GRADUATE OUTCOMES SOC CODING - INDEPENDENT VERIFICATION ANALYSIS REPORT

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INTRODUCTION

One of the main outputs of Graduate Outcomes is employment data on recent graduates. This data is coded to the standard industry and occupation classification frameworks developed by the Office for National Statistics. As with any other statistical output, quality assurance of coded data is essential to ensure the production of reliable outputs that meet users' requirements.

Following a series of discussions with the Higher Education sector, a three-part quality assurance strategy was formulated to review the quality of SOC coded data. One of the strands of this strategy is independent verification of data coded by HESA's coding supplier Oblong.

Quality assurance of coded data using intercoder reliability testing is a well-established methodology in scientific research. It involves the use of two or more independent coders, coding the same set of data using the same classification framework. A commonly used statistic in the determination of coding reliability of nominal data is Cohen's Kappa. It provides a measure of agreement between independent coders while considering the level of agreement reached purely by chance. Its use in the assessment of coded medical and socio-economic data is well documented in the literature (McHugh, 2012; Warrens, 2015; Schmitz and Forst 2016; Steinsvag et al 2007).

Independent verification of Graduate Outcomes data was carried out by the Office for National Statistics (ONS) who also advised on the sampling methodology and statistical analysis and contributed to the review of the findings and this report. This is explained in detail in the next section on Methodology. Also contained in this section is an overview of the analysis carried out by HESA using the two sets of independently coded records. Results from this analysis are outlined in the following section, followed by a set of conclusions and recommendations for the future.

METHODOLOGY

The objective of this exercise is to measure the reliability of SOC codes derived from the coding of Graduate Outcomes. In its guidance on the administration of population censuses and the subsequent coding of industries and occupations, the International Labour Organisation (ILO) recommends the use of a sample-based assessment to determine the reliability of coded data (ILO, 2001). It further highlights the subjective nature of occupation and industry coding which could lead to errors and variance in results. This is possible even when the coders are highly trained and the survey questions and coding tools have been subject to rigorous testing. In addition to other quality assurance checks, independent testing of a sample is likely to provide additional assurance to data users on the consistency and accuracy of coding. For Graduate Outcomes a sample of records containing employment data from the survey was shared with ONS' Classifications team who were asked to code it independently. The two sets of codes have been compared to measure the extent to which they match or agree.

Following the release of the latest iteration of SOC in 2020, it was decided that employment data from Graduate Outcomes will be coded using SOC2020. It was also agreed that data from year one of the survey, which were previously coded using SOC2010, were to be recoded using SOC2020. Recoded data from the first year was available in time for this assessment but had not been finalised by our coding supplier. Due to time constraints, it was decided that a provisional version of this dataset will be used despite the possibility of some quality issues which would have been ironed out if we were working with a final version. By the time the data were received from ONS, a later version of year one data was available and was used in the analysis.

While both sets of coders received the same set of records to code, they used two different methodologies to complete the task. Broadly speaking, HESA's coding supplier Oblong uses a combination of automated coding followed by manual coding. The entire dataset is thoroughly checked for consistency at the end of the exercise. They also use a wide range of data items to derive the final code. Details of this methodology are published on HESA's website[1]. In contrast, ONS used a methodology based entirely on manual coding and a much smaller set of data items[2]. Some degree of disagreement is therefore expected to result from the use of different coding tools and methodologies but given the common coding framework underpinning these practices, the impact of differences between techniques should be minimal.

For the purposes of this assessment, a stratified random sample of 2,400 records was selected. It was stratified by 'Skill group' level which is a 3-tier aggregation of the nine SOC major groups: Highly Skilled (major groups 1-3), Medium Skilled (major groups 4-6), Low Skilled (major groups 7-9). This aggregation is also used in the published statistical outputs (HESA, 2020). 800 records from each of these three groups make up the entire sample.

Once received, the new set of codes from ONS were compared with the primary set of codes delivered by Oblong. Inter-rater reliability between the codes was measured using Cohen's Kappa. A high degree of agreement between coders is not only an indication of reliability in the codes but also reflects positively on the design and specification of the coding framework, implying its applicability is universal and consistent.

The value of Kappa is often evaluated against a benchmark, first identified by Landis and Koch (1977). The defined ranges and labels are arbitrary but are the most common interpretation of this statistic used by researchers worldwide.

Table 1: Range and description of Kappa values

Value of Cohen's Kappa (k)	Strength of agreement
< 0.00	Poor
0.00-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Substantial
0.81-1.00	Almost Perfect

[1] https://www.hesa.ac.uk/data-and-analysis/graduates/methodology/data-processing#data-coding

[2] Employer's name, Employer's duties, Job title, Job duties, Level of qualification, Subject of qualification, Whether qualification was required for job.

Once the statistical test was determined, it was important to define the levels at which agreement would be measured. Given the aim of this exercise is to quantify the extent to which data are coded to a good standard, it was important to measure inter-reliability at each of the 4-digits of SOC codes. Additionally, disaggregation of major groups into skill levels is known to be of significance for statistical outputs. This resulted in the creation of five comparison groups:

i. Each of the 4 digits in SOC codes which represent major groups, sub-major groups, minor groups and unit groups in the SOC classification system,
ii. At the 'Skill group' level defined above

Finally, where significant differences at the major-group level are identified between the two sets of codes, a further manual assessment was carried out to identify possible systemic issues in the coding of specific occupation groups (for definition of systemic issues, see https://www.hesa.ac.uk/definitions/operational-survey-information). Findings from this assessment were fed back to the primary coder in time for the finalisation of the datasets for publication.

RESULTS

For this section, HESA's primary coding supplier is referred to as Coder A and ONS is referred to as Coder B.

Descriptive statistics

Table 2: Descriptive statistics on the sample, following primary and secondary coding[3].

	Count	**Proportion (%)**
Records in the sample	2,400	100
Perfect agreement between coders A and B (at the 4-digit level)	1,783	74.3
Records returned 'uncodable' by coder B[4]	50	2.1
Records coded in the same major group by coders A and B	253	10.5
Records coded in different major groups by coders A and B (i.e. disagreement at 1-digit level)	314	13.1

[3] The two sets of codes for all the records have been added to an appendix.
[4] All records in the original sample of 2400 were assigned a SOC code by coder A.

One of the basic requirements in the calculation of Kappa is the presence of a contingency table with perfect matches listed along the diagonal and mismatches spread out on either side. Tables 3 and 5 contain such crosstabulations for the main groups of interest. Tables 4 and 6 provide an indication of the level of percentage agreement i.e., the percentage of records coded by coder A which are coded in the same way by coder B.

Table 3: Coder A vs coder B contingency table at 'Skill group' level

		Coder A			
	Skill group	Highly skilled	Medium skilled	Low skilled	**Total**
Coder B	Highly skilled	755	89	28	872
	Medium skilled	24	663	26	713
	Low skilled	5	29	731	765
	Total	784	781	785	**2350**

Note: This table excludes the 50 records that were returned as uncodable by coder B

Table 4: Agreement rate at 'Skill level'

Comparison group		**Agreement rate**
Coder A Highly Skilled	Aggregate 1-digit	96.3%
	Aggregate 4-digit	72.2%
Coder A Medium Skilled	Aggregate 1-digit	84.9%
	Aggregate 4-digit	75.4%
Coder A Low Skilled	Aggregate 1-digit	93.1%
	Aggregate 4-digit	80.0%

The above table implies that of all the records coded by coder A under high, medium and low skilled; at the 1-digit level, nearly 85% have also been coded in the same skill group by coder B.

Table 5: Coder A vs coder B contingency table at 1-digit level (major group)

		Coder A										
	Major group	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
Coder B	**0**	0	10	7	8	5	4	1	7	6	2	50
	1	0	195	0	4	3	8	2	8	0	0	220
	2	0	20	251	25	12	13	3	0	7	0	331
	3	0	29	6	225	14	21	13	10	3	0	321
	4	0	2	3	8	224	0	1	7	1	2	248
	5	0	3	1	0	0	214	0	0	9	1	228
	6	0	0	0	7	0	0	224	1	2	3	237
	7	0	1	0	1	8	3	3	231	0	14	261
	8	0	1	1	0	0	5	1	2	227	0	237
	9	0	1	0	0	1	3	5	1	11	245	267
	Total	0	262	269	278	267	271	253	267	266	267	**2400**

Table 6: Agreement rate at Major Group level

Comparison group		Agreement rate
Coder A MG1*	1-digit	77.4%
	4-digit	57.1%
Coder A MG2	1-digit	95.8%
	4-digit	85.5%
Coder A MG3	1-digit	83.3%
	4-digit	73.3%
Coder A MG4	1-digit	85.5%
	4-digit	74.4%
Coder A MG5	1-digit	80.1%
	4-digit	73.4%
Coder A MG6	1-digit	88.9%
	4-digit	78.6%
Coder A MG7	1-digit	88.8%
	4-digit	79.2%
Coder A MG8	1-digit	87.3%
	4-digit	75.4%
Coder A MG9	1-digit	92.5%
	4-digit	85.3%

*MG=Major Group

As observed in table 4, agreement rates are lower among the 4-digit codes compared with 1-digit codes. Furthermore, the lowest agreement rate has been found in the 4-digit Major Group 1 category although the same is not true of the 1-digit code in the same major group suggesting that while the two coders agree on the classification of records into major group 1, the assignment into different unit groups varies markedly in many records. The reason for this variation has not been explored as part of this exercise but will be in scope of a post-assessment review.

The presence of variance at the major group level might be pointing towards systemic issues in the coding of occupations that were included in the sample. To mitigate this risk, a manual check on the largest 'mismatches' was performed in parallel. In Table 5, the mismatches of greatest concern (based on magnitude) have been marked in red. Occupations corresponding to records in these cells were reviewed separately to identify any systemic issues or inconsistencies in coding, using definitions referenced in the previous section. One systemic issue and one inconsistency were identified as a result. These were fed back to coder A and the data were subsequently corrected. The remaining mismatches were not deemed actionable as the code assigned by coder A seemed correct or the error affected a very small number of records, below the pre-defined threshold.

Inter-rater agreement

Having reviewed the literature on Cohen's Kappa, one of the analytical dilemmas we experienced was around the handling of records that were returned as uncodable by coder B. For the 50 records in this category, a SOC code was returned by coder A but not by coder B. One set of codes is therefore missing for these records.

A comprehensive assessment of options on how to handle units with one or more missing ratings was recently offered by Raadt et al (2019). They propose one of the following three ways to handle missing data in the calculation of Kappa;

i. Listwise deletion i.e. remove all units with missing rating(s)
ii. Produce adjusted Kappa using both variants – with and without missing data
iii. Re-classify all units with one or more missing ratings under a new rating.

Using simulations, they evaluated each of these approaches for the magnitude of bias and mean squared error assuming missingness was or wasn't completely at random. The researchers concluded in favour of listwise deletion as the most effective approach to deal with missing data.

Applying this principle to our analysis meant that we had to exclude those records where a SOC code was only returned by one of the two coders. This resulted in a useable sample of 2,350 records for which Kappa was estimated using the software R. Kappa values and confidence intervals were computed using the *cohen.kappa* function in the psych package with a probability level of 0.05. It uses the standard method of calculation where Kappa (k) is defined as:

$(p_o-p_e)/(1- p_e)$, where $\mathbf{p_o}$ is the observed probability of agreement and $\mathbf{p_e}$ is the expected probability of agreement.

The following table contains results for each of the five comparison groups.

Table 7: Kappa statistic by comparison group

Comparison group	**Kappa**	**Confidence Intervals**
Skill level – High, Medium, Low	0.87	0.85-0.89
1-digit – Major group	0.85	0.83-0.87
2-digit - Major + Sub-major group	0.84	0.82-0.85
3-digit - Major + Sub-major group + Minor group	0.80	0.78-0.82
4-digit - Major + Sub-major group + Minor group + Unit Group	0.76	0.74-0.77

Using the common benchmarks used to interpret these results, it is evident that an almost perfect agreement was achieved at the Skill level, 1-digit and 2-digit SOC groups. A substantial agreement was also observed for the remaining two groups. This is supported by the values recorded for the 95% confidence intervals, which fall within the almost perfect and substantial agreement levels. As expected, the higher the aggregation, the greater the level of agreement among coders.

Kappa was not calculated across major groups as the rater responses could not have been distributed across all valid response categories. Calculated agreement rates were deemed sufficient for analysis purposes at this level.

DISCUSSION AND CONCLUSION

Independent verification of SOC 2020 data from the first year of Graduate Outcomes has identified a strong agreement between codes assigned independently by two different organisations, using different methods, for the same set of records. Agreement is substantial for all groups and almost perfect for some. As inter-rater agreement is a measure of reliability, these findings provide substantial confidence in the reliability of codes delivered by Oblong and supplied by HESA to the higher education sector in the form of data deliveries and statistical outputs.

Beyond the overarching conclusion, it is important to note some of the other advantages of this exercise and the possible direction HESA could take to secure the quality of this data in future.

As a follow-up to this exercise it is recommended that the records that were returned as uncodable by one of the two coders are reviewed separately, with the two coders working in collaboration to determine the underlying cause for discrepancy. Reducing the number of uncodable records in the final dataset is desirable but it should not pose a risk to the integrity of the data. This was the only unexpected outcome of this review and requires further investigation.

Similarly, a review of areas of disagreement between the two organisations is also likely to provide useful insights into coding practices and the application of the coding framework. In doing so it is recommended that differences between automated and manual coding are considered, among other considerations.

While the results of this assessment seem favourable, complacency is not an option. Every organisation is likely to approach coding slightly differently and would therefore observe a slightly different set of codes assigned to the same set of records. A level of variability is therefore natural and expected (as indicated by the results of this assessment). But the combined effect of staff turnover, technological changes, and increasing pressures on time and resource, one could presume a level of decline in quality if timely checks and balances are not in place. HESA is very confident that the methods and training adopted by Oblong thus far are fit for purpose. To ensure this important data continues to be of high quality it is recommended that a similar exercise is carried out regularly. It is worth acknowledging though that this type of independent verification is a resource-intensive exercise for all organisations involved. While an annual review may not be possible, it is recommended this assessment is conducted every three years.

For a new data collection that informs both policy and practice, such as Graduate Outcomes, it is vital that outputs are available for peer review and external, objective scrutiny. It has the potential to provide the much-needed assurance sought by data users. This exercise achieves that objective and has the potential to offer a prototype for similar endeavours in other parts of this project.

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APPENDIX

The following pages contain the two sets of codes returned for each of the 2,400 records.

Records marked **u/c** were uncodable by Coder B.

A	B	A	B	A	B	A	B	A	B	A	B
1111	1232	1131	1111	1139	1255	1150	1150	1222	1222	1224	3412
1112	1112	1131	3556	1139	1139	1150	1150	1222	1222	1225	2494
1121	1121	1132	1111	1139	3534	1150	2432	1222	1222	1231	1171
1121	2482	1132	1131	1139	3582	1150	1150	1222	1222	1231	2224
1121	1131	1132	3554	1139	2432	1150	1150	1222	3557	1231	2112
1121	2494	1132	u/c	1139	u/c	1150	1150	1222	3557	1231	2221
1121	1121	1132	1111	1139	1111	1150	1150	1222	3557	1231	3224
1121	3556	1135	u/c	1139	2161	1161	1161	1222	1222	1231	1259
1121	1150	1135	1135	1139	1259	1161	3311	1222	1222	1232	1232
1121	1259	1136	1136	1139	3556	1161	3311	1222	1222	1232	1232
1121	5432	1136	1136	1139	1139	1161	1161	1222	1222	1232	1232
1121	1252	1136	1136	1139	3542	1161	1161	1222	1222	1232	1232
1121	3556	1136	1136	1139	1255	1161	1161	1223	4143	1232	1232
1121	1121	1136	1136	1139	1259	1161	3574	1223	3557	1233	1233
1121	3429	1136	1136	1139	2161	1161	1161	1223	1223	1241	1241
1121	3422	1136	1136	1139	1122	1161	1161	1223	1223	1241	1243
1121	1121	1136	1136	1140	1111	1162	1162	1223	1223	1241	8233
1121	u/c	1137	1136	1140	1241	1171	1171	1223	1223	1241	1241
1122	1122	1137	2132	1150	1150	1171	3416	1223	5436	1242	1242
1122	1122	1137	2422	1150	1222	1171	1131	1223	1223	1242	1242
1122	1122	1137	2134	1150	1135	1171	u/c	1223	1223	1242	1242
1122	1122	1137	1111	1150	1150	1171	1121	1224	3416	1243	1243
1122	1122	1137	1111	1150	1150	1171	1171	1224	3556	1243	1243
1122	1122	1137	1137	1150	1241	1171	1171	1224	3432	1251	1251
1122	1122	1137	2134	1150	u/c	1171	1171	1224	u/c	1251	1251
1123	1123	1137	1137	1150	1150	1171	1135	1224	3557	1251	1251
1123	1123	1137	2135	1150	1150	1211	1211	1224	1259	1251	1251
1131	u/c	1137	2134	1150	1150	1211	1211	1224	1224	1251	5223
1131	1131	1139	1121	1150	1121	1211	9119	1224	7129	1251	1251
1131	1111	1139	1139	1150	1150	1211	1211	1224	1224	1251	1111
1131	1131	1139	1139	1150	1150	1211	1211	1224	1224	1251	1251
1131	1131	1139	1122	1150	1150	1212	4159	1224	2440	1251	1251
1131	1131	1139	1259	1150	3556	1221	1221	1224	1224	1251	1251
1131	1131	1139	1139	1150	1150	1221	1221	1224	1259	1251	1251
1131	1131	1139	1139	1150	1150	1221	1221	1224	1224	1251	1251

A	B	A	B	A	B	A	B	A	B	A	B
1253	1259	1259	1259	2134	2134	2226	2162	2313	2313	2412	2412
1253	1253	1259	1259	2134	2134	2229	2229	2313	2313	2412	2412
1253	1253	2111	2111	2134	3412	2229	2229	2313	2319	2412	2412
1255	1255	2111	2111	2134	2134	2231	2231	2313	2313	2412	2412
1255	2491	2113	2113	2135	2135	2232	2232	2313	2313	2412	2412
1255	1111	2113	2113	2135	2135	2232	2232	2313	2313	2419	2419
1255	1255	2113	2113	2139	2135	2233	2233	2313	2313	2419	2419
1255	3416	2114	2114	2139	2135	2234	2234	2313	2323	2419	2419
1255	1139	2114	2114	2141	2141	2236	2236	2313	2313	2419	2419
1255	1255	2115	2434	2141	2141	2237	2237	2313	2313	2419	2419
1257	1257	2119	2113	2142	2142	2237	2237	2313	2313	2419	2419
1257	1257	2119	2119	2142	3421	2237	2237	2313	2313	2419	2419
1257	1257	2119	2119	2142	2492	2237	2237	2314	2314	2421	2421
1257	1257	2119	2162	2142	2142	2237	2235	2314	2314	2421	2421
1257	1257	2121	2121	2142	2142	2237	2237	2314	u/c	2421	2421
1257	1257	2121	5319	2142	2142	2237	2237	2314	2314	2421	2422
1257	1257	2121	2121	2142	2142	2237	2237	2314	2314	2421	2421
1257	1257	2121	2121	2142	2142	2251	2251	2314	2314	2421	4122
1258	1131	2121	2121	2142	2142	2251	2251	2314	2314	2421	2421
1258	1111	2121	2121	2161	2161	2251	2251	2314	2314	2421	2421
1258	1259	2121	2121	2161	2161	2253	2253	2314	2314	2421	2421
1258	1258	2122	2122	2162	2162	2254	2254	2314	2314	2421	2421
1258	1258	2122	2122	2162	2162	2254	2254	2314	2314	2421	2421
1259	1259	2122	2122	2162	2162	2254	2254	2314	u/c	2421	2421
1259	3557	2122	2122	2162	2162	2254	2254	2314	2314	2421	4122
1259	1259	2124	2124	2211	2211	2255	2255	2314	2314	2421	4122
1259	1137	2126	2127	2211	2211	2259	u/c	2314	2314	2422	2422
1259	1259	2129	2129	2211	2211	2259	2259	2314	u/c	2422	2422
1259	1136	2129	2125	2211	2211	2259	2259	2314	2314	2422	u/c
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1259	1139	2134	2134	2212	2211	2313	2313	2317	2313	2423	2423
1259	u/c	2134	2134	2212	2212	2313	2313	2319	2313	2431	2431
1259	1259	2134	2134	2212	2212	2313	2321	2319	2319	2431	2431
1259	1224	2134	2134	2221	2221	2313	2313	2319	2319	2432	2432
1259	u/c	2134	2134	2221	2221	2313	2313	2319	2319	2433	2433
1259	1111	2134	2134	2222	2222	2313	2313	2319	2313	2433	2433
1259	1259	2134	2134	2222	2222	2313	2313	2319	u/c	2433	2433
1259	1259	2134	2134	2223	2223	2313	2313	2319	2311	2433	2433
1259	3554	2134	2134	2224	2224	2313	2313	2324	2324	2433	2433
1259	1259	2134	2134	2224	2224	2313	2313	2411	2411	2434	2434
1259	1259	2134	2134	2225	2225	2313	2313	2412	2412	2434	u/c
1259	1139	2134	3544	2226	2226	2313	2313	2412	2412	2434	2114

A	B	A	B	A	B	A	B	A	B	A	B
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