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As Math Literacy Goes, So Goes Financial Literacy-Based on International Educational Systems

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Abstract

Some researchers suggest that the financial illiteracy of American consumers is a major reason behind the Great Recession. The U.S. ranks below average in financial literacy out of 18 countries according to the Organization for Economic Cooperation and Development (OECD) in 2012. We examine the role of math in delivering early financial education. Using 2012 OECD data on 15-year-olds, we estimate a simple linear financial literacy production model in which math literacy is the key explanatory variable. The results show a statistically significant and large association between math and financial literacy. Financial literacy increases by 0.71 unit for every unit increase in math literacy, controlling for reading and science literacy and economic and demographic factors.

As Math Literacy Goes, So Goes Financial Literacy –

Based on International Educational Systems

Many in the academic community believe that financial illiteracy among consumers was a key reason for the Great Recession of 2007 to 2009 (Gerardi, Goette, & Meier, 2013). This deepest recession since the Great Depression is attributed to the loans issued by banks with insufficient collateral to people who could not afford them, which resulted in mortgages to default and leading to the collapse of the housing bubble (Baker, 2008). In the end, the American people bailed out the banking industry ($0.7 trillion in 2008, with further additions totaling over $1.6 trillion) to prevent a potential collapse of the U.S. and world economies (Arnold, 2014). Subsequently, there was an increase in mandatory financial education in high schools within the United States. Between 2007 and 2009, implementation of mandatory financial education in secondary schools increased from seven states to thirteen states. However, this number plateaued at 17 in 2014, according to the 2014 and 2016 surveys of the Council of Economic Education (Council for Economic Education, 2016).

In a 2012 study of the financial literacy of 15-year-old students in 18 international jurisdictions (educational systems) conducted by the Organization for Economic Co-operation and Development (OECD), the U.S. ranked just below average, with Colombia ranking the lowest and Shanghai, China, ranking the highest (OECD, 2012). International educational systems in the study had limitations. For example, China limited its study to Shanghai, which had a population of 24 million under its jurisdiction. A comparative analysis by Lusardi and Mitchell (2014) measured the financial literacy of U.S. consumers with high school education to be 19%. This compared to 52% in Germany. Knowing such a higher score was feasible in another industrialized country suggests that it could be a realistic goal for America as well.

However, the effectiveness of financial education in improving financial literacy is debated. Mandell (2008), using biannual surveys from 1997 through 2008 from Jumpstart (an organization chartered to promote early financial literacy), does not find support for the effectiveness of early financial education. Nevertheless, there is strong empirical support for the value of financial education found by Walstad, Rebeck, and MacDonald (2010) and Lusardi and Mitchell (2009, 2014). Instead of debating the effectiveness of existing financial education, the more appropriate concern may be how to create truly effective financial education. This paper takes a step in that direction by examining the role of a preparatory subject like math in delivering early financial education.

Specifically, this paper investigates the relationship between financial literacy and math, controlling for reading and science skills. Discovery of such a relationship may justify the increased emphasis on the linked teaching of basic math and basic personal finance in grades K-12. Perhaps a K-12 personal finance curriculum could be incorporated into the mathematics curriculum. For example, more personal finance examples could be used in math problems beginning in kindergarten.

In this paper, a simple linear production function is estimated in which financial literacy depends on literacies in math controlling for reading and science literacies, and also demographic and economic factors. This model is estimated using data from the Program for International Student Assessment (PISA) limited to participating countries or jurisdictions within the countries via Least Squares Regression with robust standard errors (PISA, 2012). The results show a significant association, both statistical and substantive, between financial literacy and math, exist but fail to find such associations between financial literacy and reading or science, holding demographic and economic variables constant. This finding may provide educational policy

direction regarding where the focus on math literacy should be to help with financial literacy. There may be an opportunity to teach math using an appropriate level of personal finance examples, benefitting both the math and financial literacies. It even may be easier to train a math teacher about personal finance. In this sense, personal finance education potentially may belong to the math department.

Literature

In this paper, financial literacy is defined as a set of minimum essential tools needed to make typical financial decisions in the life of a consumer. These include, for example, understanding the real cost of securing a payday loan, a student loan, or a mortgage loan while having an appreciation for the time value of money. Even when the consumer resorts to professional help, financial decisions are generally in the hands of the consumer, necessitating a minimum level of financial literacy.

The existing literature on the effectiveness of early financial planning education is conflicting. Mandell (2008), who conducted periodic surveys (1997-2008) for JumpStart, does not find support for the effectiveness of early financial education. Based on Mandell's analysis, Willis (2008) argues for alternatives to such financial education like just-in-time education (i.e., education only when people need to apply such literacy). An example would be providing education about mortgages at the time a consumer applies for a mortgage loan. Willis also makes the argument that not everyone needs to be proficient in financial planning; they can seek such a service. After all, everyone need not become a doctor to get treated medically, nor does everyone need to be a lawyer to address personal legal matters. The possible difference here is that many financial planning professionals might not find it worthwhile to service low-asset

clients. These professionals face the paradox of having to charge these clients, who can ill-afford it, a higher percentage on assets managed.

However, Walstad et al. (2010) and Lusardi and Mitchell (2009, 2014) find strong empirical support for the value of financial literacy education in dealing with day-to-day financial issues such as planning for retirement and creating wealth. Wagner (2015) also finds positive associations between financial education, financial literacy, and financial behavior, referring to such behavior as financial capability by using the 2012 National Financial Capability Survey (NFCS). Also using these data, Joseph, Kalenkoski, and Lacombe (2016) find value in financial literacy at the macro level from a strong association between state-level per capita GSP and financial literacy and also between state-level per capita income and financial literacy in the U.S. They also find that improving a state's financial literacy score by about 33 percentage points would be equivalent to nearly double the percentage of college graduates in terms of the effect on state-level per capita GSP or per capita income. Lusardi and Mitchell (2014) document a similar gap of 35 percentage points (19% vs. 52%) between the financial literacy of U.S. high school graduates and those in Germany. The existence of such higher levels of financial literacy elsewhere suggests that an increase in financial literacy by 33 percentage points might be realistic for the U.S. On the other hand, when the cost of college is already at such a high level, it may not be realistic to create the needed infrastructure and resources to about double the number of college graduates.

There is theoretical support also for the benefits of literacy in general. Literacy leads to enhanced human capital in an economic sense (Becker, 1993). It can shift the value of work from low-paying physical labor to more financially rewarding mental labor, which may be considered desirable by many. This desire for greater rewards and satisfaction drives progress in

the economy, supported by the consumer preference axiom of "more is better." Regarding axioms, there is an axiom in education, that reading, writing, and arithmetic (the three Rs) are foundational components of literacy (Webb, 2006).

Indeed, educational and microeconomic theories support literacies in reading and math as preparatory skills for financial education. Gagne (1985) describes the phases of learning with math skills only second to reading skills in terms of importance. Lusardi and Wallace (2013) point out that mathematics is foundational to anything financial. A simple linear production function forms the basis for the model estimated in this study, associating financial literacy with literacies in math controlling for reading and science literacies and also the demographics (Bowles, 1970; Hanushek, 2008).

Empirical evidence in support of a relationship between math and financial literacy also exists. Regarding the role of numeracy in financial literacy education, Lusardi and Wallace (2013) assert that quantitative literacy is needed to respond to the financial literacy questionnaires. Gilliland, Melfi V., Sikorskii, Corcoran, and Melfi E. (2011) also find a positive relationship between quantitative and financial literacies in a sample of 531 incoming 2010 freshmen students at Michigan State University (MSU). However, the MSU study has a limited select sample of 531 incoming freshmen. This paper employs data from the 2012 PISA study, which represents 18 international educational systems, a more global sample, to estimate a continuous regression model of financial literacy. In this model, financial literacy depends on literacies in math, controlling for reading and science literacies as well as demographic and economic factors. These data do not support statistically significant associations between financial literacy and reading or science literacies, holding demographic and economic variables constant.

Data

This paper utilizes data from the 2012 PISA study conducted on behalf of the OECD. The National Center for Education Statistics (NCES), which is part of the U.S. Department of Education, is responsible for the PISA study in the U.S. The PISA study limits itself to 15-year-old students by design. It is a very complex but well-resourced study involving 65 international jurisdictions or educational systems. Thirty of these are non-OECD partners. OECD uses the term 'jurisdiction' because countries who pay for the study can adjust the area of coverage of the study. Different educational systems may be more appropriate in place of jurisdictions. For example, China limits the study to the Shanghai province, and hence, it is just representative of the Shanghai province and not all of China.

On the other hand, the U.S. adds three individual states as additional educational systems over and above the country as a whole. However, the three states are not included in this paper as the U.S. is included broadly. Thus, this analysis is limited to countries or limited areas, as is the case in some countries, and it is not representative of the countries worldwide. The data averages used in this paper for each of the educational systems are representative of the participating countries or jurisdictions. A better representation of the unit of observation may be the international educational systems represented in the study limited to 15-year-olds.

Financial literacy assessment is optional for the PISA study. Eighteen educational systems opted for it in 2012. In addition, there is an optional assessment of creative problem-solving skills. However, few educational systems opting for financial literacy assessment also opt for assessment of problem-solving skills. The 2012 PISA database is selected for this paper, as it is the latest dataset available with financial literacy scores and has the most educational systems included at 18.

The randomized PISA survey includes about 150 schools from each educational system and about 40 students per school, with standby schools to draw from if a school does not meet the student count requirement. Because this assessment is limited to 15-year-olds, it primarily captures U.S. students in the 10th grade. There is a concern about how students can answer a question if the subject matter has not yet been taught. The ability or inability of 15-year-olds to deal with the survey questions is part of the design to assess such literacies, comparing educational systems broadly. PISA considers the unit of analysis to be an individual educational system and forms the unit of observation in this paper. Nineteen observations, including the average of the OECD countries, are utilized in this analysis. This limits the number of observations in the analysis. However, each observation is an average of about 6000 students representing each educational system. The low number of observations still allows detection of statistical significance in the ensuing analysis, at least for the key explanatory variable of interest – ML (Austin & Steyerberg, 2015). However, care should be exercised about any statistical insignificance of the other explanatory variables.

The dependent variable selected from the PISA data is financial literacy. PISA transforms the data to a continuous score ranging 0-1000, centered at 500, utilizing approximately 6,000 students per educational system. The key independent variable is math literacy, with literacies in reading and science as control variables. These variables are also transformed to a continuous score ranging 0-1000, centered at 500 by PISA. Examples of math and financial literacy questions are provided in Appendix A. A PISA-generated index of Economic, Social and Cultural Status (ESCS) is included as a control variable for demographic factors (PISA Process, 2012). This variable also is transformed to a continuous scale by PISA and further transformed to a range of 0 -1000, centered at 500, for the current analysis to be

consistent with the rest of the other variables. This ESCS index is critical as a control variable in the statistical analysis of data from different worldwide educational systems as broad as Colombia, the U.S., or Shanghai.

The descriptive statistics of the variables are in Table 1. Although the means of these variables are centered at 500 when examining all educational systems, these data are only from those educational systems participating in the financial literacy assessments. Therefore the means here are slightly different from 500.

(Suggested space for Table 1)

Problem-solving skills as a control variable are also examined separately, but this causes a loss of two educational systems leaving only 17 units of observations. The problem-solving skills variable, like others, utilizes a continuous score ranging 0-1000 and centered at 500. Descriptive statistics for this smaller sample are summarized in Appendix B.

Model

The model to be estimated is motivated by a simple linear production function for financial literacy. It is given by:

$$\text{Financial Literacy}_i = \beta_0 + \beta_1 \text{ Math Literacy}_i + \beta_2 \text{ Reading Literacy}_i + \beta_3 \text{ Science Literacy}_i + \beta_4 \text{ Socioeconomic-cultural-status}_i + \epsilon \quad (1)$$

where the β's are the coefficients to be estimated and ϵ is the error term assumed to follow a normal distribution. β_0 is the constant term. β_1 is expected to be associated positively with financial literacy. This is because math literacy, at least at a basic level, is a critical component of any financial computation (Lusardi & Wallace, 2013). β_2 and β_3 also are expected to be positive. This is because education, in general, provides incremental economic value, according to the human capital theory (Becker, 1993). β_4 also is expected to be positive. This is because

the relatively new sociocultural theories of education state that the social and cultural settings of the learning atmosphere shape teaching and learning literacy (NEA, 2006).

Results

The Least Squares Regression estimates with robust standard errors of equation (1) are shown in Table 2. Math literacy is statistically significant at the 1% level. For every unit change in math literacy, financial literacy is estimated to increase by 0.71 unit; all else held constant. Neither reading literacy nor science literacy is statistically significant.

(Suggested space for Table 2)

Reading literacy is part of the basic literacies along with writing and math literacies, which are part of the control variables in this analysis. Writing is not part of this international data. Reading was expected to be associating positively with financial literacy, and such an association is found statistically insignificant in this analysis. When science literacy was not included as a control variable (Appendix C), the statistical significance for reading literacy is found at the 10% level.

An attempt is made to examine if there is a pattern in the association between financial and math literacies at various levels of the socioeconomic levels. Two regression methods are used. The first approach separates financial literacy by the quartiles of the ESCS as a control variable for separate Least Squares Regressions with robust standard errors. It yields mixed results of significance likely due to narrowing of the variabilities within each of the ESCS segments. Quantile regression using Simultaneous Bootstrap replications (100) is also explored. This separates financial literacy into 25%, 50%, and 75% quintiles and does not provide statistically significant associations.

The robust standard errors from adding problem-solving skills to the control variables are reported in Appendix D. The variable for problem-solving skills is found statistically insignificant.

The association of math literacy with financial literacy in this analysis may offer insights into a possible direction to achieve financial literacy within the U.S.

Conclusions

Researchers state that the financial illiteracy of American consumers is the reason behind the Great Recession of 2007 to 2009 (Gerardi et al., 2013). The housing bubble preceding this recession is reportedly the result of consumers buying houses they could not afford, aided by unscrupulous lending practices (Baker, 2008). The American public eventually bailed out the banking system with a quick infusion of 0.7 trillion dollars in 2008 to prevent a collapse of the U.S. and world economies (Arnold, 2014).

The U.S. is just below the average in financial literacy out of 18 countries, as measured for OECD by PISA (2012). Periodic surveys from 1997 through 2008 by Jumpstart Coalition for Personal Financial Literacy conclude that early financial education is ineffective in dealing with consumers' day-to-day needs. On the other hand, studies by Walstad (2010) and Lusardi and Mitchell (2014) find positive correlations between financial literacy and routine personal financial management skills, including planning for retirement. The real question of how best to improve financial literacy in the U.S may come down to how best to deliver effective financial education. This paper takes a step toward examining effective financial education by identifying math literacy as an important determinant of financial literacy.

Using data from the 2012 PISA, this paper finds that financial literacy is statistically and substantially associated with math literacy, but not to literacies in reading or science. Additional

analysis separating the regression data into quartiles of the socioeconomic index developed by PISA fails to isolate patterns in this association within the socioeconomic ladder.

The present paper may provide educational policy direction towards math literacy as a significant area that helps deliver financial literacy. Increased emphasis on the cooperative teaching of basic math and essential personal finance from kindergarten to 12th grade (K-12) may be justified to benefit both education and retention of math and financial literacies. Educators may consider giving math lessons by increasing personal finance examples of interest to students. Educationalists may also decide whether to place the K-12 personal finance curriculum within mathematics education to generate more time for financial education. Additional research may explore breaking down the PISA data into lower units of observations within each educational system, mainly in the U.S., even though PISA does not directly support such analysis. Future research also may examine pedagogical avenues to bring out the greatest collaboration between delivering math and financial education at all levels.

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Appendix A

Illustration: Examples of Math Literacy and Financial Literacy Questions from PISA (2012) Assessment

Illustrative Examples from PISA Financial Literacy Questions

One of the math questions, arguably a more difficult one, is below. Boldface emphasis in the questionnaire is duplicated below. Italics are added to identify the parts in the questionnaire.

The problem starts with: *Here you need to use geometrical theorems.*

A schematic of a pyramid with a square base and isosceles triangle sides follows. One of the sides of the base and the isosceles triangle sides are marked *12 cm* each. This is followed by a question: *Determine the height of the pyramid*.

This is followed by a statement: *We need to know about your experience with these types of problems at school. Do not solve them.*

This is followed by a four-point Likert scale question: *How often have you encountered these types of problems in your* ***mathematics lessons****?* This is followed by four choices of *Frequently, Sometimes, Rarely, and Never* marked 1 through 4, in that order. The second part of the question is: *How often have you encountered these types of problems in the* ***tests you have taken at school?***

Another Likert scale question of the same kind is initiated by: *Here you have to know what a prime number is.* This is followed by *If n is any number, can* $(n+1)^2$ *be a prime number?*

One of the financial literacy questions is paraphrased: Have you heard about the prepaid debit card? This is subjectively a simpler question about math. Yet, only about 3% answered affirmatively in the U.S., the same as Colombia, but about ten times as many responded affirmatively in Shanghai.

Appendix B

Summary Statistics: Financial and Math Literacies Based on International Educational Systems - Including Problem Solving

Variable	Observations [a]	Mean	Std. Dev.	Minimum	Maximum
Financial Literacy	17	495.6	44.97	379	603
Math Literacy	17	493.4	42.16	376	613
Reading Literacy	17	495.6	32.07	403	570
Science Literacy	17	499.9	34.97	399	580
Problem Solving	17	490.9	32.03	399	536
ESCS Index [b]	17	488.9	33.06	374	525

[a] Educational Systems

[b] Economic, Social & Cultural Status Index

Note: All variables are on a continuous scale: 0 - 1000, centered on 500, and are pre-weighted by PISA to be representative of Educational Systems

Source: PSIA (2012)

Appendix C

Regression Estimates (Robust Standard Errors) of Simple Linear Financial Literacy Production Function on Math Literacy (Without Science Literacy in Table 2), Based on International Educational Systems

Dependent Variable: Financial Literacy

	Coeff-icient	Robust Std. Error		t	95% Conf.	Interval
Math Literacy	0.724	0.1063	***	6.81	0.498	0.951
Reading Literacy	0.296	0.1646	*	1.8	-0.055	0.646
ESCS Index [b]	0.118	0.0718		1.64	-0.036	0.271
Constant	-64.265	41.1833		-1.56	-152.04	23.52

Statistical Significance Levels: ***1%, **5%, *10%

Measures of Model Fit: Adj. R Sq. = 0.93
Educational Systems = 17

[b] Economic Social & Cultural Status Index

Note: All variables are on a continuous scale: 0 - 1000, centered at 500, and are pre-weighted by PISA to be representative of Educational Systems

Source: PISA (2012)

Appendix D

Regression Estimates (Robust Standard Errors) of Simple Linear Financial Literacy Production Function on Math Literacy – Including Problem Solving, Based on International Educational Systems

Dependent Variable: Financial Literacy

	Coeff-icient	Robust Std. Error		t	95% Conf.	Interval
Math Literacy	0.762	0.2632	**	2.89	0.18	1.34
Reading Literacy	0.297	0.1819		1.63	-0.10	0.70
Science Literacy	-0.106	0.4058		-0.26	-1.00	0.79
Problem Solving	0.084	0.2546		0.33	-0.48	0.64
ESCS Index [b]	0.100	0.1073		0.93	-0.14	0.34
Constant	-64.739	54.7472		-1.18	-185.2	55.8

Statistical Significance Levels: ***1%, **5%, *10%

Measures of Model Fit: Adj. R Sq. = 0.94
Educational Systems = 17

[b] Economic Social & Cultural Status Index

Note: All variables are on a continuous scale: 0 - 1000, centered at 500,
and are pre-weighted by PISA to be representative of Educational Systems

Source: PISA (2012)

Tables

Table 1

Descriptive Statistics: Assessment of Preparatory Literacies for Early Financial Literacy - Based on International Educational Systems

Variable	Observ-ations[a]	Mean	Std. Dev.	Minimum	Maximum
Financial Literacy	19	497.2	42.78	379	603
Math Literacy	19	493.6	42.16	376	613
Reading Literacy	19	496.2	32.07	403	570
Science Literacy	19	500.9	34.97	399	580
ESCS Index [b]	19	488.9	33.01	374	525

[a] Educational Systems

[b] Economic, Social & Cultural Status Index

Note. All variables are on a continuous scale: 0 - 1000, centered at 500, and are designed by PISA to be representative of Educational Systems

Source: PSIA (2012)

Table 2

Regression Estimates (Robust Standard Errors) of Simple Linear Financial Literacy Production Function on Math Literacy, Based on International Educational Systems

Dependent Variable: Financial Literacy

	Coeff-icient	Robust Std. Error		t	95% Conf.	Interval
Math Literacy	0.711	0.2300	***	3.09	0.218	1.205
Reading Literacy	0.289	0.2081		1.39	-0.157	0.736
Science Literacy	0.022	0.3697		0.06	-0.771	0.815
ESCS Index [b]	0.116	0.0868		1.33	-0.071	0.302
Constant	-65.021	41.376		-1.57	-153.763	23.72

Statistical Significance Levels: ***1%, **5%, *10%

Measures of Model Fit: Adjusted R Sq.= 0.93

Educational Systems = 19

[b] Economic Social & Cultural Status

Note. All variables are on a continuous scale: 0 - 1000, centered at 500, and are designed by PISA to be representative of Jurisdictions or Educational Systems

Source: PISA (2012)