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Statistical Audit of the Corporate Tax Haven Index

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Abstract

This technical report aims at investigating and analyzing the statistical side of the Corporate Tax Haven Index (CTHI). The CTHI methodology is coherent and thoroughly considered by experts of tax evasion. We found that the differences in scoring of indicators influences their distributions, their correlation with other indicators and all these influences the final CTHI scores and rankings. Hence, CTHI developers may wish to consider the use of further quantitative indicators suggested in earlier empirical studies, which are less exposed to the subjectivity of scoring and distributed on a continuous scale. We suggest on the basis of our audit to weigh up the possibility of using a geometric average, as it may better reflect the non-compensatory nature of tax avoidance. In general, the CTHI is found to be robust, top ten ranked countries of the CTHI are in the top of other lists of tax havens in recent studies, applying different empirical methods for the identification. As recommended by the JRC team in its Financial Secrecy Index (FSI) audit, it would be worthwhile to publish confidence intervals alongside the ranking.

Contents

Summary

The Corporate Tax Haven Index (CTHI) is built on 20 Indicators that are grouped further into a Haven Score and aggregated together with a global scale weight (GSW) across 64 jurisdictions. The CTHI also complements the Financial Secrecy Index (FSI), which ranks countries according to financial secrecy. Tax avoidance by multinational companies and the contribution to the race to the bottom have not been fully captured by the FSI, as its indicators focus more on secrecy than on corporate tax, and on portfolio financial flows rather than on FDI or corporate profits. As the CTHI's methodology is similar to that of the Financial Secrecy Index, and the FSI has been earlier audited by the JRC, we will refer to the findings of the FSI audit if relevant in case of the new index.

The developers define a corporate tax haven as a jurisdiction that seeks to attract multinational companies by enabling them to escape or undermine the tax laws, rules and regulations of other jurisdictions, reducing their tax payments.

The CTHI is a combination of the Haven Score (HS) and the Global Scale Weight (GSW). The HS is a qualitative component derived from its 20 indicators based on laws, regulations and documented administrative practices in the jurisdictions. The Global Scale Weight (GSW) is the other component of the index and measures the relevance of each jurisdiction for cross-border direct corporate investment.

The HS is calculated as the average of its five pillars, which are driven by a total of 20 indicators. Each indicator is given a score between 0 (no harmful impact, zero corporate tax haven attributes) and 100 (full corporate tax haven attributes). The Haven Score is cubed and the weighting is cube-rooted before being multiplied to produce the Corporate Tax Haven Index value, which determines the CTHI ranking.

The statistical audit discussed in this paper constitutes the second collaboration between the Tax Justice Network and the European Commission's Joint Research Centre (JRC).

This statistical assessment of the CTHI has been undertaken between Dec 2019 and June 2020 by the JRC. Preliminary JRC suggestions were taken into account by TJN for the final computation of the CTHI scores and rankings.

The aims of the JRC's audit are to:

• Investigate the characteristics of the underlying data and check for eventual errors in calculation
• Assess the associations between indicators and see to what extent they agree with the conceptual framework
• Review the methodology used to treat, weight, and aggregate data
• Assess the impact of modelling assumptions and robustness of CTHI ranks
• Eventually recommend modifications based on the conclusions of the above.

In particular, the JRC analysis complements the reported CTHI ranks for the 64 jurisdictions with estimated confidence intervals, in order to better appreciate the robustness of these ranks to some modelling choices (such as the choice of indicators, the weighting scheme and the aggregation formula). Importantly, the construction of a composite indicator is a balance between statistical “rigour" and conceptual considerations, which can frequently contradict each other. This audit aims to investigate and analyse the statistical side of the equation, and only aims to offer conceptual suggestions from the statistical point of view. In general, conceptualisation is better left to experts in international finance and regulations), they could strike balance between statistics and the concept of tax havenry.

1. Construction of the Corporate Tax Haven Index

The Corporate Tax Haven Index (CTHI) of each country is a product of the countries Haven Score (HS) cubed and the cube root of the Global Scale Weight (GSW) (Equation 1). The HS is a qualitative component derived from its 20 indicators based on laws, regulations and documented administrative practices in the jurisdictions. The Global Scale Weight (GSW) measures the relevance of each jurisdiction for cross-border direct corporate investment.

$$CTHIi = HSI_I^3 \cdot GSW_I^{(1/3)} \quad (1)$$

The HS is calculated as the average of its five pillars, grouping a total of 20 indicators. Each indicator is given a score between 0 (no harmful impact, zero corporate tax haven attributes) and 100 (full corporate tax haven attributes).The choice of aggregating the 20 indicators is conceptually well justified and responds to a political need of tracking progress at global level.

PILLAR 1, LACIT: 1.1 Lowest Available Income Tax

PILLAR 2, Loopholes and gaps: 2.1 foreign investment income treatment, 2.2. loss utilisation, 2.3 capital gains taxation, 2.4 sectoral exemptions, 2.5 tax holidays and economic zones, 2.6 patent boxes, 2.7 fictional interest deduction,

PILLAR 3, Transparency: 3.1 public company accounts, 3.2 country by country reporting, 3.3 local filing of country by country reporting, 3.4 tax rulings and extractive contracts, 3.5 reporting of tax avoidance schemes, 3.6 tax court secrecy

PILLAR 4, Anti-avoidance: 4.1 deduction limitation for interest, 4.2 deduction limitation for royalties, 4.3 deduction limitation for service payments, 4.4 dividend withholding taxes, 4.5 controlled foreign company rules

PILLAR 5, Double Tax Treaty Aggressiveness: 5.1 double tax treaty aggressiveness

A novelty of the CTHI is that it is based on the ‘lowest common denominator" or "weakest link" principle. Therefore, if a jurisdiction offers three types of companies, two of which are required to publish financial statements online, but the third is not, then the index assesses the jurisdiction based on the least transparent case, because that's the one that will most likely attract the harmful corporate activity.

The second component of the CTHI is the global scale weight (GSW) attributed to each jurisdiction. The GSW is based on an assessment of the size of each jurisdiction’s share of the global total of foreign direct investment (FDI).

The objective of the global scale weight is to quantify the importance of each jurisdiction considered in the CTHI. It represents a measure of the volume at stake in each country when assessing the risks associated with it being a corporate tax haven. In the final stage of

constructing the CTHI, the cube root of the global scale weights is multiplied by the cube of the haven scores to create a ranking of each jurisdiction's contribution to the global problem of corporate tax havens (Equation 1). The developers note that GSW alone does not imply anything wrong. The United States, the Netherlands and Luxembourg, the three countries that have the highest GSW, are not necessarily or in reality the three largest tax havens in the world.

There may be a conceptual issue of causality that could be further considered by developers. The HI indicators could be considered as reasons for tax avoidance and the GSW to some extent as a result. The question is however, how to filter out the element of the GSW which is related to the tax avoidance opportunities and not to legal financial services and opportunities in the given corporate tax haven. For example, Zucman (2020) suggested the wage to profit ratio as a measure of tax avoidance activity. Our correlation analysis (see in section 4) suggests that his measure is better associated with the HI indicators than the GSW.

2. Data

The CTHI 2019 index was calculated for 64 jurisdictions. The CTHI database is the result of over a year of desk-based research by a dedicated team, and by numerous researchers around the globe. It is based on reports, legislation, regulation and news available as of December 31, 2018. For some indicators, more recent data has been included. For each country's database report developers used up to 74 criteria that are combined into 20 Haven Indicators.

The main data sources were official and public reports by the OECD, the associated Global Forum, the FATF, the IMF and the EU. In addition, specialist tax databases and websites such as by the IBFD, and "Big Four" accounting firms, and others have been consulted.

If the developers couldn't find a source, they registered the data as unknown, and this led to a negative rating. While this could be seen as a conservative approach, it can also lead to a possible negative bias in case of some jurisdictions. The lack of data can be considered as non random, but probably not always. The authors add that ‘given the sheer scale of this project’, they had to use reasoned judgement, occasionally, which may have an impact on the accountability and reliability of the index. To minimize controversies of such kind, developers have sought to be fully transparent about the criteria and reasons, with references to all sources used, and copious notes and supporting information.

Since each data source has differing objectives and layouts, combining them has been a major undertaking, however, could be also seen as a source of information uncertainty embedded in the CTHI.

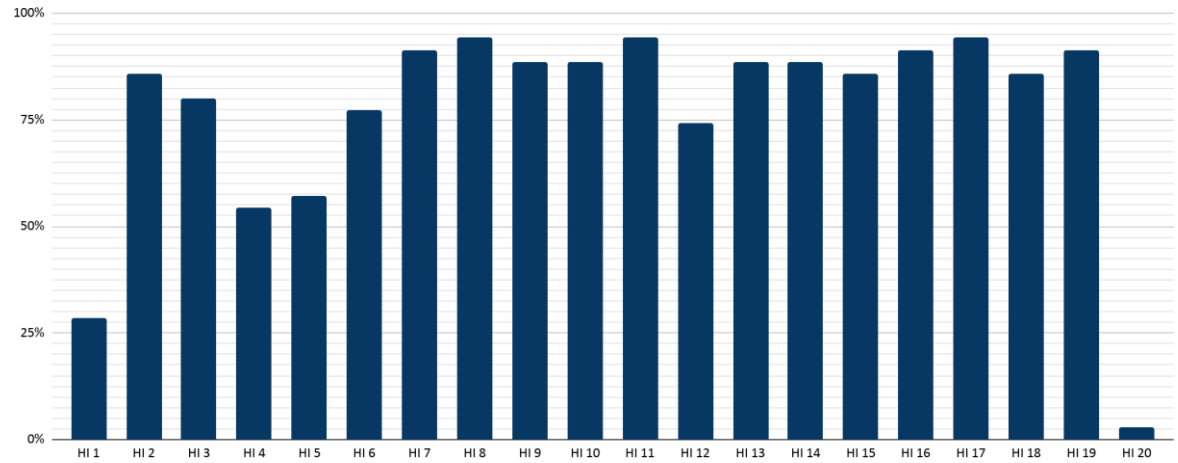
3. Scoring and normalisation

The developers used boundaries on the lower and upper bounds of the indicator scales. In this way, the rescaled data became easy to communicate to a wider public and to compare across all indicators. The authors acknowledge that the choice of method to combine haven score and scale is necessarily subjective.

A factor that may influence the final scorings is the scale of scoring within the 0-100 scale of indicators. Some of the indicator scales are continuous, but the indicator data is largely discrete, with many indicators having only a small number of unique values, see **Figure 1** below. For example, indicator 1.1 (LACIT), the jurisdiction's LACIT is subtracted from the CIT of 35% and the haven score is then calculated by placing it on a scale of 0-100. However, for example indicator 2.1 (foreign investment income treatment) can take on only the value of 0, 25, 50, 75, 100, depending on how the jurisdiction treats different incomes, such as interest (+25), royalty(+25) and dividend payments (+25) for related company (+25) for non-related company. Or indicator 2.8 (fictional interest deduction), the jurisdiction scores 100 if it offers a fictional interest deduction regime, and 0 if not.

The differences in scoring of indicators influences the distribution of indicators (**Figure 1**), their correlation with other indicators (see Section 4) and all these influences the final HS and ranking.

Figure 1 : Ratio of unique values in each HI over all jurisdictions



The comparison of HI1 ("Lowest Available Income Tax") and HI4 ("Capital Gains Taxation") suggest another possible discrepancy of the scoring methodology. In case of HI1, the jurisdiction's lowest available corporate income tax rate (LACIT) is extracted from 35% and the differential is scaled on a scale between 0 and 100. In case of HI4 ("Capital Gains Taxation") the transformation is more complex. The lowest available corporate capital gains tax rate in each of the two indicator components (domestic securities, foreign securities) is assessed against 35% . A zero capital gains tax rate or an exemption from capital gains tax in each of the components

equals a haven score of 50 in each of the components. If both types of securities are exempt from capital gains tax or are taxed at 0%, the combined resulting haven score is thus 100. If the lowest available capital gains tax rate is 35% in each of the components, the haven score is zero. Any rate in between is linearly scaled against 35%. The result is rough scoring in case of HI4 and more granular in case of HI1, although the concept is very similar (distance to 35% tax rate).

Table 1 : Ordered value of HI indicators, the HS Score and the CTHI

country	HI 1	HI 2	HI 3	HI 4	HI 5	HI 6	HI 7	HI 8	HI 9	HI 10	HI 11	HI 12	HI 13	HI 14	HI 15	HI 16	HI 17	HI 18	HI 19	HI 20	HI Score	CTHI absolute
British Virgin Islands	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	2256
Bermuda	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	2161
Cayman Islands	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	2064
Netherlands	93	100	88	100	75	0	100	0	100	50	100	75	100	100	75	100	100	100	75	53	78	1948
Switzerland	93	100	88	100	56	13	100	0	100	100	100	100	100	100	100	100	100	100	100	59	83	1528
Luxembourg	99	100	38	100	63	13	100	0	25	50	100	75	100	75	90	100	100	100	75	40	72	1462
Jersey	100	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100	100	100	100	100	98	1256
Singapore	100	75	100	100	88	75	100	0	100	100	100	100	100	75	100	100	100	100	100	34	81	1213
Bahamas	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	1123
Hong Kong	100	100	50	100	81	0	0	0	100	90	100	75	100	100	100	100	100	100	100	24	73	1118
Ireland	100	75	100	100	63	0	100	0	50	50	100	100	80	50	100	100	100	100	75	49	76	1111
United Arab Emirates	100	100	100	100	100	100	100	100	100	100	100	50	100	100	100	100	100	100	100	100	98	1014
United Kingdom	46	50	88	100	38	13	100	0	0	50	100	100	50	50	90	100	100	100	75	65	63	870.1
Mauritius	100	100	50	100	100	75	100	0	100	100	100	50	100	100	100	100	100	100	100	33	80	774.1
Guernsey	100	100	100	100	100	100	100	100	100	100	100	100	100	25	100	100	100	100	100	100	98	725.7
Belgium	92	75	38	100	50	0	100	100	0	50	100	50	100	75	80	100	100	100	75	28	68	670
Isle of Man	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	655.3
Cyprus	64	75	13	100	31	0	100	100	100	50	100	100	100	50	100	100	100	100	100	48	71	568.7
China	29	0	38	29	44	100	90	0	100	100	100	100	100	100	100	100	100	100	75	25	58	536.5
Hungary	74	75	13	87	63	25	100	0	50	50	100	100	100	100	90	100	100	100	75	43	69	457
Curacao	100	100	50	100	81	13	90	0	100	100	100	100	100	100	80	100	100	100	100	2	72	450.1
France	2	100	88	88	75	100	90	0	50	50	0	75	100	75	90	100	100	100	0	63	56	428.1
Malta	86	100	50	100	31	13	100	100	50	50	100	100	100	75	90	100	100	100	75	39	74	422.9
Germany	35	25	88	97	50	0	0	0	100	50	0	70	100	100	90	75	100	100	0	47	52	375.5
USA	40	25	38	40	50	13	100	0	100	100	100	80	30	50	75	50	0	14	0	34	43	332
Panama	100	100	0	86	100	25	90	0	100	100	100	100	100	100	100	100	100	86	100	5	72	330.1
Spain	29	75	38	100	50	25	100	0	100	75	0	75	100	25	90	100	100	100	0	48	55	328.4
Gibraltar	100	75	38	86	50	0	0	0	100	100	100	100	80	75	100	100	100	100	100	0	66	324.4
Sweden	37	50	100	100	13	0	0	0	50	50	100	75	100	100	75	100	100	100	0	51	56	297
Italy	23	50	38	97	63	0	100	0	50	50	100	75	100	75	90	100	100	100	0	27	51	246
Czech Republic	46	100	13	100	38	0	0	0	25	50	100	100	100	100	100	100	100	100	100	34	59	219.7
Turks and Caicos Islands	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	216.3
Austria	29	50	50	64	38	0	0	0	50	50	100	100	100	100	100	50	100	100	0	47	52	210
Finland	43	50	38	100	50	0	0	0	50	50	100	75	100	100	90	100	100	100	0	41	55	192.7
Anguilla	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	189.8
Denmark	37	25	38	69	56	0	0	0	100	50	100	75	100	50	75	100	100	100	0	40	52	184.5
Liechtenstein	64	100	38	100	38	0	100	100	100	100	100	100	100	100	100	100	100	100	100	15	70	182.6
Lebanon	100	75	13	100	100	88	100	0	100	100	100	0	100	75	100	100	100	100	100	17	73	179.7
Estonia	100	100	0	100	100	0	0	0	50	50	100	75	100	100	90	100	100	100	75	18	67	172.3
Monaco	100	25	88	100	100	50	0	0	100	100	100	0	100	75	100	100	100	100	100	7	68	168.6
Latvia	100	100	0	100	100	13	0	0	100	50	100	75	100	100	90	100	100	100	75	15	68	160.1
South Africa	20	50	50	68	50	13	0	0	100	100	100	88	50	25	90	75	100	100	0	33	47	149.9
Romania	54	100	38	100	6	25	0	0	100	50	100	100	100	100	75	100	100	100	0	19	56	144.8
Seychelles	100	100	13	100	88	38	100	0	100	100	100	88	100	75	100	50	0	100	100	14	68	132.9
Bulgaria	71	25	13	86	56	0	0	0	25	50	100	0	100	100	80	100	100	100	100	22	56	117.1
Macao	66	100	13	83	38	0	0	0	100	100	100	0	100	100	100	100	100	100	100	1	57	117.6
Slovakia	40	100	13	100	6	0	90	0	0	50	100	100	100	75	55	100	100	100	75	24	53	110.8
Croatia	49	50	13	74	38	25	0	0	100	50	100	100	100	100	80	100	100	100	0	28	55	103.5
Portugal	14	25	0	100	25	25	100	100	100	50	100	100	50	50	80	100	100	100	0	10	46	103.8
Taiwan	43	0	38	100	50	25	0	0	100	100	0	100	100	50	80	100	100	40	75	7	47	97.84
Andorra	94	50	38	100	63	0	100	0	100	100	100	75	100	100	100	100	100	100	100	5	69	88.99
Lithuania	57	50	38	100	6	38	100	0	100	50	100	100	100	50	90	100	100	100	0	8	55	86.98
Poland	46	25	0	46	0	0	0	0	25	50	100	100	80	100	80	75	0	100	0	20	40	80.01
Aruba	71	100	50	100	75	13	100	0	100	100	100	100	100	100	100	50	100	86	100	1	64	74.68
Slovenia	46	50	38	73	63	0	0	0	25	50	100	100	100	75	80	100	100	100	0	19	50	65.73
Botswana	37	0	50	100	69	13	100	0	100	100	100	50	100	100	90	100	100	100	100	2	55	60.56
Liberia	29	100	38	64	0	25	0	0	100	100	100	20	100	100	100	100	100	86	100	0	49	58.1
Kenya	14	100	100	100	50	75	0	0	100	100	100	50	100	50	75	100	100	100	100	1	51	49.27
San Marino	51	75	0	51	38	25	90	0	100	100	100	100	100	100	100	100	100	100	100	16	62	46.12
Ghana	29	0	63	64	56	88	0	0	100	100	100	50	100	50	80	100	100	100	100	1	49	45.92
Greece	17	25	13	100	31	0	100	0	100	50	100	100	100	50	80	50	0	100	0	10	39	43.59
Tanzania	14	0	100	57	6	75	0	0	100	100	100	95	100	100	100	50	100	86	75	1	46	32.65
Gambia	23	0	38	29	13	38	0	0	100	100	100	100	100	100	100	100	100	100	100	1	48	7.49
Montserrat	100	100	13	100	100	50	0	0	100	100	100	0	100	100	100	100	100	57	100	0	65	5.728

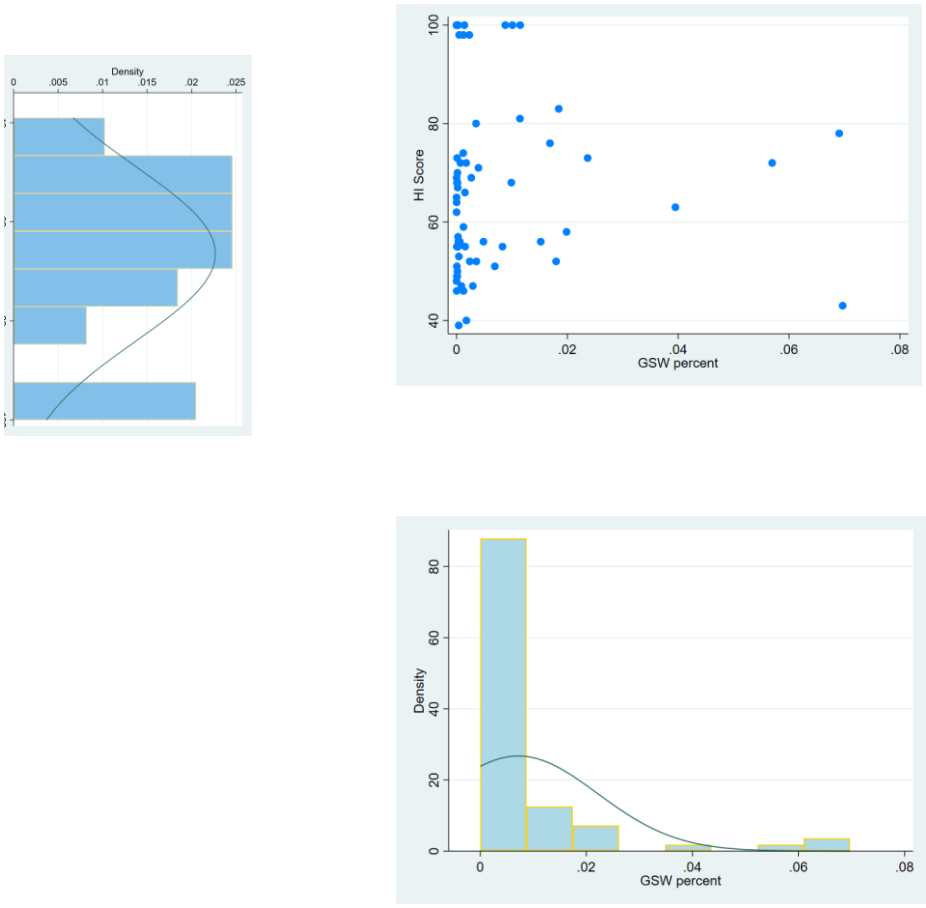
Index developers may wish to consider the use of further quantitative indicators in earlier studies, which are less exposed to the subjectivity of scoring and distributed on a continuous scale. For example, the wage to profit ratio (Zucman, 2020) could be an input, as the author published data for most of the CTHI countries. Garcia-Bernardo, J. Fichtner, F.W. Takes and E.M. Heemskerk (2017) identified Offshore Financial Centers (OFC) as a jurisdiction (often a country) that provides corporate and financial services to non-resident companies on a scale that is incommensurate with the size of its economy. Fichtner (2017) used stock data on international banking assets, portfolio investment, and foreign direct investment (FDI) in relation to the gross domestic product (GDP) of a jurisdiction to calculate an 'offshore-intensity ratio'. Fichter's methodology is very similar to the global scale weight component of the CTHI, however not only the FDI is considered but other types of foreign investments too.

4. Distribution of the CTHI

The distribution of the two factors of the CTHI points towards a specific difficulty of the index construction. Although the distribution of the HS is roughly normal, the GSW distribution is highly skewed to the left, because some few jurisdictions have very large GSW, while the large majority have very small GSWs. This high skewness becomes a problem when aggregating indicators, because the variability of the indicator is only due to some very few points, with the remainder having (relatively) almost no variability. This problem has been highlighted by the JRC during the audit of the Financial Secrecy Index, which is constructed similarly.

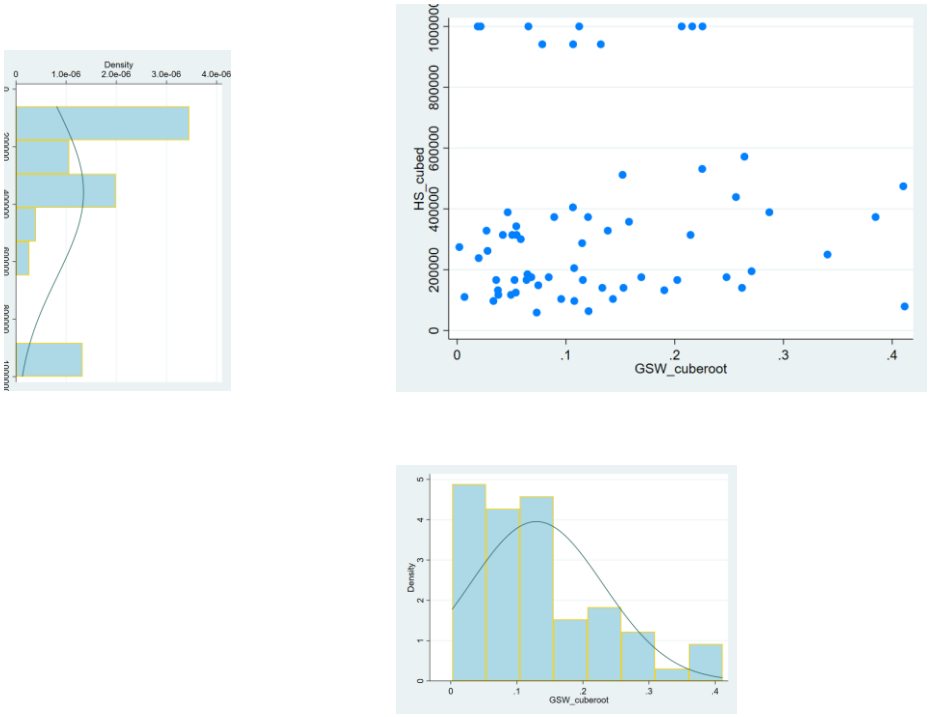
The Tax Justice Network (TJN) addresses the issue of skewness by taking the cube root of the GSW and cube of HS. The distribution of the GSW is much improved, although still slightly skewed to the left. The imbalance between GSW and Haven Score is not as severe as the equivalent problem in the FSI. Using the CTHI formula, the CTHI has a correlation value of 0.69 with the Haven Score, and 0.48 with the GSW. However, if a simple multiplication were used, these values would be 0.13 and 0.97 respectively. This justifies the use of some kind of correction to balance out the two quantities. That said, investigations in the FSI audit demonstrated that the ranking is quite sensitive to the aggregation method used, and this should again be reviewed with great care.

Figure 2: Scatterplot and histograms of GSW and HS



Source: European Commission, Joint Research Centre (2020)

Figure 3: Scatterplot and histograms of HSI_i^3 and $GSW_i^{(1/3)}$



Source: European Commission, Joint Research Centre (2020)

5. Correlation structure

In the case of the CTHI, the discrete values cannot be interpreted by linear regression. To understand the data structure, the Spearman rank correlation is used: this is essentially a measure of how similar the ranking is between pairs of indicators. The large majority of CTHI input indicators are positively correlated, although they are not in general strongly correlated. Only a few strong correlations (above 0.6) are present. In particular, HI12 ("Tax Rulings and Extractive Contracts"), HI13 ("Reporting of Tax Avoidance Schemes"), HI17 ("Service payment deduction") and HI18 ("Dividend Withholding Taxes") have low, sometimes negative and statistically insignificant association to most of the other indicators. This could be the consequence of the rough and discrete measurement of some of these indicators and the concentration of the scores at one particular value (more than 70% of the scores are 100 in case of several indicators). In particular, the Transparency pillar (HI 9-14) is not significantly represented in the overall index. The implication is that the overall CTHI score does not have much relation with indicators related to transparency. This could potentially be addressed by adjusting indicator groupings, weighting, or adding/removing indicators.

Pairwise correlations of pillars with the index are balanced except for pillar 2 and pillar 3, suggesting that their weight could be reduced. The correlation between GSW and the Haven Score is not statistically significant - see log plot of **Figure 5**. This points to the possibility of presenting results on a 2D map. An alternative could also be to group countries into size groups by GSW – this is the approach taken by other indexes such as the Cultural and Creative Cities Monitor, for example[1].

The Correlation between GSW and HS (and its pillars) is close to zero, suggesting that they are almost independent. This observation is very similar to the one mentioned by the JRC in its FSI audit. Therefore, CTHI developers might wish to further consider other indicators to measure real tax avoidance by extracting the component from the GSW which is related to the manifestation of tax avoidance activity. As a crosscheck, we investigated the rank correlation of the HIs with the measure proposed by Zucman (2020), the wage to profit ratio. The majority of the CTHI pillars are associated with the wage-to-profit ratio, except for Pillar 5 (HI20) "Double Tax Treaty Aggressiveness").

[1] https://composite-indicators.jrc.ec.europa.eu/cultural-creative-cities-monitor/performance-map

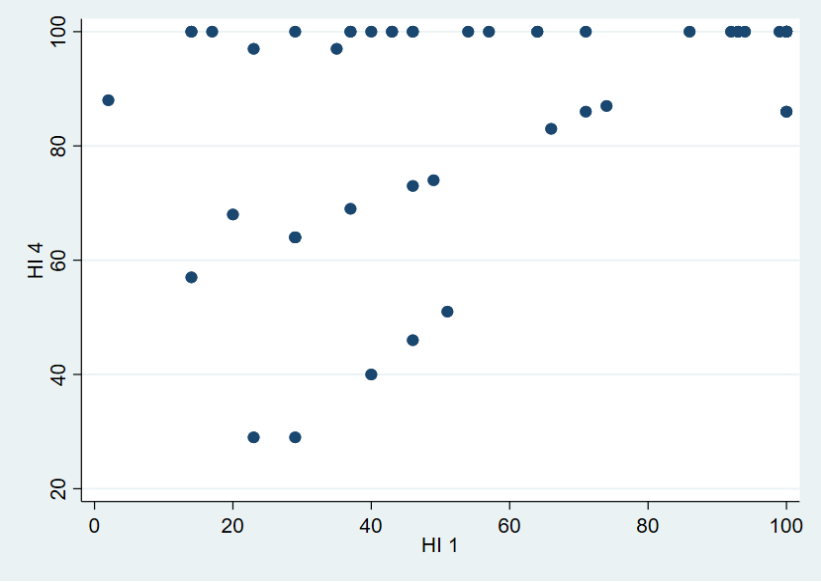
Table 2 : Spearman rank correlation*

	HI1	HI2	HI3	HI4	HI5	HI6	HI7	HI8	HI9	HI10	HI11	HI12	HI13	HI14	HI15	HI16	HI17	HI18	HI19	HI20	HIScore	CTHIabsolute	GSWpercent	Pill 1	Pill 2	Pill 3	Pill 4	Pill 5	Zucman (wage to profit ratio)
HI1	1.0																												
HI2	0.6	1.0																											
HI3	0.2	0.2	1.0																										
HI4	0.5	0.5	0.2	1.0																									
HI5	0.7	0.4	0.3	0.4	1.0																								
HI6	0.2	0.2	0.6	0.0	0.5	1.0																							
HI7	0.3	0.3	0.2	0.3	0.3	0.3	1.0																						
HI8	0.4	0.3	0.4	0.3	0.3	0.5	0.5	1.0																					
HI9	0.1	0.0	0.2	0.0	0.3	0.4	0.1	0.1	1.0																				
HI10	0.3	0.1	0.3	-0.1	0.4	0.6	0.2	0.2	0.7	1.0																			
HI11	0.3	0.1	-0.1	-0.1	0.0	0.0	0.1	0.1	0.0	0.1	1.0																		
HI12	-0.1	0.0	0.1	-0.1	-0.1	0.0	0.3	0.2	0.0	-0.1	0.0	1.0																	
HI13	0.2	0.3	0.1	0.3	0.2	0.2	-0.1	0.0	0.1	0.0	-0.1	-0.1	1.0																
HI14	0.3	0.2	0.0	-0.1	0.1	0.0	-0.1	0.0	0.0	0.1	0.2	-0.1	0.4	1.0															
HI15	0.4	0.3	0.2	0.0	0.4	0.4	0.2	0.3	0.4	0.5	0.1	0.0	0.2	0.3	1.0														
HI16	0.3	0.3	0.1	0.3	0.2	0.2	0.1	0.2	-0.1	0.0	0.0	-0.2	0.3	0.1	0.0	1.0													
HI17	0.1	0.2	0.3	0.3	0.2	0.1	-0.1	0.1	0.0	0.0	-0.1	-0.1	0.3	0.2	0.2	0.6	1.0												
HI18	0.1	0.2	0.1	0.2	0.0	0.1	0.1	0.2	-0.2	-0.2	0.2	0.1	0.4	0.1	0.1	0.3	0.3	1.0											
HI19	0.6	0.4	0.2	0.2	0.5	0.4	0.2	0.3	0.2	0.6	0.3	-0.2	0.3	0.3	0.5	0.3	0.3	0.1	1.0										
HI20	0.4	0.4	0.7	0.3	0.5	0.6	0.4	0.7	0.0	0.1	0.0	0.3	0.0	0.0	0.2	0.2	0.1	0.2	0.1	1.0									
HIScore	0.8	0.6	0.6	0.5	0.7	0.6	0.5	0.7	0.2	0.4	0.2	0.2	0.3	0.2	0.5	0.3	0.3	0.2	0.6	0.8	1.0								
CTHIabsolute	0.5	0.4	0.6	0.3	0.4	0.3	0.4	0.4	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.7	0.7	1.0							
GSWpercent	**0.0**	**0.0**	**0.2**	**-0.1**	**0.0**	**-0.1**	**0.3**	**-0.1**	**-0.1**	**-0.1**	**-0.1**	**0.1**	**-0.4**	**-0.1**	**-0.2**	**-0.1**	**-0.2**	**-0.3**	**-0.1**	**0.2**	**0.0**	0.5	1.0						
Pill 1	1.0	0.6	0.2	0.5	0.7	0.2	0.3	0.4	0.1	0.3	0.3	-0.1	0.2	0.3	0.4	0.3	0.1	0.1	0.6	0.4	0.8	0.5	0.0	1.0					
Pill 2	0.6	0.6	0.6	0.5	0.7	0.7	0.7	0.7	0.2	0.4	0.1	0.2	0.2	0.0	0.4	0.2	0.2	0.2	0.5	0.8	0.9	0.6	0.0	0.6	1.0				
Pill 3	0.4	0.2	0.2	-0.1	0.3	0.4	0.2	0.3	0.7	0.7	0.4	0.3	0.3	0.5	0.5	0.0	0.1	0.1	0.5	0.1	0.5	0.2	-0.2	0.4	0.4	1.0			
Pill 4	0.5	0.4	0.3	0.3	0.4	0.4	0.2	0.3	0.1	0.4	0.2	-0.2	0.5	0.3	0.5	0.7	0.7	0.4	0.8	0.2	0.6	0.3	-0.2	0.5	0.5	0.4	1.0		
Pill 5	0.4	0.4	0.7	0.3	0.5	0.6	0.4	0.7	0.0	0.1	0.0	0.3	0.0	0.0	0.2	0.2	0.1	0.2	0.1	1.0	0.8	0.7	0.2	0.4	0.8	0.1	0.2	1.0	
Zucman (wage to profit ratio)	0.6	0.3	0.2	0.2	0.4	0.4	0.3	0.3	0.3	0.5	0.3	0.1	0.1	0.1	0.6	0.0	-0.1	0.0	0.6	0.0	0.5	0.1	-0.4	0.6	0.4	0.4	0.5	0.0	1.0

Source: European Commission, Joint Research Centre (2020)

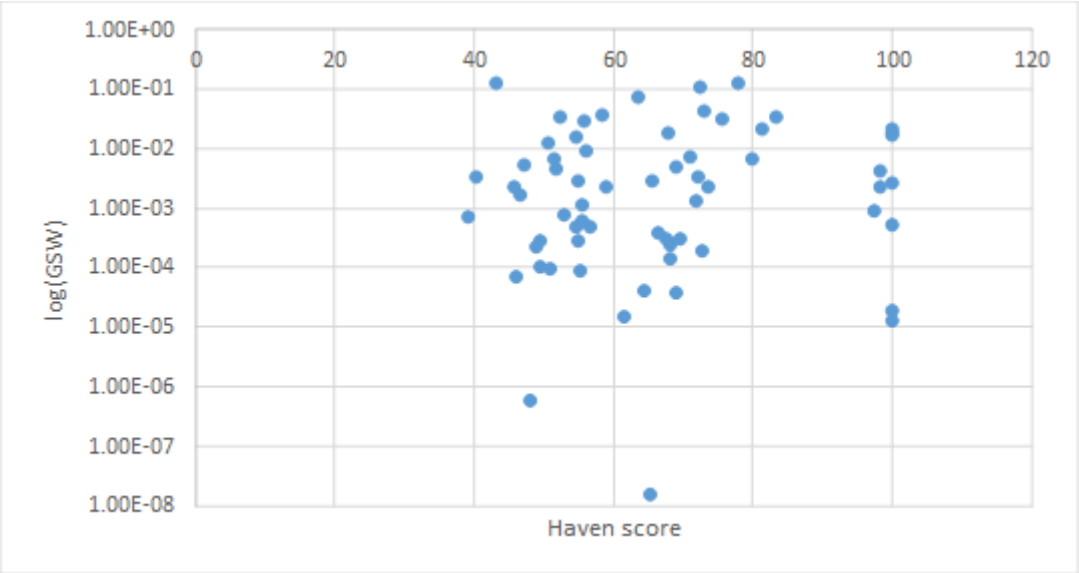
HI1 (lowest available CIT) and HI4 (CIT of shares and bonds) are very similar in concept, still their correlation is relatively low (0.5). However, there was a very strong positive correlation if the extreme scores (HI4 - 100) were omitted.

Figure 4: Scatter plot of HI1 ("Lowest Available Income Tax") and HI4 ("Capital Gains Taxation")



Source: European Commission, Joint Research Centre (2020)

Figure 5: Scatter plot of the Haven Score and the log(GSW)



6. Weighting and aggregation

A further consideration that might be relevant to the CTHI is the way that the indicators are aggregated to give the Haven Scores. The current method is to take the arithmetic mean: this is a compensatory formula that allows poor values in one HI to be "compensated" by good values in another, i.e. two indicators with values 0.1 and 0.9 would have an average score of 0.5. An alternative aggregation is to use the geometric mean, which compensates much less—in fact, the geometric mean of 0.1 and 0.9 is 0.3.

The distribution of indicators between the pillars of the Haven Score is quite unequal. While this is not necessarily a problem, the implication is that indicators in pillars with many indicators (e.g. Loopholes and Gaps) will have less weight in the Haven Score (and hence the final index) than indicators in pillars with fewer indicators (LACIT and Double tax treaty aggressiveness in particular).

Table 3 : Weighting scheme of the CTHI

	Pillar 1	Pillar 2	Pillar 3	Pillar 4	Pillar 5
	LACIT	Loopholes & Gaps	Transparency	Anti-Avoidance	Double Tax Treaties
No of indicators	1	7	6	5	1
Weight (pillar)	0.2	0.2	0.2	0.2	0.2
Weight (indicators of the pillar in index)	0.200	0.029	0.033	0.040	0.200

The choice of aggregation is obviously a subjective decision on whether substitution between indicators is allowed. In case of the measurement of negative practices (tlike tax avoidance) the geometric mean could be an appealing choice, as all kind of tax avoidance should be avoided. An example could be that the high corporate income tax rate can not compensate the lack of transparency and reporting, which could open a door for tax base erosion. If the geometric mean were to be considered, the scale of the HSs would also have to be adjusted to avoid all zeros and adjusted as the higher the better.

7. Robustness and uncertainty analysis

To take a first look at the robustness of the CTHI rankings, we compared the rankings to other recent corporate tax haven rankings. In general, top ten ranked countries of the CTHI are in the top of other lists of tax havens in recent studies, applying different empirical methods for the identification (Hines Jr., 2010, Zucman 2020, Oxfam, 2016, OFC Meter, 2018).

Table 4: Top-ranked countries in corporate tax haven rankings

	CTHI (2019)	ITEP (2017)	Hines (2010)	Zucman (2020)	Oxfam (2016)	OFC Meter (2017) -SINK	OFC Meter (2017) -CONDUIT
British Virgin Islands	1	10	10	2	15	1	
Bermuda	2	3	5	9	1	4	
Cayman Islands	3	5	2	2	2	5	
Netherlands	4	1	8	5	3		1
Switzerland	5	6	4	4	4		3
Luxembourg	6	4	1	6	7	12	
Jersey	7		7		12	3	
Singapore	8	7	9	3	5		4
Bahamas	9	8			11	16	
Hong Kong	10	9	6	8	9	23	
Ireland	11	2	3	1	6		5

Source: European Commission, Joint Research Centre (2020)

Impact of modelling assumptions on the CTHI Index results

The development of the CTHI, like the construction of any composite indicator, involves assumptions and subjective decisions. This section aims to test the impact of varying some of these assumptions within a range of plausible alternatives in an uncertainty analysis similarly to Papadimitriou et al. (2019). Here, the objective is to attempt to quantify the uncertainty in the ranks of the CTHI Index, which can demonstrate the extent to which countries can be differentiated by their scores. Although many assumptions made in the development of the CTHI Index could be examined, three particular assumptions were examined in this uncertainty analysis (**see Table 5**). These were chosen as plausible alternative pathways in the construction of the CTHI Index, which can be relatively easily investigated.

Table 5. Tested assumptions of the CTHI index

Assumption	Alternatives
1. Indicator set	A. [Full set] B. [Reduced set]
2. Aggregation method	C. [Arithmetic mean] D. [Geometric mean]
3. Weights	Randomly varied +/-25% from EW

The first tested assumption is the inclusion of indicators. In this statistical audit, the 20 indicators were divided into two groups (group 1: H1 to H10; group 2: H11:H20). All indicators were retained in the final index, but the effect is tested here of removing some indicators simultaneously, resulting in a "reduced o" of indicators (group 1) which can be viewed as an alternative approach to building the index.

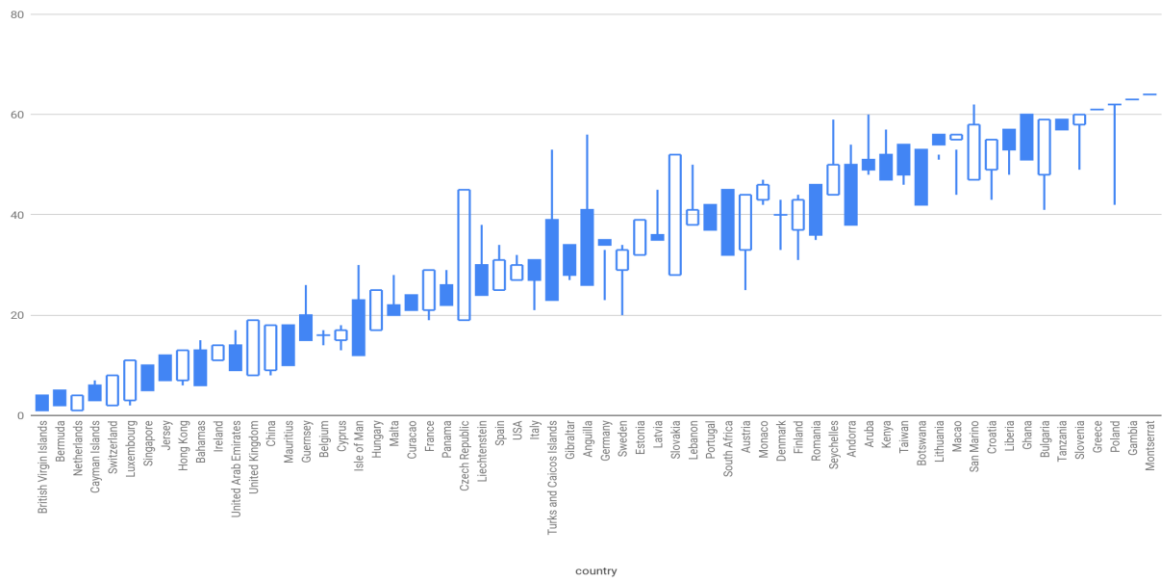
The second assumption which is varied is the aggregation method. In the CTHI Index, the scores are aggregated into their pillars using an arithmetic average. An alternative approach would be to use the geometric average, which is non-compensatory, and represents the idea that high scores in one goal should not compensate low scores in another.

Finally, nominal weights assigned at the pillar level are all equal. The effect of randomly varying indicator weights by +/-25% is investigated, to check modest variations in the importance of individual goals.

To analyze the impact of varying these assumptions, a Monte Carlo experiment was performed, which involved re-building the CTHI Index 4000 times, each time with a randomly-selected combination of assumptions 1-3. The overall results are shown in **Figure 6**.

The uncertainty in the rankings, given the assumptions tested, is mostly quite modest. Country ranks can be stated to within around 13 places of precision (**Figure 6**), although some countries are especially sensitive to the assumptions made. This information should be also used to guide the kind of conclusions that can be drawn from the index. For example, differences of two or three places between countries cannot be taken as "significant", whereas differences of 10 places upwards can show a meaningful difference. One can also observe from **Figure 5** that the confidence intervals are generally wider for mid-ranking countries, and narrower for top and bottom-ranking countries. The Monte Carlo results can also give an idea of sensitivity to the various assumptions.

Figure 6 Simulated rankings (median values and confidence intervals*)

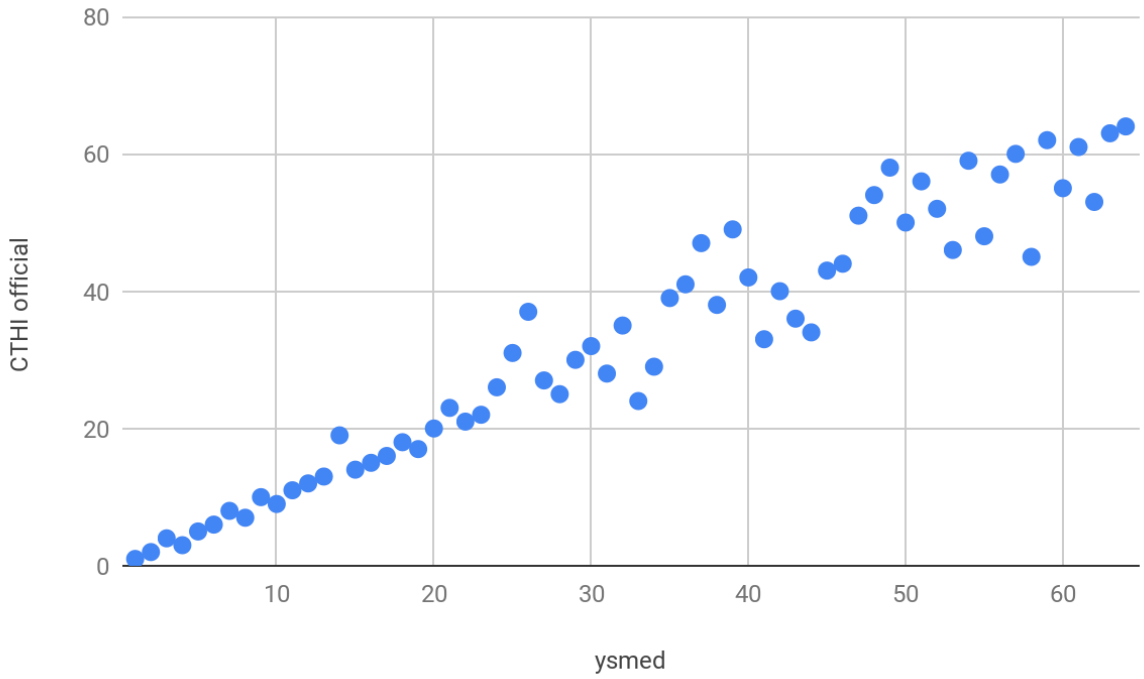


** Confidence intervals show the 30-70% and 5-95% percentiles*

Source: European Commission, Joint Research Centre (2020)

The simulated median rankings of the CTHI Index correlate well with the 'official' CTHI rankings (Pearson correlation = 0.96) **Figure 7**, especially in case of corporate tax havens (top 20 low-rankings).

Figure 7: Simulated median rankings and the CTHI 'official' ranking



Source: European Commission, Joint Research Centre (2020)

Figure 8 and **9** show the median ranks of the CTHI Index for simulations with the full set of indicators against those with the reduced set, and for simulations with the arithmetic mean against the geometric mean. This gives an idea of sensitivity of the rankings to these assumptions. The plot of the simulation results with the full and reduced indicator set show a noticeable scatter, while the scatter of the aggregation formula is fairly limited. This implies that the selection of indicators causes greater extreme rank shifts.

To delve slightly further into the possibility of using a geometric mean, **Figure 7** shows the ranks of the arithmetic average plotted against the simulated ranks with a geometric mean. This is different from **Figure 6** in that the uncertainty in the other assumptions is not considered. The results show that the impact of changing to a geometric mean is fairly limited, with an average rank shift of around five places. However, some countries do shift by a significant amount, including Germany (23 places).

The JRC recommends to weigh up the possibility of using a geometric average: it may better reflect the non-compensatory nature of tax avoidance. Furthermore, a novelty of the CTHI is that it is based on the 'lowest common denominator" or "weakest link" principle at the indicator level. Therefore, if a jurisdiction scores high on some indicators, but very low on others, then the weakest link principle assessment of the jurisdiction could be based on the low-scoring indicators, because these will most likely attract the harmful corporate activity.

The overall implications of the uncertainty analysis are that the uncertainty in the rankings is manageable, and allows meaningful conclusions to be drawn from the index, although the set of indicators do cause a contribution to the uncertainty.

Figure 8: Simulated rankings (the arithmetic mean against the geometric mean)

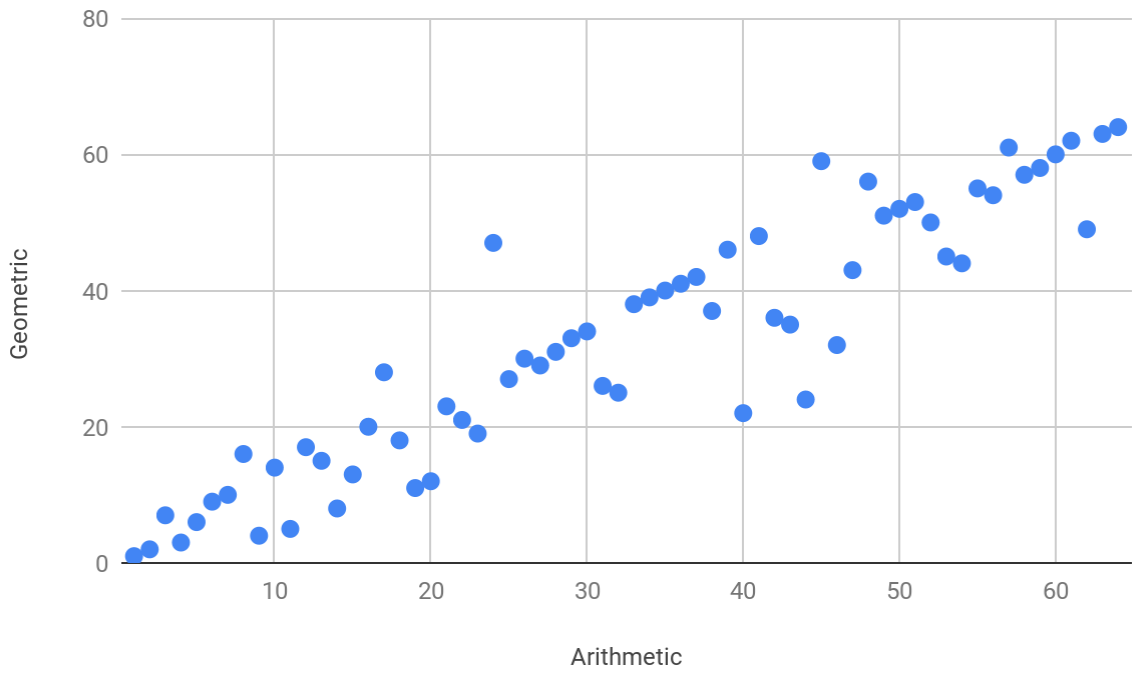
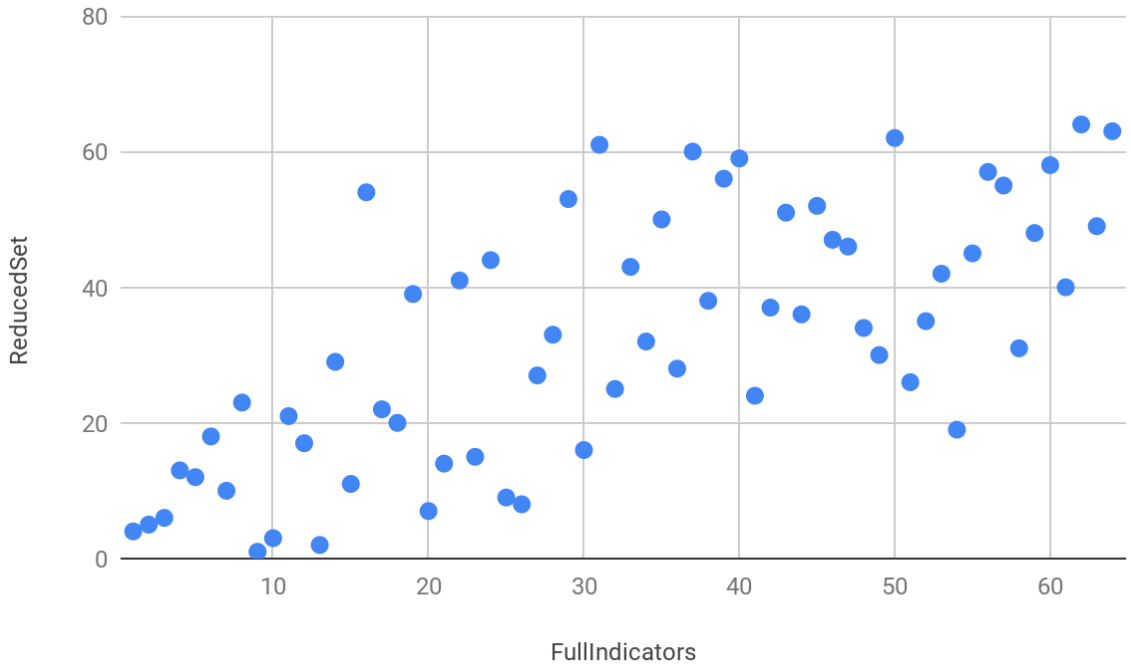


Figure 9: Simulated rankings (the 'reduced set' of indicators against the 'full set')



8. Consistency with FSI audit

Similarly to the financial secrecy index, the CTHI is dominated by the scale factor. Also, in the CTHI, the components of HI and the scale have a negative statistical relationship. Hence, it would be better to present them separately and to focus more on narrative reporting for individual jurisdiction', or constructing a better scale measure, for example by building on other metrics proposed in the tax haven literature.

In the CTHI there may be an uncertainty of the rankings around the choice of scale measure. As recommended by the JRC team in its FSI audit, it would be worthwhile to publish confidence intervals alongside the ranking similarly to the FSI (recommended by JRC and accepted by developers).

We can also check the similarity with the Financial Secrecy Index. The figures below show the ranks of the two indexes plotted against each other. While there is some similarity (rank correlation 0.77), the differences are substantial enough to show the conceptual added value of the CTHI. The correlation between the two indices of the Tax Justice Network is rather the result of the correlation of the GSW component of the two indices (correlation of 0.7), the correlation of between the Haven Scores and the Financial Secrecy Scores is lower (0.5).

Figure 10: Scatter plot of the FSI and CTHI indices

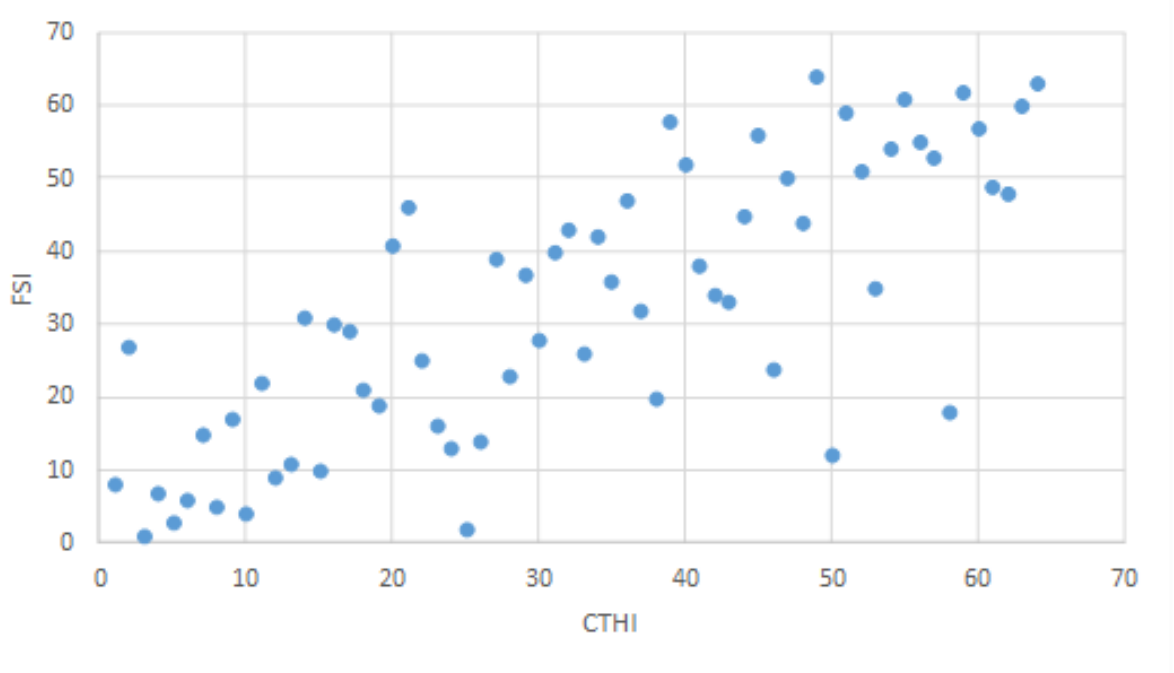
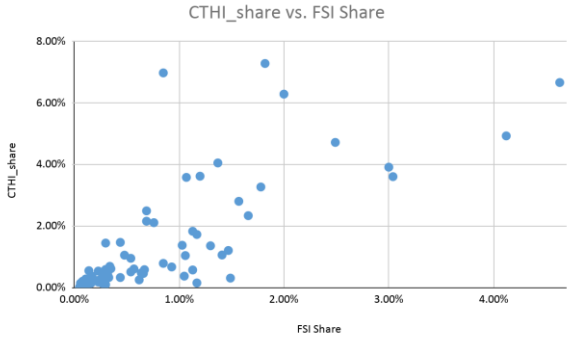
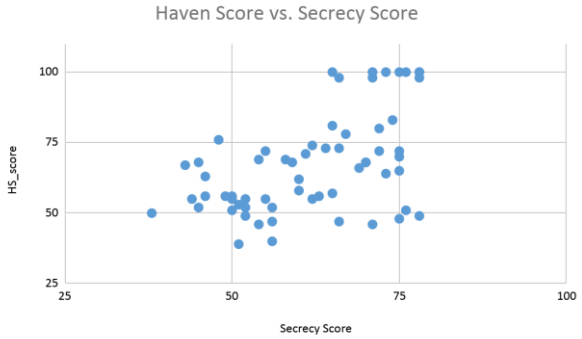


Figure 11: Scatter plot of the Scores and Global Scale Weights in the FSI and CTHI indices


CTHI_share vs. FSI Share
8.00%
6.00%
4.00%
2.00%
0.00%
CTHI_share
0.00%
1.00%
2.00%
3.00%
4.00%
FSI Share


Haven Score vs. Secrecy Score
100
75
50
25
HS_score
25
50
75
100
Secrecy Score

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