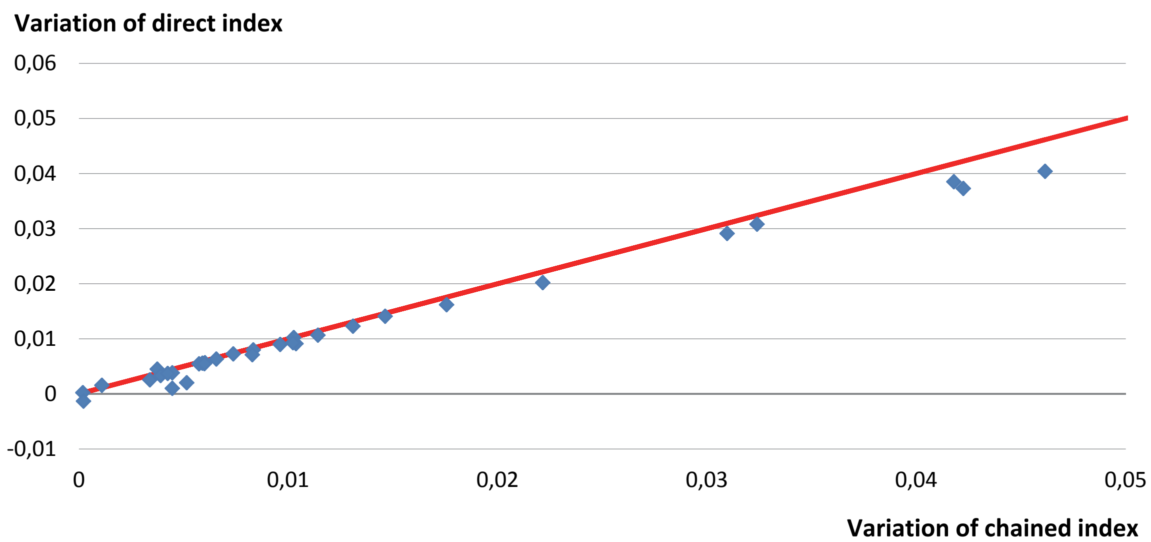

Figure 2. Chained versus direct index variations. The figure shows the relation between the chained and direct index variations for the private sector where the red line presents zero difference.

2. Long term chaining

For the long term drift illustration, periods of one, two and three years (during 2016-2018) were analysed and the error values found for the index number were still the same size as the rounding errors. It is worth pointing out that the same effect size has been found for short term intervals, as described in the above paragraphs. This shows that the drift does not accumulate with time for reasonable time series data of prices and weights, at least for moderately long (few years) periods of time.

The numerical analysis of the terms in the drift equation (eq.2) explains this lack of accumulation. They are all of comparable sizes but alternating signs. The only situations when they can add up is when the covariance signs, for the terms (see eq.1) which involve the end versus the beginning of the interval, are different, and this may happen, especially on short periods when the relation between the variation of prices and weight difference changes.

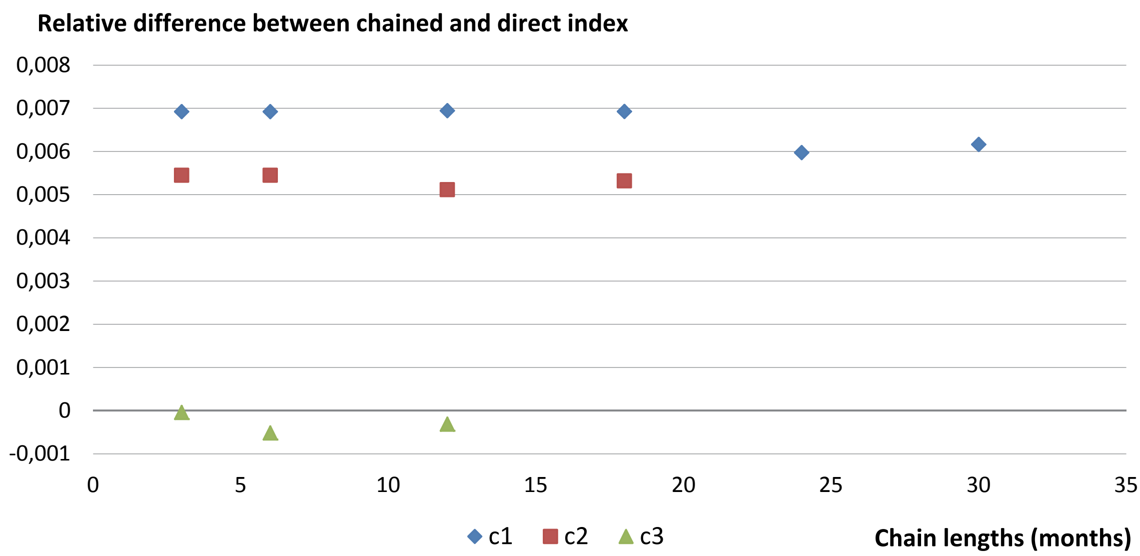

Figure 3. Relative difference between chained and direct index as a function of the chain length. The three symbols denote three different chains, each starting at different moments in time: 0 (the blue diamonds), 12 (the red squares), and 16 (the green triangles) months.

Figure 3 shows also that the drift may be of either sign, and the at least for few years, it does not grow with time.

Life cycle effects

Statistical tests for life cycle dependency of relative prices and for weights show very weak effects. For this analysis, the following methods are used:

1. In order to decide whether the age of the item has an effect on the value of the index number, at any given point in time, this dependency is modelled as described in the previous section and in Appendix 4 and tested for significance the age-dependent factor of the models

2. In order to decide whether the moment in time when this dependency is measured has an influence on the results:
    2.1. the time-dependent factor in the models of Appendix 4 were tested for significance
    2.2. the distributions of the index numbers for different moments in time and fixed age of items were compared

These tests showed weak relations between the items' indices and items' ages.

Modelling the (mean value) elementary index as a linear *function of the age* of the items shows a very weak such dependency:

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	.00001	.000003	4.069	.00008
age	8.3e-08	4.6e-08	1.787	0.0762

Residual standard error: .00002, on 132 degrees of freedom

The distributions of the indices of elementary aggregates for different fixed ages of items show small differences as well. For example, when distributions at ages 30 and 100 months were compared the following results were obtained:

Although a two-sample Kolmogorov-Smirnov test of differences in distributions gives (D = 0.1607, p-value = 0.0008), the mean values of such distributions are not significantly different (two sample t-test, t = -0.0994, df = 176.544, p-value = 0.921, 95% CI (-.00003, .00003), the mean of first distribution is 1.000012 and of second 1.000013).

Outliers do exist, for both very short and very long life of items, as illustrated in Figure 4. This figure represents the variation with items' age for the mean values of the index numbers of elementary aggregates in the private economical sector, at a given time.

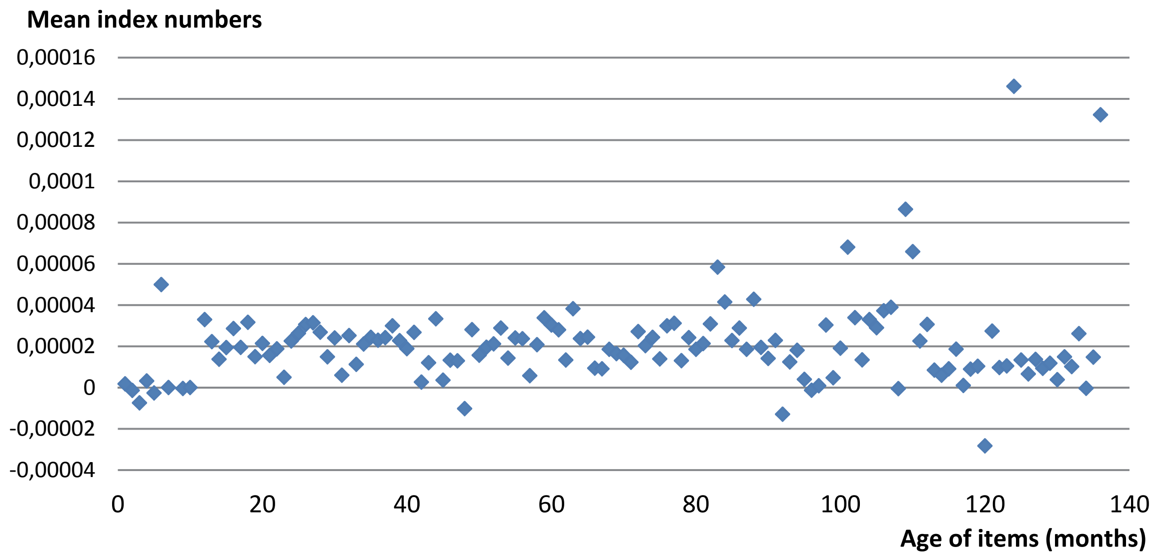

Figure 4. Life cycle effects illustration. Mean values of index numbers, by age of items, at a given time.

The weights and price variations display same type of weak dependency on items' age, with a small but statistically significant slope for the weight variations.

Discussion and conclusions

This paper describes how the IWPI is calculated in context of the general price index methodology. The IWPI is found to be of good quality, using standard methods of price index theory utilising comprehensive data. Its main challenges are lack of coverage and adequate sample refresh.

In order to obtain information of known biases in price indices, the sizes of errors and bias due to chaining the index over time and due to the life cycle of items, i.e. of hourly wages paid by employers to employees for the same job, defined by occupation and economic activity, have been estimated. One of the main goals was to evaluate *the impact* of these errors on the quality of the IWPI.

The conclusion of the analysis is that the accumulated drift is small as it is only of the order of magnitude of the rounding errors for the (higher aggregates level) index, at least for short (months) and medium terms (several years). It can only be inferred that this behaviour is conserved for longer term, due to the structure of the drift as a sum of alternating sign terms of comparable sizes. Locally, at a given point in time, the drift may become significant, when strong fluctuations in data take place. Therefore, one should aim at minimizing the influence of such points, for example by using variable length chaining.

The following influence of the life cycle (age) of items was observed: the distribution of elementary index values are very similar for each fixed age of items, at various points in time; the differences in distributions of the elementary index numbers for different ages at fixed points in time, are statistically significant but very small. The aggregated index numbers may be still affected by the age composition of the sample if this composition is significantly different from the one observed in the population. This was outside the scope of the paper, but one can formulate the conjecture that an adequate sample refresh would correct for any effect related to such discrepancies.

Future plans

The present analysis is not comprehensive and many aspects of data and possible errors still have to be studied in the context of the IWPI. This includes the influence of the choice of the elementary aggregate (comparing for example the ideal one with others based on homogeneous groups of items), quality changes and the formula for aggregation of the total index. Studies of the quantitative effects of sample refresh or weights updating schedule on the index results and quality might also be a topic for the future.

Evaluating and testing novel ways of improvement of the IWPI should also be the object of a future analysis. Statistics Iceland could for instance test for the IWPI data methods like:

- a combination of fixed base and chaining methods,
- an optimally linked index, i.e. variable length chaining, depending on local data features (Ehemann, 2005),
- multilateral index numbers, as proposed in Invacic, Diewert and Fox (2009) or de Haan (2011)

The dissemination of results regarding the IWPI could also be re-evaluated, in order to include more information such as uncertainty measures and additional index numbers derived from alternative definitions of wage transactions content.

Conclusions

This paper is the first step towards a revision of data and methods used to build the IWPI. Statistics Iceland will continue to assess new theoretical developments regarding the index and consult with users and experts in order to develop a best practice approach to building and communicating the IWPI content.

References

Alterman, W. F., Diewert, W. E., & Feenstra, R. C. (1999). *International trade price indexes and seasonal commodities*. US Department of Labor, Bureau of Labor Statistics.

ABS. (2012). Wage price index: Concepts, sources and methods. Retrieved 01.08.2018 from http://www.abs.gov.au/ausstats/abs@.nsf/mf/6351.0.55.001

Balk, B. M., and Diewert, W. E. (2001). A characterization of the Törnqvist price index. *Economics Letters*, *72*(3), 279-281.

Balk, B. M. (2008). *Price and quantity index numbers, models for measuring aggregate change and difference*. 1st edition. Cambridge University Press.

Clements, K. W., Izan, I. H., and Selvanathan, E. (2006). Stochastic index numbers: A review. *International Statistical Review, 74*(2), 235–270.

Clews, G., Dobson-McKittrick, A., and Winton, J. (2014). Comparing class level chain drift for different elementary aggregate formulae using locally collected CPI data, ONS paper. Retrieved:23.07.2018,from http://webarchive.nationalarchives.gov.uk/search/result/?q=Comparing+class+level

DARES. (2012). Éléments de comparasion entre un indice de saleire horaire de base pour les ouvriers et les employés et un indice de salaire horaire pour l'ensemble des salaries, à partir de l'enquête trimestrielle acemo. Retrieved 01.08.2018 from http://dares.travail-emploi.gouv.fr/IMG/pdf/note_methodologique_sur_la_construction_de_l_indice_shboe-2.pdf

de Haan, J. and van der Grient, H. A. (2011). Eliminating chain drift in price indexes based on scanner data. *Journal of Econometrics, 161*(1), 36–46.

de Haan, J., & Hendriks, R. (2013, November). Online data, fixed effects and the construction of high-frequency price indexes. In *Economic Measurement Group Workshop* (pp. 28-29).

Diewert, W. E. (1976**).** Exact and superlative index numbers. *Journal of Econometrics 4*(2), 115-145.

Diewert, W. E. (1978). Superlative index numbers and consistency in aggregation. *Econometrica, 46*(4) 883-900.

Diewert, W. E. (1987). Index numbers. in J. Eatwell, M. Milgate and P. Newman (eds.), *The New Palgrave: A Dictionary of Economics*, (vol. 2, pp.767–780). The Macmillan Press.

Diewert, W. E. (1993). Index numbers, in W.E. Diewert, W. E. and A.O. Nakamura (eds.), *Essays in Index Number Theory*, (vol. 1, Chapter 5, pp. 71–108). Elsevier Science Publishers.

Diewert, W. E. (2002). The quadratic approximation lemma and decompositions of superlative indexes. *Journal of Economic and Social Measurement 28*(1 , 2), 63–88.

Divisia, F. (1926). L'indice monétaire et la théorie de la monnaie. *Revue d'économie politique*, *40*(1), 49-81.

Ehemann, C. (2005). Chain drift in leading superlative indexes. *BEA Working Papers*. Retrieved 23.07.2018 from https://faq.bea.gov/papers/pdf/ChainDriftinLeading.pdf

Eurostat. (15.06.2018). *Labour cost index (lci)* http://ec.europa.eu/eurostat/cache/metadata/en/ lci_esms.htm

Eurostat. (2008). NACE rev. 2. *Statistical classification of economic activities in the European Community*. Luxembourg: Office for Official Publications of the European Communities, 2008. http://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-RA-07-015

Feenstra, R. C., & Reinsdorf, M. B. (2007). Should Exact Index Numbers Have Standard Errors? Theory and Application to Asian Growth. In *Hard-to-Measure Goods and Services: Essays in Honor of Zvi Griliches* (pp. 483-513). University of Chicago Press.

Fisher, I. (1922). *The Making of Index Numbers*. Boston: Houghton Mifflin.

Forsyth, F. G., and Fowler, R. F. (1981). The theory and practice of chain price index numbers. *Journal of Royal Statistical Society*. *Series A (General)*, 224–246.

Hagstofa Íslands (2009a). *ÍSTARF95* (Based on ISCO-88). Reykjavík: The author.

Hagstofa Íslands (2009b). *ÍSAT2008* (Based on NAC rev. 2). Reykjavík: The author.

Hill, R. J. (2006). Superlative index numbers: not all of them are super. *Journal of Econometrics 130*(1), 25-43.

ILO, IMF, OECD, Eurostat, United Nations, and World Bank (2004). *Consumer price index manual: Theory and practice*, ILO Publications, Geneva. Retrieved 23.07.2018 from http://gauss.stat.su.se/master/es/CPIM-TP.pdf

Ivancic, L., Diewert, E. W., Fox, K. J. (2009). Scanner data, time aggregation and the construction of price indexes. UBC discussion paper 09-09. Retrieved 01.08.2018 from https://www.economics.ubc.ca/files/2013/06/pdf_paper_erwin-diewert-09-9-scanner-data.pdf

Melser, D., Syed, I.A. (2016). The product life cycle and sample representativity bias in price indexes, UNSW Research Paper No. 2016 ECON 07. Retrieved 01.08.2018 from http://research.economics.unsw.edu.au/RePEc/papers/2016-07.pdf

Lent, J. (2000). Chain drift in some price index estimators. In *Proceedings of the survey research methods section*.

Ruser, J. W. (2001). The employment cost index: what is it. *Monthly Lab. Rev.,* 124, 3.

Selvanatan, E. and Rao, D. P. (1994). *Index numbers: A Stochastic approach*. University of Michigan Press.

Statistics Iceland (n.d). *The Act on the Wage Index No 89/1989*. https://statice.is/about-statistics-iceland/laws-and-regulations/act-on-the-wage-index/. Translated from Icelandic: https://www.althingi.is/lagas/nuna/1989089.html

Appendix 1 A few comments on the methods of calculating wage changes

Hagstofa Íslands, *Rósmundur Guðnason* / 29.janúar 2018

English summary:

A few comments on the methods of calculating wage changes

In this internal memo, the historical background of the wage index in Iceland is described. The construction of the wage index is explained, showing the types of index numbers used at lower and higher levels of the aggregation hierarchy and pointing out alternative methods of index compilation. Two of the issues discussed by the author are very important for the users of the IWPI:

- the differences observed when comparing the IWPI changes with the average Earnings changes do not have to reflect errors of either of these two measures but mainly the fact that they are calculated according to different formulae, different assumptions and describe different phenomena. For example, the average wage may change if the availability of cheap workflow changes, but only changes in wages may affect the results of the index calculations

- the comparison of the annual changes in the IWPI and average Earnings shows that either of these two measures may be higher than the other and it is different for different periods in time, suggesting that the drift due to chaining is not a problem for the IWPI.

Minnisblað: *Nokkrir punktar um aðferðir við útreikning á breytingum launa*

1. Launavísitalan er hrein verðvísitala og mælir eingöngu verðbreytingar launa. Hún er hluti af tölfræði um laun sem Hagstofan útbýr og á að gefa heildarmynd af launum og breytingum þeirra á vinnumarkaði. Til viðbótar við launavísitöluna eru meðallaun reiknuð og í þróun er útreikningur á launakostnaðarvísitölu að Evrópskri fyrirmynd. Launavísitalan og meðallaun endurspegla breytingar á launum hjá launþegum en launakostnaðarvísitalan sýnir laun frá sjónarhorni fyrirtækja. Breytingar launa vegna kjarasamninga hafa bein áhrif á útreikninginn og einnig önnur atriði samninga sem ná til allra, til dæmis hækkanir vegna starfsaldurs. Við það hækkar launakostnaður og launagreiðslur starfsmanna og þær niðurstöður endurspeglast í launavísitölu, meðallaunum og launakostnaðarvísitölu.Fá ríki reikna hreinar verðvísitölur sem stafar aðallega af því að nægilega ýtarleg laungögn skortir til að unnt sé að reikna þær á öruggan hátt. Undanfarið hefur áhugi á verðvísitölum aukist í Evrópu og er unnið að gerð slíkra vísitalna í nokkrum ríkjum.
2. Sögulegar rætur launavísitölu tengjast verðtryggingu fjárskuldbindinga. Launavísitala (lög nr. 89/1989) varð til þegar ákveðið var að bæta launum inn í lánskjaravísitölu til verðtryggingar. Frá árinu 1979 var grunnur verðtryggingarinnar samsettur að 2/3 úr framfærsluvísitölu og 1/3 af byggingarvísitölu. Í febrúar 1989 var þessu breytt og lánskjaravísitalan miðuð að jöfnu við launavísitölu, byggingarvísitölu og

framfærsluvísitölu og þá þurfti mánaðarlegan útreikning á öllum vísitölunum. Þessi breyting leiddi til þess að sérstök lög voru sett um launavísitöluna.

3. Miðað við þessi not var mikilvægt var að vísitalan mældi eingöngu verðbreytingar launa en ekki magn- eða samsetningarbreytingar þeirra. Þessu er lýst í 2 gr. laganna: „Launavísitala skv. lögum þessum skal sýna svo sem unnt er breytingar heildarlauna allra launþega fyrir fastan vinnutíma. Er þá átt við breytingar greiddra launa fyrir dagvinnu, eftirvinnu og næturvinnu að meðtöldum starfs- eða launatengdum álögum og kaupaukum.“ Launavísitalan er því hrein verðvísitala og eru forsendur á útreikningi hennar greidd laun allra launþega fyrir fastan vinnutíma en ekki tekjur þeirra.
4. Fyrirkomulagi verðtryggingar fjárskuldbindinga var aftur breytt á apríl 1995, en þá var verðtryggingin miðuð við vísitölu neysluverðs og hætt var að nota launavísitölu í þeim tilgangi. Þrátt fyrir það var algengt að vísitalan væri notuð sem viðmið við verðtryggingu launa og verksamninga ásamt notum við ýmiss konar greiningar á vinnumarkaði og í efnahagsmálum. Not vísitölunnar dag eru víðtæk og hún nýtt sem almennur mælikvarði á verðbreytingar launa og þörf á slíkri verðvísitölu í þjóðfélaginu.
5. Í upphafi var verulegur skortur á nægilega ítarlegum og tímanlegum launaupplýsingum til að reikna launavísitöluna. Á þessu hefur orðið veruleg breyting hin síðari ár með tilkomu launarannsóknar Hagstofunnar þar sem viðamikið úrtak er valið handahófskennt fyrir launþega í fyrirtækjum með tíu eða fleiri starfsmenn. Safnað er saman í hverjum mánuði upplýsingum rafrænt um laun og launakostnað vegna allra starfa í þessum fyrirtækjum. Í dag er grunnur launavísitölunnar og annarrar launatölfræði sem Hagstofan vinnur reistur á þessum umfangsmiklu gögnum. Því er allur rammi úrvinnslu launavísitölunnar mun traustari nú, en var þegar henni var komið á fót. Þessi ýtarlegu gögn gera það að verkum að unnt er að birta ársfjórðungslega sundurliðaðar niðurstöður á störf.
6. Mánaðarleg launavísitalan er reiknuð í grunni sem Törnquist afburða vísitala á reglulegum launum fyrir pöruð störf einstaklinga. Í efra lagi vísitölunnar er hún reiknuð sem Laspeyres fastgrunnsvísitala. Á upphafsárum launavísitölunnar var nokkur vandi á höndum við útreikning á pöruðum niðurstöðum vegna óstöðugleika í niðurstöðum vegna skorts á fullnægjandi gögnum. Gjörbreyting varð á þessu ástandi þegar launarannsókn Hagstofunnar kom til þar sem miklu umfangsmeiri upplýsingum er safnað. Við útreikning vísitölunnar getur orðið vandi ef fjöldi í hverri einingu sem liggur að baki útreikningum er ekki nægjanlegur en það gerist varla vegna umfangs launaupplýsinganna sem safnað er. Hugsanlegt er að beita öðrum reikniaðferðum en mánaðarlegum pöruðum samanburði og nýta meira af þeim viðamiklu gögnum sem safnað er við útreikninginn.
7. Skekkjur eða bjagi í vísitölum getur verið ýmiss konar og áreiðanleiki launavísitölu, meðallauna og launakostnaðarvísitölu háður óvissu vegna þessa. Skekkjur í grunngögnum geta verið ýmsar eftir því hvort um er að ræða skekkjur í úrtaki eða aðrar skekkjur sem tengjast öflun gagna. Skekkjur vegna grunngagna eru eins fyrir alla launatölfræði sem Hagstofan vinnur þar sem hún er reist á sömu gögnum. Til

viðbótar skekkju vegna grunngagna geta aðrar skekkjur verið vandamál. Líklegt verður að teljast að skekkur vegna breytinga á gæðum sem ekki er tekið tillit til gætu verið helsta vandamálið af þessum toga.

8. Munur sem stafar af mismunandi umfangi á launavísitölu eða meðallaunum getur ekki talist vera skekkjur eða bjagi. Launavísitölur geta verið skekktar eða bjagaðar og meðallaun einnig, en mismunandi aðferðafræði við útreikning talnaraða endurspegla ekki endilega bjaga heldur mun á milli útreikningsforsenda. Talnaraðir sem eru reiknaðar með mismunandi aðferðum sýna oft ólíkar niðurstöður og þrátt fyrir það er ekki endilega hægt að tala um bjaga í því sambandi. Meðallaun geta breyst ef framboð á ódýrara vinnafli breytist en breytingar launa eiga hinsvegar einar að hafa áhrif á niðurstöður fyrir launvísitöluna. Þá geta breytingar á grunngögnum til dæmis þegar fjölgað er í úrtaki grunngagna haft áhrif á niðurstöðurnar og gert allan samanburð vandasaman.
9. Launavísitalan er keðjutengd í hverjum mánuði. Rek *(e. drift)* er bjagi sem getur orðið þegar vísitölur eru keðjutengdar og leiðir til þess að þær ofmæli eða vanmæli verðbreytingar við keðjutenginguna. Slíkt getur til dæmis orðið ef miklar verðbreytingar eru í mánuðinum þegar keðjutengt er og vísitalan fer ekki í sömu stöðu og áður ef þær ganga til baka. Samanburður á ársbreytingum launavísitölu og meðaltekna sýna að launavísitalan hækkar ýmist umfram meðallaun eða lækkar. Meðallaun hækka meira á ári en launavísitalan í um það bil þriðjungi tilvika árin 2005-2016, en mismunandi eftir starfsstéttum. Fyrir stjórnendur breytast meðallaun meira en launavísitalan í um það bil 75% tilvika, en fyrir tækna og sérmenntað starfsfólk og verkafólk í tæplega fimmtungi tilvika. Það er því ekki um að ræða að munur á niðurstöðunum sé eingöngu til hækkunar. Séu uppsafnaðar ársbreytingar launavísitölu og meðallauna umreiknaðar til árshækkunar eftir tímabilum árin 2005 til 2016 koma í ljós afar mismunandi niðurstöður. Allt frá óbreyttri niðurstöðu fyrir heildina (2005-2009) til 0,9% hækkunar (2005-2012) þegar hæst er. Fyrir verkafólk eru lægstu tölur 0,7% og hæstar 2,8%. Niðurstaðan er að sá mismunur sem er fyrir hendi er afar mismunandi eftir tímabilum og með engum hætti hægt að segja að hann stefni í eina átt. Þessar niðurstöður benda ekki til þess að rek sé vandamál.

Appendix 2 Calculation of the drift effect

Calculation of the drift effect, for *one chaining step*, for elementary aggregates:

$$\ln\left(\frac{I_{k,k''}}{I_{k,k'}I_{k',k''}}\right)$$
$$= \sum_j \widetilde{w}_j(k,k'')ln\left(\frac{p_j(k)}{p_j(k'')}\right) - \sum_j \widetilde{w}_j(k,k')ln\left(\frac{p_j(k)}{p_j(k')}\right)$$
$$- \sum_j \widetilde{w}_j(k',k'')ln\left(\frac{p_j(k')}{p_j(k'')}\right)$$

By writing $\frac{p_j(k)}{p_j(k')} = \frac{p_j(k)}{p_j(k'')}\frac{p_j(k'')}{p_j(k')}$,$\frac{p_j(k')}{p_j(k'')} = \frac{p_j(k)}{p_j(k'')}\frac{p_j(k')}{p_j(k)}$, we obtain:

$$\ln\left(\frac{I_{k,k''}}{I_{k,k'}I_{k',k''}}\right)$$

$$= \sum_j \widetilde{w}_j(k,k'')ln\left(\frac{p_j(k)}{p_j(k'')}\right) - \sum_j \widetilde{w}_j(k,k')ln\left(\frac{p_j(k)}{p_j(k'')}\right) + \sum_j \widetilde{w}_j(k,k')ln\left(\frac{p_j(k'')}{p_j(k')}\right)$$
$$- \sum_j \widetilde{w}_j(k',k'')ln\left(\frac{p_j(k)}{p_j(k'')}\right) + \sum_j \widetilde{w}_j(k',k'')ln\left(\frac{p_j(k')}{p_j(k)}\right)$$
$$= \sum_j (\widetilde{w}_j(k',k'') - \widetilde{w}_j(k,k') - \widetilde{w}_j(k',k''))\, ln\left(\frac{p_j(k)}{p_j(k'')}\right)$$
$$+ \sum_j ln\left(\frac{p_j(k')}{p_j(k)}\right)^{\widetilde{w}_j(k',k'')}\left(\frac{p_j(k'')}{p_j(k')}\right)^{\widetilde{w}_j(k,k')}$$

By using the definition of the weights of the Törnqvist index number, $\widetilde{w}_j(k_1,k_2) = \frac{1}{2}\left(w_j(k_1) + w_j(k_2)\right)$ for $(k_1,k_2) \in \{(k',k''),(k,k'),(k',k'')\}$ and direct calculations, we obtain$\widetilde{w_j}(k',k'') - \widetilde{w_j}(k,k') - \widetilde{w_j}(k',k'') = 0$. This concludes our calculation with:

$\ln\left(\frac{I_{k,k''}}{I_{k,k'}I_{k',k''}}\right)$ =$\sum_j ln\left(\frac{p_j(k')}{p_j(k)}\right)^{\widetilde{w}_j(k',k'')}\left(\frac{p_j(k'')}{p_j(k')}\right)^{\widetilde{w}_j(k,k')}$, i.e. with the fact that the drift of an elementary aggregate is dominated by the terms of significant price variation.

Appendix 3 Calculation of the drift size

Calculation of the drift size, for multiple chaining steps, for *any sub-aggregates*, in terms of covariance, using the notation $w_j(t_1, t_2) = w_j(t_1) - w_j(t_2)$:

$ln(I_{\{t_0,t\}}) - \sum_{\{k,k+1=k' \ in \ t_0,\dots,t\}} ln(I_{\{k,k'\}})$ =

$$= \sum_{k'=t_0+1}^{t-1} \sum_j \big(w_j(k',t) \ln l_j(k',t_0) - w_j(t_0,k') \ln l_j(k',t)\big) \quad (3)$$

Using elementary algebra and definition of covariance, similar to the method in (Forsyth and Fowler ,1981), (Lent 2000) and (Ehemman 2005), we obtain:

$\frac{N}{2}\sum_{k=t_0+1}^{t-1} c\big(l_{k-1,k}, d_{t,k}\big) - \frac{N}{2}\sum_{k=t_0+2}^{t} c\big(l_{k-1,k}, d_{k-1,t_0}\big)$, which in turn may be written as:

$$= -\frac{1}{2}\sum_{k=t_0+2}^{t} l_{k-1,k} \cdot d_{k-1,t_0} + \frac{1}{2}\sum_{k=t_0+1}^{t-1} l_{k-1,k} \cdot d_{t,k}$$

$$+\frac{1}{2N}\sum_{k=t_0+2}^{t}\big(\sum l_{k-1,k}\big) \cdot \big(\sum d_{k-1,t_0}\big) - \frac{1}{2N}\sum_{k=t_0+1}^{t-1}\big(\sum l_{k-1,k}\big) \cdot \big(\sum d_{t,k}\big) \quad (4)$$

We have denoted: $x \cdot y = \sum_J x_J y_J$ and $\sum l_{k-1,k} = \sum_J l_J(k-1,k)$ and similar for the terms containing differences *d*. We use the trivial relation:
$$\frac{1}{2}\big(-d(k-1,t_0) + d(t,k)\big) = -\frac{1}{2}\big(w(k) + w(k-1)\big) + \frac{1}{2}\big(w(t_0) + w(t)\big)$$
$$= \widetilde{w}_{0t} - \widetilde{w}_{k,k-1},$$
By isolating the term with $k = t$ in the sums $\sum_{k=t_0+2}^{t}$, the term with $k = t_0 + 1$ in $\sum_{k=t_0+1}^{t-1}$ and re-grouping the terms in (2) we obtain:

$$\sum_{k=t_0+2}^{t-1} l_{k-1,k} \cdot \big(\widetilde{w}_{0t} - \widetilde{w}_{k,k-1}\big) - \frac{1}{N}\sum_{k=t_0+2}^{t-1}\big(\sum l_{k-1,k}\big) \cdot \Big(\sum\big(\widetilde{w}_{0t} - \widetilde{w}_{k,k-1}\big)\Big)$$

$$+\frac{1}{2}(l_{t_0,t_0+1} \cdot d_{t,t_0+1} - l_{t-1,t} \cdot d_{t-1,t_0})$$

$$+\frac{1}{2N}\big(\sum l_{t-1,t}\big) \cdot \big(\sum d_{t-1,t_0}\big) - \frac{1}{2N}\big(\sum l_{t_0,t_0+1}\big) \cdot \big(\sum d_{t,t_0+1}\big)$$

This expression of the drift shows in a more clear way how different terms may cancel each other for reasonable behaviours of the weight and sub-aggregate variations.

Appendix 4 Life cycle effects

Life cycle effects

We model prices and weights, as depending on the life cycle as follows:

$$\ln p_j(t) = a_i + f\left(\mathrm{l_j(t)}\right) + \delta_t + \epsilon_{it}$$

$$w_j(t) = b_j + g\big(l_j(t)\big) + \delta_t + \epsilon_{jt}$$

where a_i , b_j represent the impact of generic characteristics and δ_t the impact of time on the hourly wages and on weights while ϵ are random errors. The functions $f\left(\mathrm{l_j(t)}\right)$ and $g\big(l_j(t)\big)$ describe the influence of life cycle on the prices and weights, at given points in time and are in our case linear functions. Therefore $\delta\ I$ = $\sum_{j\in\widehat{M}_{01}} \widehat{w}_j(t_0,t_1)ln\left(\frac{p_j(t_0)}{p_j(t_1)}\right)$ - $\sum_{j\in M_{01}} \widetilde{w_j}(t_0,t_1)ln\left(\frac{p_j(t_0)}{p_j(t_1)}\right)$=

$\sum_{\widehat{M}_{01}}\left(\widehat{g_j}(t_0,t_1)\right)(\mathrm{f(l_j(t_1)} - \mathrm{f(l_j(t_0))}$-$\sum_{M_{01}}\left(g_j(t_0,t_1)\right)(\mathrm{f(l_j(t_1)} - \mathrm{f(l_j(t_0))}$ where $g_j(t_0,t_1) = \frac{1}{2}\Big(g\left(l_j(t_0)\right) + g\big(l_j(t_1)\big)\Big)$.

Appendix 5 Data structure of the Icelandic Survey of Wages, Earnings and Labour Cost

Following is a list of the entry items used in the survey of wages, earnings and labour cost at Statistics Iceland.

No.	*Item designation*	*Label*
1.	Company ID No.	F
2.	Municipality	F
3.	Economic activity (5 digit)	F
4.	Employee's ID No.	S
5.	Month and year of birth	S
6.	Sex	S
7.	Union	S
8.	Pension fund	S
9.	Education code (1 digit)	S
10.	Occupation code (5 digit)	S
11.	Length of service (date of employment)	S
12.	Proportion to full-time employment	S
13.	Pay period	S
14.	Contractual working hours	S
15.	Annual leave entitlement percentage	S
16.	Annual leave arrangement	S
17.	Agreement	S
18.	Wage group	S
19.	Wage level	S
20.	Basic wages and salaries	L
21.	Normal hours	V
22.	Additional payments	L
23.	Expenses payments	L
24.	Bonus payments	L
25.	Piecework payments and output work	L
26.	Shift premium	L
27.	Hours with shift premium	V
28.	Overtime pay	L
29.	Overtime hours	V
30.	Sickness pay	L
31.	Sickness hours	V
32.	Lump sums and special payments	L
33.	Committee or management payments	L
34.	Payments for transport	L
35.	Fringe benefits	L
36.	Other payments	L

37.	Remuneration paid for leave	L
38.	Pension fund contribution	K
39.	Social security tax	K
40.	Sickness fund payment	K
41.	Vacation (union) housing fund fee	K
42.	Science fund / continued education	K
43.	Other labour costs	K
44.	First day of payment period	T
45.	Final day of payment period	T

Data on the enterprises is indicated by the letter F and information on the employees by the letter S. Wage items are signified by L, details on working hours by V and labour cost by K. Time aspects are labelled with a T.

Explanations of survey items

1. Company ID No.: The ID No. of the firm shall be entered here, in a scrambled form. In instances of an operations department or branch office having a different ID No. from the parent enterprise, the operations department or branch office ID No. shall be used.
2. Municipality: The municipality code for the employee's place of work, according to the municipality categories used by Statistics Iceland, shall be entered here.
3. Economic activity: The economic sector code for the enterprise shall be entered here, 5 digit, according to the ISAT 08 (ISAT 95 before 2008) which is an economic activity classification used by Statistics Iceland (based on Nace rev.2.2). If the firm is divided into departments, the economic sector code shall be recorded for the department in which the employee works.
4. Employee's ID No.: The ID No. of the employee shall be entered here, in a scrambled form.
5. Month and year of birth: The employee's month and year of birth shall be entered here, in that order.
6. Sex: For a male employee, 1 shall be entered; for a female employee, 2.
7. Union: Using the Statistics Iceland system of categories, the code of the labour union which the employee pays into shall be recorded here.
8. Pension fund: Using the Statistics Iceland system of categories, the code of the pension fund which the employee pays into shall be entered here.
9. Education code: The employee's education shall be entered here, 1 digit, according to the Statistics Iceland ISCED system of classification (based on ISCED97).
10. Occupation code: The occupation number (the first four digits) appropriate to the employee shall be entered here, according to the ISTARF 95 occupation classifications of Statistics Iceland (based on ISCO-88). In addition there is an Icelandic addition of a 5th digit in the occupational code to distinguish general employees (0), general foremen (1), skilled craft workers (2) and skilled foremen (3), general self-employed workers (4), owner that works as general workers (5), skilled craft self-employed workers (6), owner that works as skilled craft workers (7) and apprentice (8).

11. Length of service (date of employment): Based on uninterrupted employment with the enterprise concerned, the month and year, respectively, in which the employee commenced work shall be listed here.
12. Proportion to full-time employment: The ratio of the employee's work commitment to a full-time position, according to the employment contract, shall be entered here (with one decimal point).
13. Pay period: The length of the period covered by the employee's pay for normal daytime working hours shall be entered here, as one of the following: (1) a week, (2) two weeks, (3) half a month, (4) a month or (5) other.
14. Contractual working hours: The employee's working hours, as detailed in the records concerning the firm's personnel, shall be entered here (with one decimal point), taking into consideration both the wage period and proportion to a full-time position.
15. Annual leave entitlement percentage: The vacation percentage (with two decimal points) by which the employee's vacation payments are calculated shall be entered here.
16. Annual leave arrangement: What shall be entered here is whether, under a standard work commitment (daytime working hours), (1) vacation pay is paid immediately (to the employee or into a vacation account) or (2) the employee receives pay during vacation in accordance with his/her number of accrued vacation days.
17. Agreement: The number of the contract concerning wages and fringe benefits according to which the employee receives regular wages shall be entered here.
18. Wage group: The number of the wage group shall be entered here on which the regular wages that the employee receives are based.
19. Wage level: Within the wage group, the wage level shall be entered here, on the basis of which the employee receives her/his regular wages.
20. Basic wages and salaries: Basic wages and salaries for normal daytime working hours shall be entered here. Basic wages and salaries are defined as base pay for normal daytime working hours during the payment period, exclusive of supplementary payments. These basic wages and salaries shall be the basis of any other additional payments, such as overtime and shift premiums, which are calculated in reference to wages for regular daytime hours. The guaranteed wages of seamen shall also be entered here.
21. Normal hours: What shall be entered here is the overall total of paid working hours (with one decimal point) on the basis of which regular daytime wages are calculated, and in the case of seamen also the number of logged days, legally recognised, that are the basis of their guaranteed wages and shares in the catch.
22. Additional payments: All types of supplementary payments added onto pay, when such payments are added onto base pay and are settled regularly in each wage period, such as premiums for heights, location, attendance, dirty conditions, being outdoors, chairing departments, and landing from ships, shall be entered here, along with overpayments, fixed overtime pay and guaranteed remunerations.

23. Expenses payments: All types of supplementary payments on account of employee expenses for their jobs, such as food, travel, clothing and tool payments shall be entered here.
24. Bonus payments: Incentive wages for performance or for individual or group achievement shall be entered here, when such payments are settled regularly in each wage period. Bonus and premium payments for fish processing shall for instance be entered here.
25. Piecework payments and output work: Incentive wages for performance or for individual or group achievement shall be entered here, when such payments are added onto base pay and are generally not settled in each wage period. Performance incentive payments for major jobs that are frequently paid for upon completion shall be entered here, including for instance piecework by skilled workers as well as the share seamen have in their ship's catch. Payments for finished jobs shall also be entered here when the number of hours worked is not the basis for payment but rather a defined task, as in cases of output work, landing from ships (when paid by the tonne), and cleaning (when performed according to measured units).
26. Shift premium: Additional payments for having been on or worked through shifts shall be entered here, although only the additional amounts, with the daytime-hour portion of the pay for the shifts being entered as basic wages and salaries.
27. Hours with shift premium: The overall total of paid working hours (with one decimal point) used as the basis for calculating shift premiums shall be entered here.
28. Overtime pay: All payments for overtime work shall be entered here, in an amount that equals the regular daytime wages that are included and the overtime premium (including premiums for high holidays).
29. Overtime hours: The overall total of paid working hours (with one decimal point) used as the basis for calculating overtime pay shall be entered here. Except for fixed overtime.
30. Sickness pay: All payments made to employees during illness shall be entered here.
31. Sickness hours: The overall total of paid working hours (with one decimal point) used as the basis for calculating sickness pay shall be entered here.
32. Lump sums and special payments: Every wage premium that is binding by contract, with examples being vacation benefits, like December supplement, low-wage compensation and the 13th-month bonus. Also, special lump sum payments due to modified provisions of labour contracts and irregular bonus payments due to the performance or profitability of the firm shall be entered here. Finally, other bonuses and additional payments not settled regularly in each wage period.
33. Committee or management payments: All payments for representing the employer on committees and boards.
34. Payments for transport: All payments for automobile expenses, whether the reimbursements are fixed or refer to a driving log, shall be entered here.
35. Fringe benefits: The employee's taxable benefits shall be entered here.

36. <u>Other payments:</u> Wages paid which do not fit under any other definite entry item for wage payments shall be entered here. Payments for being on call shall be entered here, whereas working during an on-call shift (being called out) shall be entered as overtime.
37. <u>Remuneration paid for leave:</u> The payments made by employers for employee vacations shall be entered here.
38. <u>Pension fund contribution:</u> An employer's reciprocal contributions to pension funds shall be entered here.
39. <u>Social security tax:</u> Employer payments for payroll tax and the Wage Guarantee Fund shall be entered here.
40. <u>Sickness fund payment:</u> Payments made by employers to union-sponsored sickness funds shall be entered here.
41. <u>Vacation (union) housing fund fee</u>: Payments made by employers to union-sponsored funds for vacation housing or fellowship buildings shall be entered here.
42. <u>Science fund / continued education:</u> Employer payments into funds for continued education or personal development in science shall be entered here.
43. <u>Other labour cost:</u> An employer's reciprocal contributions due to employee’s personal pension funds shall be entered here.
44. <u>First day of payment period:</u> The day determining the commencement of the time period to which regular daytime wages relate shall be entered here.
45. <u>Final day of payment period:</u> The day determining the conclusion of the time period to which regular daytime wages relate shall be entered here.

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