The Money Advice Service

Numeracy Deep Dive

Final Report

Prepared for:

- The Money Advice Service
- 23 January 2017
- Change to Final Report

Contents

1.   Background

Back in 2015, the Money Advice Service (MAS) carried out a series of research studies to further inform their wider Financial Capability strategy. These comprised of the Financial Capability Survey ("Financial Capability"), conducted by GfK; and the OECD INFE Financial Literacy and Inclusion Measurement Exercise ("Financial Literacy") conducted by Critical Research. Both sets of research explored the financial confidence levels, knowledge and skills of the general population, with respect to day-to-day financial management and understanding.

The MAS Insight and Evaluation team is keen to build on these foundations by conducting a series of 'deep dives' into existing datasets to derive further insight. MAS is currently undertaking 'deep dives' into a number of areas, including 'Older People in Retirement', 'Young Adults' and 'Savings'.

This report is for the 'Numeracy' deep dive, which has implications for national policy development. The outcomes of this exercise will be used to inform an expert roundtable of stakeholders, to be convened by MAS in Autumn 2016. Recommendations and identification of knowledge gaps will play an important role in this debrief.

MAS aim to make use of the Financial Capability and Financial Literacy studies to enhance this understanding, and would also like to utilise the datasets obtained by National Numeracy (NN), in an effort to examine the inter-relationship between numeracy and financial capability more closely. A review of the following datasets was utilised in the additional analysis:

- *Nationwide Digital Numeracy Screeners* – A largely attitudinal piece of research conducted amongst Nationwide customers, exploring the aspects of Digital Engagement, Investment Risk, Financial Control, Financial Awareness and Financial Stability.
- *National* Numeracy *Challenge* – A 70,000-respondent dataset of members of the population who completed the National Numeracy Challenge test, the results of which consider how answers to Financial questions correlate to other indicators of numerate behaviour.

2.   Approach

The following stages for this exercise were established to examine the inter-relationship between financial capability and numeracy:

- **Dataset Review.** All existing datasets were reviewed and their potential contributions to theory building and regressions are assessed.
- Theory Development. A number of statements or theories linking numeracy and financial capability were developed as a consequence of the literature review. Theories to be carried through into the statistical testing stage typically had an underpinning across multiple studies.
- Statistical Testing. The data from the Financial Literacy study was used to test the theories. As the majority of theories touched upon aspects that the Financial Literacy study explored, this made it the logical choice to use. Using a combination of CHAID, PCA and Regression analyses, it was possible to determine if other theories were emerging, such as co-dependence of variables, which could form the basis for additional research. Ultimately, this stage was necessary to elicit evidence that may assist understanding and potentially enable us to formally establish a link between financial capability and numeracy.
- Reporting. Once theories had been tested, the analysis should support a number of primary findings (findings with the most evidence), and secondary results (ones which may be helpful but more indicative). The analysis should also allow us to identify any knowledge gaps, such as information that if it were present would have aided understanding. The reporting process may also be able to establish key questions which could be included on subsequent research surveys which might elicit greater understanding of the link between numeracy and financial capability.

3.   Dataset Review

Thus far four sources have been evaluated:

- "National Numeracy Challenge" data was reviewed first, in order to establish the initial links between numeracy and financial numeracy. Similarly, the work conducted with Nationwide customers about numeracy skills was also evaluated.
- Critical's "OECD Financial Literacy" data was then reviewed to establish direct and indirect links between financial well-being and measures of financial capability. The study also contained a financial numeracy component, which allowed the knowledge gap to be bridged with the National Numeracy Challenge, and made statistical analysis of the relationship possible.
- GfK's "Financial Capability" data and Nationwide's "Screener and Check-Up" data was examined to provide further support for measures of financial capability and financial well-being, and helped to embolden the theories emerging from the Financial Literacy review.
- In addition, the authors have reviewed supplementary materials provided by the Financial Conduct Authority (FCA) and Understanding Society (US) to provide further context to the financial capability aspect.

3.1   National Numeracy Challenge

3.1.1   Background

The 'National Numeracy Challenge' is an extensive online numeracy test administered by National Numeracy, an independent charity aiming to improve the UK's numeracy levels by nurturing positive attitudes towards mathematics. As a consequence, this initiative is of considerable real-world benefit to those responsible for managing personal or household finances in the population, and, therefore, provided substantial relevance to this enquiry. With data on over 70,000 adults who have taken part in the National Numeracy Challenge to date, the depth of the sample suggested any strong conclusions reached from analysis of this dataset could be considered plausible. This boded well for establishing the link between general numeracy and financial numeracy.

3.1.2 Dataset Composition

Each participant was asked six initial 'screener' questions to determine the level they were currently working at, with regards to numeracy. Their performance over these six questions determined the route they would take through the Check-Up questions.

Participants were assigned levels according to how well they had performed in the test.[1] The aim of the study was to draw attention to low numeracy rates in UK adults and to encourage respondents to take the challenge to improve results, tackle any 'negative attitudes' towards maths, and boost confidence in numeracy, overall.

Questions with a financial element, or measures of financial numeracy, were identified in both the 'Screener' and 'Check-up' sections, and the results for these questions were compared to the results for the general (non-financial) numeracy questions. An analysis of common questions answered *incorrectly* was also provided, which looked at the attitudinal and demographic differences between individuals, with regards to numeracy.

3.1.3 Measures of Numeracy

Screener – Phase 1

The 'Screener' questions were asked of all respondents, and the following four questions were seen to contain a financial element:

NS1.   *Put these amounts of money in the correct order: 56p, 68p, 86p, £2.08, £2.56, £3* **(Single Code)**

   Variation of this question also asked: Put these amounts of money in the correct order: 35p, 57p, 75p, £3.05, £3.50, £4 **(Single Code)**

NS2.   *Answer the following sums: 6+8, 27-16, 3x5* **(Single Code)**

   Variation of this question also asked: Answer the following sums: 5+7, 38-15, 4x5 **(Single Code)**

NS3.   *Joe has a budget of £30 to buy the ingredients. Fill in this chart to work out how much each item will cost. Amount for 24 people: mince 2.4kg @ £1.50 per 400g, butter 300g @ £1 per 250g pack, onions 12 @ 3 for 95p, tomatoes 6 tins @ 39p per tin.* **(Single Code)**

   Variation of this question also asked: Answer the following sums: Joe has a budget of £30 to buy the ingredients. Fill in this chart to work out how much each item will cost. Amount for 24 people: mince 3.6kg @ £1.05 per 300g, butter 300g @ £1 per 250g pack, onions 6 @ 2 for 69p, tomatoes 12 tins @ 33p per tin. **(Single Code)**

NS4.   *Select which of these cakes is the most expensive he can afford with the money he has left: £6.36, £8.10, £9.83, £10.25.* **(Single Code)**

   Variation of this question also asked: Select which of these cakes is the most expensive he can afford with the money he has left: £6.36, £8.10, £9.83, £10.25. **(Single Code)**

Check-Up – Phase 2

The 'Check-Up' questions with a financial element varied from respondent to respondent, depending on their performance on the 'Screener' questions – but the following seven questions were the most commonly asked throughout the Challenge exercise:

NT1.   *Study this chart. It shows the average price of detached houses in the East Midlands for the years 2011 and 2012. Which 2 quarters saw a drop in prices from the previous quarters? What do these 2 quarters have in common?* **(Single Code)**

NT2.   *What is the difference in the total of money spent in 2008 from 2007? To the nearest whole number, what percentage increase has there been between 2007 and 2008?* **(Single Code)**

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[1] Specifically: pre-entry level, entry level 1, entry level 2, entry level 3, level 1, level 2

NT3. How much more was spent on Local Authority Housing than on Services to the Public in 2008? *(Single Code)*

Variation of this question also asked: How much more was spent on Local Authority Housing than on Court and Probation in 2008? *(Single Code)*

NT4. What was the annual spending on Highways Road & Transport in 2012 to the nearest million pounds? *(Single Code)*

Variation of this question also asked: What was the annual spending on Education in 2012 to the nearest million pounds? *(Single Code)*

NT5. Put these amounts of money in the correct order: 56p, 68p, 86p, £2.08, £2.56, £3 *(Single Code)*

Variation of this question also asked: Put these amounts of money in the correct order: 35p, 57p, 75p, £3.05, £3.50, £4 *(Single Code)*

NT6. Joe has a budget of £30 to buy the ingredients. Fill in this chart to work out how much each item will cost. Amount for 24 people: mince 2.4kg @ £1.50 per 400g, butter 300g @ £1 per 250g pack, onions 12 @ 3 for 95p, tomatoes 6 tins @ 39p per tin. *(Single Code)*

Variation of this question also asked: Answer the following sums: Joe has a budget of £30 to buy the ingredients. Fill in this chart to work out how much each item will cost. Amount for 24 people: mince 3.6kg @ £1.05 per 300g, butter 300g @ £1 per 250g pack, onions 6 @ 2 for 69p, tomatoes 12 tins @ 33p per tin. *(Single Code)*

NT7. Study this chart. It shows the average price of detached houses in the East Midlands for the years 2011 and 2012. What was the mean price to the nearest £100 for 2011-2012? *(Single Code)*

Attitudinal Analysis – Phase 3

The final analysis compared answers to the mathematics attitudinal questions to four of the financial numeracy questions most commonly answered incorrectly in the Challenge. These questions were chosen based on the number of responses received, the percentage of people who answered them incorrectly, and the unambiguous nature of the questions. The top four financial numeracy questions selected for this exercise were as follows:

NI1. What was the annual spending on Education in 2012 to the nearest million pounds? *(Single Code)*

NI2. Jan bought a dress in the sale which had been reduced by 20%. If she paid £40 for it, what was the original price? *(Single Code)*

NI3. How much would I earn if I worked for 30 hours at £6.53 an hour? *(Single Code)*

NI4. How much more was spent on Local Authority Housing than on Services to the Public in 2008? *(Single Code)*

The attitudinal questions that these were compared against were as follows:

NA1. Can everyone get better at maths if they try? *(Single Code)*

NA2. Do people who are good at maths have more opportunities to do well in life? *(Single Code)*

NA3. Does your mind go blank when you need to do maths? *(Single Code)*

NA4. When you are given a maths task, are you happy to 'play around' with it? *(Single Code)*

NA5. Do you think that everyone struggles with maths sometimes? *(Single Code)*

NA6. When you get stuck with maths, can you think of different ways to keep trying? *(Single Code)*

3.1.4 Evidence

Screener - Phase 1 Evidence

The study first made a connection between the four 'screener' questions and the seven 'check-up' questions with financial elements, to establish a measure of "Financial Numeracy".

As shown by below (Figure 1), those performing poorly on the 'screener' questions were most likely to be awarded 'Entry Level 2 or below' in the 'Check-Up' (43%). Just 1% of participants who achieved the Challenge equivalent of 'Entry Level 2'

in the 'Screener' went on to score a Level 2 in the 'Check-Up'. In contrast, 20% of those who achieved a Challenge equivalent of 'Level 2' in the 'Screener' went on to achieve Level 2 in the 'Check-Up'. Retention of outcome level, across both exercises, was highest for those scoring a 'Check-Up' outcome of 'Entry Level 3' (47%); but worthy of note is that those who achieved Level 2 in the 'Screener' were much less likely to score Entry Level 3 in the Check-Up. No-one scored Level 2 in the 'Screener' dipped below 'Entry Level 3' in the 'Check-Up'.
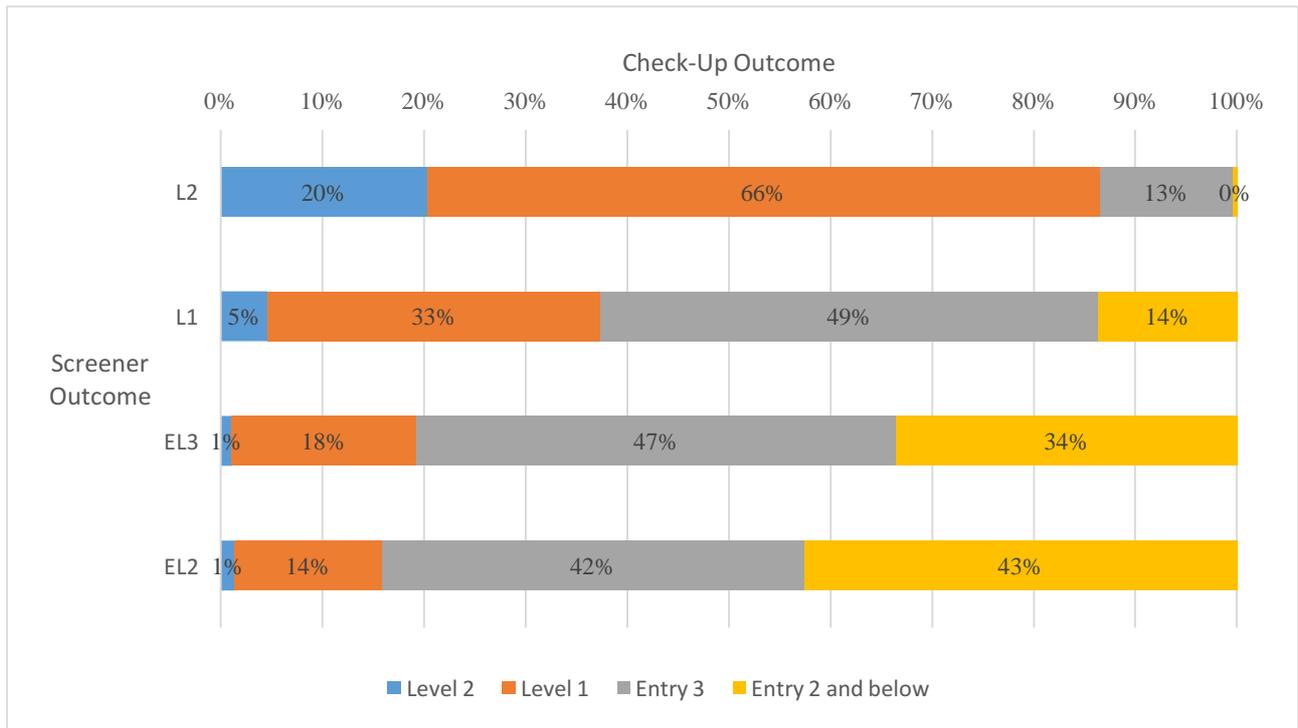
Figure 1. Changes in outcome from Screener to Check-Up

In general, it was found that those who achieved high 'Screener' scores were more likely to go on to achieve a high 'Check-Up' outcome; whereas those who scored poorly on the 'Screener' were more likely to achieve a low outcome in the 'Check-Up'. With performance outcomes for the 'Screener' translating into 'Check-Up' outcomes at a similar

level, particularly when comparing the conversions at the top and bottom ends of the numeracy scale, it can be suggested at this stage that stronger numeracy sAkills are in some way linked to an ability to answer questions with a financial element effectively.[2]

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[2] Whilst the majority of the screener questions do have a 'financial' element, this does make the assumption that together the screener questions are indicative of financial numeric ability.

Check-Up - Phase 2 Evidence

With the link between 'Screeners' and 'Check-Up' questions established, a link was then explored between conceived adeptness with "Financial Numeracy" and "Overall Numeracy". Success at questions with a financial element in the 'Check-Up' was found to be positively correlated with "Overall Numeracy" scores – with Financial Numeracy scaling with Overall Numeracy. The analysis showed that the higher the score in these 7 questions, the higher the overall numeracy score at the end of the exercise – a summary of which is shown in the table below.

To put this into context with the Phase 1 analysis, the higher the overall numeracy score at the end of the 'Check-Up', the more likely the participant was to have answered the financial numeracy questions in the 'Check-Up' correctly, which, in turn, suggests they were more likely to have answered the financial numeracy questions in the 'Screener' correctly.
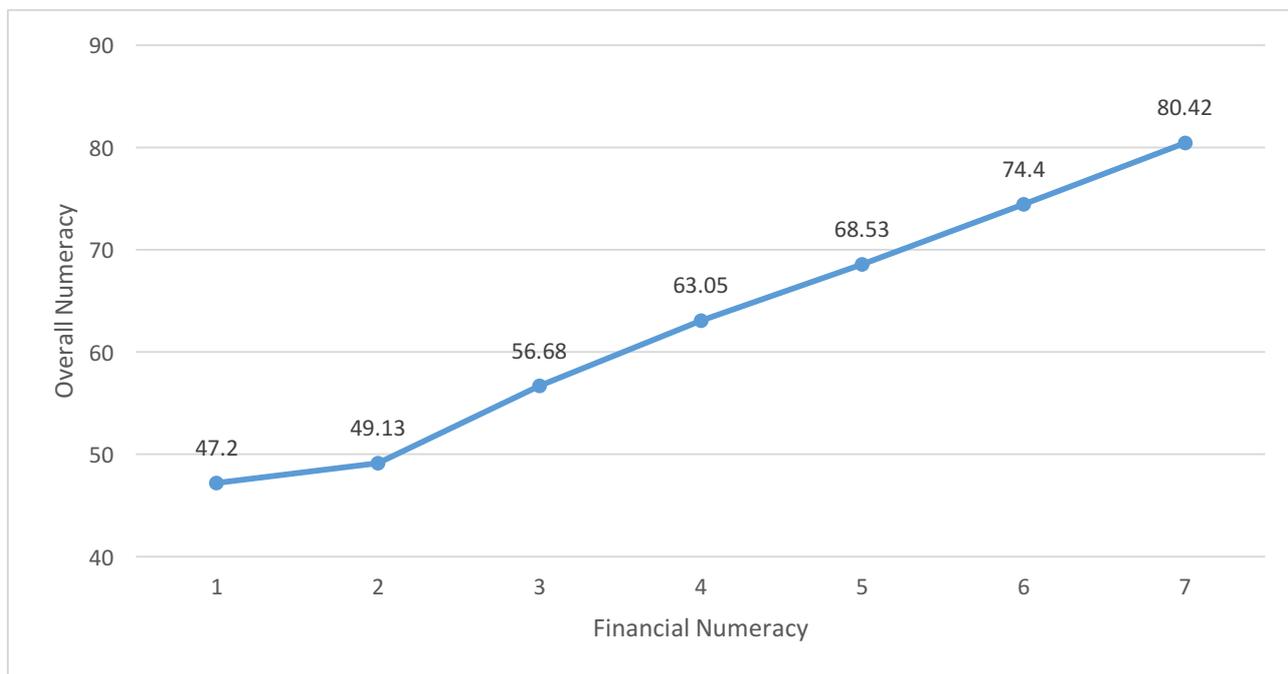
Figure 2. Financial Numeracy and Overall Numeracy Score

As the summary graph above demonstrates (Figure 2), the average overall numeracy score for those who answered just 1 of the financial numeracy questions correctly was 47.2, which increased with each 'check-up' financial question answered correctly. Those who answered all 7 of these questions correctly had an average score of 80.42, adding strength to the theory of financial numeracy correlating with general numeracy.[3]

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[3] Whilst this does provide strong evidence of a link between financial numeracy and general numeracy, it is worth noting that the 'check-up' questions were not asked of all the respondents so those who performed well on the initial questions would be more likely to be asked additional questions. This may in turn create a more 'savvy' base for each question.

Attitudinal Analysis - Phase 3 Evidence

The study also explored the questions that participants answered *incorrectly,* by evaluating demographic composition and attitudes towards general numeracy and mathematics. The final analysis found that a positive attitude towards maths appears to translate into higher levels of numeracy, and, especially, financial numeracy. For instance, those who responded to the question "Can everyone get better at maths if they try?" with "Yes, definitely" were much more likely to be placed in a higher level for financial numeracy (50%) than those who said "Definitely not" (36%). The outcomes of all six 'attitude questions' followed a similar, positive pattern.

However, despite this observation, it is not possible to conclude a cause and effect relationship, as those with a positive attitude could result in higher numeracy just as equally as those with higher numeracy have a positive attitude.

3.1.5 Conclusions

The Challenge dataset contained evidence from both the 'screener' questions and the 'check-up' questions that there is a fundamental relationship, in some form, between financial numeric ability and general numeric ability. Having established a link with numeracy, the findings from this study laid the foundations for exploring the Financial Literacy dataset to investigate the link with financial capability, in general.

3.2 Financial Literacy

With the numeracy link established, the OECD/INFE Financial Literacy questionnaire was assessed, and relevant questions were picked out as indicators for either financial well-being or numeracy. This was a questionnaire of UK adults conducted by Critical Research for the Money advice service. Analysis was conducted on these questions to enable comparisons between numeracy and financial well-being, and where appropriate establish co-dependency.

3.2.1 Measures of Numeracy

The OECD include the following questions in the "quiz" module of the questionnaire. These questions were established to indicate people who are knowledgeable about financial matters, and as a result involve a degree of numerical agility. As such, together these five questions can be seen to represent a degree of numeracy.

QK3. *Five brothers are going to be given a gift of £1,000 in total to share between them. The brothers have to wait for one year with inflation at 3% percent. Now imagine that the brothers have to wait for one year to get their share of the £1,000 and inflation stays at 3 percent. In one year's time will they be able to buy... (Single Code)*

QK4. *You lend £25 to a friend one evening and he gives you £25 back the next day. How much interest has he paid on this loan? (Single Code)*

QK5. *Suppose you put £100 into a no fee, tax free savings account with a guaranteed interest rate of 2% per year. You don't make any further payments into this account and you don't withdraw any money. How much would be in the account at the end of the first year, once the interest payment is made? (Single Code)*

QK6. *And how much would be in the account at the end of five years? Would it be... (Single Code)*

QK7b. *I would like to know whether you think the following statements are true or false... (Single Code)*
b) High inflation means that the cost of living is increasing rapidly

Furthermore, these question are similar in style to those which analysis of the NN Challenge data showed were a good indicator of numeracy.

3.2.2 Measures of Financial Capability

The Financial Literacy study also included the following questions to determine the financial well-being of the respondent.

QF1. *Who is responsible for making day-to-day decisions about money in your household? (Single Code)*

QF2. *And, does your household have a budget? (Single Code)*

QF5. *Do you (personally, or with your partner) have any financial goals? (Single Code)*

FC-C1. *To what extent do you feel that keeping up with your bills and credit commitments is a burden? (Single Code)*

QF8. *Overall, on a scale of 1 to 5 where 1 is very confident, and 5 is not at all confident; how confident are you that you have done a good job of making financial plans for your retirement? (Single Code)*

Qprod3_2. *And which sources of information do you feel most influenced your decision {about which FINANCIAL PRODUCT to take out}? (Multi Code)*
o *Best-buy tables in financial pages of newspapers/magazines*
o *Best-buy information found on the internet*
o *Specialist magazines/publications*
o *Recommendation from independent financial adviser or broker*

FC-E10. *How do you generally handle paying your bill each month for your credit card(s) or store card(s)? (Single Code)*

QF10. *I am now going to read out some statements. I would like to know how much you agree or disagree that each of the statements applies to you, personally. (Single Code)*
c) Before I buy something I carefully consider whether I can afford it
d) I pay my bills on time

QF11. Sometimes people find that their income does not quite cover their living costs. In the last 12 months, has this happened to you, personally? (Single Code)

FC-I8. Now some questions about personal and household budgeting. Thinking overall about your approach to keeping track of income and expenditure, how well do you think this approach works? (Single Code)

FC-F2. The next question is about the current account that you use most often for your daily outgoings. Which of these best describes how accurately you know the balance on this account? (Single Code)

QK1. Could you tell me how you would rate your overall knowledge about financial matters compared with other adults in the UK? (Single Code)

3.2.3   Evidence

The initial analysis consisted of constructing a set of data tables from the Financial Literacy dataset, using the indicators above. Although a number of the measures could be considered direct measures of financial capability or numeracy, there are some which were less direct and were classed as "inferred measures" or "proxies". These secondary measures formed the basis of wider theories outside of the core reasoning that developed.

The data tables were re-run[4] using the numerical measures as cross-breaks. These breaks were defined simply as correct answers vs incorrect answers. In addition to this, a 0-5 scale was developed based on the 5 measures of numeracy, with 5 out of 5 correct answers indicating "very highly numerate" respondents, and 0 out of 5 indicating "very low or no" numerical understanding.

Initial theories were developed by testing the financial well-being measures against the new Numeracy cross-breaks. These were derived using simple comparisons and correlations from the data tables, using the weighting and significance testing measures used in the original study.

Using this approach, a number of theories emerged, which were checked against the findings of the Financial Literacy report, to ensure that no key theories were missing. Outcomes were also checked against the NN Challenge report to make sure they were in keeping with outcomes found there.

3.2.4   Creating a composite numeracy score

In order to refine these initial theories, it was necessary to develop a way for the data to be used in statistical modelling. To do this, a single numeracy score was developed that would accurately portray an individual's skill with numeracy, using the 5 questions identified as measures of numeracy. The process followed is described below.

- A points based system was established, which awarded scores based on the *perceived difficulty* of each of the 5 numeracy questions from the Financial Literacy study. Perceived difficulty was defined by the 'pass rate' for each question. For example, if 80% of respondents answered QK3 correctly, and only 30% of respondents answered QK4 correctly, QK3 would be perceived as a relatively easy question, and so a correct answer at QK3 would carry less weight.
- Points were awarded using an inverse scoring method. For example, if 82% of respondents answered QK3 correctly, these respondents were awarded a score of 1.8/10 for their answer, as many appeared to find it "easy". Conversely, if a respondent answered QK4 correctly, but just 30% of respondents, overall, answered QK4 correctly, they would be awarded a score of 7/10 as it was seen as a question that was comparably harder to pass.

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[4] These data tables are available for review.

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Date Last Edited: 1 November 2017

- Once respondent answers were given a score, the 5 weighted scores were summed to produce a single numeracy score that provides a weighted summary of numerical ability, as an individual. These were rounded to the nearest integer. By using this method, it can be said, broadly speaking, *the higher the numeracy score, the more numerate the individual over a range of concepts.*

Once the summary scores were calculated, this resulted in an estimate of individual overall "Numeracy" which can be taken forward and used to investigate its relationship with other variables (attitudinal, behavioural and demographic).

3.3 Financial Capability Review

The Money Advice Service's "Financial Capability Survey", a survey conducted by GfK in 2015 with over 3,400 respondents, was also assessed, again, by picking out the key questions linked to financial capability, and three 'skills or knowledge' questions to be used as an indicator of financial numeracy. Evidence from this report was used, both to develop theories, and to provide support for theories developed from the Financial Literacy report.

3.3.1 Measures of Numeracy

The following questions were used in the survey as to determine the numeric skills/knowledge of the respondents.

n1. *Looking at this example of a bank statement, please can you tell me how much money was in the account at the end of February? (Single Code)*

n2. *If the inflation rate is 5% and the interest rate you get on your savings is 3%, will your savings have more, less or the same amount of buying power in a year's time? (Single Code)*

n3. *Suppose you put GBP100 into a savings account with a guaranteed interest rate of 2% per year. You don't make any further payments into this account and you don't withdraw any money. How much would be in the account at the end of the first year, once the interest payment is made? (Single Code)*

3.3.2 Measures of Financial Capability

The Financial Capability study included the following questions to assess a variety of aspects of the respondents financial well-being. They have been selected due to results showing a relationship with the numeracy questions.

B4. *How confident do you feel making decisions about financial products and services? (Single Code)*

B3. *How confident do you feel managing your money? (Single Code)*

C1. *To what extent do you feel that keeping up with your bills and credit commitments is a burden? (Single Code)*

C2. *In the last 6 months, have you fallen behind on, or missed, any payments for credit commitments or domestic bills for any 3 or more months? (Single Code)*

D1. *Do you have any financial goals for the next five years? (Single Code)*

D3_2. *How much of a plan do you have about how you will achieve your financial goal for (answer from D2)? Paying off my debts/ reducing debts (Single Code)*

E6. *People often take out short term loans to cover unexpected expenses or for other reasons. In the last year, have you taken out any of the following short term loans? (Multi Code)*

E10. *How do you generally handle paying your bill each month for your credit card(s) or store card(s)? (Single Code)*

F2. *Which of these best describes how accurately you know the balance on this account? (Single Code)*

G9. *Thinking about people like (...), do you think the amount of money you have in savings is...? (Single Code)*

I8. *Thinking overall about (...) approach to keeping track of income and expenditure, how well do you think this approach works? (Single Code)*

O1. *Imagine someone offers you GBP200 now or GBP400 in two months. Would you ...? (Single Code)*

O2_2. *To what extent do you agree or disagree with the following statements? Thinking about my financial situation makes me anxious (Single Code)*

O2_5. *To what extent do you agree or disagree with the following statements? I regularly read the financial pages in the papers or online (Single Code)*

3.4 Nationwide Screeners and Check-Ups

The Nationwide "Screeners and Check-Up" dataset comprised of data from a survey amongst 1000 nationwide customers. This involved a short numeracy screener, and then further numeracy check-up questions. The check-up questions were linked to one of five 'financial attitudes'; Digital Engagement, Investment Risk, Financial Control, Financial Awareness and Financial Stability.

Participants were given one of two levels for the screener questions; amber or green and then a level for the screener questions based on the levels used for the national numeracy challenge: below entry level, entry level 3, level 1 and level 2.

There was a very strong relationship between those the levels achieved from the screener level and the level achieved from the 'check-up' questions. A Chi-Squared Test of Independence analysis showed a 0.00046 degree of independence – strongly suggesting that the screener questions are an accurate measure of numeracy. The results showed that there was an especially strong link between the numeracy level and two of the 'financial attitudes' in particular.

It was also found that those who achieve a higher score at the screener question have a greater Financial awareness and Investment risk, suggesting that those who have a high level of numeracy, have a higher financial awareness and investment risk.

3.4.1 Evidence

Financial Awareness

Financial awareness was shown to have a strong link to numeracy levels so the differences between those in the high group of financial awareness and the low group of financial awareness are representative of the differences between those with high levels of numeracy and those with low levels of numeracy.

For instance, 99% of those who were 'aware' said they believe "it is important to be well informed about things" compared to 56% of those who were 'unaware' which lends support to our theory that 'higher numeracy skills lead to a greater knowledge of financial matters' (4.13). The average salary for those who were 'Aware' was £60,000 compared to £28,000 for those who were unaware, this was the

2nd biggest difference out of all the financial attitudes, given additional support to the idea that higher numeracy leads to greater all-round financial well-being.

Furthermore, this data shows that those who are 'aware' are 86% male and those who are 'unaware' are 86% female suggesting males are more financially aware than females (4.9)

Support for our theory that "poorer numeracy skills mean you are less likely to save money" was found here as those who were more financially aware were slightly more likely to have savings account 76% vs 73% (4.16)

Investment link

Also has a strong link to numeracy, second only to 'financial awareness'.

- 55% of those who are risk takers read the financial pages in the paper compared to 21% of people who are risk adverse. (4.13)

Financial Stability

The nationwide survey showed no direct link to numeracy…

- those who are financially unstable are 57% female, 43% male (4.9)
- 45% of those who are financially stable read the financial pages in papers compared to 13% of those who are financially unstable (4.13)
- 8% of those who were unstable were overdrawn in the past 3 months compared to 1% of those who are financially stable (4.8)
- 97% of those who are financially stable always know how much is in their bank account compared to 90% of those who are financially not stable (4.3)

3.5 FCA Occasional paper

In August 2016, the FCA published research conducted by the University of Nottingham into financial distress[5] with the aim of attempting to predict which consumer credit users will suffer financial distress.

People suffer financial distress when they face financial and non- financial difficulties from repaying their outstanding debts. The paper analyses the prevalence of financial distress, how this distress is related to consumer credit use, and whether financial distress can be predicted. Using data from the Wealth and Assets Survey, the majority (61%) of individuals in Great Britain have at least one consumer credit product and that at any time roughly one in four people hold outstanding debt. The paper estimates that 17% of individuals with outstanding consumer credit debt, or 7% of those holding a consumer credit product, face moderate or severe financial distress. This is a large number of individuals, approximately 2.2 million. Compared to other individuals, those in financial distress are typically younger, with lower income and higher DTI ratios. They also have noticeably worse self-reported measures of well-being. DTI (debt-to-income) ratio is a strong predictor of future financial distress, even after controlling for 'life events' that may cause financial distress, such as becoming unemployed. The top 10% of individuals by DTI ratio are much more likely to suffer financial distress than other individuals. And those who hold the majority of their debts in higher-cost products are substantially more likely to experience financial distress than holders of other forms of credit, such as personal loans.

This research, based largely on statistical analysis of a large dataset, helps provide some wider context to financial well-being as a whole, and to that end has helped inform some of the theories detailed later in this report.

3.6 Understanding Society dataset

The Understanding Society study, is a longitudinal piece conducted by the Institute for Social and Economic Research, surveying households across the United Kingdom, since 2009.

The research engaged with the financial concepts that have been covered in the other studies researched for this report, including topics such as savings, budgeting, and retirement planning. Furthermore, the study also included a component (introduced in 2011) that was used to assess financial numeracy as a measure of wider cognitive ability, by asking respondents a sequence of numerical reasoning questions.

This dataset has only become available in the latter stages of compiling this report and as such, there has been very little opportunity to include any findings. Nonetheless, the study does appear to examine the inter-relationship between numeracy and financial capability, and the authors recommend this as a useful starting point for further research.

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[5] Can we predict which consumer credit users will suffer financial distress? FCA Occasional Papers in financial regulation (August 2016). https://www.fca.org.uk/static/documents/occasional-papers/occasional-paper-20.pdf

4. Theory Development

This section combines evidence from each of the sources reviewed at earlier stages. The supporting evidence includes the question number and title of the survey the evidence was drawn from, along with relevant data from the report. Some theories relate specifically to financial behaviours and actions and suggest a link to numeracy from these observations, others relate to demographic trends that might underpin a relationship.

At this stage, these theories are just that – nothing more than educated postulations made as a result of conducting simple analyses and reviewing relevant material. Each theory is discussed in turn, but nothing should be inferred from the order of the theories.

4.1 Higher numeracy skills are associated with the setting of financial goals

The evidence supporting this theory is as follows:

- Financial Literacy - QF5 - 62% of people with very high numeracy skills set goals compared to 37% of those with low numeracy scores, and 45% of those with very low numeracy skills.
- Financial Capability – D1 – Those with a degree (66%) were significantly more likely than those without any qualifications (40%) to have set some financial goals for the next 5 years.
- Financial Capability - Respondents who had set goals were significantly more likely to answer all the numeracy 'skills' questions correctly (N1, N2, and N3).
- Financial Capability – D3 – This was also seen when asked if they had any plans to meet their debt-reducing goals: 45% of those with a graduate qualification had plans to meet their goals compared to 19% with no qualifications.
- Financial Capability - Those who got the 'interest plus' question correct and the 'savings' question correct were more likely to have plans to set goals. Interest plus – 41% vs 33% had set goals.

4.2 Higher numeracy skills are associated with seeking out best-buy literature to make financial decisions

The evidence supporting this theory is as follows:

- The higher the numeracy skill the more likely they are to seek this medium for making decisions.
- Financial Literacy - Qprod3 – Significantly more people with high numeracy skills (38%) consume best-buy literature compared to 19% with low numeracy scores.
- Financial Capability - M3 – 9% of university educated respondents use financial magazines and sections in newspapers to find out "anything to do with money" – significantly more than the 4% who had up to a school qualification and 1% who had no qualification. They were also significantly more likely to get the three 'skills' questions correct.

4.3 Higher numeracy skills are associated with keeping track of finances, in general

The evidence supporting this theory is as follows:

- Financial Literacy - FC-I8 – Those with higher numeracy scores were more likely to rate their approach for keeping track of finances as 9 or 10 on a ten-point scale (34% vs 29%). Although those with moderate numeracy scores were the most likely to do so.
- Financial Literacy - The higher the numeracy scores the more likely the individual was to agree with the statement "I keep a close personal watch on my financial affairs". 55% of those with 'Very high numeracy scores' compared to 38% of those with 'Very low numeracy scores' completely agreed with this.
- Financial Capability- F2 – more of those who had GCSE or A level qualifications reported that they would know the amount in their bank account to within £50 (60%) than those with a university education (54%) although this could be explained by a difference in earnings.

- Financial Capability- Respondents who answered the bank statement question correctly were more significantly more likely to know the amount in their account within £50 (58% vs 48%) Although no significant difference in the other two questions.
- Nationwide – 97% of those considered financially stable agree they "always know how much is in their bank account" compared to 90% of those in the financially not stable group.

4.4 In addition, higher numeracy skills are associated with both affluence and keeping track of finances, in conjunction

The evidence supporting this theory is as follows:

- Financial Literacy - When combined with affluence, the higher the numerical understanding the more likely the individual is to keep track of their finances. 21% of those who are affluent and keep track of their finances are highly numerate compared to 10% of those with low numeracy scores.

4.5 Higher numeracy skills indicate keeping up with bills is less burdensome

The evidence supporting this theory is as follows:

- A moderate level of numerical understanding seems to be required to make keeping up with bills easier.
- Likewise, lower numeracy skills are associated with more burdensome experiences.
- Financial Capability - c1– those with no qualifications were most likely to claim this a heavy burden – 21% said it was compared to 12% of those with qualifications. In all three of the 'skills' questions, those who got the answer wrong were significantly more likely to claim that keeping up with their bills and credit a heavy burden.

4.6 Higher numeracy skills are associated with an ability to pay off major expenses and settle bills in full

The evidence supporting this theory is as follows:

- Significantly more individuals could pay off a major expense if they possessed more than a "moderate" level of understanding, than those with lower abilities.
- Those who answered the question related to 'Interest' were significantly more likely to pay in full each month when settling bills.
- Financial Capability - E10– Those with very high numeracy scores are most likely to pay their bills off in full each month. Those with low numeracy scores are most likely to make the minimum payment (73%).

4.7 Lower numeracy skills are associated with lower levels of progression within education

The evidence supporting this theory is as follows:

- Significantly more likely to be highly numerate if you have been to university.
- More likely to possess poorer numeracy skills with less education involvement.
- Financial Literacy - 54% of the very high numeracy group was made up of university graduates compared to just 13% of very low numeracy.
- Those with very low numeracy were most likely to come from the group which had only completed secondary school (42%) which was significantly lower than the 31% average.
- Financial Capability N1 – those with a degree were significantly more likely than those with no qualifications to get this question correct (68% vs 28%) with the same pattern being seen in N2 and N3.

4.8 In addition, less educated individuals are associated with greater financial distress

The evidence supporting this theory is as follows:

- FCA/University of Nottingham findings from the WAS survey[6] -> those individuals with just an A-Level education are more likely to have 'high cost credit' (64%), whereas just 9% of Degree-educated individuals use payday loan options.
- Financial Capability E6 – For all three questions, those who answered correctly were less likely to use payday loans, 11% of people who use answered the 'read bank statement correctly' compared to 5% who answered incorrectly.
- However, people who had qualifications were more likely to use payday loans than people with no qualifications (7% vs 1%).

4.9 In general, females are more likely to have lower numeracy skills than males

The evidence supporting this theory is as follows:

- Financial Literacy - the low numeracy group was made up of 37% males and 63% females.
- Financial Capability- males were significantly more likely to answer the 'savings' and 'inflation' skills questions and the 'Interest plus principle' question correctly. Although no significant difference was found in the bank statement question.
- Nationwide – Using the logic of inference from theory 4.13, we deduce that males (86%) are much more likely to be financially aware than females (14%); and, conversely, females are much more likely to be financially unaware than males, by the same proportions.
- Nationwide – Females (57%) are more likely to be considered "financially not stable" than males (43%).

4.10 Lower numeracy skills are associated with unemployed individuals

The evidence supporting this theory is as follows:

- No significant support in Financial Literacy – although those who had a high numeracy score were least likely to be unemployed.
- Financial Capability - N1 - unemployed people were the least likely to get this question correct (67%) compared to 82% of employed people. Unemployed people were also least likely to answer N2 and N3 correctly.

4.11 Lower numeracy skills are associated with impulsivity in spending

Supported by:

- Those who disagree with the statement "Before I buy something I carefully consider whether I can afford it" are more likely to possess lower numeracy skills.

  - They were also significantly more likely to get the question relating to 'Inflation' wrong.
  - Financial Literacy QF10_1 - 35% of people with very low numeracy skills agreed with this compared to 7% of those with very high numeracy.
  - Financial Literacy 24% of those who got the inflation question wrong disagreed with this statement compared with 12% who got the question correct.

- Financial Capability - o4_1 – Those who disagreed to the statement 'I often buy things on impulse' were significantly more likely to get the answer to n2 and n3 correctly. 57% of people who answered the savings and inflation question correctly disagreed whereas 49% of people who answered incorrectly disagreed.
- Nationwide – Almost all of those considered "risk takers" (96%) check against multiple sources before purchasing decisions, compared to just 24% of those considered "risk averse".

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[6] See footnote 5

4.12 Lower numeracy skills are associated with delays in bill payment

The evidence supporting this theory is as follows:

- The majority of those disagreeing with the statement "I pay my bills on time" possess low numeracy skills.

  - The higher the numerical understanding the more likely agreement with the statement occurred.
  - Financial Literacy QF10_4 – Those with very low numeracy scores were most likely to disagree with this (24%).
  - Financial Literacy Those with very high numeracy scores were most likely to agree (93%).

- Financial Capability - E10– moderate evidence for this, when asked how much of their bills they pay off each month. Those who answered the 'interest plus' question correctly was more likely to pay off the whole amount (43%) compared to 36% of people who answered it incorrectly. (As in 4.6)

4.13 Higher numeracy skills are associated with a greater knowledge of financial matters

The evidence supporting this theory is as follows:

- Individuals are significantly more likely to state their knowledge of financial matters as "high" if their numerical understanding is also high.
- In contrast, lower knowledge is associated with poorer numerical understanding.
- Financial Literacy QK1 – Those with very high numeracy scores were most likely to report high knowledge (46%) compared to 31% average.
- Nationwide – 99% of respondents who were considered "financially aware" agreed with the statement "it is important to be well informed about things"; whereas only 56% of those who were "financially unaware" agreed. As financially aware respondents were more likely to have scored Level 2 on the Check-Up, and, by extension, achieve Green on the Screener (and due to the strong inter-dependence of these results), we can say with a degree of confidence that numeracy has helped nurture strong financial awareness.

- Nationwide - In addition, those who are financially stable are more likely to read the financial pages in newspaper (45%) than those considered financially not stable (13%) – indicating wider reading is contributory to their financial stability.
- Nationwide - Those with a greater financial awareness are more likely to "thoroughly research products before buying them" (65%) than those who are financially unaware (25%).
- Nationwide – Risk takers, with a good numerical understanding, are more likely to read the financial pages in the newspapers (55%) than risk averse individuals (21%).

4.14 Higher numeracy skills are associated with fewer financial difficulties

The evidence supporting this theory is as follows:

- Less likely to have experienced financial difficulties with higher skills in numeracy.
- More likely to experience financial difficulties if numeracy is poor.
- Financial Literacy QF11 – Those in the high numeracy score group were least likely to report that at some point in the last 12 months they had not been able to cover their living costs (21%), significantly less that the 31% of the low numeracy scores group.
- Financial Capability - C2– When asked if they had fallen behind on, or missed, any payments for credit commitments or domestic bills, there was a significant difference found with all three knowledge questions. Those who got the questions incorrect being more likely to miss payments than those who answered the question correctly. For instance, 21% of people who answered the 'read bank statement incorrectly said they had fallen behind on some payments compared to 12% of people who answered the question correctly.

- FCA Occasional paper – those with better education are less likely to have dangerous[7] DTIs (Debt to income ratios.
- Nationwide – 27% of those considered to be "not in control" financially have recently used their overdraft, compared to just 2% of those "in control".

4.15 Higher numeracy skills are associated with better management of income and expenditure

The evidence supporting this theory is as follows:

- Those with higher levels of numeracy are significantly more likely to say their approach works very well.
- Those of lower abilities find it more challenging to develop an approach that works well.
- However, high numeracy skills are contributory but not guaranteed to provide an effective approach to income and expenditure.
- Financial Capability - I8 –Those who answered all three questions correctly were significantly more likely to rate their approach as 8-10 on a ten-point scale than those who answered the question incorrectly. The most sizable difference was with the question involving 'savings and inflation', where 61% of people who answered this question correctly reported their approach to keeping track of spending to be 8-10 out of ten compared to 45% of people who answered this question incorrectly.

4.16 Lower numeracy skills are associated with a reduced likelihood to save money

The evidence supporting this theory is as follows:

- The lower the numeracy skills the more likely saving is a behavioural rarity.
- Financial Literacy FC-G3 – Those with high numeracy scores are most likely to save every month (41%) and those in the low numeracy scores least likely (31%).

- Financial Capability - G2 – When asked if they saved some money each month, those with a graduate qualification were most likely to say yes (65%) compared to 21% of people with no qualifications. So 79% with no qualifications said they were not saving each month. This was further supported by the answers to all three skills question which showed significantly more people getting the answer correct, also saved every month (In the interest plus question this was 59% vs 52%).
- Nationwide – 92% of those who are "in control" financially agree they "hate to borrow and would rather save up in advance", compared to 68% of those who are "not in control".

4.17 Lower numeracy skills are associated with greater worries for basic costs of living

The evidence supporting this theory is as follows:

- Low numeracy skills associated with agreement with the statement "I tend to worry about paying my normal expenses".
- High numeracy skills associated with disagreement with this statement.
- Financial Literacy QF10_10 – 26% with high numeracy scores agreed, which was significantly lower than the 39% with low numeracy scores.
- Financial Capability - O2_2 –- Those who agreed with the statement "Thinking about my finances makes me anxious" were significantly less likely to get the three skills'/knowledge questions right. Those who disagreed were most likely to have a university education. N2 – those who got the question wrong were much more likely to say that their finances made them anxious.
- Strong support for this. 63% of people who said "financial situations make me anxious" got the interest savings correct compared to 72% of people who disagreed.

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[7] Dangerous DTIs (regardless of income) are those identified in the August 2016 occasional paper as the level at which a group is suffering or will soon be suffering financial and emotional distress.

4.18 Lower numeracy skills are associated with lower confidence in managing money

The evidence supporting this theory is as follows:

- Financial Capability B3 - When asked "How confident do you feel managing your money?" 57% of those who answered the savings and inflation correctly ranked their confidence as 8-10 out of ten compared to 45% of those who answered it incorrectly.
- A similar pattern was also seen when respondents were asked "How confident do you feel making decisions about financial products and services?" There was a significant difference in all three of the skills questions. 45% of those who answered the interest plus question correctly rated themselves an 8-10 for confidence compared to 34% of those who answered incorrectly.

4.19 Higher numeracy skills are associated with a stronger ability to delay reward

The evidence supporting this theory is as follows:

- Financial Capability. Those who were highly numerate were much more likely to take the £400 in two months than those who were less numerate-shown with significant differences in all three questions and in the three qualification groups.

  - For instance, 83% of those who correctly answered the bank statement correctly opted to take the money in 2 months compared to 54% of those who answered this question incorrectly.

5.   Exploratory Analyses

Cross-tabulations and the literature review were both useful for identifying theories, but this surface-level analysis alone was not enough to properly establish whether these theories hold water. Further statistical inferences can explore the true differences in and between datasets and more thoroughly put theories to the test.

As the Financial Literacy questionnaire was designed to assess aspects of both financial capability and of financial numeracy, and thus providing a link between the two concepts, this was the more obvious dataset to conduct further analysis on. In addition to Critical's full understanding of the dataset having conducted the research, the reasonable sample size (n=1000) also made it a suitable candidate for further analysis.

5.1   Distribution Overview

Having selected the dataset to experiment with, its distribution was inspected to identify any potential skews within the data (Figure 3). A simple banding exercise on the composite numeracy scores, mentioned earlier in this report (3.2.4 , found that there were indeed certain groupings within the data that could have an effect on further analyses. Four distinct "spikes" in the distribution were found. These spikes, or *sub-groups*, were defined by grouping (in 10s) the aggregated numeracy scores, as shown in Figure 3 below.
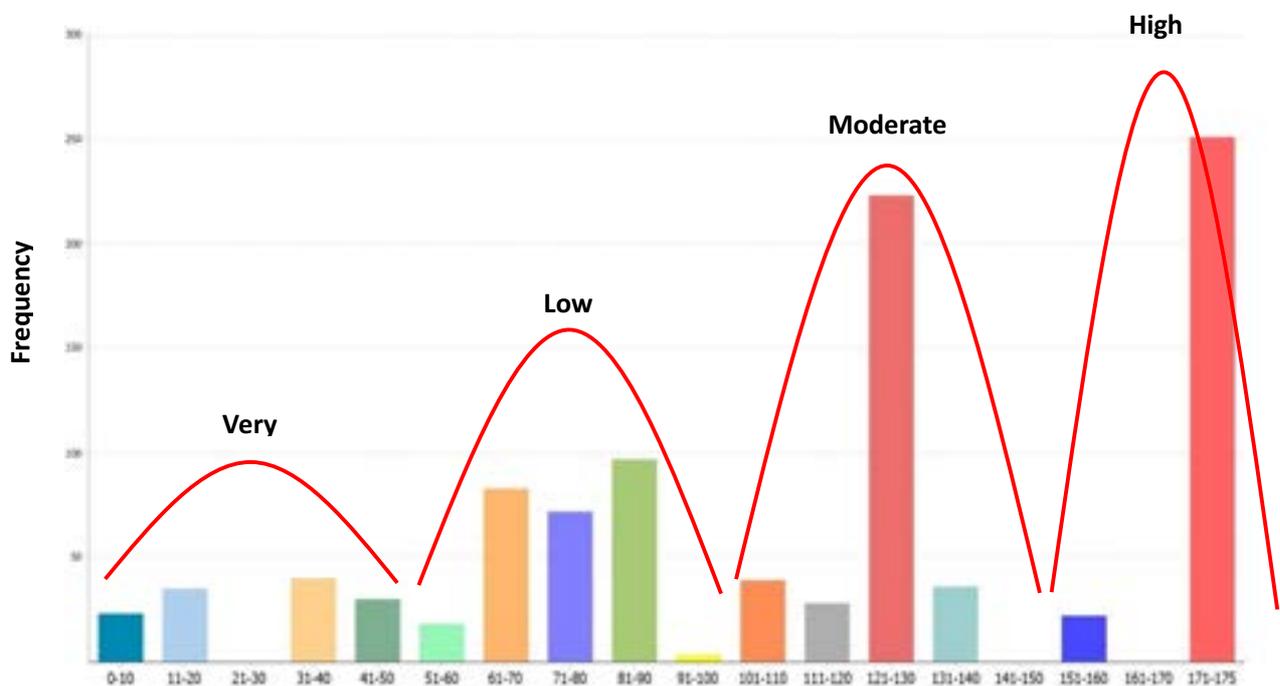
Figure 3. Frequency distribution plot of composite numeracy scores within the Financial Literacy dataset.

As a result of this distribution, it was theorized that individuals within each of these four sub-groups may possess unique attributes that would distinguish them from other sub-groups, and so any links to suggest financial capability in subsequent analyses could be more easily spotted amongst these sub-populations.

Additionally, it is also useful to separate the data in this way so that any conclusions could be drawn about these individual sub-populations which could help inform policy decisions for these groups. For example, the *Very low* group (those at the lower end of the numeracy spectrum who are associated with financial vulnerability) could be ring-fenced and more easily prescribed potential solutions.

The numeracy score parameters for allocating sub-groups needed to leave robust enough sample sizes to be used within analysis, whilst recognising real distinctions within the overall population. To achieve this, the data was divided along the following boundaries:

High Numeracy Skills — Aggregated Score of **151-175 out of 175** (n=273), with a Mean Numeracy Score of **171** out of 175.

Moderate Numeracy Skills — Aggregated Score of **101-150 out of 175** (n=326), with a Mean Numeracy Score of **123** out of 175.

Low Numeracy Skills — Aggregated Score of **51-100 out of 175** (n=273), with a Mean Numeracy Score of **74** out of 175.

Very Low Numeracy Skills — Aggregated Score of **0-50 out of 175** (n=128), with a Mean Numeracy Score of **27** out of 175.

5.2   Statistical Analysis Outline

For statistical analyses to deliver meaningful results, the data used must first lend itself to the type of analysis that is asked of it. The statistical analysis took three forms:

CHAID Analysis

A data classification technique that develops a "tree-like" system, which organises the data in such a way as to highlight the key *discriminating* criteria within the given dataset. This is a relatively quick method of deconstructing groups within the data to identify the attributes which describe the most important differences, and hence guide subsequent analyses (such as Principal Component Analysis).

Principal Component Analysis

Primarily a data reduction technique, whereby data is fed into a statistical model on a variable-by-variable basis to ascertain the *key driving forces* within the data. The aim of the Principal Component Analysis exercise is to identify '*components*', or underlying themes within the dataset that are able to explain differences. Combined with the CHAID analysis, this is a powerful tool to help identify key variables that may be contributing to differences within the data as a whole as well as between different sub-groups.

Multiple Linear Regression Analysis

Multiple Linear Regression attempts to understand the relationship between a predicting variable, in this case Numeracy score, and response variables, such as demographics, behaviour and attitudes, that may be driving factors and predictors of numeracy. It is a statistical trade-off, of sorts, and investigates the degree of difference within a given dataset to determine which variables are having the largest effect. The eventual outcome of a regression model is to discover the relative contribution of 'independent' variables as predictors of our dependent variable – in our case Numeracy score.

5.3   CHAID

The CHAID analysis involved two preliminary stages: distribution review and variable selection.

5.3.1   Distribution Review

After running an initial four-way[8] CHAID exercise for the overall population exploring discriminating criteria across all four sub-groups (see Appendix 1, Figure 4), it became clear that by combining sub-groups into simpler groupings was going to be a useful way of viewing the dataset. The corresponding sample sizes for each group were still sufficiently large to help identify top-order differences, however when viewing the "tree" at deeper levels, the sample sizes for four-way sub-groups were diminishing too rapidly through the "branches" to be considered reliable.

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[8] The 4 ways were based on our four identified Numeracy sub-groups

A larger sample size in statistical analysis is always preferred, and so the decision was made to combine the four sub-groups into two sub-groups – namely "*higher numeracy*" (or "H/M", i.e. combining High and Moderate groups) and "*lower numeracy*" (or "L/VL", i.e. combining Low and Very Low). Whilst this did reduce granularity, in doing so, it allowed discriminating criteria to be identified at opposite ends of the numeracy scale.

As a result of the regrouping, parameters in numeracy scores were shifted to the following boundaries:

Higher numeracy	Aggregated Scores of 101-175 out of 175 (n=599), with a Mean Numeracy Score of 141 out of 175.
Lower numeracy	Aggregated Scores of 0-100 out of 175 (n=401), with a Mean Numeracy Score of 60 out of 175.

5.3.2   Variable Selection

To a large extent, the statistical techniques applied to the data were determined by the nature of the variables included within the Financial Literacy questionnaire. The most useful question types to use within a CHAID analysis are typically those pertaining to demographic attributes, such as *Gender*, *Age*, *Working Status*, etc. Behavioural variables can also be used within this method, making it possible to test certain financial behaviours within the CHAID model. However, the greatest benefit of using CHAID (and its associated emphasis on demographics) is the ability to profile and control for certain circumstantial attributes within the data, so that conclusions reached can be

based on differences beyond those described by simple demographics.

5.3.3   Methodology

Having re-grouped the data into the two numeracy sub-groups, a first CHAID analysis was run on the total population using all the main demographic variables within the study questionnaire - *Education, Age, Gender, Nation, Salary, Working Status* and *Household Composition*. Analyses were then run, using the same demographic variables, on each of the sub-groups, in turn, to identify key discriminators within sub-groups. In a further exploratory step, the three populations (overall, higher and lower) were re-run against both those demographic variables that had been found to be useful discriminators (education, age, gender and salary) and behavioural variables, to see if certain behavioural elements would be found to be a discriminator.

Key behavioural traits that were used in these separate analyses were the tendency to *Keep Track* of finances, and the setting of financial *Goals* - widely recognized as strong indicators of a financially-conscious individual.

For the purposes of CHAID, these were selected as reliable proxies of wider financial behaviour as a whole. Tree diagrams of note have been included in the Appendix section. [9]

5.3.4   CHAID Interpretation

Total (Two Way) Population Observations

From the two-way (*Higher numeracy* vs *Lower numeracy*) analysis on the total population,[10] it is clear that *Education* is the demographic variable with the highest degree of discrimination within the dataset. Within each of the educational nodes, there are a number of sub-discriminators that demonstrate differences within each of the educational levels – for example, this suggests that

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[9] The output of these CHAID trees are found in Appendix 1: CHAID runs

[10] See Figure 5Figure 5 in Appendix 1: CHAID runs

amongst those who are University educated, *Age is* the next most discriminatory attribute, and so on.

When looking at the population as a whole, those who stayed in education to a University or a Technical or Vocational level are more likely to score at the upper end of the numeracy score scale compared to those who completed Secondary school only or below.

When the behavioural variables of *Keeping track* and *Goals* were factored into the overall population model,[11] *Education* still remained the most discriminatory factor within the dataset – but the sub-discriminators on the secondary level have been displaced by *Keeping track*, regardless of *Education* type. This suggests that *Keeping track* is important to understanding the disparity in numeracy scores within the total population.

Amongst certain educational types there were tertiary branches of the CHAID solution, indicating further differences with respect to *Gender* and *Salary*. This indicated that sub-populations are clearly operating within the data, each with their own attributes and points of interest.

To summarise: when exploring differences between *Higher numeracy* and *Lower numeracy* groups, *Education* is the key discriminator alongside *Keeping track* of finances. Furthermore, *Age* is an important within-group differentiator. At a lower level, *Gender* and *Salary* may also help explain differences.

Sub-Population Observations

Within the *Lower numeracy* sub-group, *Education* was again the most discriminating variable amongst the demographics[12], although the tree displayed a difference between those of Secondary level education and above, and those without a Secondary education. Those with higher levels of education were more likely to possess Low

numeracy skills than those who had not completed Secondary school, where the scores were more mixed. Given the context of the population (lower numeracy scores, in general), the fact that the education division occurs at the point of completing Secondary school suggests that education has a major bearing on whether or not numeracy scores are considered *Very Low* or just *Low*, and indicates its importance in the process of developing competency.

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[11] See Figure 8 in Appendix 1: CHAID runs

[12] See Figure 6 in Appendix 1: CHAID runs

Within the highly educated group[13], *Salary* and *Age* were found to be sub-discriminators on the secondary and tertiary levels respectively, meaning that education may not always be the chief determinant of numerical ability.

Interestingly, when factoring in *Keeping track* and *Goals* amongst the *Lower numeracy* sub-group,[14] *Keeping track* in fact displaced *Education* as the most discriminatory criteria within the sub-population, highlighting the complexity of the relationship with numeracy scores.

Amongst the *Higher numeracy* sub-group,[15] *Education* was the main discriminating force. The three-way split of the education node, and the distributions by education type, imply that only around Secondary level education and below do chances of achieving a high numeracy score fall, as levels of Moderate and High numeracy are significantly more mixed when examining the upper levels of education, by comparison. Again, the correlation with numeracy score is shown to be multi-dimensional, and is complicated by factors such as *Gender* for the University educated node, and *Salary* level for the less educated.

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[13] See in Figure 6 in Appendix 1: CHAID runs

[14] See Figure 9 in Appendix 1: CHAID runs

[15] See Figure 7 in Appendix 1: CHAID runs

5.3.6 CHAID Conclusions and the Link to Postulated Theories

The emergence of *Keeping track* as a key sub-discriminator in the analysis of the overall population suggests **Theory 4.3 does have traction** as a hypothesis. As *Keeping track* appeared as the key discriminator in the *Lower numeracy* sub-group, and hence is deemed a make-or-break criterion between *Low* and *Very Low* numeracy scores, it suggests that an ability to keep track of finances is of significance to the numeracy-financial capability relationship, in some capacity. Moreover, although *Keeping track* was not noted as a key discriminator within the *Higher numeracy* sub-group: it's absence could suggest that those with higher numeracy skills have already adopted such a behaviour, and so there is limited basis to discriminate based on this criterion. This perhaps lends further support for Theory 4.3, as those with higher numeracy scores could have benefitted from *Keeping track* to achieve such a score.

The related **Theory, 4.4 also has support** due to this particular observation. Although *Keeping track* did not feature in the *Higher numeracy* group as a key discriminating criterion, and if we assume this is because those in this sub-group have adopted healthy financial behaviour such as *Keeping track* of finances, thus contributing to their numeracy scores, *Salary* (a pre-cursor for affluence) was identified as a sub-discriminator for Technical and Vocational education types. However, *Salary* only appears as a discriminator after *Education* on the primary level, and does not feature amongst any other education types. This suggests that, although affluence and *Keeping track*, in conjunction, may have some impact amongst particular sub-populations, the evidence is inconclusive.

When factoring in financial *Goals* as a variable across all three populations, it did not appear as a key discriminator at all, **this does not help support Theory 4.1**. Although setting financial goals may be an admirable trait of a financially-conscious individual, the CHAID seems to show that it is

unlikely to play a significant role in the relationship with numeracy.

Theory 4.7 was also considered using our CHAID exercises, and was demonstrated to have **a fair degree of support.** Judging from the distributions across all populations, those respondents achieving lower numeracy scores were more likely to be found within the nodes pertaining to unfinished Secondary school or Secondary school education only. Additionally, given the break-point in numerical ability at Secondary school level once *Keeping track* is taken into account, this suggests that lower numeracy skills are indeed associated with lower levels of progression within education.

Gender disparities were found between High and Moderate numeracy skill levels amongst the *Higher numeracy* sub-group – which **could lend support for Theory 4.9.** Females were more likely to achieve a *Moderate* numeracy score compared to Males, who were more likely to achieve a *High* numeracy score. However, this observation is made within the context of University educated individuals only, and it is only made clear within the wider context of the sub-group as a whole, that the disparity in *Gender* is unique to this sub-population. This could suggest that the theory needs to be refined to reflect education levels.

Some support was found for Theory 4.10 in the CHAID exercise. Within the overall population, *Working Status* was a sub-discriminator within the sub-population who have only completed education to Secondary school level. More respondents who completed Secondary education were designated in the *Lower numeracy* sub-group if they were not currently employed, in contrast to those who worked being more likely to appear in the *Higher numeracy* sub-group. *Employment* may well be a discriminating factor for other education types, but other demographic circumstances take higher precedence.[16]

In summary, the CHAID demonstrated support was found for Theories 4.3, 4.4, 4.7, 4.9, and 4.10. There appeared to be less evidence for Theory 4.1.

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[16] See Figure 5Figure 5 in Appendix 1: CHAID runs

5.4 Profiling and control using CHAID

The CHAID exercise also highlighted that not only were there differences in Numeracy levels across the whole population, there was also a distinct group of people with lower numeracy levels. It was also clear across multiple CHAID runs that *Education* was the attribute with the most observable differences, particularly at the overall level.

For the purposes of the roundtable, relationships occurring at sub-group level may be of greater interest – in particular those at the lower end of the numeracy score scale, who may be more likely to be classed as more "financially vulnerable". The *Lower numeracy* sub-group may require further ongoing scrutiny and insight, especially as a talking point of the roundtable is expected to be to alleviate barriers and to promote financial confidence and competence.

As there are a variety of sub-populations occurring within the Financial Literacy dataset, each with different trade-offs with respect to numeracy as the dependent variable, profiling and controlling for these differences in the population is a necessary step to take before continuing with analysis.

5.4.1 Primary Discriminator - Education

The CHAID analyses showed it was possible to identify those variables that are likely to be the main discriminators of numeracy score i.e. the variables that identify the greatest differences in Numeracy score across different groups of respondents.

In each of the demographic-only CHAID analyses, *Education* was found to be the key discriminator – as illustrated in Table 1 below. Whilst the overall mean Numeracy score across the Financial Literacy study population was estimated at 103 out of 175, those with a University education possess an average mean score of 122, compared with those with a Secondary-level education who had an average score 92**.** The small proportion of the study population who, in education terms, are classed as Secondary / Non Complete (5%) had a yet lower mean Numeracy score of 81. The range clearly demonstrates a correlation between *Education* and *Numeracy*.

DESCRIPTORS	Overall Profile (%)	Overall Mean Score	Higher Group Profile (%)	Higher Mean Score	Lower Group Profile (%)	Lower Mean Score
Overall (%/Score)	100	103.2	53.6	140.4	46.4	60.2
EDUCATION						
University	30	121.6	39	147.3	20	63.7
Technical/Vocational	30	105.9	31	139.3	29	64.6
Secondary	32	91.6	26	133.3	39	59.5
Secondary/ Not Complete	5	81.4	4	130.6	7	51.2
Profile Adjusted	-	-	-	135.2	-	60.1

Table 1. Profiles and mean numeracy scores for the primary node Education

When examining the Numeracy relationship within sub-groups, the *Higher numeracy* group comprises a higher proportion with a University education (39%), compared with just 20% in the *Lower* *numeracy* group. As such, the differences in mean Numeracy scores for the groups may be partly explained by the differences in education profiles of the two groups.

Within the overall population, 30% claimed to have a University education compared with 39% of those in the *Higher* group. In index terms *Higher* are 30% more likely than the average person to have had a University education, and amongst those in the *Lower* sub-group we see they are 22% more likely than the average person to have had Secondary education. These profile differences are illustrated below, both comparing the four subgroups of *High, Moderate, Low* and *Very Low* (***Error! Reference ource not found.***), and then just the two way split *Higher* and *Lower* (**Error! Reference source not**
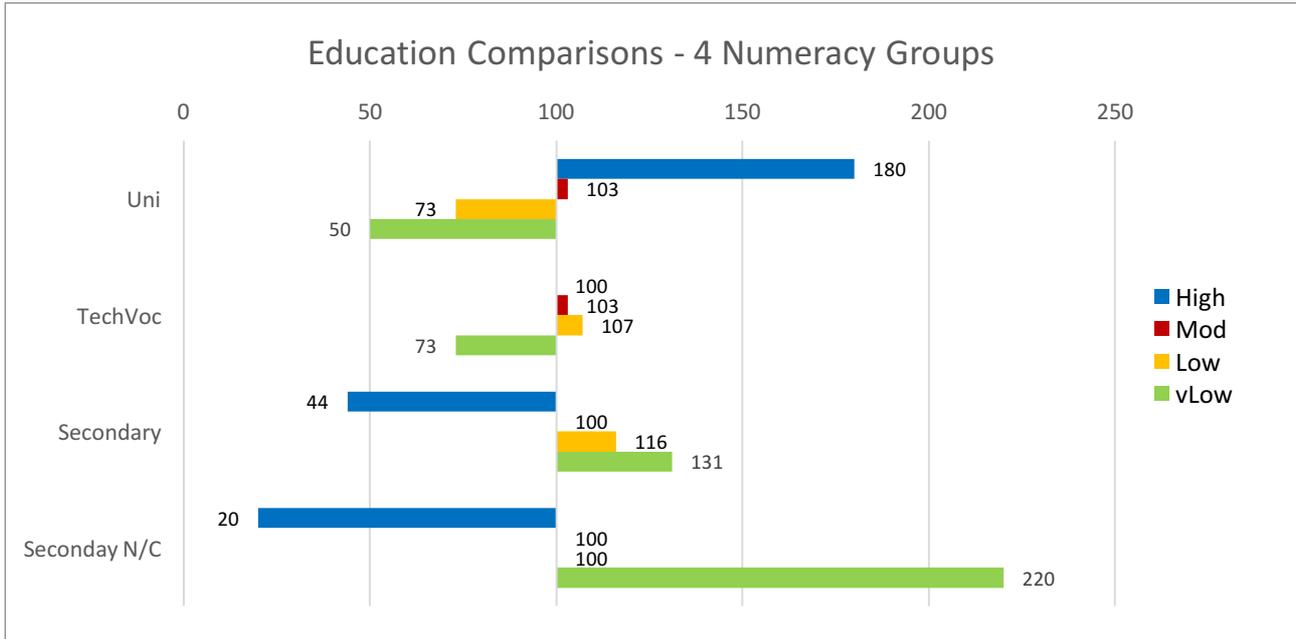

Figure 4. Comparing the four-way numeracy score split with the overall population (Index Score = 100)
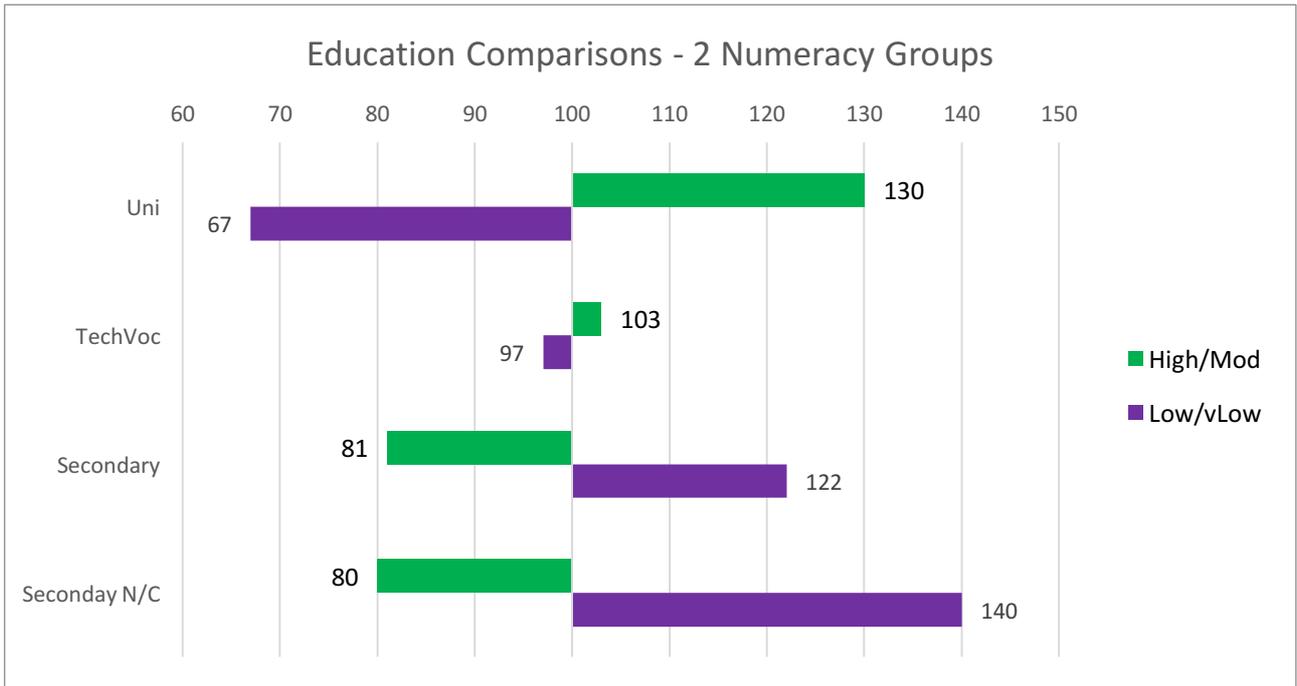

Figure 5. Comparing the two-way numeracy score split with the overall population (Index 100 = Overall)

ound.).

When controlling for profile differences it is possible to assess the impact on mean scores of the different education profiles, i.e. we can estimate what the mean group score would have been if the profile of the *Higher numeracy* group had the same educational profile as the overall population.[17]

We saw that the overall mean Numeracy score for those in *Higher* was **140** and those in the *Lower* group was **60** (see Table 1). Controlling for the differences in profiles of the two groups, we were able to estimate the mean Numeracy scores for each group if they had the same (overall population) profiles. When controlling in this way, the *Higher group* mean score came down only slightly from 140 to 135, and for the *Lower numeracy* group it remained at 60.

This is perhaps a somewhat unexpected result. However, within both our *Higher* and *Lower* groups, the mean Numeracy scores by education actually vary significantly less than in the overall population. We see amongst the *Higher* group those with Secondary education have a mean score of 133, which is only slightly below those in the *Higher* group with Technical/Vocational qualifications (mean score of 139). Similarly, amongst the *Lower* group mean scores for University respondents are 64 compared with a score of 65 for Technical/Vocational respondents.

Clearly, whilst overall education may be an important discriminator, there are still sizeable differences within educational groups. We see that the 20% of *Lower* group with a University education (c. 10% of the overall population) have a score of 64, whereas the 39% of the *Higher* group (c. 20% of the overall population) have a mean Numeracy score of more than double this (147).

This analysis of education at the sub-group level tells us that there are in fact other variables, together with *Education*, that impact on Numeracy scores.

This led us to make subsequent checks on other variables that our CHAID work had identified as likely key discriminators. We looked at *Age* (a CHAID discriminator at the secondary level), and *Gender* (a discriminator at the tertiary level). Results for these further controls were similar in conclusion to that for *Education*: the variables are discriminatory at an overall level, but within sub-groups Numeracy scores did not vary nearly as much by *Age* and *Gender*. Detailed breakdowns of the secondary and tertiary levels are found in Appendix 2: CHAID profiles

As a result, *Education* has been focused on as the primary discriminator for the purposes of this report, but subsequent analysis of nodes can be found in Appendix 1: CHAID runs

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5.5   Principal Component Analysis

With CHAID revealing some important demographic discriminators and methods for controlling them in analysis, PCA was then undertaken to identify the underlying themes within each population. These are themes that are responsible for driving the differences in how questions were answered.

In many ways PCA is a method of simplifying the data, using groups of variables which are largely independent of each other (Components) to explain differences occurring within the data. Since PCA identifies differences using attitudinal and behavioural variables, rather than demographic variables, this made it a useful technique for understanding the financial capability side of the numeracy-financial capability relationship.

Based on the existing analysis of the Financial Literacy study compiled in the report for MAS and OECD, a number of linked questions were combined together to create overall estimates for Financial Attitude, Financial Behaviour and Financial Knowledge. Whilst these measures were useful, it was also necessary to look at the underlying

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[17] In general terms, "controlling" allows specific contributing variables to be set at a known level, thus allowing the impact of other variables to be viewed more clearly

questions to help support or reject the postulated Theories.

The original questions that were combined to create Financial Attitude and Financial Behaviour are shown below:

Financial Attitudes

QF10_2. I would like to know how much you agree or disagree that each of the statements applies to you, personally… I tend to live for today and let tomorrow take care of itself

QF10_3. I would like to know how much you agree or disagree that each of the statements applies to you, personally… I find it more satisfying to spend money than to save it for the long term

QF10_8. I would like to know how much you agree or disagree that each of the statements applies to you, personally… Money is there to be spent

Financial Behaviour

QF10_1. I would like to know how much you agree or disagree that each of the statements applies to you, personally… Before I buy something I carefully consider whether I can afford it

QF10_4. I would like to know how much you agree or disagree that each of the statements applies to you, personally… I pay my bills on time

QF10_6. I would like to know how much you agree or disagree that each of the statements applies to you, personally… I keep a close personal watch on my financial affairs

QF10_7. I would like to know how much you agree or disagree that each of the statements applies to you, personally… I set long term financial goals and strive to achieve them

QF2. And, does your household have a budget?

QF3. In the past 12 months have you been [personally] saving money in any of the following ways, whether or not you still have the money?

QPROD2. And which of the following statements best describes how you made your choice [for this financial product]?

QPROD3. And which sources of information do you feel most influenced your decision (about which financial product to take out)?

QF12. What did you do to make ends meet the last time this happened [regarding greater expenditure than income]?

To ensure an we could cover many of the attitudinal variables within the dataset when exploring the data using PCA with the limitations of the sample size available to investigate differences, the data needed to be sorted in a way that may help us to explore the differences of response to these attitudinal and behavioural questions. Response categories were organized into larger sub-groups (e.g. comparing those who "agree" with those who "disagree" rather than looking at all the different levels of agreement), otherwise the distribution of respondents across the answer codes would become too stretched and sample sizes would be reduced too significantly to be reliable.[18]

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[18] On occasion, if combining the responses in this way did not deliver sufficiently populous groupings, then a new grouping structure to split the data was trialled, such as grouping all those who "Agree strongly" and all those who did not "Agree strongly". Binary groupings such as this are usually the most effective way of preparing data for PCA by maximising sample size.

5.5.2　Methodology

Using the large sample size for the overall population (1,000), the PCA was run to link variables into combining 'components' which, when grouped together, help explain the variance in the dataset. A further explanation of the PCA solution method used is described in Appendix 3: Principal Components Analysis Methodology

The components for the overall population are detailed in Table 2, together with the comparative weights of those key variables (questions) that combine to create each independent component, showing the relative 'importance' of variables to each.

As with our CHAID analyses we ran a number of PCAs – testing a number of different variables, both attitudinal and behavioural, and looked at different solutions – some analyses suggested four or five Component solutions to help explain differences within the datasets, others more. By looking at the amount of variance explained by different solutions, and by the variable content of the individual components we assessed the likely 'usefulness' of the different solutions. We have reported those solutions we deemed most powerful when considering our 'Overall', 'Higher' and 'Lower' groups.

Having also established that sub-populations were present within the data (chiefly *Higher numeracy* and *Lower numeracy*), PCA was then run to identify further independent variables for the regression stage for the *lower numeracy* sub-group (n=401), and then the *higher numeracy* sub-group (n=599). The components identified by the sub-group analyses are in Table 2, Table 3 and Table 4 below.

Component 1: "VIGILANCE"	Component 2: "GOALS"	Component 3: "FINANCIAL DIFFICULTY"	Component 4: "IRRESPONSIBLE SPENDING"	Component 5: "BEST-BUY LITERATURE"	Component 6: "SAVVY SOURCES"
FQF10_6. I keep a close personal watch on my financial affairs - Keeping track WEIGHT 0.927	**FQF5.** "Setting of Goals" WEIGHT 0.933	**FFC_C1.** To what extent do you feel that keeping up with your bills and credit commitments is a burden? WEIGHT 0.771	**FQF10_3X.** I find it more satisfying to spend money than to save it for the long term WEIGHT 0.752	**FQPROD3_2B.** And which sources of information do you feel most influenced your decision? [Best-buy information found on the internet] WEIGHT 0.771	**FQPROD3_2C.** And which sources of information do you feel most influenced your decision? [Specialist magazines/publications] WEIGHT 0.689
FQF10_4. I pay my bills on time WEIGHT 0.673	**FQF10_7.** I set long term financial goals and strive to achieve them WEIGHT 0.904	**FQF11.** Sometimes people find that their income does not quite cover their living costs. In the last 12 months, has this happened to you, personally? WEIGHT -0.717	**FQF10_2.** I tend to live for today and let tomorrow take care of itself WEIGHT 0.728	**FQPROD3_2A.** And which sources of information do you feel most influenced your decision? [Best-buy tables in financial pages of newspapers/ magazines] WEIGHT 0.731	**FQPROD3_2D.** And which sources of information do you feel most influenced your decision? [Recommendation from independent financial adviser or broker] WEIGHT 0.674
FQF10_1. Before I buy something I carefully consider whether I can afford it WEIGHT 0.561		**FQF8.** How confident are you that you have done a good job of making financial plans for your retirement? WEIGHT 0.668	**FQF10_8.** Money is there to be spent WEIGHT 0.715		
Proportion of Variance Explained by Component 1: 16.24%	**Proportion of Variance Explained by Component 2:** 11.07%	**Proportion of Variance Explained by Component 3:** 10.78%	**Proportion of Variance Explained by Component 4:** 10.36%	**Proportion of Variance Explained by Component 5:** 7.91%	**Proportion of Variance Explained by Component 6:** 7.42%

Table 2. Components identified from the <u>total population</u> PCA. This analysis used attitudinal and behavioural variables only.

Component 1: "VIGILANCE"	Component 2: "GOALS"	Component 3: "IRRESPONSIBLE SPENDING"	Component 4: "FINANCIAL DIFFICULTY"	Component 5: "CONFIDENCE"
FQF10_6. I keep a close personal watch on my financial affairs - Keeping track WEIGHT 0.923	**FQF5.** "Setting of Goals" WEIGHT 0.926	**FQF10_3X.** I find it more satisfying to spend money than to save it for the long term WEIGHT 0.747	**FFC_C1.** To what extent do you feel that keeping up with your bills and credit commitments is a burden? WEIGHT 0.72	**FQF1.** Who is responsible for making day-to-day decisions about money in your household? WEIGHT 0.744
FQF10_4. I pay my bills on time WEIGHT 0.667	**FQF10_7.** I set long term financial goals and strive to achieve them WEIGHT 0.869	**FQF10_2.** I tend to live for today and let tomorrow take care of itself WEIGHT 0.739	**FQF11.** Sometimes people find that their income does not quite cover their living costs. In the last 12 months, has this happened to you, personally? WEIGHT -0.668	**FQK1.** Could you tell me how you would rate your overall knowledge about financial matters compared with other adults in the UK? WEIGHT 0.689
FQF10_1. Before I buy something I carefully consider whether I can afford it WEIGHT 0.641		**FQF10_8.** Money is there to be spent WEIGHT 0.711	**FQF8.** How confident are you that you have done a good job of making financial plans for your retirement? WEIGHT 0.628	
Proportion of Variance Explained by Component 1: 19.36%	**Proportion of Variance Explained by Component 2:** 12.98%	**Proportion of Variance Explained by Component 3:** 11.61%	**Proportion of Variance Explained by Component 4:** 11.24%	**Proportion of Variance Explained by Component 5:** 8.55%

Table 3. Components identified from the Lower numeracy sub-population PCA. This analysis used attitudinal and behavioural variables only.

Component 1: "VIGILANCE"	Component 2: "GOALS"	Component 3: "FINANCIAL DIFFICULTY"	Component 4: "IRRESPONSIBLE SPENDING"	Component 5: "BEST-BUY LITERATURE"	Component 6: "AUTONOMY"
FQF10_6. I keep a close personal watch on my financial affairs - *Keeping track* WEIGHT 0.952	**FQF5.** "Setting of Goals" WEIGHT 0.949	**FFC_C1.** To what extent do you feel that keeping up with your bills and credit commitments is a burden? WEIGHT 0.802	**FQF10_3X.** I find it more satisfying to spend money than to save it for the long term WEIGHT 0.763	**FQPROD3_2B.** And which sources of information do you feel most influenced your decision? [Best-buy information found on the internet] WEIGHT 0.792	**FFC_F2.** Which of these best describes how accurately you know the balance on this account? WEIGHT 0.76
FQF10_4. I pay my bills on time WEIGHT 0.641	**FQF10_7.** I set long term financial goals and strive to achieve them WEIGHT 0.92	**FQF11.** Sometimes people find that their income does not quite cover their living costs. In the last 12 months, has this happened to you, personally? WEIGHT -0.729	**FQF10_2.** I tend to live for today and let tomorrow take care of itself WEIGHT 0.751	**FQPROD3_2A.** And which sources of information do you feel most influenced your decision? [Best-buy tables in financial pages of newspapers/ magazines] WEIGHT 0.774	**FQF1.** Who is responsible for making day-to-day decisions about money in your household? WEIGHT 0.666
		FQF8. How confident are you that you have done a good job of making financial plans for your retirement? WEIGHT 0.701	**FQF10_8.** Money is there to be spent WEIGHT 0.687		
Proportion of Variance Explained by Component 1: 15.87%	**Proportion of Variance Explained by Component 2:** 12.04%	**Proportion of Variance Explained by Component 3:** 11.76%	**Proportion of Variance Explained by Component 4:** 11.09%	**Proportion of Variance Explained by Component 5:** 8.49%	**Proportion of Variance Explained by Component 6:** 7.62%

Table 4. Components identified from the Higher numeracy sub-population PCAs. This analysis used attitudinal and behavioural variables only.

5.5.3 Total Population Observations

Referring to Table 2, the components can be grouped under themes as follows:

Vigilance

Variables under Component 1 were responsible for explaining the highest proportion of variance (16%) in the overall population, and were related to the theme of being vigilant with regard to financial affairs. As noted in the CHAID analysis phase, *Keeping track* was viewed as a good sign of a financially conscious individual. This perception holds steady in the PCA as it was strongly correlated with the concept of financial vigilance, along with making punctual bill payments and carefully considering purchases. As the most powerful set of variables for explaining differences in the overall population, the analysis suggests that the adoption of these healthy financial behaviours (or indeed not adopting these behaviours) makes a real difference to financial numeracy.

Goals

In keeping with this observation, the related theme of setting financial *goals* and the likelihood to set them was correlated strongly with Component 2: responsible for explaining 11% of the variance. CHAID did not strongly identify *goals* as a key discriminator but the PCA shows the importance of *goals* is more pronounced. It must be remembered that PCA produces components which are generally independent of each other, so *goals* were identified and is independent of *vigilance*. Put another way, knowing an individual's *goals* score does not enable us to predict their likely *vigilance* score. It also implies that one can be financially vigilant without necessarily setting financial goals, and vice versa.

Financial difficulty

Component 3 highlighted the differences explained by *financial difficulty*, combining the themes of burdensome bill payments, expenditure exceeding income, and retirement planning. This Factor explained a further 11% of the variance, which helps us understand that sub-populations within the dataset cope with their financial circumstances in different ways.

Irresponsible spending

A similar proportion of variance was explained by a group of statements at Component 4 (10%), which together are best described as *Irresponsible Spending* or possibly short-termism. The strong correlation with this factor suggests that diverging attitudes with regards to savings and expenditure are apparent in the overall population.

Best-buy literature and Savvy sources

Components 5 and 6, which explain a further 8% and 7% of the variance respectively, related to the themes of *Best-Buy Literature* and engaging with (financially) *Savvy Sources*. This suggests that a respondent's access to (and the influence of) either best-buy guidance materials or other informed sources impacts their financial numeracy.

Altogether, these six components with an attitudinal element about financial behaviour explain 64% of the differences in the overall population.

5.5.4 Sub-Population Observations

Similar themes emerged in the sub-population PCA as to the total population; however, the proportion explained by each overlapping factor varies considerably. This suggests that whilst similar themes are at play, certain behaviours or attitudes are acting in different degrees within the two sub-groups.

Referring to Table 3 and Table 4, 19% of variance in the *lower numeracy* sub-group was explained by the *Vigilance* factor; indeed, a higher proportion than both in the overall population (16%) and in the *higher numeracy* sub-group (16%). This suggests that disparities in how individuals approached *Keeping track* of finances and *Bill payments* were the key contributors to differences between those of *Low* and *Very low* numeracy skills.

Setting *goals* was the second most important factor amongst the *lower numeracy* group, which is consistent with the findings for the total population. In addition, more differences were highlighted between the *Low* and *Very low* groups (13%) within the *lower numeracy* sub-group than in any other population (Overall 11%; *higher numeracy* 12%). This suggests that the habit of

setting financial goals is more of a factor dividing the *lower numeracy* sub-group than first thought in the CHAID.

Irresponsible Spending (Factor 3) is considered a more powerful factor within the *lower numeracy* sub-group analysis for explaining variance than *Financial Difficulty*. This contrasts with the overall population and the *higher numeracy* sub-group analysis, which suggests *Financial Difficulty* is more important than *Irresponsible Spending* in those populations. The fact that this is more of a factor in the *lower numeracy* sub-group is telling, as it suggests there is a greater chance of finding 'negative' spending habits amongst those who possess lower numeracy skills than in any other type of population.

5.5.5 New components in the sub-populations: Confidence and Autonomy

One additional component that appeared in the *lower numeracy* analysis but not in the overall or *higher numeracy* analyses was that of *Confidence* (Component 5). Explaining 9% of variance, this can be considered a noteworthy theme within the *lower numeracy* group, and raises questions over the capacity and capability to deal with financial matters amongst these respondents.

In contrast, the *higher numeracy* group divulged a factor relating to *Autonomy* (Component 6) relating to self-sufficiency and competence with certain financial aspects such as knowing account balances. The fact that a factor relating to autonomy appeared at all within the *higher numeracy* group is evidence in itself of the competence of individuals within the sub-group when it comes to financial matters. This is directly divergent to the *lower numeracy* sub-group, who appear to be dealing more with issues of *Confidence*.

Overall, five components were identified for explaining differences in the *lower numeracy* sub-group, totalling 64% of variance explained; whilst six components appeared in the analysis for the *higher numeracy* sub-group explaining 67% of the differences in the subset.

5.5.6 PCA Conclusions and the Link to Postulated Theories

The PCA demonstrated there were certain commonalities within the data, both between and within numeracy sub-groups. Given the overlap and prominence of the *Vigilance* and *Goals* factors at both of these levels, the analysis suggests that specific actions taken, or not taken, over finance management were the most important drivers throughout.

The behavioural variable of *Keeping track* held the strongest correlation in all three population analyses, which further emphasizes its significance in the wider picture. Having featured heavily in the CHAID and PCA, this suggested that an ability to keep track of finances would likely feature as a key variable in the final multivariate analyses, as well, when formally testing theories. Nevertheless, the PCA alone **lends further support for Theory 4.3** given the strong correlation of *Keeping track* within the most powerful factor of *Vigilance*.

Given the high precedence of *goals* as a discriminator within the overall population, it could be said that this is **evidence contributing to Theory 4.1.** Although g*oals* did not crop up in the CHAID analyses, this could perhaps be because it was eclipsed to some extent by the level of discrimination demonstrated by those *keeping track* of finances and those who do not. Nonetheless goal-setting behaviour has been shown in the PCA to have a good degree of bearing on differences within the overall population.

Those seeking out *best-buy literature* were theorized to be associated with higher numeracy skills in **Theory 4.2**. PCA showed that this is largely true, as differences pertaining to *best-buy literature* were not identified as a factor within the *lower numeracy* sub-group, but differences were present within the *higher numeracy* and overall analyses. Although not all respondents in the *higher numeracy* sub-group are likely to seek out *best-buy literature* to make financial decisions, the sheer absence of this behaviour as a relevant factor within the *lower numeracy groups* suggests it is only really a trait of *higher numeracy* people.

Theories relating to financial issues, be it distress (**Theory 4.8**), bill payments (**Theory 4.5** and **Theory 4.12**) or general difficulties (**Theory 4.14** and **Theory 4.18**) **were also somewhat supported** by the findings from the PCA across all three populations.

Encountering financial difficulties, in particular keeping up with bill payments (**Theories 4.5 and 4.12**), was the third most powerful factor in the whole dataset, which suggests there are clear disparities in how individuals approach their bills. These differences were less prominent amongst the *lower numeracy* sub-group however, where other factors were superior in explaining variance.

There is **additional support to Theory 4.8**. We know from CHAID analysis that less educated individuals are more likely to comprise the *lower numeracy* sub-group, and as such financial distress is a more tangible reality for those at the lower end of the spectrum. In addition to bill payment burdens, this no doubt has a knock on effect to wider fears regarding basic costs of living (**Theory 4.18**).

However, even those at the upper end of the numeracy spectrum are not immune from the challenges faced by these financial realities with *Financial Difficulty* amongst the *higher numeracy* population contributing to 12% of the variance. Consequently, it cannot be conclusively said, in this case, that higher numeracy skills necessarily go hand in hand with fewer financial difficulties (**Theory 4.14**), since *Financial Difficulty* occurs as a factor across all populations tested.

Not much support was found for Theory 4.16, relating to savings, as savings as a behavioural variable was not found to be correlated to any significant factors, across any of the populations. Indeed, it was removed during the PCA model building process due to its apparent insignificance.

PCA of the *lower numeracy* population indicated that differences in attitudes towards spending money were more prevalent in separating the data at this sub-group level than overall. Given the higher proportion of differences explained, this could imply that those with poorer numeracy skills take a more mixed attitude towards money, perhaps meaning a degree of impulsivity in this group, as discussed in **Theory 4.11**. Regardless, an outright link is not clear as a consequence of this analysis.

The absence of *Confidence* as a component in the overall population, but the presence in the *lower numeracy* sub-group, suggests that financial capability is a distinctive issue at the lower end. Variables relating to who takes decision-making responsibility and the overall knowledge of financial matters were associated with *confidence.* This could also be considered as differing levels of engagement with financial processes, which would indicate **some support for Theory 4.13**, and could **perhaps support Theory 4.18** in a more general fashion.

In summary, the PCA exploratory work indicated support for Theories 4.1, 4.2, 4.3, 4.8, and 4.13; inconclusive evidence was found for Theories 4.5, 4.11, 4.12, 4.14, and 4.18. There appeared to be no evidence for Theory 4.16.

5.6 Multiple Linear Regression Analysis

5.6.1 Rationale

Multiple Linear Regression was selected as the most appropriate technique for investigating the Financial Literacy dataset. Given the spread of variable types (attitudinal, demographic, and behavioural) present, the data lends itself to the exploring these interplays. The variables which survived the model building process were included in the final solution helped further evaluate theories.

5.6.2 Methodology

Numeracy scores for the individual respondents, developed by the inverse scoring stage during the cross-tabulations, were chosen as a continuous dependent variable. Independent variables were those to be investigated as possible predictors of numeracy. These were tested in a series of regression analyses, step-wise, against the individual numeracy scores achieved by respondents, and variables which were seen to have no significant effects were removed along the way.

The multiple linear regression analyses were first conducted on the total population (n=1000) to identify variables having an effect on numeracy scores, overall. Using the overall population meant that conclusions reached could be applied to populations examined in other studies identified by this report, and hence aid the proving, or disproving, of theories. The output of the overall population analyses found to be potentially of most interest is shown in Appendix 4: Multiple linear regression modelling

5.6.3 Interpreting the Models

The purpose of Multiple Linear Regression is to indicate whether relationships between the independent variables (attitudes, behaviours and demographics) and the dependent variable (numeracy score) are statistically significant. If they are found to be significant, the technique can establish

whether they are robust enough to be counted as evidence for our theories. Notes on the output statistics and their interpretation can also be found in Appendix 4: Multiple linear regression modelling

5.6.4 Total Population Observations

As shown by the unstandardized coefficient beta scores (in simple terms the higher the score the greater the impact on numeracy prediction), demographic variables were the more powerful predictors of numeracy score (in particular *Education*, *Age* and *Gender*).

Education level, had the greatest effect on the numeracy scores, affirming the observations of the initial CHAID analyses, and going some way to highlight the role played by education institutions in developing numeracy skills. *Age* and *Gender* were comparably less predictive measures of numeracy score.

Amongst the attitudinal and behavioural variables included (those identified in the Component Analysis – see Table 2), *Vigilance* was shown to be the most impactful for predicting numeracy scores, with an unstandardized beta score of -11.378. Within the model, *Vigilance* was considerably more powerful than *Financial Difficulty* and *Best-Buy Literature* for predicting numeracy scores, as indicated by the stronger standardized correlation coefficient (-0.242). This suggests that the attitudes and behaviours correlating with Component 1 were influential in determining numeracy skills, including the habit of *Keeping track* of finances.

Variables correlating with Component 3 (*Keeping Up with Bills*, *Confidence in Retirement Plans* and *Expenditure Exceeding Income*) were seen to have a lesser effect on numeracy scores, but were nonetheless significant within the model. Likewise, Component 5 (*Best-Buy Information* and *Best-Buy Tables*) was found to have a similar marginal effect on numeracy score differences, which implies that an individual's level of *Financial Difficulty*, and the level of engagement with *Best-Buy Literature*, are of some benefit in predicting numeracy, but other components are also contributing.

Amongst the overall population, nine independent variables were found to have an effect on numeracy score to a statistically significant degree (P<0.05). The model suggested that, individually, these small number of variables could help predict numeracy scores with up to 47.5% precision.[19] The key variables are *Education*, *Age*, *Gender*, *Vigilance*, *Financial Difficulty* and *Best-Buy Literature*.

5.6.5   Sub-Population Observations

One important difference for the regression modelling of the overall population is that, during initial modelling of the sub-populations, groupings of attitudinal and behavioural data identified by the PCA were not significant enough to be carried further into refining the model. This is may be partly because our sub-group sample sizes are significantly lower (599 and 401) resulting in notable absences of variables from the final models for both *higher numeracy* and *lower numeracy* sub-groups. It may also be because for the sub-groups some components are not as significant.

For example, PCA run on these subsets had given greater perceived importance to *Goals* than the regression models were showing; however, this component grouping was slowly erased from the process as it became apparent that it was not significant. This suggested that component groupings may not be particularly helpful when investigating differences through regression on the sub-group level, and so the components were broken down into their component variables instead. These were then fed into the developing model, step-wise, to identify if specific components were having an impact as individual variables.

In contrast to the overall population, *Age* displaced *Education* in the *lower numeracy* model as the most prominent demographic variable affecting numeracy scores, by a considerable margin (comparative weights of: -10.377 to -4.822). This is expected because the majority of respondents

taking education further than secondary level, as suggested by CHAID, were found in the *higher numeracy* sub-group – respondents which, by definition, were excluded from this sub-group analysis.

In the higher numeracy sub-group analysis itself, *Age* did trump *Education* as the top demographic predictor variable, but only very slightly (-6.079 to -5.941). In contrast to the *lower numeracy* sub-group, this small range between beta scores suggests that educational type can be used to predict Numeracy differences within sub-groups.

Although *Goals* turned out to be a weaker lead than previously supposed, the component variable of *Keeping track*[20] was not only present in the sub-group model, but was seen as the most powerful predictor of numeracy score amongst the sub-population as a whole. As all aspects of Component 1 were considered predictors of numeracy score in the overall population model, the fact that *Keeping track* survived within the *lower numeracy* model and not in the *higher numeracy* model suggests that this is a key link in the relationship between numeracy and financial capability. We can therefore say that differences in behaviour when individuals are keeping track of their finances are useful in gauging numeracy.

How efficiently respondents in the *lower numeracy* and *higher numeracy* sub-groups claimed to pay their bills were also found to be having a significant impact on numeracy scores. Since this variable did not feature in the final Principal Component Analysis for either sub-group, it is perhaps unsurprising that it only adds a minor contribution to both models – but this shows that differences in payment efficiency are still relevant as a predictor of numeracy levels.

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[19] Multiple Regression techniques include a number of measures to help determine how well the 'model' fits the data. 'R' – the multiple correlation coefficient, is one such measure showing the quality (or precision) of the prediction of the dependent variable – in this case Numeracy score.

[20] Identified as the variable with the strongest correlation to Component 1 (*Vigilance*)

Knowledge of Financial Matters appeared as the most powerful predictor variable within the *higher numeracy* model, suggesting this variable has a significant degree of impact on numeracy score levels within the sub-group. Given this variable did not appear in the *higher numeracy* PCA model,[21] this suggests that financial knowledge could perhaps be considered a trait that is endemic to *higher numeracy* individuals. In contrast, differences in the *lower numeracy* PCA model identified this variable as a component of component 5 (*Confidence*), which means those at the lower end of the numeracy scale are more divided over the extent of their financial knowledge, whereas the *higher numeracy* sub-group are more homogenous in this aspect.

Four independent variables were found to be having a significant impact on numeracy scores in both *higher numeracy* and *lower numeracy* sub-groups, and varied by numeracy ability. In the *lower numeracy* sub-group these included *Education*, *Age*, *Keeping track* and *Bill Payments*, predicting a Numeracy score with about 40% precision[22] (39.7%). In the *higher numeracy* sub-group these were *Education*, *Age*, *Bill Payments*, and *Knowledge of Financial Matters*, with 34% prediction power.

5.6.6 Multiple Linear Regression Analysis Conclusions and the Link to Postulated Theories

Theory 4.3, suggesting the association between keeping track of finances and numeracy, is supported by the overall population model. However, **Theory 4.4 (regarding the link between affluence and Keeping track and numeracy skills) cannot be conclusively supported** by this outcome, because *salary* was not found to be significant in the model.

Whilst the component of *Financial Difficulty* in the overall population model appeared, it was not seen to have a particularly impactful effect on numeracy scores. Its presence in the model does suggest that **Theory 4.14 is true to an extent**, but it cannot be conclusively suggested that higher numeracy skills are associated with fewer financial difficulties as sub-group analysis did not confirm this trend. Whilst there are other sources that can supplement this particular theory, the regression model only goes a little way to strengthening it.

Best-Buy Literature was only seen to have an impact on numeracy scores where the entire population was concerned. Whilst the regression did not show this up, a propensity to use (or not use) these sources for making financial decisions was identified within the PCA stage as a key driver of differences amongst the overall and *higher numeracy* populations. It is interesting to note that in both PCA and Multiple Linear Regression analyses, *best-buy literature* did not feature for the *lower numeracy* sub-group. This could suggest that respondents at the lower end of the numeracy spectrum are less likely to engage with best-buy literature, both in the wider frame and when examined separately. This goes someway to supporting **Theory 4.2**, that those who are considered *higher numeracy* are associated with seeking these sources of information out.

A distinctive addition within sub-group regression models that is missing from the overall population analysis is the differences explained by *bill payment* efficiency. **Theory 4.6** suggested that higher numeracy skills, exclusively, were associated with an ability to pay off major expenses and settle bills in full, and yet the regression models show that differences in this variable occur in both sub-populations. Whilst it is a minor variable of prediction within the dataset, it nonetheless suggests that the scope of Theory 4.6 may not be supported, and this ought not to be used as a link between financial capability and numeracy without refinement.

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[21] PCA highlights significantly *different* variables and groups them together under specific themes

[22] See Footnote 19

Somewhat related to this was the theory of attitudes towards bill payments in **Theory 4.12**, which suggested that lower numeracy skills were associated with longer delays in payment of bills. Given that *Vigilance* appears in the overall population model[23] this suggests that delays in bill payment have partial significance within the relationship between financial capability and numeracy. We cannot conclude conclusively that attitudes towards bill payments is a crucial predictor on its own, as the other composite variable within Component 1, *Keeping track*, was discarded in building the overall population Regression model, but at the very least it can be said that this variable combined with other variables provides a link to numeracy.

Theory 4.13, meanwhile, does have support from the regression models. It was supposed that "higher numeracy skills are associated with a greater knowledge of financial matters", which appears to be the case when considering the variables mentioned as predictors in the *higher numeracy* sub-group analysis. It was also the most powerful predictor within the sub-group.

In summary, the relationship linking numeracy to financial capability appears to be a complex one, and the output from each of our study population indicates that, in addition to the variables identified, a number of unseen factors (variables perhaps not covered within the research) exist that have an effect on numeracy scores. This complexity is further confirmed by the fact that, when scores were standardized[24] in both population sizes to a -1 to 1 scale, the correlations tended to be weak. This suggests that, although these variables were significant in having an effect on numeracy scores, there is no "silver bullet" variable that is driving the relationship between financial capability and numeracy. Having identified some of the predictors within this study, further research would be needed to explore and build on the links made.[25]

In summary: support was found for Theories 4.2 and 4.3; inconclusive evidence was found for Theories 4.4, 4.12, and 4.14; however, there appeared to be less support for Theory 4.13, and Theory 4.6 in its current form, as a consequence of Multiple Linear Regression Analysis.

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[23] Vigilance is the grouping factor containing the key attitudinal statement underpinning Theory 4.12

[24] Standardisation of variables is used to enable comparisons of the relative importance and strength of variables to be made on a common scale so we can look at relative contributions of different variables to the predictive value of the model

[25] And perhaps to explore further some of the theories which remain unsupported by this work

6. Conclusions in summary

Whilst the statistical techniques employed have been useful to untangle some of the relationships between financial ability and other behaviours, simple correlations from cross tabs, work conducted by other organisations and literature reviews are also vital in helping to form an overall view of financial numeracy. It should be stressed that all our observations here are based on our review and analyses of the reports and information available to us during our review work. There may be additional evidence that exists that would add to our abilities to test our theories and indeed develop additional theories.

Taking all elements reviewed for this report into account, each theory has been detailed and given a verdict below to help focus policy discussions at the roundtable. Using a combination of observational evidence, statistical evidence, and some researcher judgement, these theories were assessed on the following scale to provide closure to the study:

- **Reject.** There is no evidence to suggest this theory is correct.
- **Inconclusive evidence.** The research revealed only a little evidence for the theory.
- **Shows promise.** Some support was found, or strong support was found but may be somewhat contradictory in places.
- **Accept.** The evidence was fairly conclusive and nothing contradictory was found.

6.1 Theories to consider rejecting, or investigating further

Theories in this category have only limited evidence supporting them. Theories in this category are:

- 4.6) Higher numeracy skills are associated with an ability to pay off major expenses and settle bills in full
- 4.15) Higher numeracy skills are associated with better management of income and expenditure

6.2 Theories with inconclusive evidence

Theories in this category have some evidence attributed to them, but these are largely observations and by no means provide strong links with numeracy in the statistical analysis. Caution should be taken when using these theories due to ambiguity in the findings. Theories in this category are:

- 4.4) Higher numeracy skills are associated with both affluence and keeping track of finances in conjunction
- 4.5) Higher numeracy skills indicate keeping up with bills is less burdensome
- 4.10) Lower numeracy skills are associated with unemployed individuals
- 4.11) Lower numeracy skills are associated with impulsivity in spending
- 4.12) Lower numeracy skills are associated with delays in bill payment
- 4.14) Higher numeracy skills are associated with fewer financial difficulties
- 4.16) Lower numeracy skills are associated with a reduced likelihood to save money
- 4.19) Higher numeracy skills are associated with a stronger ability to delay reward

6.3 Theories showing promise

Theories in this category have, over the course of this investigation, amassed a body of evidence supporting them, but the connection to numeracy is caveated. These theories do have potential, but further studies might be necessary to conclusively establish the link. Theories in this category are:

- 4.1) Higher numeracy skills are associated with the setting of financial goals
- 4.8) Less educated individuals are associated with greater financial distress
- 4.9) In general, females are more likely to have lower numeracy skills than males
- 4.17) Lower numeracy skills are associated with greater worries for basic costs of living
- 4.18) Lower numeracy skills are associated with lower confidence in managing money

6.4   Theories accepted

Theories in this category have solid evidence underpinning them, and are the major theories linking financial capability to numeracy. Theories in this category are:

- 4.2) Higher numeracy skills are associated with seeking out best-buy literature to make financial decisions
- 4.3) Higher numeracy skills are associated with keeping track of finances, in general
- 4.7) Lower numeracy skills are associated with lower levels of progression within education
- 4.13) Higher numeracy skills are associated with a greater knowledge of financial matters

Appendix 1: CHAID runs
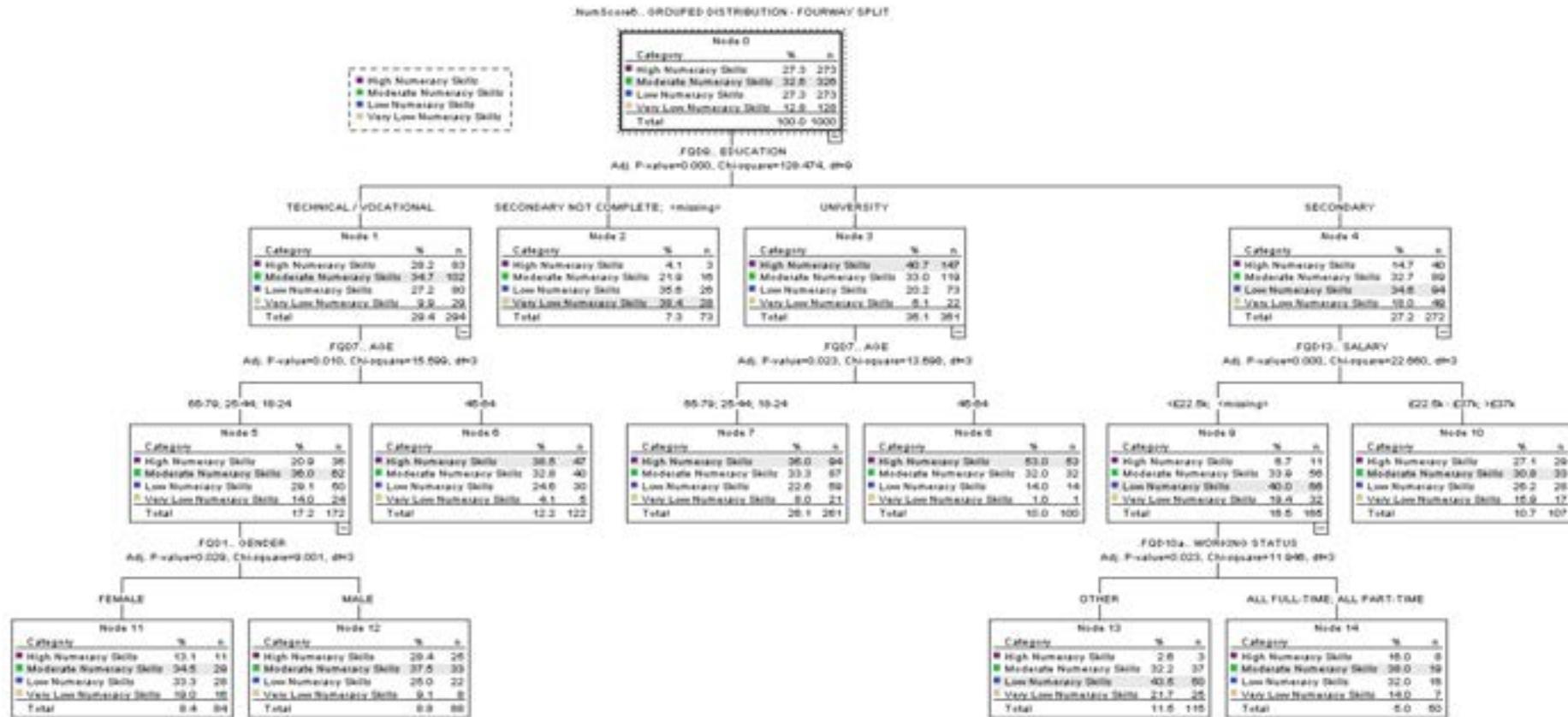
Figure 4. Initial four-way CHAID analysis of the overall population, assessing discriminators between High, Moderate, Low and Very Low sub-groups. This analysis used demographic variables only.

Figure 5. Two-way CHAID analysis of the total population, assessing discriminators between High/Moderate and Low/Very Low sub-groups. This analysis used demographic variables only.

.NumScore6.. GROUPED DISTRIBUTION - FOURWAY SPLIT

Legend:
- ■ Low Numeracy Skills
- ■ Very Low Numeracy Skills

Node 0

Category	%	n
■ Low Numeracy Skills	68.1	273
■ Very Low Numeracy Skills	31.9	128
Total	100.0	401

.FQD9.. EDUCATION
Adj. P-value=0.011, Chi-square=11.408, df=1

TECHNICAL / VOCATIONAL; UNIVERSITY; SECONDARY

Node 1

Category	%	n
■ Low Numeracy Skills	71.2	247
■ Very Low Numeracy Skills	28.8	100
Total	86.5	347

SECONDARY NOT COMPLETE; <missing>

Node 2

Category	%	n
■ Low Numeracy Skills	48.1	26
■ Very Low Numeracy Skills	51.9	28
Total	13.5	54

.FQD13.. SALARY
Adj. P-value=0.024, Chi-square=8.528, df=1

<£22.5k; £22.5k - £37k

Node 3

Category	%	n
■ Low Numeracy Skills	65.8	144
■ Very Low Numeracy Skills	34.2	75
Total	54.6	219

>£37k; <missing>

Node 4

Category	%	n
■ Low Numeracy Skills	80.5	103
■ Very Low Numeracy Skills	19.5	25
Total	31.9	128

.FQD7.. AGE
Adj. P-value=0.006, Chi-square=11.184, df=1

65-79; 45-64

Node 5

Category	%	n
■ Low Numeracy Skills	92.2	59
■ Very Low Numeracy Skills	7.8	5
Total	16.0	64

25-44; 18-24

Node 6

Category	%	n
■ Low Numeracy Skills	68.8	44
■ Very Low Numeracy Skills	31.2	20
Total	16.0	64

Figure 6. Two-way CHAID analysis of the lower numeracy sub-group, assessing discriminators between Low and Very Low sub-groups. This analysis used demographic variables only.

.NumScore6.. GROUPED DISTRIBUTION - FOURWAY SPLIT

Node 0		
Category	%	n
■ High Numeracy Skills	45.6	273
■ Moderate Numeracy Skills	54.4	326
Total	100.0	599

.FQD9.. EDUCATION
Adj. P-value=0.000, Chi-square=26.389, df=2

SECONDARY NOT COMPLETE; SECONDARY; <missing>

Node 1		
Category	%	n
■ High Numeracy Skills	29.1	43
■ Moderate Numeracy Skills	70.9	105
Total	24.7	148

UNIVERSITY

Node 2		
Category	%	n
■ High Numeracy Skills	55.3	147
■ Moderate Numeracy Skills	44.7	119
Total	44.4	266

TECHNICAL / VOCATIONAL

Node 3		
Category	%	n
■ High Numeracy Skills	44.9	83
■ Moderate Numeracy Skills	55.1	102
Total	30.9	185

.FQD13.. SALARY
Adj. P-value=0.000, Chi-square=16.570, df=1

.FQD1.. GENDER
Adj. P-value=0.039, Chi-square=4.247, df=1

<£22.5k

Node 4		
Category	%	n
■ High Numeracy Skills	12.1	8
■ Moderate Numeracy Skills	87.9	58
Total	11.0	66

>£37k; £22.5k - £37k; <missing>

Node 5		
Category	%	n
■ High Numeracy Skills	42.7	35
■ Moderate Numeracy Skills	57.3	47
Total	13.7	82

FEMALE

Node 6		
Category	%	n
■ High Numeracy Skills	48.3	58
■ Moderate Numeracy Skills	51.7	62
Total	20.0	120

MALE

Node 7		
Category	%	n
■ High Numeracy Skills	61.0	89
■ Moderate Numeracy Skills	39.0	57
Total	24.4	146

Legend: ■ High Numeracy Skills ■ Moderate Numeracy Skills

Figure 7. Two-way CHAID analysis of the "higher numeracy" sub-group, assessing discriminators between High and Moderate sub-groups. This analysis used demographic variables only.

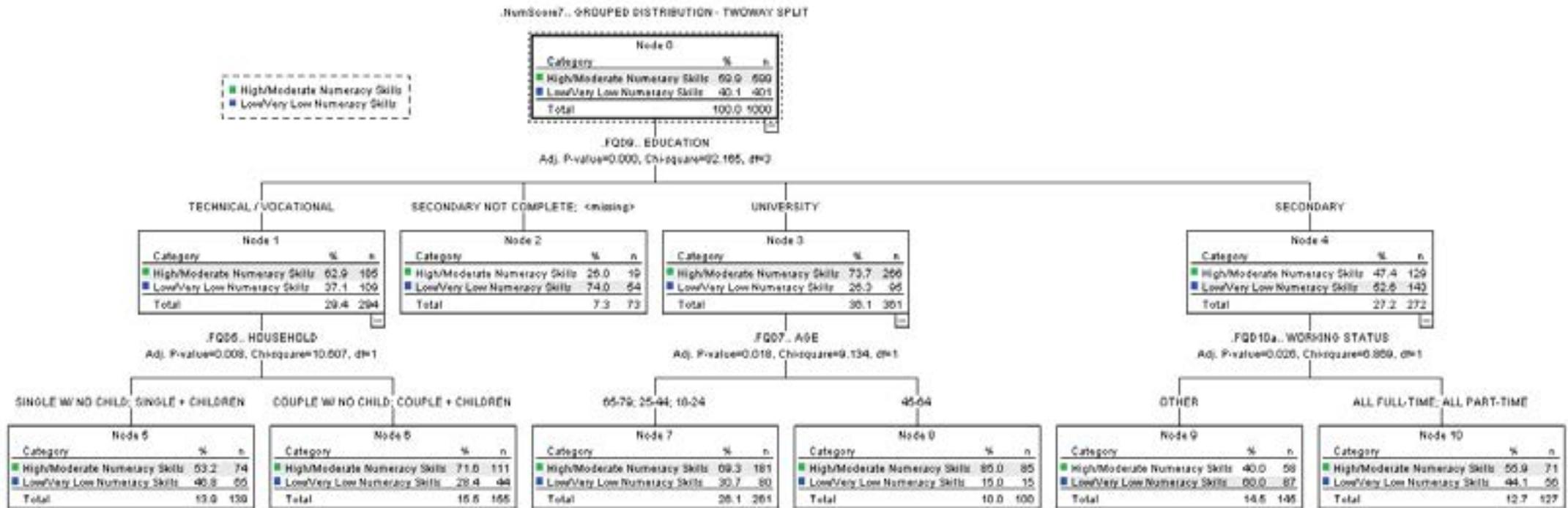*Figure 8. Two-way CHAID analysis of the overall population, assessing discriminators between "highly" and "lowly" numerate sub-groups. This analysis used both demographic variables and the behavioural variables Keeping track and "Goals".*

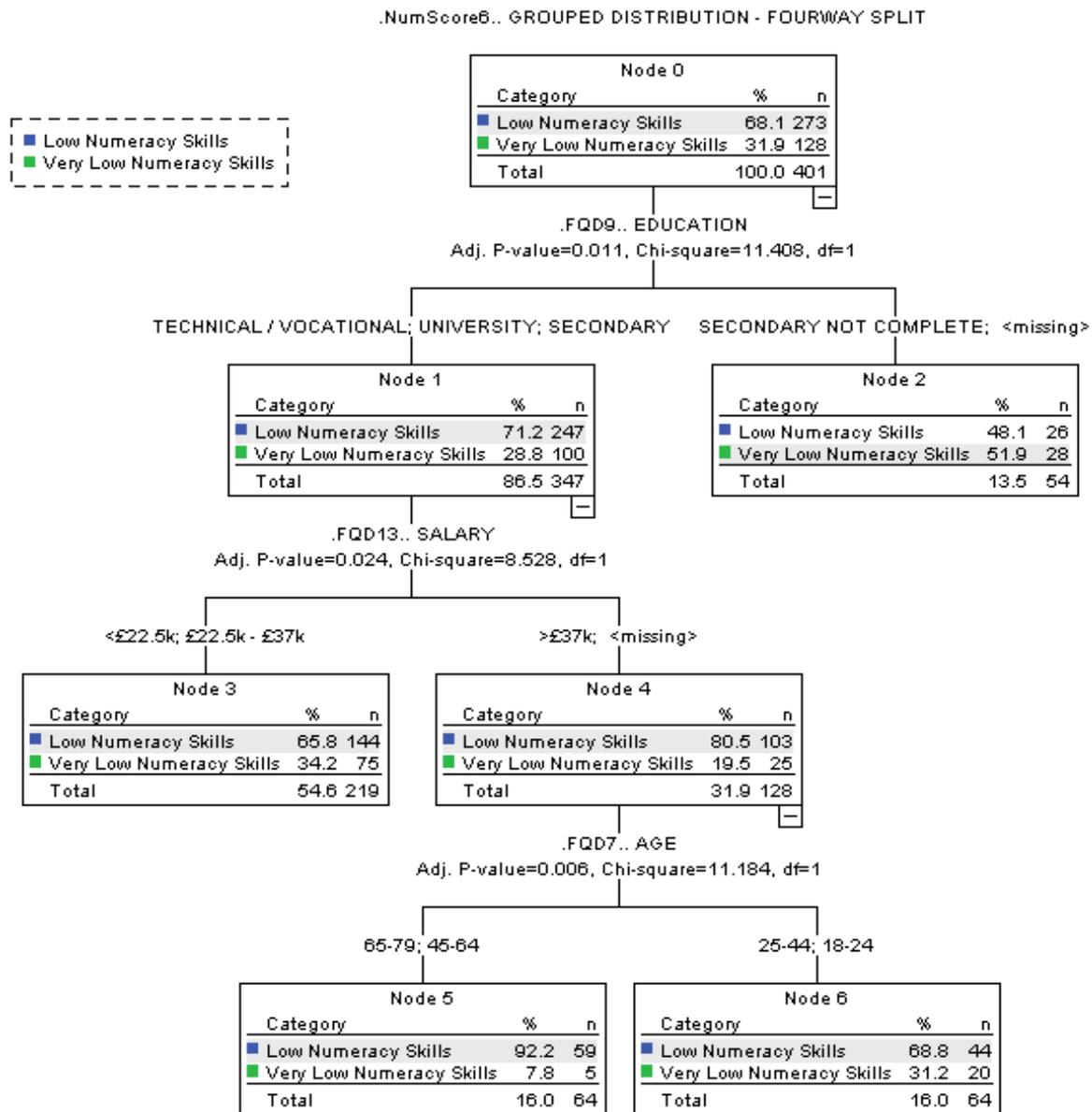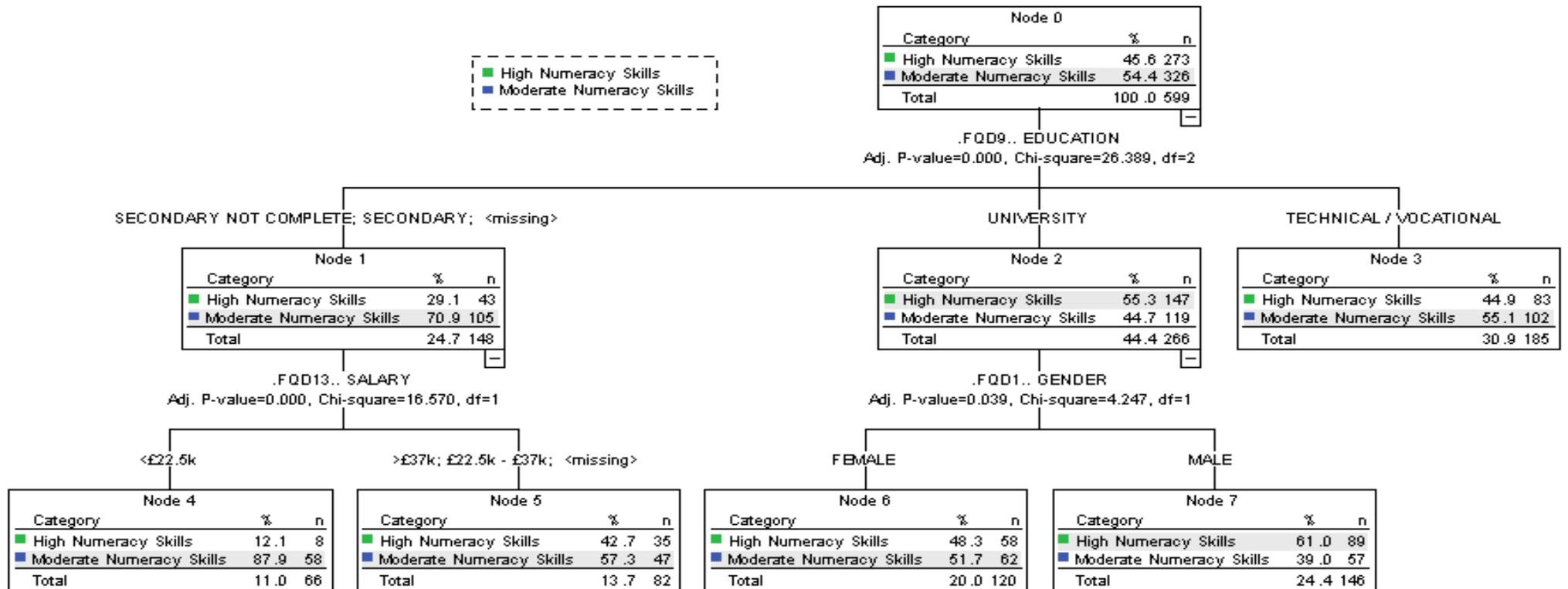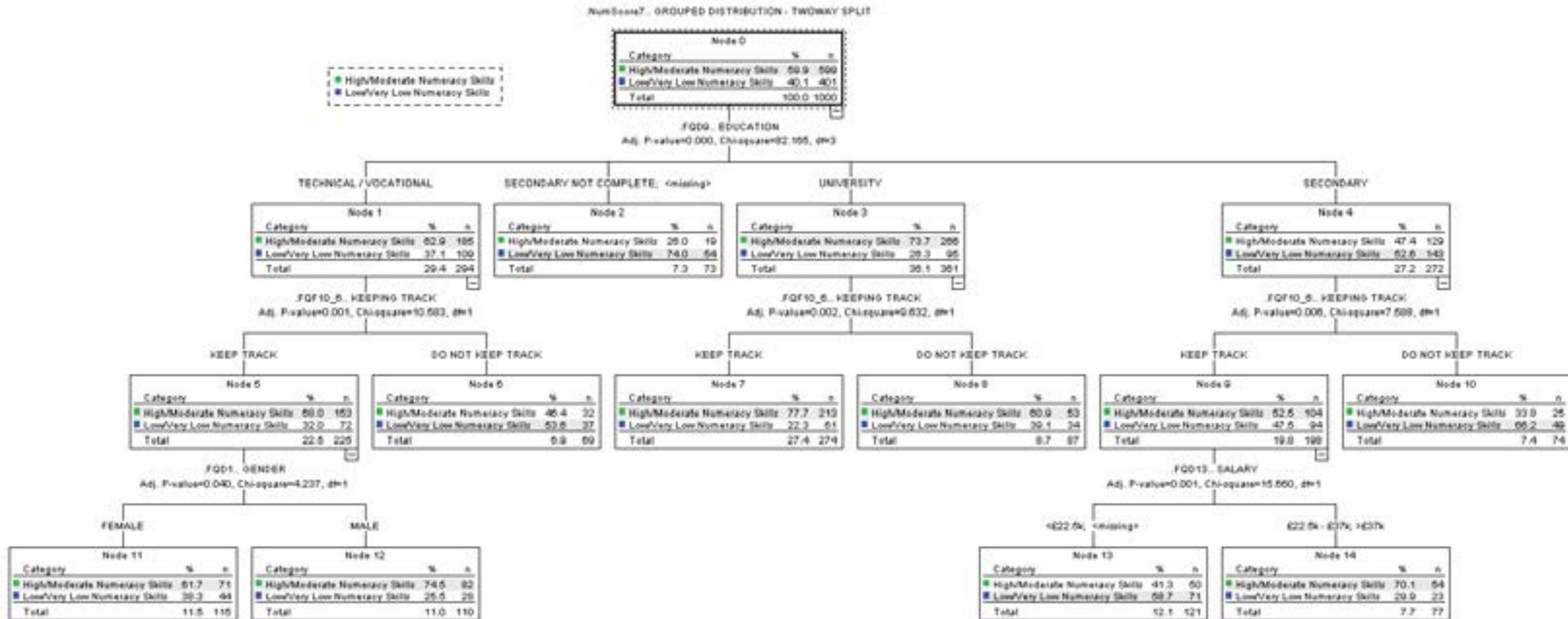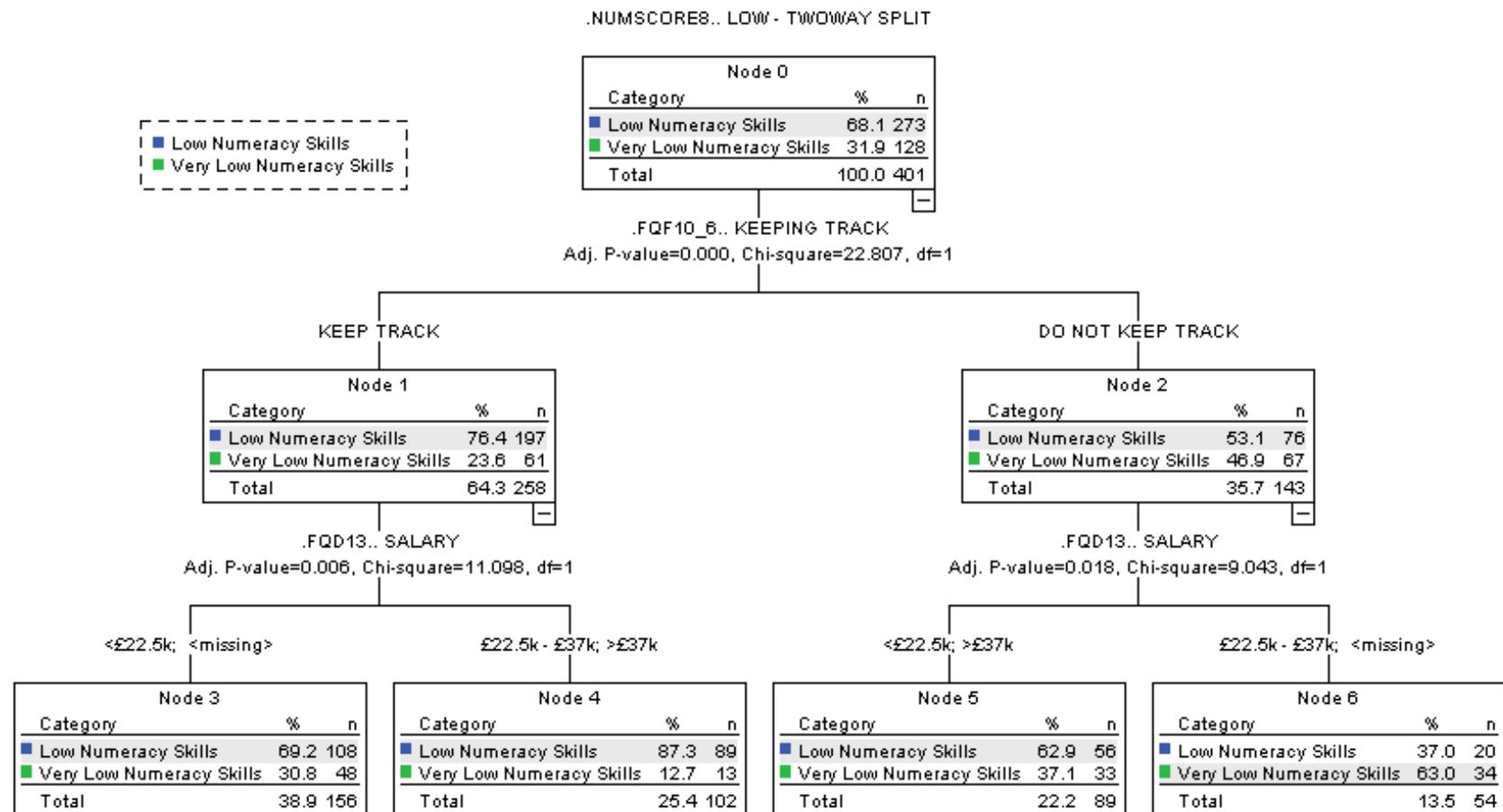*Figure 9. Two-way CHAID analysis of the lower numeracy sub-group, assessing discriminators between Low and Very Low sub-groups. This analysis used both demographic variables and the behavioural variables Keeping track and "Goals".*

Appendix 2: CHAID profiles

Secondary Node – Age

DESCRIPTORS	"Overall" Profile (%)	"Overall" Mean Score	"Highly" Within-Group Profile (%)	"Highly" Mean Score	"Lowly" Within-Group Profile (%)	"Lowly" Mean Score
Overall (%/Numeracy Score)	100	103.2	53.6%	140.4	46.4%	60.2
AGE						
18-24	11.6	99.7	11	141.2	12	52.9
25-44	33.9	109.3	39	142.9	28	53.8
45-64	32.5	106.6	32	140.5	33	68.5
65-79	22.1	90.7	17	134.3	28	59.6
Middle Aged (45-64)	32.5	106.6	32	140.5	33	68.5
Not Middle Aged (18-44,65-79)	67.5	101.6	68	140.4	67	56.1
Profile Adjusted (Overall Profile laid onto Age Profiles)	-	-	-	140.2	-	59.8

Table 5. Profiles and mean numeracy scores for the secondary node "Age".

Between Sub-groups: Higher numeracy vs. Lower numeracy

This exercise highlighted a split by Age within these education subsets. Those in the 25-44 age group (34%) scored an average of **109.3** out of 175 (34%) and the 45-64 age group scored an average of **106.6** (32%); whereas those at the lower end in the 18-24 (12%) and 65-79 (22%) age groups had scores averaging **99.7** and **90.7**. The small range between the four age sub-groups indicated Age was not a hugely influential discriminator between groups, but that it was still playing a role in the formation of the overall numeracy scores. The lesser effect of Age was to be expected as Education was determined as the most influential variable, first and foremost.

Similarly, to education, the Age profiles of the *Higher* and *Lower numeracy* sub-groups are significantly different. Within the *Higher numeracy* sub-group, 39% are within the 25-44 age bracket compared to 28% in the *Lower numeracy* sub-group. 25-44s achieved, on average, higher numeracy scores **(109.3)**, but their inflated presence within the dataset is undoubtedly having an effect on the *Higher numeracy* mean numeracy score **(140.4)**, overall, with respect to the *Lower numeracy* overall mean numeracy score **(60.2)**. In contrast, 65-79 year olds account for 28% of the *Lower numeracy* sub-group, whereas 17% ended up in the *Higher numeracy* sub-group. 65-79 year olds averaged lower numeracy scores **(90.7)**, but are over-abundant in the *Lower numeracy* group – see Table 2. This drives the overall mean score down for the *Lower numeracy* sub-group, and makes it difficult accept the profile at the overall level.

Within Sub-groups: Higher numeracy vs. Lower numeracy

However, when looking at the *Higher numeracy* sub-population in isolation, the range in numeracy scores was 134.3 to 142.9 out of 175 and very close to the overall mean numeracy score for the *Higher numeracy*. Similarly, within the *Lower numeracy* sub-population, the range was 52.9 to 68.5 out of 175, and only slightly deviated from the overall score of 60.2 for the sub-group.

Furthermore, when the data was organized into the nodal splits from Figure 1A for Age (Middle Aged vs. Non-Middle Aged), the differences in mean numeracy score by Age for the *Higher numeracy* sub-group were almost non-existent (140.4 to 140.5) and in line with the overall mean score for the sub-group (140.4). The *Lower numeracy* sub-group ranges (56.1 to 68.5) were even closer to the overall *Lower numeracy* profile mean

score (60.2). Even when applying the overall age profile to the *Higher numeracy* and *Lower numeracy* sub-group mean scores to produce 'profile adjusted" mean scores, the deviation from the overall means was hardly noticeable (140.2 for the *Higher numeracy* and 59.8 for the *Lower numeracy*).

Tertiary Node – Gender

DESCRIPTORS	"Overall" Profile (%)	"Overall" Mean Score	"Highly" Within-Group Profile (%)	"Highly" Mean Score	"Lowly" Within-Group Profile (%)	"Lowly" Mean Score
Overall (%/Numeracy Score)	100	103.2	53.6%	140.4	46.4%	60.2
GENDER						
Male	48.5	110.5	55	143.0	41	60.7
Female	51.5	96.4	45	137.4	59	59.9
Profile Adjusted (Overall Profile laid onto Gender Profiles)	-	-	-	140.1	-	60.1

Table 6. Profiles and mean numeracy scores for the tertiary node "Gender".

Between Sub-groups: Higher numeracy vs. Lower numeracy

Overall differences in mean numeracy score between genders were reasonably small (96.4 for females compared to 110.5 for males) – an early indication that Gender, although a discriminator in the data, was perhaps not influential *enough* to be controlled for in subsequent analyses.

Within Sub-groups: Higher numeracy vs. Lower numeracy

When investigating Gender within the sub-groups separately, a higher proportion of Males were present in the *Higher numeracy* sub-group compared to the overall population (55% compared with 48.5%); and the *Lower numeracy* sub-group was over-represented by females (59% compared with 45%). Although Females scored slightly lower than Males in the overall population, the range in numeracy scores were even smaller between the genders within the highly numerate sub-group (137.4 to 143), and within the lowly numerate sub-group (59.9 to 60.7), than between the two sub-groups. Furthermore, when the overall profile of the population was laid onto the Gender profile, profile-adjusted mean numeracy scores for the two sub-groups indicated no significant differences to the overall population whatsoever (140.1 compared to 140.4 for the *Higher numeracy*; and 60.1 compared to 60.2 for the *Lower numeracy*).

Appendix 3: Principal Components Analysis Methodology

We used the SPSS Data Reduction programme to explore the data and search for 'groupings' of observed variables that could explain more of the total observed variance of the dataset than a single observed variable. The SPSS Data Reduction programme users as its extraction method Principal Components Analysis (PCA). We used Varimax rotation and the analysis utilized the Bartlett method of testing for sorting the data into 'factors' or components. This method measures how close the correlation of selected 'factors' is to an 'identity matrix' – or a matrix with parameters between -1 and 1. 'Factors' whose correlation falls below an arbitrary threshold do not appear in the analysis, leaving the strongly correlated variables (those variables which are responsible for explaining the differences) alive within the process – which means that useful interpretations may be reached from its output. As the Bartlett method filters out unnecessary information along the way, and due to its straightforwardness to implement in SPSS, this was the preferred method for this exploratory Data Reduction exercise. When reporting the results of our PCA exploration work, we reported on the number of components that appeared to explain more of the variance in the dataset than that expected from a single observed value; additionally, we looked at the observed variables that contributed to each extracted component and considered if they indeed appeared to have some 'common' thread.

Given the dataset we were exploring had a total sample size of 1000, and data that covered a multitude of variables of potential use in our search for those that may impact on 'Numeracy scores', our data reduction work was very much exploratory. The 'surrogate' Numeracy variable we had developed appeared to imply that the overall distribution of 'Numeracy' may in fact hide different sub-populations of Numeracy – Very Low, Low, Moderate and High, so when undertaking data reduction we were mindful that we may need to investigate not just the overall population, but that the different sub-populations may be very different. Hence our approach was one that was very much exploratory rather than exhaustive, and was meant to provide an overall indication of likely variables or 'Components' of use.

Whilst generally most data reduction techniques use continuous variables (and often categoric variables) as inputs, we used, in an exploratory way, dichotomous variables when their distributions were close to 50:50 so that correlations were not suppressed and therefore helped in the search for variables or 'factors' that were helpful in explaining the data.[26]

In our data exploration, given we were working with a relatively small dataset (n=1000) and one that had not been designed to explicitly investigate 'Numeracy', and that we had only a 'surrogate' for what was to be the variable of most interest (Numeracy Score), and that we had many observed variables that may be of possible value in helping to explain the data and very little allocated time to explore the data we created a number of 'binary' variables as inputs to our initial PCA work.

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[26] Dichotomous variables have been successfully used in this way in other published work, for example: http://vanneman.umd.edu/socy699J/FilmerP01.pdf

Appendix 4: Multiple linear regression modelling

We ran exploratory Regression analyses using the SPSS (Linear) Regression programmes.

Multiple regression is an extension of simple linear regression. It is used when we want to predict the value of a variable based on the value of two or more other variables. The variable we want to predict is called the dependent variable (or sometimes, the outcome, target or criterion variable). The variables we are using to predict the value of the dependent variable are called the independent variables (or sometimes, the predictor, explanatory or regressor variables). Multiple regression allows us to determine the overall fit (variance explained) of the model and the relative contribution of each of the predictors to the total variance explained.

There are several assumptions that are required for multiple regression to give a valid result. It is often the case with 'real world' data that when analysing your data using SPSS Statistics, one or more of these assumptions is violated (i.e., not met). This is not uncommon when working with real-world data rather than textbook examples, which often only show how to carry out multiple regression when everything goes well. However, it is generally accepted that even when the data fails certain assumptions, there are often ways to overcome this. At this exploratory stage, we did not examine the assumptions in significant detail but kept them in mind when considering the basic findings from different MR analyses:

Assumption 1: Your **dependent variable** should be measured on a continuous scale (i.e., it is either an **interval** or **ratio** variable).

Assumption 2: There should be **two or more independent variables**, which can be either **continuous** (i.e., an **interval** or **ratio** variable) or categorical (i.e., an **ordinal** or **nominal** variable).

Assumption 3: There should be **independence of observations** (i.e., **independence of residuals**).

Assumption 4: There needs to be a **linear relationship** between (a) the dependent variable and **each** of your independent variables, and (b) the dependent variable and the independent variables **collectively**.

Assumption 5: Data needs to show **homoscedasticity**, which is where the variances along the line of best fit remain similar as you move along the line.

Assumption 6: Data must not show **multicollinearity**, which occurs when there are two or more independent variables that are highly correlated with each other. This leads to problems with understanding which independent variable contributes to the variance explained in the dependent variable, as well as technical issues in calculating a multiple regression model.

Assumption 7: There should be **no significant outliers**, **high leverage points** or **highly influential points**. Outliers, leverage and influential points are different terms used to represent observations in the data set that are in some way unusual when you wish to perform a multiple regression analysis. These different classifications of **unusual points** reflect the different impact they have on the regression line. An observation can be classified as more than one type of unusual point. However, all these points can have a very negative effect on the regression equation that is used to predict the value of the dependent variable based on the independent variables. This can change the output that SPSS Statistics produces and reduce the predictive accuracy of results as well as their statistical significance.

Assumption 8: Finally, the **residuals (errors)** in the data should be **approximately normally distributed**

The limited exploration we undertook of the FinLit dataset was largely because we felt we had a derived dependent variable (Numeracy score estimate) that is untested, we had a datafile of (just) 1000 responses derived from a study that had not been designed to rigorously explore 'Numeracy' in this way, and we believed that our Numeracy measure suggested that rather than a single distribution the analyses of this variable appeared to suggest there may be very different sub-populations – at the very least High Numeracy and Low Numeracy groups. Our MR work was very exploratory and broad brush – with the aim of hopefully identifying potential independent variables that could then be compared with our different hypotheses.

Consequently, our Regressions were run in a step-wise fashion. The first Regression runs we explored for each population (All, High and Low sub-groups) used the same input variables – i.e. our surrogate Numeracy estimate as the independent variable, the 6 component scores suggested from the PCA and the 5 demographic variables identified by the orders of CHAID. On the initial regression run on the Overall population, these 11 variables were deemed sufficient to continue with the Component-Score-Plus-Demographics-Only approach to its conclusion, resulting in the 6 variables detailed in the report.

These 6 variables were encompassing enough of the full variable list to apply to multiple theories, and so we could then begin to draw conclusions about the Overall population in the report. (Please note in the report that interpretation of each of the previous stages of analysis (CHAID/PCA) relate to specific theories and hypotheses because of the input variables used – this MR stage was no exception).

Following the 'Overall Population' exploration we then moved onto the Sub-Groups using the same 11-variable approach; however, when we conducted the initial run by this method, these variable combinations did not appear to yield a substantial enough model to test multiple theories at the sub-group levels (Low/High Numeracy groups). Indeed, the first exploratory run on the Low group, for example, only identified 3 variables from the list of 11. Accepting such a model as definitive of the Low sub-group could arguably have taken place here with just these three variables, but we decided to go one step further because just using 3 variables was likely to limit the breadth of our conclusions. Since we'd devised the theories from multiple sources in the first place, it made sense to explore more variables in a circumstance such as this, as we needed to pull a conclusion together for multiple theories.

Whilst the PCA suggested likely key variables which indicated an underlying theme, and hence which component score variables to use in the MR, it is also very important to remember what the PCA **did not** say, namely those variables which were excluded in the formation of the 6 factors. We decided to, therefore, test combinations of demographic variables and **all** the individual variables that were initially put into the PCA - which included selected individual variables such as "FFC_E10. Bill Payment", which ultimately did not form part of any factors, and "FQF10_6. Keeping Track", which did. In the Low group's final model, this approach turned out to be more beneficial for bolstering theories that using the 3 variables found using the 11-variable approach used initially.

The same approach was then taken with the High sub-group, and the individual variables of "FQK1. Knowledge of Financial Matters" and "FFC_E10. Bill Payment" were found to be integral to the final model – allowing us to draw conclusions about financial knowledge, which the various outputs and analyses up to this point had seldom allowed us to do. The list of variables explored later in the sub-groups work, included a list of all individual variables used initially in the PCA analysis that we tried in various combinations in tandem with the demographic variables. In summary, our final analyses of sub-groups did not include component score variables used when we revised the approach, but were assessed as individual variables instead.

Because of our concerns about the applicability of the FinLit datafile, the appropriateness of the surrogate Numeracy score we had postulated, the overall sample size and the distribution of our derived Numeracy variable (suggesting that there may be different numeracy sub-populations), we initially searched for dependent variables that the analyses suggested as 'explanatory' but looked for significance levels of $p<0.005$ rather than the more traditional $p<0.05$. By setting a higher 'likely significance' level for variables that may have a positive impact within the regression work we felt that variables we identified from the Overall (n=1000) analyses could be more realistically tested within the High and Low sub-group datasets. Hence much of our initial exploration work concentrated on variables that were very likely to be useful.

Notes on the output statistics and their interpretation for each model are shown below. Detailed outputs from the statistical analyses are available if required.

- One of the most important statistics is the *P-Value,* or significance, which ultimately determines whether or not the variables settled on are meaningful additions to the model, as changes in the predictor's value are related to changes in the response variable value. Significance levels of $P<0.05$ (using the 95% confidence interval) suggested the variables were acceptable – with any variables exceeding this limit being removed from the model building process due to a lack of significance.
- *Coefficients* provide context to the impact of the individual independent variable, whilst all the other independent variables are held at a constant level. The statistical control that regression provides is beneficial, as this isolation effect of a single variable makes drawing conclusions easier. In a sense, coefficients are the *degree of fit, or association,* between the independent variable and the dependent variable.
- F-Tests compare the *fit* of the regression model to that of a controlled linear model, i.e. one without predictor variables included. Whilst a t-Test tests one coefficient against this model, an F-Test compares multiple coefficients, i.e. all significant independent variables, to the control. An F-Score below the P-Value of $P<0.05$ suggests the fit is better than the controlled model, which means the independent variables included improved the model and are indeed impactful.
- The R Score (the multiple correlation coefficient) is considered to be one measure of the quality of prediction of the dependent variable, in this instance, numeracy. This is an important statistic that gives an indication of the likely *precision of the model in predicting numeracy skill.*

These statistics for each of our three populations (Overall, *Higher numeracy* and *Lower numeracy* are shown below).

R Score: 0.475 (47.5%)	Unstandardized Coefficients		Standardized Coefficients	P<0.05	
	Beta Scores	Standard Error	Beta Score	t Score	Significance
(Constant)	186.301	7.443	-	25.03	.000
Education	-16.057	1.667	-0.277	-9.631	.000
Age	-14.228	2.923	-0.14	-4.868	.000
Gender	-11.755	2.798	-0.121	-4.2	.000
Factor 1 – Vigilance	-11.738	1.395	-0.242	-8.413	.000
Factor 3 – Financial Difficulty	-6.444	1.391	-0.132	-4.633	.000
Factor 5 – Best-Buy Literature	-6.185	1.374	-0.129	-4.501	.000
Salary	-9.255	3.215	-0.092	-2.878	.004
Gender	-10.707	2.977	-0.110	-3.596	.000
Factor 6 – Savvy Sources	3.146	1.443	0.066	2.180	.030

Table 7. Overall population: Independent variables impacting numeracy score. Demographic, attitudinal and behavioural variables were used in this analysis. For reference, variables with dark shading were noted at the P<0.05 level of significance.

R Score: 0.397 (39.7%)	Unstandardized Coefficients		Standardized Coefficients	P<0.05	
	Beta Scores	Standard Error	Beta Score	t Score	Significance
(Constant)	115.147	6.768	-	17.012	.000
Education	-4.822	1.444	-0.161	-3.34	.001
Age	-10.377	2.646	-0.194	-3.922	.000
Bill Payments	-4.403	1.454	-0.149	-3.029	.003
Keeping Track	-10.608	2.511	-0.208	-4.224	.000
Pay Bills On Time – Agree	-12.501	3.118	-0.225	-4.010	.000
Set Long Term Goals – Agree	5.968	2.489	0.121	2.398	.017
Spending > Saving - Disagree	14.752	5.956	0.301	2.477	.014
Savings	-8.788	3.538	-0.302	-2.484	.013

Table 8. Lower numeracy population: dependent variables impacting numeracy score. Demographic, attitudinal and behavioural variables were used in this analysis. For reference, variables with dark shading were noted at the P<0.05 level of significance.

R Score: 0.34 (34%)	Unstandardized Coefficients		Standardized Coefficients	P<0.05	
	Beta Scores	Standard Error	Beta Score	t Score	Significance
(Constant)	189.038	5.196	-	36.383	.000
Education	-5.941	1.234	-0.19	-4.816	.000
Age	-6.079	2.042	-0.117	-2.978	.003
Bill Payments	-3.512	1.122	-0.125	-3.129	.002
Knowledge of Financial Matters	-8.954	2.058	-0.171	-4.351	.000
Factor 6 – Savvy Sources	3.162	.967	0.132	3.270	.001
Salary	-5.055	2.281	-0.093	-2.216	.027
Gender	-5.410	2.099	-0.106	-2.578	.010
Accuracy to Balance	-2.740	1.238	-0.089	-2.212	.027

Table 9. Higher numeracy population: Independent variables impacting numeracy score. Demographic, attitudinal and behavioural variables were used in this analysis For reference, variables with dark shading were noted at the P<0.05 level of significance.