

# Identifying School Climate Variables Associated with Students' Financial Literacy Outcomes

*A Cross-Country Comparison  
Using PISA 2018 Data*

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Identifying School Climate Variables Associated with Students' Financial Literacy  
Outcomes

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敬致父母

To my parents

*Study hard what interests you the most in  
the most undisciplined, irreverent and original  
manner possible.*

*Richard P. Feynman*

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# Acknowledgement

Thank-you goes to





# Popular Abstract

This is a press release style abstract.



# Abstract

Repeated economic crises in recent memory have exposed the harsh consequences of financial *illiteracy* shared by high proportions of the general population. Policy makers experienced little resistance when identifying youth as the most effective group for bringing about improvement in citizens' ability to engage with economic and financial matters, but opinions quickly diverge over the optimal approaches for achieving such targeted outcome. Existing literature frequently reports the importance of family environment in cultivating students' financial literacy through the process of "financial socialisation" – [definition goes here] (reference). Such practice, however, encounters interrogation by educators over equity concerns should families remain the main arena for financial literacy development. Schools play vital roles in alleviating inequality in accessing education and training in general but scarce research so far has been devoted into identifying the specific classroom factors that are most effective in advancing students' financial literacy outcomes. The current study therefore attempts to contribute to this enquiry by investigating the relationship between school climate variables and students' financial literacy achievement with an aim of stimulating policy debate about the levers and instruments available to education interventionists for the purpose of improving young people's financial literacy and preparedness as they step into an increasingly uncertain world. Using the 2018 PISA dataset, this paper employs a three-level hierarchical model to conduct cross-country comparisons to highlight school climate variables that are most strongly associated with high financial literacy outcomes.



# Chapter 1

## Introduction

This is a line that recently got added.

### 1.1 Broad motivations

As shown in ??, the world is not that bad.

### 1.2 Quick definitions of key terms

#### 1.2.1 Financial literacy vs finance

#### 1.2.2 Flow vs stock: teaching vs assessment of financial literacy

### 1.3 My topic(s)

### 1.4 Zooming out: Why this topic is important?

(Abu Bakar & Abu Bakar, [2020](#); Agarwal et al., [2015](#); Agnew & Cameron-Agnew, [2015](#); Agnew & Harrison, [2015](#); Agyei, [2018](#); Akben-Selcuk & Altioek-Yilmaz, [2014](#); Ali et al., [2014](#); Allgood & Walstad, [2016](#); Amagir et al., [2018](#); Aprea et al., [2015](#); Arceo-Gómez & Villagómez, [2017](#); Arellano et al., [2014](#), [2018](#); Arthur, [2012](#); Atkinson & Messy, [2011](#); Bartholomae & Fox, [2016](#); Batsaikhan & Demertzis, [2018](#); Becchetti et al., [2013](#); De Beckker et al., [2019](#), [2020](#); Beckmann & Reiter, [2020](#); Behrman et al., [2012](#); Bel & Eberlein, [2015](#); Belás et al., [2016](#); Bernheim et al., [2001](#); Birbili & Kontopoulou, [2015](#); L. Blue & Brimble, [2014](#); L. Blue et al., [2014](#); L. E. Blue, [2020](#); L. E. Blue et al., [2018](#); L. E. Blue & Pinto, [2017](#); Boisclair et al., [2017](#); Bongini et al., [2012](#); Bottazzi &

Lusardi, 2016; Bover et al., 2018, 2020; Bowen, 2002; Bray & Thomas, 1995; Breitbach & Walstad, 2016; Brimble & Blue, 2013; Brown & Graf, 2013; Brown et al., 2018; Brown et al., 2016; Buccioli et al., 2020; Bucher-Koenen et al., 2016; Caliendo & Findley, 2013; Cameron et al., 2013; Van Campenhout, 2015; Campioni et al., 2017; Carlin & Robinson, 2012a, 2012b; Caro & Biecek, 2017; Carvalho, 2020; Chambers & Asarta, 2018; Chambers et al., 2019; Chatfield, 1978; Chen & Garand, 2018; Chiang, 2020; Ciemleja et al., 2014a, 2014b; Cole et al., 2016; Cole et al., 2009; Collins, 2013; Connolly & Nicol, 2015; Cordero & Pedraja, 2019; Cude et al., 2016; Cupak et al., 2018a, 2018b; Cupák et al., 2018; Curugan et al., 2020; Danes & Haberman, 2007; von Davier, 2014; Davies et al., 2016; Davoli & Rodríguez-Planas, 2020; Driva et al., 2016; Eickelmann et al., 2016; Emmons, 2005; Endsley, 2020; Eniola & Entebang, 2016; Erner et al., 2016; Fabris & Luburić, 2016; Farinella et al., 2017; Fernandes et al., 2014; Ferrari, 2019; Fonseca et al., 2012; Fornero & Lo Prete, 2019; Förster et al., 2017; Frączek & Klimontowicz, 2015; Frisancho, 2019; Garder, 1985; Garg & Singh, 2018; Geiger et al., 2016; Gomes, 2020; Goodman, 1975; Goyal & Kumar, 2020; Gramaṭki, 2017; Green, 1956; Grohmann, 2016; Grohmann et al., 2018; Grohmann et al., 2015; Grund et al., 2020; Gudmunson & Danes, 2011; Gudmunson et al., 2016; Guest & Brimble, 2018; Guttman, 1944; Hanushek & Woessmann, 2012a, 2012b; Happ et al., 2016; Hastings et al., 2013; Henderson et al., 2020; Hira, 2016; Ho & Lee, 2020; Holtsch & Eberle, 2016; Huston, 2010, 2012; Ibarra et al., 2019; Janssen et al., 2019; Jappelli, 2010; Jappelli & Padula, 2013, 2015; Jorgensen & Savla, 2010; Jüttler & Schumann, 2016; Kaiser & Menkhoff, 2020; Kalmi & Ruuskanen, 2018; Karakurum-Ozdemir et al., 2019; Kell, 2014; Kenayathula et al., 2020; Khalil, 2020; Khan et al., 2017; Khoirunnisaa & Johan, 2020; Kiliyanni & Sivaraman, 2016; Kim et al., 2020; Klapper & Lusardi, 2019; Klieme, 2020; Kosor et al., 2020; Kunovskaya et al., 2014; Laukaityte & Wiberg, 2018; Leumann et al., 2016; Li, 2020; Liaqat et al., 2020; Longobardi et al., 2017, 2018; Lusardi, 2012, 2015a, 2015b, 2019; Lusardi & Lopez, 2016; Lusardi et al., 2019; Lusardi & Mitchell, 2007, 2008, 2011, 2014; Lusardi et al., 2010; Lusardi et al., 2017; Lusardi & Wallace, 2013; Mancebón et al., 2015; Mancebón et al., 2019; Mandell & Klein, 2009; Mändmaa, 2020; Marsh et al., 2004; Marsh et al., 2012; Marsh et al., 2019; Matheson et al., 2020; Mitchell & Lusardi, 2015; Mohammadpour, 2013; Moreno-Herrero et al., 2018a, 2018b; Mountain et al., 2020; Norvilitis & MacLean, 2010; Norvilitis et al., 2006; Nurhasanah et al., 2020; Oberrauch & Kaiser, 2019; OECD, 2005, 2009, 2020; Oliver-Márquez et al., 2020; Opletalová, 2015; Ozkale & Erdogan, 2020; Page, 2020; Paolo Stella et al., 2020; Pesando, 2018; Peugh, 2010; L. Pinto & Couson, 2011; L. E. Pinto, 2012, 2013; Pokropek, 2016; Potrich et al., 2015; Potrich et al., 2016; Preston & Wright, 2019; Lo

Prete, [2013](#); R Core Team, [2020](#); Remund, [2010](#); Riitsalu & Pöder, [2016](#); Rinaldi & Todesco, [2012](#); Rodríguez et al., [2020](#); Rohatgi & Scherer, [2020](#); van Rooij et al., [2011](#); Rubin, [1987](#); Rust, [2014](#); Rustomfram & Robinson, [2015](#); Rutkowski et al., [2010](#); Savard et al., [2020](#); Sawatzki et al., [2020](#); Schmeiser & Seligman, [2013](#); Schuhen & Schürkmann, [2014](#); Schürkmann & Schuhen, [2013](#); Sellar & Lingard, [2013](#); Serido & Deenanath, [2016](#); Shadish et al., [2002](#); Shen et al., [2016](#); Shim et al., [2010](#); Shim et al., [2009](#); Siegfried, [2016](#); Silgoner et al., [2015](#); Skagerlund et al., [2018](#); Söderlund & Eriksson, [2020](#); Sole, [2014](#); Spataro & Corsini, [2017](#); Stanisavjević & Stojković, [2018](#); Stolper & Walter, [2017](#); Strahija et al., [2020](#); Strietholt & Scherer, [2018](#); Sun et al., [2012](#); Sutter et al., [2020](#); Taylor & Wagland, [2013](#); Tchatoka & Varvaris, [2020](#); Te’eni-Harari, [2016](#); Tezel, [2015](#); Thomas & Spataro, [2018](#); Thomson & De Bortoli, [2017](#); Titko, Ciemleja et al., [2015](#); Titko, Lace et al., [2015](#); Toosi et al., [2020](#); UiO, [2020](#); United Nations, [2020](#); Utkarsh et al., [2020](#); Vale et al., [2020](#); Vyvyan et al., [2014](#); Walstad et al., [2016](#); H. Wang & Xu, [2020](#); M.-T. Wang & Degol, [2015](#); Willis, [2008](#); World Bank, [2020](#); Yoshino et al., [2015](#); J. H. Young, [2013](#); R. Young & Johnson, [2015](#); Zhu, [2012](#); Zhu et al., [2015](#); Zokaityte, [2016](#))





## Chapter 2

# Conceptual Framework

### 2.1 In-depth definitions of “financial literacy”

- 2.1.1 Every term my readers need in order to understand my research question
- 2.1.2 Survey not only PISA but also alternative definitions, even critiques of such definitions
- 2.1.3 Any practices that are common in maths/literature but uncommon in financial literacy? Meaning? Implies?

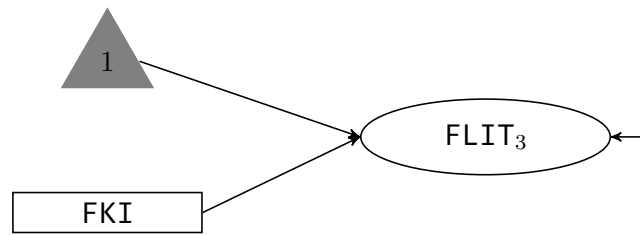
## 2.2 Country-level Financial Knowledge Index

PISA 2018 financial literacy dataset (OECD, 2020) provides rich information about students and schools. For the purpose of cross-country comparison, however, the country-level financial literacy information must be addressed separately by the researchers. Earlier attempts such as Moreno-Herrero et al. (2018a) approximated this information using a variable “quality of math and science education” to control for country-level differences since consensus is yet to emerge about the most appropriate measure for countries’ financial knowledge. Inspired by the UN’s approach to forming Human Development Indices, a recent publication by Oliver-Márquez et al. (2020) proposed a macroeconomic measure for countries’ general financial knowledge levels by examining their economic capability, educational training, existing practices in the financial markets as well as incentives to interact with financial products. More specifically, the authors considered a country’s economic capability, represented by its GDP per capita, to be a key dimension in bringing about its financial knowledge index (FKI). Secondly, literature converges on the importance of educational training for a country’s financial knowledge capability (OECD, 2005). Thirdly, countries with regular engagement with sophisticated financial products and financial markets should possess higher FKI. Lastly, countries with higher aggregate consumption levels and with ageing populations are likely to possess higher FKI due to more frequent exposure and pressure in retirement provision, respectively. Macroeconomic data needed for these computations can be sourced from the World Bank (World Bank, 2020) and the United Nations’ *Human Development Reports* (United Nations, 2020).

Combining individual and institutional data sources can be a productive approach in international large-scale assessment (ILSA) research. According to the framework for comparative education analyses (Bray & Thomas, 1995), this project extends education outcome measures to a country level, addresses the aspect of society and labour market, and relates countries’ entire populations to ILSA research (Strietholt & Scherer, 2018). By combining education outcome data with countries’ economic performance indicators, this project remains most comparable to Hanushek and Woessmann (2012a)—while these authors looked into the relationship between countries’ education achievement and their GDP growth, the current investigation highlights how countries’ GDP, along with other macroeconomic practices, in turn systematically impacts on their youth’s educational performance.

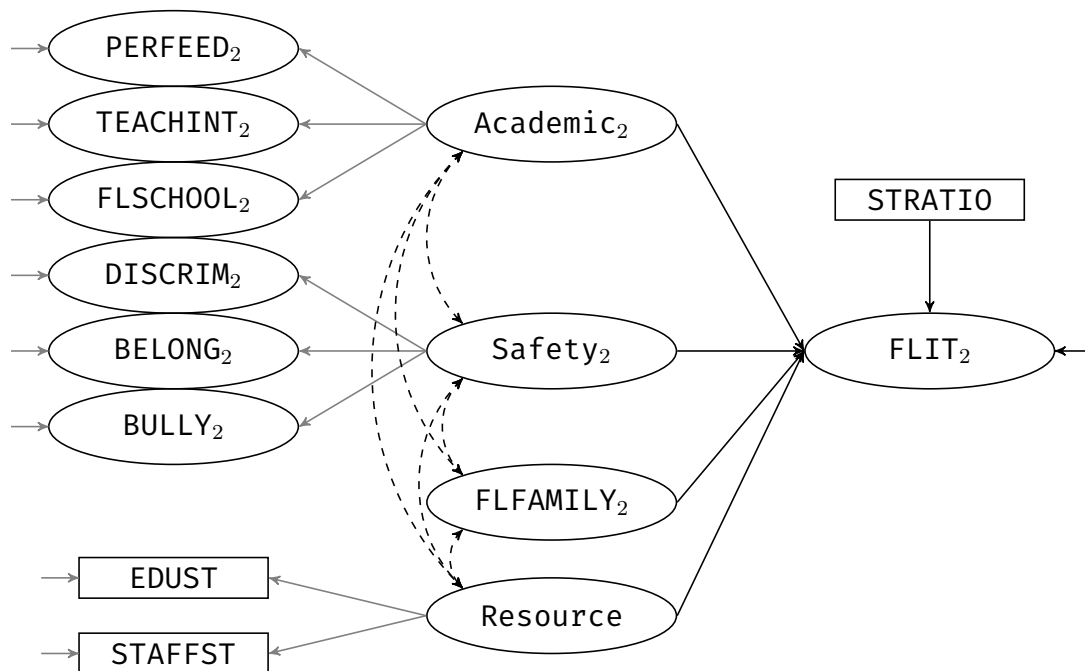
**Figure 2.1**

*Path Diagram: Country-level (L3)*



**Figure 2.2**

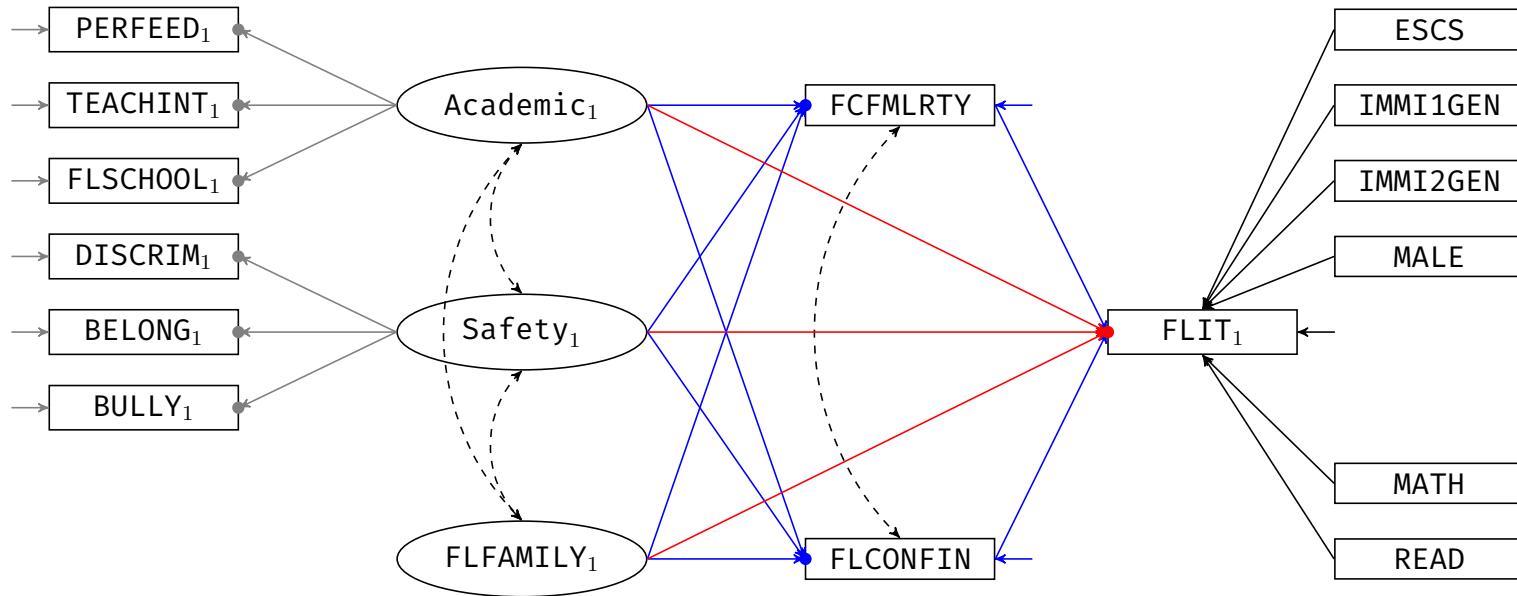
*Path Diagram: School-level (L2)*



*Note.* Manifest variables are surrounded by rectangles and latent variables by ovals. Covariances between variables are represented by dashed arcs. Error variances are shown as short arrows.

**Figure 2.3**

*Path Diagram: Student-level (L1)*



*Note.* Measurement models are coloured in gray. The direct and indirect paths of the structural component are represented in red and blue respectively.

## Chapter 3

# Methods

### 3.1 Data / Sample / Participants

This study drew its primary data source from PISA 2018 database (OECD, [2020](#)) containing 107,174 observations spanning 20 countries, in which students were asked about their demographic background, family lives and school experiences. For the financial literacy section, in particular, students responded to questions about their confidence about financial matters, familiarity with concepts of finance, their parental involvement in matters of financial literacy. Ten plausible values were subsequently generated by PISA organisers as measures of students' financial literacy outcomes and were used as the dependent variable.

Student-level independent variables are

School-level independent variables are

Country-level independent variables are

Missing data are handled using Mplus's multiple imputation procedure with ten imputations generated and pooled subsequently following Rubin's Rule (Rubin, 1976).

A three-level multigroup structural equation model was employed to account for the hierarchical structure of the PISA design, with private versus public school as the grouping variable.

## **3.2 Measurement of financial literacy**

### **3.2.1 Background questions**

### **3.2.2 Students' motivation of spending money**

### **3.2.3 Four-point Likert scale**

### **3.2.4 Averages**

### 3.3 Country-level Financial Knowledge Index

This project closely follows Oliver-Márquez et al.’s (2020) procedure in developing country-level financial knowledge indices using four sub-indices: economic capability (**EC**), educational training (**ET**), existing practices in financial market (**Use**), and incentives (**Need**) to engage with financial products. The first sub-index **EC** is calculated using the logarithm of a country’s GDP per capita in current international dollars (purchasing power parity adjusted). For the **ET** sub-index, a country’s highly skilled workforce is represented by its postgraduate to total tertiary graduation ratio, and the mean years of schooling is used to measure its general education level. For the **Use** sub-index, gross portfolio equity assets (GPEA) and insurance company assets (ICA) are considered sophisticated financial products a country engages in. Additionally, in order to capture the central role of technology in amplifying the proliferation and use of financial assets, the proportion of a country’s Internet users (IUS) enters the definition via

$$\text{Use} = (\text{GPEA} + \text{ICA})^{\text{IUS}}.$$

The final sub-index **Need** is compiled as

$$\text{Need} = (\text{PFA} + \text{AC})^{\text{AGEING}},$$

where PFA is the pension fund assets to GDP ratio. Aggregate consumption is defined as:

$$\text{AC} = \frac{2\% \times \text{household final consumption expenditure}}{\text{GDP}},$$

with the “2% rule” being drawn from Caliendo and Findley’s (2013) derivation, and the proportion of ageing population is computed as

$$\text{AGEING} = \frac{\left[ \frac{\text{population}(>65)}{\text{population}(20\sim64)} \right]_{2018} - \left[ \frac{\text{population}(>65)}{\text{population}(20\sim64)} \right]_{2009}}{\left[ \frac{\text{population}(>65)}{\text{population}(20\sim64)} \right]_{2009}}.$$

#### 3.3.1 Data Collection and Missing Data Treatment

The data sources for FKI computation are documented in Table 3.1 and its associated notes. Sub-indices **ET** and **Use** both contain missing observations for the year 2018. Majority of such missing data appear to be the result of administrative delay, with historic observations available until 2017. It is therefore feasible to conduct time-series forecasts using prior year observations to best approximate 2018 values.

**Table 3.1***Data Sources for FKI Computation*

Database <sup>a</sup>	Country <sup>b</sup>	Series	Time
Economic Capacity			
WB-dev	20	GDP per capita, PPP (current international \$)	2018
Educational Training			
WD-ed	20 \ Russia	Graduates from ISCED 7 programmes in tertiary education, both sexes (number)	2013– <b>2018</b>
		Graduates from ISCED 8 programmes in tertiary education, both sexes (number)	2013– <b>2018</b>
		Graduates from tertiary education, both sexes (number)	2013– <b>2018</b>
RS	Russia	PhD (Type 1) <sup>c</sup> , PhD (Type 2) <sup>d</sup>	2018
RE	Russia	Master (Type 1) <sup>e</sup> , Master (Type 2) <sup>f</sup> , total tertiary <i>excluding</i> PhD <sup>g</sup>	2018
HDR	20	Dimension = Education; Education = Mean years of schooling (years)	2018
Use			
WB-fin	20	Gross portfolio equity assets to GDP (%)	2011– <b>2018</b>
		Insurance company assets to GDP (%)	2011– <b>2018</b>
WB-dev	20	Individuals using the Internet (% of population)	2009– <b>2018</b>
Need			
WB-fin	20 \ Georgia	Pension fund assets to GDP (%)	2008– <b>2018</b>
GP	Georgia	Minutes of the meeting of the investment board of the Pension Agency <sup>h</sup>	2019 <sup>*</sup>
GS	Georgia	GDP at current prices, billion GEL <sup>i</sup>	2018
WB-dev	20	Household and NPISHs final consumption expenditure, PPP (current international \$)	2018
		GDP, PPP (current international \$)	2018
		Population ages 0–14, male	2009, 2018
		Population ages 0–14, female	2009, 2018
		Population ages 15–64, male	2009, 2018
		Population ages 15–64, female	2009, 2018
		Population ages 65 and above, male	2009, 2018
		Population ages 65 and above, female	2009, 2018
		Population ages 15–19, male (% of male population)	2009, 2018
		Population ages 15–19, female (% of female population)	2009, 2018

*Note.* Sub-indices are shaded in gray. Bold font signifies this year contains missing data.



- <sup>a</sup> WB-dev = [World Bank – World development indicators](#)  
 WB-ed = [World Bank – Education statistics – All indicators](#)  
 WB-fin = [World Bank – Global financial development](#)  
 HDR = [Human Development Reports – Data](#)  
 RS = [Russian Federal State Statistic Service](#)  
 RE = [Russian Ministry of Education and Science](#)  
 GP = [Pension Agency of Georgia](#)  
 GS = [National Statistics Office of Georgia](#)
- <sup>b</sup> “20” = the 20 participating countries in 2018 PISA financial literacy test: Brazil, Bulgaria, Canada, Chile, Estonia, Finland, Georgia, Indonesia, Italy, Latvia, Lithuania, the Netherlands, Peru, Poland, Portugal, Russian Federation, Serbia, Slovak Republic, Spain, and the USA. “\” = excluding or except
- <sup>c</sup> [https://rosstat.gov.ru/storage/mediabank/asp-2\(1\).xls](https://rosstat.gov.ru/storage/mediabank/asp-2(1).xls), Sheet “по направлениям подготовки”, Cell C7 = number of PhD graduates (Type 1)
- <sup>d</sup> <https://rosstat.gov.ru/storage/mediabank/asp-3.xls>, Sheet “по научным специальностям”, Cell B7 = number of PhD graduates (Type 2)
- <sup>e-g</sup> [https://minobrnauki.gov.ru/common/upload/download/VPO\\_1\\_2018.rar](https://minobrnauki.gov.ru/common/upload/download/VPO_1_2018.rar) contains a spreadsheet [СВОД\\_ВПО1\\_ВСЕГО.xls](#), Sheet “P2\_1\_3(1)”, Cell E198 = number of master graduates (Type 1)<sup>e</sup>, Cell E410 = number of master graduates (Type 2)<sup>f</sup>, Cell E592 = total tertiary graduates *excluding* PhD<sup>g</sup>
- <sup>h</sup> [Minutes of the meeting of the investment board of the Pension Agency](#), p. 4, no. 3
- <sup>i</sup> [Gross domestic product \(GDP\)](#), row = GDP at current prices, billion GEL, column = 2018
- <sup>\*</sup> Georgia started a [new pension system](#) on 1 January 2019. Since 2018 was a transitional period with scarce data, 2019 is used as the best approximation for Georgia’s pension system for 2018.

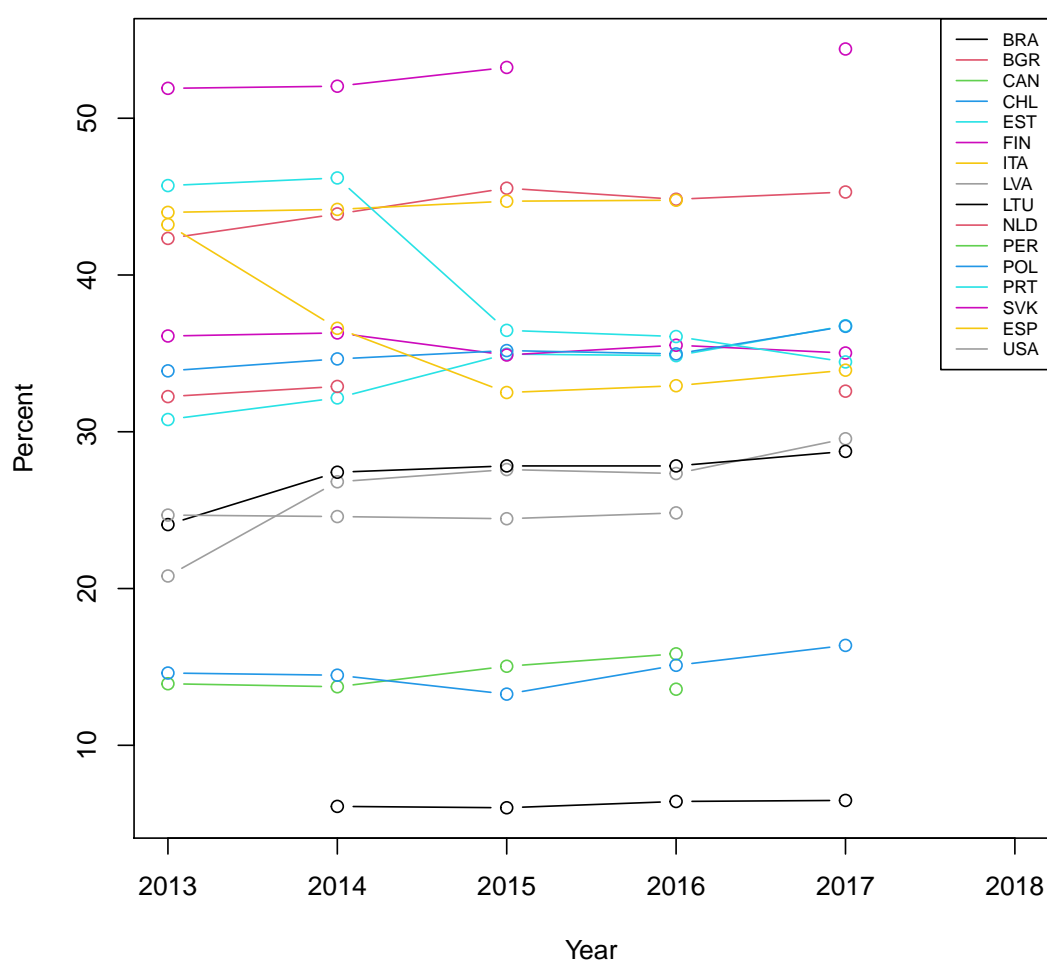
## Sub-index ET

The 2018 archive for the number of master (ISCED 7), PhD (ISCED 8), and total tertiary graduates are incomplete for all participating countries except Georgia, Indonesia and Serbia. **Figure 3.1** presents a time series plot of

$$\text{SKILLED} = \frac{\text{number of masters} + \text{number of PhDs}}{\text{total number of tertiary graduates}}$$

**Figure 3.1**

*Proportion of Postgraduates to Total Tertiary Graduations*



*Note.* “Postgraduate” is defined as master (ISCED 7) and PhD (ISCED 8) graduates. Countries not shown: GEO, IDN and SRB (2018 data available) and RUS (consult other sources)

and suggests that this ratio is likely to be stable over time, especially between adjacent

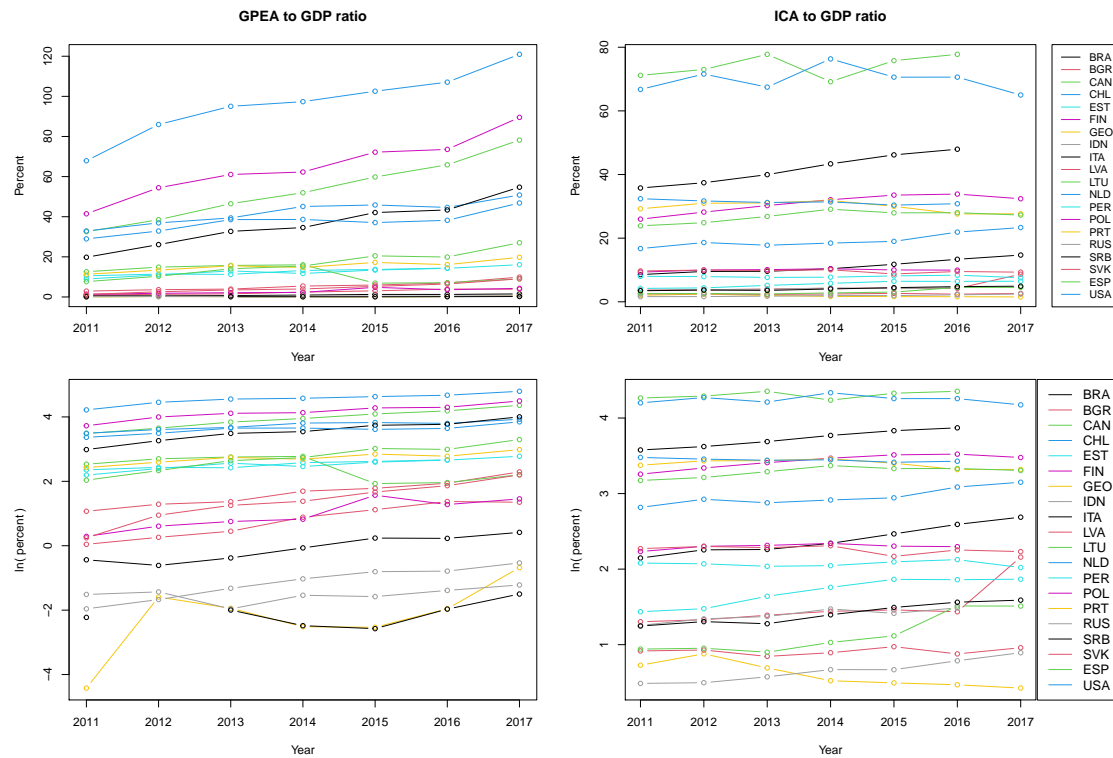
years. A “naive forecast”, where the nearest available year’s data are to be duplicated for 2018, is applied for SKILLED.

## Sub-index Use

All series involved in calculating this sub-index, GPEA, ICA and IUS, contain missing data. When time series data contain only exponential growth but no underlying trend, a simple exponential smoothing would suffice (Gardner, 1985); if trend is present, Holt-Winters method is superior (Chatfield, 1978). Figure 3.2 facilitates this decision making by plotting both the original and log-transformed versions of GPEA and ICA series. Since curves after log-transformations have slopes, it is prudent to apply the Holt-Winters forecasting method in order to account for possible trends contained in the original series.

**Figure 3.2**

*Time Series Trend Test*



*Note.* The time series plots after natural logarithm transformations (bottom panels) are not flat, suggesting the original series (top panels) contain trends. Holt-Winters method therefore is preferred over simple exponential smoothing for 2018 forecasts.

The IUS series contains missing data for Canada, Chile and the United States. Similar Holt-Winters procedure is applied to recover 2018 IUS data.

**Table 3.2***Data Utilised for Computing FKI*

	Economic Capacity	Educational Training		Use			Need		
	GDP per capita	Skilled	Schooling	GPEA	ICA	IUS	PFA	AC	AGEING
BRA	9.612	6.484	7.8	1.683	16.259	70.434	11.827	1.210	0.288
CHL	10.117	16.371	10.4	51.755	25.591	89.531	73.225	1.073	0.214
EST	10.501	36.765	13	16.399	7.681	89.357	18.012	0.876	0.163
GEO	9.588	24.039	12.8	0.784	1.469	62.718	0.834	1.227	0.042
IDN	9.362	7.771	8	0.636	4.612	39.905	1.826	1.059	0.145
ITA	10.665	44.771	10.2	57.434	51.260	74.387	10.589	1.075	0.155
LTU	10.487	28.749	13	9.008	5.500	79.723	7.457	1.107	0.149
PER	9.479	13.577	9.2	16.027	6.505	52.540	22.530	1.187	0.227
POL	10.368	36.725	12.3	4.853	9.535	77.542	9.838	1.085	0.355
PRT	10.444	34.454	9.2	19.353	25.579	74.661	8.761	1.133	0.237
SVK	10.391	54.417	12.6	10.644	8.873	80.660	12.497	0.962	0.300
ESP	10.609	33.929	9.8	27.681	28.230	86.107	10.235	1.044	0.186
USA	11.048	24.825	13.4	55.505	30.183	84.881	150.040	1.364	0.252

*Note.* Full variable names: Skilled = Postgraduate to total tertiary ratio; Schooling = Mean year of schooling; GPEA = Gross portfolio to GDP ratio; ICA = Insurance company assets to GDP ratio; IUS = Number of Internet users per 100 population; PFA = Pension fund assets to GDP ratio; AC = 2% of household final consumption expenditure to GDP ratio; AGEING = Aged-to-productive-population ratio (% change between 2009 and 2018)

### Other Items with Data Concerns

Russia reported 67.96% and 61.01% of its total university degree recipients to be post-graduates for the year 2013 and 2015 respectively (2014 missing). This figure rapidly declines to 41.6% in 2016 and further down to 25.69% in 2017. Such volatility goes against the stable patterns shared by most countries in [Figure 3.1](#), casting doubt on data reliability. Separate investigation is therefore conducted using Russian government archive (Notes c to g in [Table 3.1](#)).

Georgia underwent pension reform in 2018 with fund balance gradually transitioning to State Pension Agency for its official resumption of duty on 1 January 2019. Resultantly, 2018 pension balance for this country is unavailable but to be best approximated using 2019 official data (Notes h, i and \* of [Table 3.1](#)).

[Table 3.2](#) documents the results of the abovementioned data recovery process.

### 3.3.2 Standardisation, Weights and FKI

Following Oliver-Márquez et al. ([2020](#))’s procedure, all series in [Table 3.2](#) undergo min-max normalisation such that the smallest entry receives a new score of 0.01 and the biggest number is re-coded to 0.99. This slight deviation from the original paper (where the min-max normalisation yields 0 to 1) is to avoid multiplying a series by zero or raising a base to the power of zero.

Variable weights are calculated following Oliver-Márquez et al. ([2020](#))’s recipe to be the inverses of each series’ standard deviations. Whereas a sub-index combines more than one series, each weight is further divided by the sum of the constituent weights so that total weights add to one.

FKI is finally computed by taking the geometric mean of all four sub-indices, subject to sub-index-weights similar to variable weights above, as presented in [Table 3.3](#).

**Table 3.3***FKI and Sub-indices*

	FKI	EC	ET	Use	Need
USA	1.029	0.990	0.590	1.467	1.580
ITA	0.810	0.767	0.601	1.603	0.767
ESP	0.661	0.734	0.464	1.012	0.670
LTU	0.609	0.664	0.633	0.325	0.801
PRT	0.606	0.639	0.401	0.869	0.719
CHL	0.589	0.449	0.302	1.372	0.939
EST	0.576	0.672	0.747	0.419	0.455
SVK	0.552	0.608	0.924	0.414	0.341
POL	0.546	0.595	0.700	0.354	0.503
GEO	0.369	0.141	0.548	0.174	0.997
PER	0.289	0.078	0.194	0.780	0.868
BRA	0.131	0.155	0.010	0.506	0.809
IDN	0.104	0.010	0.040	0.975	0.734

*Note.* Table sorted in descending order by countries' FKI. FKI = financial knowledge index, EC = Economic Capability, ET = Educational Training.

### **3.4 What exactly I was using to address my research question**

**3.4.1 Sum score? Averages? One particular question?**

**3.4.2 Factor loading? Latent variables?**

**3.4.3 Motivation for choosing these measures**

### **3.5 Software and version**

### **3.6 My models**

**3.6.1 Motivation for choosing this particular model**

**3.6.2 Refer to my research question**

### **3.7 Estimators I obtained**

**3.7.1 Motivation why these estimators rather than others**

### **3.8 Weights? Plausible values?**

### **3.9 Missing data and how I treated missing data**

### **3.10 Model comparison**

### **3.11 Guidelines and indices**





## Chapter 4

# Results

### 4.1 Descriptive statistics

### 4.2 Correlation matrices

#### 4.2.1 Across countries

#### 4.2.2 Across levels: Country | School | Students

### 4.3 Examination of measurement models

### 4.4 Address the research question

**Table 4.1**  
*Parameter Estimate*

	Model 0		Model 1		Model 2	
	Par.	S.E.	Par.	S.E.	Par.	S.E.
<b>FIXED EFFECTS</b>						
Intercept	481.17	(10.50)	376.22	(13.47)	27.80	(4.61)
<b>Student-level Predictors</b>						
Academic						
Safety						
Financial Socialisation						
Familiarity						
Confidence						
SES					0.30 <sup>†</sup>	(0.53)
Male					7.30	(1.40)
1st Generation Migrant					0.05 <sup>†</sup>	(3.65)
2nd Generation Migrant					−1.25 <sup>†</sup>	(2.17)
Numeracy					0.57	(0.01)
Literacy					0.38	(0.02)
<b>School-level Predictors</b>						
Academic						
Safety						
Resource shortage						
Student-teacher ratio						
<b>Country-level Predictors</b>						
Financial Knowledge Index			151.91	(21.42)	0.55	(0.05)
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<b>RANDOM EFFECTS</b>						
Student-level	6034.80	(317.12)	6004.72	(313.32)	1645.19	(52.95)
School-level	2775.10	(328.71)	2882.72	(356.54)	56.89	(12.27)
Country-level	5163.06		5158.35		110.97	(36.57)
<b>MODEL FIT INDICES</b>						
Log-likelihood	−0.63	(189.96)	−0.63	(190.95)	−0.53	(373.04)
AIC	1.25	(379.91)	1.25	(381.89)	1.06	(746.08)
BIC	1.25	(379.91)	1.25	(381.89)	1.06	(746.08)
SABIC	1.25	(379.91)	1.25	(381.89)	1.06	(746.08)
$\chi^2$ Test of Model Fit			25.00	(3.52)	0.55	(0.14)
RMSEA						
CFI			0.40	(0.35)		
TLI						
SRMR L1			0.00	(0.00)		
SRMR L2			0.06	(0.01)		
SRMR L3			0.20	(0.01)	0.08	(0.01)

*Note.* Par. = parameter estimate, S.E. = standard error, <sup>†</sup> = estimate that failed to reach 0.05 significance level, *M* = mean estimate over ten plausible values, pooled using Rubin's Rule, *SD* = standard deviation of estimates over ten plausible values. Mean estimates for log-likelihood, AIC, BIC and SABIC are recorded in  $\times 10^6$  (i.e., millions), whose standard deviations are in original scale.

## Chapter 5

# Discussion

### 5.1 Brief summary

5.1.1 Remind readers what my research questions are

### 5.2 The implication of this study

### 5.3 Limitation and future directions

5.3.1 Word in positive form

### 5.4 Bird-eye view

5.4.1 What conclusion I can draw from this paper/study



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# Appendices



## Appendix A

# GDPR Documentation and Ethical Approval

This research project discharges its duty imposed by EEA's general data protection regulation (GDPR) by following Norwegian Centre for Research Data (NSD)'s [notification test](#) on Friday, 11 September 2020. Both [PISA 2018 Database](#) and the [World Bank Open Data](#) contain only aggregated and de-personalised datasets with no possibility of back-tracing to any particular participant. Resultantly, no identifiable personal data were collected or used at any stage of this research. The NSD's assessment letter outlines the agency's decision of not subjecting this project to the GDPR notification. The NSD decision letter also satisfies University of Oslo's [ethical approval requirement](#) and concludes the approval process.

About us ([/personvernombud/en/about\\_us.html](/personvernombud/en/about_us.html))

Norwegian ([/personvernombud/meld\\_prosjekt/meldeplikttest.html](/personvernombud/meld_prosjekt/meldeplikttest.html))

NSD (</>) > Personvern tjenester (</personvernombud/>) > Data Protection Services (</personvernombud/en/>) > Notify project (</personvernombud/en/notify/>) > Notification Test

Denne siden på norsk ([/personvernombud/meld\\_prosjekt/meldeplikttest.html](/personvernombud/meld_prosjekt/meldeplikttest.html))

## Will you be processing personal data?

Are you unsure whether your project is subject to notification? Feel free to try our informal Notification test. Note that the test is intended as a guidance and is not a formal assessment.

**Will you be collecting/processing directly identifiable personal data?** ☐ Yes ☒ No

A person will be directly identifiable through name, social security number, or other uniquely personal characteristics.

Read more about personal data (</personvernombud/en/help/vocabulary.html?id=8>) and notification (</personvernombud/en/notify/index.html>).

NB! Even though information is to be anonymized in the final thesis/report, check the box if identifying personal data is to be collected/processed in connection with the project.

**Will directly identifiable personal information be linked to the data (e.g. through a reference number which refers to a separate list of names/scrambling key)?** ☐ Yes ☒ No

Note that the project will be subject to notification even if you cannot access the scrambling key (</personvernombud/en/help/vocabulary.html?id=11>), as the procedure often is when using a data processor (</personvernombud/en/help/vocabulary.html?id=3>), or in register-based studies ([/personvernombud/en/help/research\\_methods/register\\_studies.html](/personvernombud/en/help/research_methods/register_studies.html)).

**Will you be collecting/processing background information that may identify individuals (indirectly identifiable personal data)?** ☐ Yes ☒ No

A person will be indirectly identifiable if it is possible to identify him/her through a combination of background information (such as place of residence or workplace/school, combined with information such as age, gender, occupation, etc.).

**Will there be registered personal data (directly/indirectly/via IP or email address, etc.) using online surveys?** ☐ Yes ☒ No

Please note that the project will be subject to notification even if you as a student/researcher cannot access the link to the IP or email address, as the procedure often is when using a data processor.

Read more about online surveys ([/personvernombud/en/help/research\\_methods/online\\_surveys.html](/personvernombud/en/help/research_methods/online_surveys.html)).

**Will there be registered personal data using digital photo or video files?**

☐ Yes

☒ No

Photo/video recordings of faces will be regarded as identifiable personal data. In order for a voice to be considered as identifiable, it must be registered in combination with other background information, in such a way that people can be recognized.

Show results

## Notify project

Do I have to notify my project? (</personvernombud/en/notify/index.html>)

Notification Form ([/personvernombud/en/notify/meldeskjema\\_link](/personvernombud/en/notify/meldeskjema_link))

Notifying changes ([/personvernombud/en/notify/notifying\\_changes.html](/personvernombud/en/notify/notifying_changes.html))

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Research methods ([/personvernombud/en/help/research\\_methods/](/personvernombud/en/help/research_methods/))

Information and consent ([/personvernombud/en/help/information\\_consent/](/personvernombud/en/help/information_consent/))

Other approvals ([/personvernombud/en/help/other\\_approvals/](/personvernombud/en/help/other_approvals/))

## Result of Notification Test: Not Subject to Notification

You have indicated that neither directly or indirectly identifiable personal data will be registered in the project.

If no personal data is to be registered, the project will not be subject to notification, and you will not have to submit a notification form.

Please note that this is a guidance based on information that you have given in the notification test and not a formal confirmation.

For your information: *In order for a project not to be subject to notification, we presuppose that all information processed using electronic equipment in the project remains anonymous.*

*Anonymous information is defined as information that cannot identify individuals in the data set in any of the following ways:*

- directly, through uniquely identifiable characteristic (such as name, social security number, email address, etc.)*
- indirectly, through a combination of background variables (such as residence/institution, gender, age, etc.)*
- through a list of names referring to an encryption formula or code, or*
- through recognizable faces on photographs or video recordings.*

*Furthermore, we presuppose that names/consent forms are not linked to sensitive personal data.*

Kind regards,  
NSD Data Protection



# Appendix B

## Analysis Code

### B.1 Chapter 1

There is no analysis code in [Chapter 1](#).

### B.2 Chapter 2

#### B.2.1 Data Import

```
1| # Housekeeping
2| library(Orcs)
3| setwdOS(lin = "~/", win = "C:/Users/Tony/")
4|
5| # Import SPSS file into R
6| library(intsvy)
7| finlit ← pisa.select.merge(
8|   student.file = "CY07_MSU_FLT_QQQ.SAV", # file ext in capital
9|   school.file = "CY07_MSU_SCH_QQQ.sav", # file ext in lower case
10|   student = c(
11|     # Control variables
12|     "ST004D01T", # Student (Standardized) Gender
13|     "IMMIG", # Index Immigration status
14|     "ESCS", # Index of economic, social and cultural status
15|     # Mediators
16|     "FCFMLRTY", # Familiarity with concepts of finance (Sum)
17|     "FLCONFIN", # Confidence about financial matters (WLE)
18|     # Academic
19|     "PERFEED", # Perceived feedback (WLE)
20|     "TEACHINT", # Perceived teacher's interest (WLE)
21|     "FLSCHOOL", # Financial education in school lessons (WLE)
22|     # Safety
23|     "DISCRIM", # Discriminating school climate (WLE)
24|     "BELONG", # Sense of belonging to school (WLE)
```

```

25 |     "BEINGBULLIED", # Student's experience of being bullied (WLE)
26 |     # Community
27 |     "FLFAMILY", # Parental involvement in matters of Financial
↵ |     Literacy (WLE)
28 |     "CURSUPP", # Current parental support for learning at home (WLE)
29 |     "PASCHPOL" # School policies for parental involvement (WLE)
30 |   ),
31 |   school = c(
32 |     "PRIVATESCH", # School type (public, private, missing)
33 |     "STRATIO", # Student-teacher ratio
34 |     "EDUSHORT", # Shortage of educational material (WLE)
35 |     "STAFFSHORT" # Shortage of educational staff (WLE)
36 |   ),
37 |   countries = c(
38 |     "BGR", "BRA", "CAN", "CHL", "ESP",
39 |     "EST", "FIN", "GEO", "IDN", "ITA",
40 |     "LTU", "LVA", "NLD", "PER", "POL",
41 |     "PRT", "QMR", "QRT", "RUS", "SRB",
42 |     "SVK", "USA"
43 |   )
44 | )
45 |
46 | # Remove columns that I do not need
47 | finlit <- finlit[, -c(5, 7:86)] # 5 = BOOKID; 7:86 = resampling weights
48 |
49 | # Some var need recording
50 | library(car)
51 |
52 | # Re-code Russian territories to RUS
53 | finlit$CNT <- recode(finlit$CNT, "
54 |   'QMR' = 'RUS';
55 |   'QRT' = 'RUS'
56 | ")
57 |
58 | # Recode ST004D01T from Sex to Male
59 | MALE <- finlit$ST004D01T - 1
60 |
61 | # Recode IMMIG to 1st and 2nd generation
62 | IMMI1GEN <- recode(finlit$IMMIG, "
63 |   1 = 0;
64 |   2 = 0;
65 |   3 = 1
66 | ")
67 |
68 | IMMI2GEN <- recode(finlit$IMMIG, "
69 |   1 = 0;
70 |   2 = 1;
71 |   3 = 0
72 | ")
73 |
74 | # Recode PRIVATESCH from texts to numbers

```

```

75| finlit$PRIVATESCH ← recode(finlit$PRIVATESCH, "
76|   'public' = 0;
77|   'private' = 1;
78|   'missing' = NA
79| ")
80| finlit$PRIVATESCH ← as.numeric(finlit$PRIVATESCH) # Force "0" to 0.
81|
82| # Stitch spreadsheets together
83| finlit ← cbind(
84|   finlit[, c(1:35)],
85|   MALE, IMMI1GEN, IMMI2GEN,
86|   finlit[, c(38:54)]
87| )
88|
89| # Use data.table for better RAM management
90| library(data.table); setDTthreads(0) # 0 means all the available cores
91| # Export data into a CSV file for faster import next time
92| fwrite(finlit,
93|   file = "finlit.csv",
94|   na = "NA", row.names = F, col.names = T
95| )

```

## B.2.2 Missing Pattern Inspection

```

1| library(Orcs)
2| setwdOS(lin = "~/", win = "C:/Users/Tony/")
3|
4| library(data.table); setDTthreads(0)
5| finlit ← fread("finlit.csv", nThread = getDTthreads())
6|
7| library(dplyr)
8| # Record how many missings each country has for each var
9| missings ← finlit %>%
10|   select(everything()) %>%
11|   group_by(CNT) %>%
12|   summarise_all(funs(sum(is.na(.))))
13| # Give me the headcount for each country
14| headcount ← finlit %>%
15|   group_by(CNT) %>%
16|   summarize(n())
17| # Stitch these two tables together
18| missing_table ← tibble(headcount, missings[, -1])
19| # Save this file
20| fwrite(missing_table, "missing_table.csv", row.names = F, col.names = T)
21|
22| # Inspect the missing table using Excel
23| # Throw away the following countries
24| #   CAN: 100% missing on too many var
25| #   BRA, FIN, LVA, NLD, RUS, SRB: private/public info missing
26| # Throw away these var
27| #   DISCRIM, CURSUPP, PASCHPOL: Too many countries have 100% missing

```

## B.2.3 Data Reimport

```
1 | # Housekeeping
2 | library(Orcs)
3 | setwdOS(lin = "~/", win = "C:/Users/Tony/")
4 |
5 | # Import SPSS file into R
6 | library(intsvy)
7 | finlit <- pisa.select.merge(
8 |   student.file = "CY07_MSU_FLT_QQQ.SAV", # file ext in capital
9 |   school.file = "CY07_MSU_SCH_QQQ.sav", # file ext in lower case
10 |   student = c(
11 |     # Control variables
12 |     "ST004D01T", # Student (Standardized) Gender
13 |     "IMMIG", # Index Immigration status
14 |     "ESCS", # Index of economic, social and cultural status
15 |     # Mediators
16 |     "FCFMLRTY", # Familiarity with concepts of finance (Sum)
17 |     "FLCONFIN", # Confidence about financial matters (WLE)
18 |     # Academic
19 |     "PERFEED", # Perceived feedback (WLE)
20 |     "TEACHINT", # Perceived teacher's interest (WLE)
21 |     "FLSCHOOL", # Financial education in school lessons (WLE)
22 |     # Safety
23 |     "BELONG", # Sense of belonging to school (WLE)
24 |     "BEINGBULLIED", # Student's experience of being bullied (WLE)
25 |     # Community
26 |     "FLFAMILY" # Parental involvement in matters of Financial
    ↪ Literacy (WLE)
27 |   ),
28 |   school = c(
29 |     "PRIVATESCH", # School type (public, private, missing)
30 |     "STRATIO", # Student-teacher ratio
31 |     "EDUSHORT", # Shortage of educational material (WLE)
32 |     "STAFFSHORT" # Shortage of educational staff (WLE)
33 |   ),
34 |   countries = c(
35 |     "BRA", "CHL", "ESP", "EST", "GEO",
36 |     "IDN", "ITA", "LTU", "PER", "POL",
37 |     "PRT", "SVK", "USA"
38 |   )
39 | )
40 |
41 | names(finlit)
42 | # Remove columns that I do not need
43 | finlit <- finlit[, -c(5, 7:86)] # 5 = BOOKID; 7:86 = resampling weights
44 |
45 | # Some var need recording
46 | library(car)
47 |
48 | # Recode ST004D01T from Sex to Male
```

```

49| MALE ← finlit$ST004D01T - 1
50|
51| # Recode IMMIG to 1st and 2nd generation
52| IMMI1GEN ← recode(finlit$IMMIG, "
53|   1 = 0;
54|   2 = 0;
55|   3 = 1
56| ")
57|
58| IMMI2GEN ← recode(finlit$IMMIG, "
59|   1 = 0;
60|   2 = 1;
61|   3 = 0
62| ")
63|
64| # Recode PRIVATESCH from texts to numbers
65| finlit$PRIVATESCH ← recode(finlit$PRIVATESCH, "
66|   'public ' = 0;
67|   'private' = 1;
68|   'missing' = NA
69| ")
70| finlit$PRIVATESCH ← as.numeric(finlit$PRIVATESCH) # Force "0" to 0.
71|
72| # Stitch spreadsheets together
73| finlit ← cbind(
74|   finlit[, c(1:35)],
75|   MALE, IMMI1GEN, IMMI2GEN,
76|   finlit[, c(38:51)]
77| )
78|
79| # Remove cases whose school weights (col #48) are NA
80| finlit ← finlit[complete.cases(finlit[, 48]), ]
81|
82| # Use data.table for better RAM management
83| library(data.table); setDTthreads(0) # 0 means all the available cores
84| # Export data into a CSV file for faster import next time
85| fwrite(finlit,
86|   file = "finlit.csv",
87|   na = "NA", row.names = F, col.names = T
88| )

```

## B.2.4 Financial Knowledge Index

```

1| # Section 0: Housekeeping
2| library(Orcs) # Set working directory depending on operating system
3| setwdOS(
4|   lin = "~/uio/", win = "M:/",
5|   ext = "pc/Dokumenter/MSc/Thesis/Data/L3/"
6| )
7|
8| # Set up a "bookshelf" to hold variables nessary to compute FK1
9| fki_raw ← matrix(NA,

```

```

10|     nrow = 13, ncol = 10, dimnames = list(
11|       c( # row names
12|         "BRA", "CHL", "EST", "GEO", "IDN",
13|         "ITA", "LTU", "PER", "POL", "PRT",
14|         "SVK", "ESP", "USA"
15|       ),
16|       c( # column names
17|         "gdp_per_capita", # economic capability (sub_ind_ec)
18|         "highly_skilled", "mean_year_of_schooling", # (sub_ind_et)
19|         "gpea", "ica", "ius", # use (sub_ind_use)
20|         "pfa", "ac", "gdp", "ageing" # need (sub_ind_need)
21|       )
22|     ) # End list()
23| ) # End matrix()
24|
25|
26| # Section 1: Economic capacity
27|
28| gdp_per_capita <- read.csv("gdp_per_capita.csv", header = T, sep = "\t")
29| # Only keep "the 13 countries"
30| gdp_per_capita <- gdp_per_capita[-c(2, 3, 6, 10, 12, 16, 17), ]
31|
32| fki_raw[, 1] <- log(gdp_per_capita[, 2])
33|
34| rm(gdp_per_capita)
35|
36|
37| # Section 2: Educational training
38|
39| # Subsection 2.1: Highly skilled
40|
41| # Masters
42| isced_7 <- read.csv("isced_7.csv", header = T, sep = "\t")
43| isced_7 <- isced_7[, -c(2, 3, 6, 10, 12, 16, 17)]
44|
45| # PhDs
46| isced_8 <- read.csv("isced_8.csv", header = T, sep = "\t")
47| isced_8 <- isced_8[, -c(2, 3, 6, 10, 12, 16, 17), ]
48|
49| # Total tertiary
50| total_tertiary <- read.csv("total_tertiary.csv", header = T, sep = "\t")
51| total_tertiary <- total_tertiary[, -c(2, 3, 6, 10, 12, 16, 17)]
52|
53| # Compute highly skilled (master + PhD) to total tertiary ratio
54| highly_skilled <- ts(
55|   (isced_7 + isced_8) / total_tertiary,
56|   start = 2013, end = 2018, frequency = 1
57| )
58|
59| # pdf("../Figures/skilled.pdf")
60| # Visualise these ratios. Turn off GEO, IDN, SRB and RUS

```

```

61 # ts.plot(100 * highly_skilled[, -c(7, 8, 16, 17)],
62 #         type = "b", col = 1:16,
63 #         xlab = "Year", ylab = "Percent"
64 # )
65 # legend("topright", colnames(highly_skilled[, -c(7, 8, 16, 17)]),
66 #       col = 1:16, lty = 1, cex = 0.65
67 # )
68 # dev.off()
69
70 # Decision: naive forecasts, i.e., copy-paste nearest available year
71 library(forecast)
72 # Create a placeholder matrix
73 placeholder <- matrix(NA, nrow = 13, ncol = 1)
74
75 # Run a loop to forecast all 13 countries, using naive method
76 for (.i in 1:13) {
77   m_naive_i <- naive(highly_skilled[, .i], h = 1)
78   placeholder[.i] <- data.frame(unlist(m_naive_i[5]))[6][1, 1]
79 }
80 # [5] = fitted values; [6] = 2018; [1,1] = only the numeric value
81
82 # GEO and IDN have 2018 data, plug actual numbers back
83 placeholder[c(4, 5)] <- highly_skilled[6, c(4, 5)]
84
85 # Save results to "bookshelf"
86 fki_raw[, 2] <- placeholder * 100
87
88 rm(
89   isced_7, isced_8, total_tertiary,
90   highly_skilled, placeholder, m_naive_i
91 )
92
93 # Sub-section 2.2: Mean year of schooling
94 mean_year_of_schooling <- read.csv("mean_year_of_schooling.csv",
95   header = F, sep = "\t"
96 )
97 fki_raw[, 3] <- mean_year_of_schooling[-c(2, 3, 6, 10, 12, 16, 17), 2]
98
99 rm(mean_year_of_schooling)
100
101
102 # Section 3: Use
103
104 gpea <- read.csv("gpea.csv", header = T, sep = "\t")
105 gpea <- gpea[, -c(2, 3, 6, 10, 12, 16, 17)]
106 gpea <- ts(gpea, start = 2011, end = 2017, frequency = 1)
107
108 # # Visualise data in both original and ln forms. Contain trend?
109 # pdf("../.. /Figures/use.pdf", width = 12.94, height = 9.15)
110
111 # # Re-set canvas layout to 2x2

```

```

112 # par(mfcol = c(2, 2))
113
114 # # Add extra space to the right of plot area
115 # par(mar = c(5.1, 4.1, 4.1, 2.1), xpd = TRUE)
116
117 # # Plot GPEA in original form
118 # ts.plot(gpea,
119 #   type = "b", col = 1:20,
120 #   xlab = "Year", ylab = "Percent", main = "GPEA to GDP ratio"
121 # )
122 # # Add the legend
123 # legend("topright",
124 #   inset = c(-0.2, 0), colnames(gpea),
125 #   col = 1:20, lty = 1, cex = 0.65
126 # )
127
128 # # Remove extra gap between the two graphs
129 # par(mar = c(5.1, 4.1, 0, 2.1), xpd = TRUE)
130
131 # # Repeat GPEA, but for the ln() version
132 # ts.plot(log(gpea),
133 #   type = "b", col = 1:20,
134 #   xlab = "Year", ylab = "ln( percent )"
135 # )
136 # # Add the legend
137 # legend("topright",
138 #   inset = c(-0.2, 0), colnames(gpea),
139 #   col = 1:20, lty = 1, cex = 0.65
140 # )
141
142 # # Plot ICA in original form
143 # par(mar = c(5.1, 4.1, 4.1, 6.1), xpd = TRUE)
144 # ts.plot(ica,
145 #   type = "b", col = 1:20,
146 #   xlab = "Year", ylab = "Percent", main = "ICA to GDP ratio"
147 # )
148 # # Add the legend
149 # legend("topright",
150 #   inset = c(-0.2, 0), colnames(ica),
151 #   col = 1:20, lty = 1, cex = 0.875
152 # )
153
154 # # Remove extra gap between the two graphs
155 # par(mar = c(5.1, 4.1, 0, 6.1), xpd = TRUE)
156
157 # # Repeat, but for the ln()
158 # ts.plot(log(ica),
159 #   type = "b", col = 1:20,
160 #   xlab = "Year", ylab = "ln( percent )"
161 # )
162 # # Add the legend

```



```

163 # legend("topright",
164 #       inset = c(-0.2, 0), colnames(ica),
165 #       col = 1:20, lty = 1, cex = 1.07
166 # )
167 # dev.off()
168
169 # Decision: since the ln() version is not flat, original time series
170 # contain trend. Use Holt method rather than simple exponential smoothing.
171
172 # Run a time series forecast using Holt method
173
174 # Create a placeholder matrix
175 placeholder <- matrix(NA, nrow = 13, ncol = 1)
176
177 # Run a loop to forecast all 13 countries, using Holt method
178 for (.i in 1:13) {
179   m_holt_i <- holt(gpea[, .i], h = 1)
180   placeholder[.i] <- m_holt_i[2]
181 }
182
183 # Only keep the 2018 forecasts
184 placeholder <- unlist(placeholder)
185
186 # Run PER (#8) separately because it misses both 2017 and 2018 data
187 m_holt_PER <- holt(gpea[, 8], h = 2); summary(m_holt_PER)
188 placeholder[8] <- 16.02698
189
190 # Push placeholder to fki_raw
191 fki_raw[, 4] <- placeholder
192
193 rm(gpea, placeholder, m_holt_i, m_holt_PER)
194
195 # Sub-section 3.2: Insurance company assets (ica)
196
197 ica <- read.csv("ica.csv", header = T, sep = "\t")
198 ica <- ica[, -c(2, 3, 6, 10, 12, 16, 17)]
199 ica <- ts(ica, start = 2011, end = 2017, frequency = 1)
200
201 placeholder <- matrix(NA, nrow = 13, ncol = 1)
202
203 for (.i in 1:13) {
204   m_holt_i <- holt(ica[, .i], h = 1)
205   placeholder[.i] <- m_holt_i[2]
206 }
207
208 placeholder <- unlist(placeholder)
209
210 m_holt_IND <- holt(ica[, 5], h = 2); summary(m_holt_IND)
211 m_holt_ITA <- holt(ica[, 6], h = 2); summary(m_holt_ITA)
212 m_holt_POL <- holt(ica[, 9], h = 2); summary(m_holt_POL)
213 m_holt_USA <- holt(ica[, 13], h = 2); summary(m_holt_USA)

```

```

214|
215| placeholder[c(5, 6, 9, 13)] ← c(
216|   4.611597, 51.2596, 9.534750, 30.18295
217| )
218|
219| fki_raw[, 5] ← placeholder
220|
221| rm(ica, placeholder, list = ls(pattern = "^m.holt"))
222|
223| # Sub-section 3.3: Individuals using the Internet (ius)
224|
225| ius ← read.csv("ius.csv", header = T, sep = "\t")
226| ius ← ius[, -c(2, 3, 6, 10, 12, 16, 17)]
227| ius ← ts(ius, start = 2009, end = 2018, frequency = 1)
228|
229| m_holt_CHL ← holt(ius[1:9, 2], h = 1); summary(m_holt_CHL)
230| m_holt_USA ← holt(ius[1:9, 13], h = 1); summary(m_holt_USA)
231|
232| ius_2018 ← ius[10, ] # Only want 2018 data
233| ius_2018[2] ← 89.5309 # CHL
234| ius_2018[13] ← 84.88108 # USA
235|
236| fki_raw[, 6] ← ius_2018
237|
238| rm(list = ls(pattern = "^ius"))
239| rm(list = ls(pattern = "^m.holt_"))
240|
241|
242| # Section 4: Need
243|
244| # Subsection 4.1: Pension fund assets (pfa)
245| pfa ← read.csv("pfa.csv", header = T, sep = "\t")
246| pfa ← pfa[, -c(2, 3, 6, 10, 12, 16, 17)]
247| # Delete GEO (#4) due to all missing. Will come back to it later.
248| pfa ← ts(pfa[, -4], start = 2008, end = 2017, frequency = 1)
249|
250| placeholder ← matrix(NA, nrow = 12, ncol = 1)
251|
252| for (.i in 1:12) {
253|   m_holt_i ← holt(pfa[, .i], h = 1)
254|   placeholder[.i] ← m_holt_i[2]
255| }
256|
257| placeholder ← unlist(placeholder)
258|
259| # Calculate GEO
260| # From Georgia Pension Agency:
261| #   2019 mesub_ind_eting minute: 372,113,933 GEL
262| # From GeoStat website:
263| #   2018 gdp = 44.6 billion GEL
264|

```

```

265 fki_raw[, 7] ← c(
266   placeholder[1:3],
267   372113934 / 446000000000 * 100, # Insert GEO figure
268   placeholder[4:12]
269 )
270
271 rm(pfa, placeholder, m_holt_i)
272
273 # Subsection 4.2: Aggregate consumption (ac)
274
275 ac ← read.csv("ac.csv", header = F, row.names = 1, sep = "\t")
276 ac ← ac[-c(2, 3, 6, 10, 12, 16, 17), ]
277 gdp ← read.csv("gdp.csv", header = F, row.names = 1, sep = "\t")
278 gdp ← gdp[-c(2, 3, 6, 10, 12, 16, 17), ]
279
280 fki_raw[, 8] ← unlist(ac * 0.02 / gdp * 100)
281
282 fki_raw[, 9] ← unlist(gdp)
283
284 rm(ac, gdp)
285
286 # Subsection 4.3: Ageing
287
288 ageing ← read.csv("ageing.csv", header = T, sep = "\t")
289 ageing ← ageing[-c(
290   2, 3, 6, 10, 12, 16, 17,
291   22, 23, 26, 30, 32, 36, 37
292 ), ]
293 attach(ageing)
294 names(ageing)
295
296 # Calculate total population
297 poptotal_f ← pop0to14_f + pop15to64_f + pop65plus_f
298 poptotal_m ← pop0to14_m + pop15to64_m + pop65plus_m
299 # Calculate population between 15 and 19
300 # Need to divide by 100 to get decimals
301 pop15to19_f ← poptotal_f * per15to19_f / 100
302 pop15to19_m ← poptotal_m * per15to19_m / 100
303 # Calculate population between 0 and 19
304 pop0to19_f ← pop0to14_f + pop15to19_f
305 pop0to19_m ← pop0to14_m + pop15to19_m
306 # Calculate population between 20 and 64
307 pop20to64_f ← poptotal_f - pop0to19_f - pop65plus_f
308 pop20to64_m ← poptotal_m - pop0to19_m - pop65plus_m
309 # Calculate 64+ / 20-to-64 ratio
310 ageing_ratio ← I(
311   (pop65plus_f + pop65plus_m) / (pop20to64_f + pop20to64_m)
312 )
313 # Split data into 2018 [ , 1] and 2009 [ , 2] portions
314 ageing ← cbind(ageing_ratio[1:13], ageing_ratio[14:26])
315 fki_raw[, 10] ← (ageing[, 1] - ageing[, 2]) / ageing[, 2]

```

```

316|
317| rm(ageing, ageing_ratio, list = ls(pattern = "^pop"))
318|
319|
320| # Section 5: FKI
321|
322| fki_raw ← fki_raw[, -9] # Throw away gdp (already in ac)
323| round(fki_raw, digits = 3) # Inspect data
324|
325| # Save data to an external file
326| library(data.table); setDTthreads(0)
327| fwrite(round(fki_raw, digits = 3), file = "fki_raw.csv")
328|
329| # Subsection 5.0: Standardise each variable to [0.01,0.99] range
330| fki_stand ← matrix(NA, nrow = dim(fki_raw)[1], ncol = dim(fki_raw)[2])
331| dimnames(fki_stand) ← dimnames(fki_raw)
332|
333| library(scales) # I wish this function could have "by.col = T". Oh well.
334| for (.j in 1:dim(fki_raw)[2]) {
335|   fki_stand[, .j] ← rescale(fki_raw[, .j], to = c(0.01, 0.99))
336| }
337|
338| rm(fki_raw)
339|
340| fki_stand ← data.frame(fki_stand)
341| attach(fki_stand)
342|
343| # Subsection 5.1: Economic capacity (sub_ind_ec)
344|
345| sub_ind_ec ← gdp_per_capita
346|
347| # Subsection 5.2: Education and training (sub_ind_et)
348|
349| wt_highly_skilled ← 1 / sd(highly_skilled)
350| wt_mean_year_of_schooling ← 1 / sd(mean_year_of_schooling)
351|
352| sub_ind_et ← (highly_skilled^wt_highly_skilled *
353|   mean_year_of_schooling^wt_mean_year_of_schooling)^
354|   (1 / (wt_highly_skilled + wt_mean_year_of_schooling))
355|
356| rm(list = ls(pattern = "^wt"))
357|
358| # Subsection 5.3: Use (sub_ind_use)
359|
360| sub_ind_u ← (gpea + ica)^ius
361|
362| # Subsection 5.4: Need (sub_ind_need)
363|
364| sub_ind_n ← (pfa + ac)^ageing
365|
366| ## Subsection 5.5: FKI

```

```

367|
368| wt_ec <- 1 / sd(sub_ind_ec)
369| wt_et <- 1 / sd(sub_ind_et)
370| wt_u <- 1 / sd(sub_ind_u)
371| wt_n <- 1 / sd(sub_ind_n)
372|
373| fki <- (
374|   sub_ind_ec^wt_ec *
375|   sub_ind_et^wt_et *
376|   sub_ind_u^wt_u *
377|   sub_ind_n^wt_n
378| ) ^ (
379|   1 / (wt_ec + wt_et + wt_u + wt_n)
380| )
381|
382| rm(list = ls(pattern = "^wt"))
383|
384| l3 <- data.frame(
385|   round(
386|     cbind(fki, sub_ind_ec, sub_ind_et, sub_ind_u, sub_ind_n),
387|     digits = 3
388|   )
389| )
390| rownames(l3) <- rownames(fki_stand)
391| attach(l3)
392|
393| rm(fki_stand, fki, sub_ind_ec, sub_ind_et, sub_ind_u, sub_ind_n)
394|
395| # Display country-level FKI, default by country code
396| l3
397|
398| # Sort FKI by country (highest to lowest)
399| l3_ordered <- l3[order(-fki), ]
400| l3_ordered
401| fwrite(l3_ordered, file = "fki.csv")
402|
403| barplot(l3_ordered$fki,
404|   names.arg = rownames(l3_ordered),
405|   xlab = "Country", las = 2, ylab = "Financial Knowledge Index (FKI)",
406|   ylim = c(0, 1), main = "FKI of the 20 participating countries"
407| )

```

