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A cross-country comparison of family effect upon students' reading literacy based on social capital theory

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Prior studies examining social capital and academic achievement have focused on individual countries, limiting cross-cultural generalizability. Additionally, inconsistent measurement of social capital hinders robust conclusions about its effects on student achievement. To add these problems, this study evaluates family-based social capital (FSC) within diverse cultural contexts using a two-stage analytical framework combining country-specific two-level hierarchical linear modeling (HLM) with meta-analyses and cultural dimension analysis, based on PISA2009 data for 14 economies, 3,420 schools and 101,370 students. Four HLM models assessed contributions of demographic characteristics and family social capital (family structure, siblings, early parental support, current parental involvement) to reading literacy. Cross-country comparisons employed Snijders and Bosker's pseudo- R^2 , intra-class correlations, and Hedges' Q tests. Correlation and regression analyses examined relationships between gross explanatory power of FSC and Hofstede's cultural dimensions. Results reveal family social capital significantly predicts reading achievement beyond demographic factors, with net explanatory power varying from 1% (Macao) to 7.8% (Hungary). Early parental support and nuclear families show positive associations, while sibling number exhibits negative effects, and effects specific to each country vary significantly. Hedges' Q tests confirm significant cross-national heterogeneity for each aspect of family-based social capital. Critically, Hofstede's Indulgence versus Restraint dimension substantially accounts for cross-national variation in FSC's explanatory power ($R^2 = 0.763$). Findings demonstrate that family social capital's impact is systematically moderated by cultural orientation, challenging universalist assumptions in Coleman's framework and highlighting the necessity for culturally informed educational theories and context-specific policies.

KEYWORDS

cross-cultural comparison, cultural dimensions, family social capital, hierarchical linear modeling, meta-analysis

1 Introduction

Family socioeconomic background has long been recognized as a pivotal factor affecting student achievement since [Coleman et al. \(1966\)](#) and [Heyneman and Loxley \(1983\)](#) found that the importance of family to student academic achievement is conditioned by national economic development ([Heyneman, 2016](#)). This implies

that inter-generational transfer of human capital is ubiquitous in the world, while the mechanism of transfer may vary across countries (Heyneman and Loxley, 1983). The intergenerational transmission of human capital (academic achievement) is incomplete without the inclusion of a third essential form of capital—social capital (e.g., Bourdieu, 1986; Broer et al., 2019; Coleman, 1988; Demir, 2021; Dika and Singh, 2002). Following the seminal contributions of Bourdieu (1986) and Coleman (1988), numerous studies have investigated the impact of various facets of social capital on student achievement (e.g., Demir, 2021; Dika and Singh, 2002; Ferguson, 2006; Mouw, 2006; Osman et al., 2021; Taysum and Ayanlaja, 2020). However, the majority of these studies have focused on individual countries or specific regions, leading to a lack of cross-cultural generalizability (e.g., An and Western, 2019; Cheung and Chan, 2008; Chu, 2004; Hoffmann et al., 2020; Huang, 2009; Okeke et al., 2023). This limits the broader understanding of how social capital impacts student achievement across diverse cultural and socioeconomic contexts. In addition, there has been a lack of consensus on the measurement of social capital, leading to variations in the operationalization of this construct across studies. These limitations hinder the ability to draw robust conclusions about the effects of social capital on student achievement.

A critical unresolved theoretical question is whether Coleman's framework, developed primarily in Western contexts, applies universally or requires cultural contextualization. Coleman (1988) emphasized universal mechanisms through which social capital operates—norms, social control, and social closure—implying that family structure, parental involvement, and intergenerational relationships should similarly influence academic achievement across diverse societies. However, Bourdieu's (1986) theory suggests that social capital operates within field-specific logics shaped by cultural structures, with different forms of capital valued and converted into educational advantage differently across contexts. While research has documented variations in family social capital's effects across individual countries (Tan and Fang, 2023; Xie and He, 2023), empirical tests identifying which cultural dimensions systematically moderate social capital's effectiveness remain absent.

In view of this research gap, we undertook an investigation into the effect of family-based social capital based on data from PISA (the Program for International Student Assessment) 2009. This dataset included a parental questionnaire administered in 14 out of 65 participating countries or economies (For the ease of reference, we will refer to all participating countries or economies as "economies" throughout this study). The data structure reflects the hierarchical organization of educational systems, with students nested within schools, which, in turn, are nested within systems. Given this data structure, we employed two-level hierarchical linear modeling (HLM) on each of 14 national datasets. Additionally, we utilized Hedges' homogeneity tests to examine whether significant variations in regression coefficients exist among the 14 economies (Hedges, 1982). Extending beyond traditional cross-national comparisons, we conducted a cultural dimension analysis to investigate whether the explanatory power of family-based social capital is systematically related to Hofstede's cultural dimensions (Hofstede et al., 2010), providing insight into the cultural moderation of social capital effects.

This paper addresses three key research questions: (1) Does family social capital affect student reading literacy beyond the effects of human and economic capital? (2) Do the effects of

different aspects of family social capital vary across economies? (3) Is the explanatory power of family-based social capital systematically related to cultural dimensions? By answering these questions, this study contributes to social capital theory by demonstrating empirically that family social capital's effects are not culturally invariant but are instead moderated by broader cultural contexts, particularly societal orientations toward indulgence versus restraint.

This paper is organized into five sections. Section 1 reviews prior literature and establishes the theoretical framework. Section 2 provides a concise overview of the PISA dataset and introduces the modeling methods employed. Section 3 presents the modeling results, meta-analysis findings, and cultural dimension analysis. Section 4 discusses the research findings, and Section 5 concludes the study with implications and suggestions for future research.

2 Literature review

2.1 Social capital

Social capital pertains to resources embedded within social relationships among individuals or groups, facilitating purposeful actions (Coleman, 1988, 1993). It encompasses both objective connections and subjective relationships characterized by elements like trust, reciprocity, and positive emotions (Paxton, 1999). Social capital can manifest at multiple social levels, including households, neighborhoods, schools, and more. Research indicates that students' academic achievements strongly relate to human, economic, and social capital across different contexts, notably within family and educational settings (Dufur et al., 2008; Parcel and Dufur, 2001; Portes, 2024; Sun, 1998). The mechanisms through which economic and human capital influence students' academic performance both at home and school are crucial determinants of academic outcomes, with social capital playing a vital role (Bourdieu and Passeron, 1990; Coleman, 1988; Demir, 2021; Portes, 2024).

Social capital may leverage the cross-generation transfer of human capital in three scenarios. First, social capital may establish contexts for the inter-generational transmission of human and economic capital (Bassani, 2007; Bourdieu, 1986; Coleman, 1988, 1993; Dika and Singh, 2002; Rodríguez-Hernández et al., 2020). Second, parents with more human and economic resources can mobilize greater social capital (Dufur et al., 2013; Israel and Beaulieu, 2002; Parcel et al., 2010). In a third scenario, social capital, parallel to human and economic capital, significantly influences student achievement (Dufur et al., 2008; Dufur et al., 2013; Nygård and Behtoui, 2020).

Since Bourdieu's seminal work in 1986 and Coleman's in 1988, numerous studies have explored the impact of various facets of social capital on student achievement (Alfred and Addo, 2017; Demir, 2021; Dika and Singh, 2002; Ferguson, 2006; Mishra, 2020; Mouw, 2006; Sobba, 2019). Most researchers have aligned with Coleman's conceptualization and measurement of social capital, with a specific focus on family social capital. Family social capital encompasses norms, social networks, and adult-child relationships beneficial for children's development (Coleman, 1993). It represents the time, effort, resources, and attention parents

invest in interacting with their children, monitoring their activities, and promoting their wellbeing (Coleman, 1988; Ferguson, 2006; Parcel and Dufur, 2001).

Smith et al. (1995) further elaborated on Coleman's social capital concept, proposing that it includes both structural and process elements, relevant to educational outcomes (An and Western, 2019; Dika and Singh, 2002; Ferguson, 2006; Hoffmann et al., 2020; Liou and Chang, 2008; Murtaza, 2019). Structural family social capital refers to objective family characteristics, such as the presence of parents and the number of siblings, indicating opportunities for interpersonal interactions and their frequency and duration. Two-parent households, as in traditional families, possess social capital that is often lacking in other family structures, such as single-parent households (An and Western, 2019; Coleman, 1988; Lee, 2018; Lindfors et al., 2018; Murtaza, 2019; Pribesh et al., 2020; Smith et al., 1995). However, an increased number of siblings may compete for parental time and attention, potentially diluting available family resources per child, thus impacting academic achievement. Research consistently demonstrates that a higher number of siblings is generally associated with lower individual academic achievement, a relationship often explained by the resource dilution model (Byun et al., 2012; Coleman, 1988). In many East Asian countries, where Confucian values and collectivist norms emphasize strong familial bonds and intensive parental involvement, intact family structures tend to enhance the transmission of educational resources and support, thereby bolstering academic success (Tan and Fang, 2023). In contrast, although research in Western contexts also shows that students from intact families often perform better academically, the adverse effects of single-parent households are frequently mediated by socioeconomic factors and external social support (Coleman, 1988; Heyneman, 2016). Recent cross-national studies further suggest that the magnitude of the association between family structure and academic achievement varies considerably with national educational practices; for instance, in countries with comprehensive social welfare systems and supportive educational policies, the negative impact of nontraditional family structures on achievement may be mitigated (Lee and Borgonovi, 2022).

Process features are assessed through activities that represent the quality of parental involvement in their children's lives (Israel et al., 2001). These activities encompass nurturing (e.g., assisting with homework, discussing school activities, setting high aspirations) and monitoring (e.g., supervising behavior at school and overseeing homework). While findings regarding the effects of parental monitoring activities are mixed, with some evidence suggesting a negative correlation with desirable academic outcomes (Bassani, 2006; McNeal, 1999; Tan and Fang, 2023), this may be explained by "reversed causality" or heterogenous operationalization of social capital. Many parents engage more with their teenage children in response to their academic and behavioral challenges (Gustafsson, 2007). In contrast, proactive nurturing activities and early parent-child interactions tend to transmit norms and expectations, influencing child development positively. In empirical studies, parental human capital (e.g., education) and economic capital (e.g., income) are often used as control variables due to their significant impact on student achievement (Bradley and Corwyn, 2002; Sirin, 2005; Van Ewijk and Slegers, 2010). Moreover, parents with higher human and economic capital are generally more capable of mobilizing social capital (Bourdieu and

Emanuel, 1996; Huang, 2009; Nygård and Behtoui, 2020; Teachman et al., 1997).

However, social capital is not universally beneficial. Portes (1998) identified potential negative consequences including exclusion of outsiders, excessive obligations, restrictions on individual freedom, and downward leveling norms. In educational contexts, intensive family social capital may generate stress, limit autonomy, or reproduce inequalities when families transmit disadvantageous norms (Lareau, 2003). When family norms conflict with school expectations, strong family social capital may paradoxically impede achievement. The extent to which these negative dimensions manifest likely varies by cultural context, with intensive parental involvement experienced as supportive in some societies but intrusive in others.

2.2 Cultural variations in social capital effects

Most studies on social capital and educational achievement have focused on effects in national or regional settings (Cheung and Chan, 2008; Chu, 2004; Huang, 2009; Nygård and Behtoui, 2020), neglecting the cross-cultural validity of social capital theory. However, limited studies have identified cultural differences in the relationship between family social capital and educational outcomes, suggesting that social capital's effects may not be universally applicable across diverse cultural contexts.

In many East Asian countries such as China, Korea, deeply ingrained Confucian values and collectivist cultural norms foster intensive, structured parental involvement that not only bolsters academic performance but can also heighten student stress through the transmission of high expectations (Tan and Fang, 2023; Xie and He, 2023). In contrast, Western educational practices tend to emphasize individualism and holistic development, with parental involvement generally characterized by emotional support and the promotion of autonomy, leading to academic outcomes that are more mediated by broader socioeconomic factors (OECD, 2019). Recent empirical studies have begun to unpack these complexities, demonstrating that the interplay between family social capital and cultural capital influences educational outcomes in ways that are uniquely context dependent (Tan and Fang, 2023; Xie and He, 2023). For example, research from South Korea indicates that while certain aspects of family social capital can mitigate academic stress, other elements may inadvertently intensify it, suggesting that the beneficial effects of social capital are not universally experienced (Jarvis et al., 2020).

These findings highlight the need for further systematic investigation to critically evaluate how cultural contexts shape the influence of family social capital on student achievement. However, existing research has not systematically examined which specific cultural dimensions moderate the explanatory power of family social capital across diverse national contexts. While Coleman's (1988) framework emphasizes universal mechanisms such as norms, social control, and social closure, the empirical evidence suggests these concepts may not be equally applicable across culturally diverse settings. Bourdieu's (1986) perspective that different forms of capital operate within field-specific logics and power structures suggests that cultural orientations may structure

how family social capital translates into educational outcomes. Yet, research has not identified which specific cultural dimensions—such as individualism versus collectivism, power distance, or indulgence versus restraint—most strongly predict cross-national variations in family social capital's effectiveness.

Understanding which cultural dimensions moderate social capital's effectiveness requires theoretical specification. Hofstede et al.'s (2010) cultural dimensions framework identifies six key axes along which national cultures vary: Power Distance (acceptance of hierarchical authority), Individualism versus Collectivism (prioritization of individual versus group goals), Masculinity versus Femininity (emphasis on competition versus cooperation), Uncertainty Avoidance (tolerance for ambiguity), Long-Term versus Short-Term Orientation (emphasis on future versus present rewards), and Indulgence versus Restraint (gratification versus regulation of desires and impulses). Each dimension plausibly moderates how family social capital translates into educational outcomes. For instance, in collectivist societies emphasizing interdependence and family obligations, parental involvement may exert stronger influence on achievement as children internalize expectations to fulfill family aspirations (Byun et al., 2012). Similarly, in high power distance cultures where hierarchical relationships are normative, parental authority and family structure may more strongly shape educational trajectories. Conversely, in indulgent societies prioritizing personal gratification and leisure, supportive family interactions may be more closely aligned with cultural values, potentially amplifying their educational effects. These hypothesized relationships remain largely untested in comparative educational research, limiting theoretical understanding of social capital's cultural contingency.

Furthermore, the operationalization of social capital in educational research has lacked consensus, leading to incomparable findings across studies. This lack of consensus has hindered the comparability of prior findings on the effect of social capital on school achievement. However, the diverse operationalization of social capital has led to inconsistent findings, making it challenging to draw generalizable conclusions (Bhandari and Yasunobu, 2009; Mikiewicz, 2021; Salloum et al., 2017). Therefore, there is a need for a more standardized and comprehensive operationalization of social capital to ensure that findings across studies are comparable and can contribute to a more cohesive understanding of the impact of social capital on educational outcomes.

2.3 Meta-analysis

Meta-analysis is a powerful statistical technique that synthesizes the results of multiple studies on a particular topic to provide a comprehensive and more accurate assessment of the research question at hand (Bohnett et al., 2013). It goes beyond individual studies, pooling data from various sources to uncover patterns, trends, and effects that may not be evident in any single study. The value of meta-analysis lies in its ability to enhance the reliability and generalizability of research findings. Despite its advantages, it also has some disadvantages. For instance, studies included in a meta-analysis may vary in terms of design, population, or methodology, leading to heterogeneity in the data, which thus undermines the equivalence of the variable under study (Cooper

et al., 2019). Besides, meta-analyses are often based on published studies, which may not represent the full spectrum of research conducted on a topic. Negative or inconclusive results are less likely to be published, potentially skewing the analysis. In some cases, meta-analysts may have limited access to data due to privacy concerns or data ownership issues (Littell et al., 2008).

To cope with these drawbacks of general meta-analyses, international data with uniform coordination under the supervision of international organizations such as the OECD can play an important role, especially when studying complex social phenomena like the effects of social capital and family socio-economic status. By incorporating data from diverse regions and populations worldwide, meta-analysts can better account for heterogeneity, improving the overall robustness of their findings. International datasets following rigorous criteria and coordinated by international organizations, minimize the bias of conceptualization, operationalization and measurements. This uniform practice in the research design and data collection highly improves the equivalence of variables. Further, international collaborations and data-sharing initiatives can provide researchers with access to extensive datasets that encompass various cultural, economic, and social contexts. This facilitates a more holistic understanding of the effects being studied.

In short, internationally coordinated data is invaluable in enhancing the quality and applicability of meta-analyses. It enables researchers to overcome the inherent limitations of this technique and delve deeper into complex research questions, such as the impact of family structure and socio-economic status on individuals and communities, with a global perspective.

3 Methodology

3.1 Data description

International assessments, such as the Programme for International Student Assessment (PISA), provide a robust platform for exploring cross-cultural variations in social capital theory. These surveys collect high-quality, representative data from diverse educational systems spanning a wide range of socioeconomic contexts. Initiated in 2000 and conducted every 3 years, PISA evaluates 15-year-old students' competencies essential for adult life, focusing on literacy in reading, mathematics, and science, rather than traditional academic achievement (OECD, 2012a). Each cycle prioritizes one major domain alongside two minor domains. In 2009, the focus was on reading literacy, with mathematics and science as secondary domains. Beyond literacy assessments, PISA administers questionnaires to students, schools, and families, gathering detailed insights into school processes and familial environments. This rich contextual data supports quantitative analyses of family-based social capital's effects, complementing the influences of human and economic capital.

PISA 2009 was selected for its comprehensive Parent Questionnaire, administered in 14 economies, which provides detailed measures of family-based social capital critical for studying reading literacy. These measures, derived through factor analyses, capture aspects such as early parental support, current parental involvement, family structure, and sibling composition,

aligning with Coleman's (1988) social capital framework. While PISA 2018 also emphasizes reading literacy and included an optional Parent Questionnaire, it placed less emphasis on detailed family social capital measures, relying more on student-reported data for constructs like Economic, Social, and Cultural Status (ESCS). Additionally, PISA 2009's post-2008 financial crisis context enriches our analysis of socioeconomic influences on family dynamics, making it uniquely suited for this study (OECD, 2013).

PISA employs item-response theory (IRT) to convert assessment outcomes into scale scores. Because individual student proficiency cannot be precisely estimated from a limited set of test items, PISA generates five plausible values per student—multiple imputed scores reflecting measurement uncertainty. This approach provides unbiased estimates of population parameters while acknowledging individual-level uncertainty (OECD, 2012a). In our HLM analyses, we estimated models separately for each plausible value and averaged results, with standard errors adjusted for imputation variability following standard procedures (OECD, 2012b). Additional background data are collected via questionnaires completed by students, school administrators, and parents.

To ensure data integrity, PISA adopts a two-stage stratified sampling approach. In the first stage, schools with 15-year-old students are systematically selected using probabilities proportional to the size (PPS) of their eligible student populations. In the second stage, up to 35 students per school are randomly sampled with equal probability; in schools with fewer than 35 eligible students, all are included, with a minimum of 20 students per school. Each economy contributes data from at least 150 schools, each with 20 or more students, where feasible. Sampling weights adjust for differential selection and participation probabilities across schools and students.

This study draws on the 2009 PISA sample from 14 economies that administered the Parent Questionnaire, emphasizing reading literacy—a domain heavily influenced by social interactions at home—as the primary outcome. Reading achievement scores, the dependent variable, were vertically equated to the PISA 2000 scale, standardized with an international mean of 500 and a standard deviation of 100. Table 1 presents the 14 participating economies along with the number of schools and students analyzed.

This study examines how family-based social capital—including family structure, number of siblings, early parental support, and current parental involvement—affects reading literacy among 15-year-old students across 14 economies, using data from PISA 2009. We analyze differences between economies by applying multilevel modeling to account for students nested within schools and meta-analysis to compare effects across nations. This approach helps identify universal and culture-specific patterns, informing educational policies to enhance student outcomes.

3.2 Research design

3.2.1 Research hypotheses

This study investigates the extent to which the overall impact and specific components of family-based social capital on reading literacy vary across economies, leveraging PISA 2009 data to test two hypotheses. These hypotheses are grounded

TABLE 1 PISA 2009 data of countries used in this study.

Country	N Schools	N Students
Chile	200	5,669
Germany	226	4,979
Denmark	285	5,924
Hong Kong	151	4,837
Croatia	158	4,994
Hungary	187	4,605
Italy	1,097	30,905
Korea	157	4,989
Lithuania	196	4,528
Macao	45	5,952
New Zealand	163	4,643
Panama	188	3,969
Portugal	214	6,298
Qatar	153	9,078
Total	3,420	101,370

in Coleman's (1988) framework, which posits that social capital—encompassing norms, trust, and obligations within social structures—facilitates academic achievement by providing supportive resources. Hypothesis 1 (H1) aligns with Coleman's view, predicting that family-based social capital (e.g., parental involvement, family structure) positively impacts reading literacy by fostering supportive home environments. Hypothesis 2 (H2) challenges Coleman's universalist perspective by hypothesizing that these effects vary across economies due to cultural differences, resonating with Bourdieu's (1986) view that social capital can reproduce inequalities in stratified systems. For instance, cultural norms in collectivist societies may amplify the role of parental involvement compared to individualistic ones, necessitating a cross-cultural analysis to test these theoretical tensions.

- **H1:** Family-based social capital positively affects student reading achievement, even after controlling for human and economic capital.
- **H2:** Effects of distinct family-based social capital dimensions (e.g., family structure, parental support, sibling composition) differ significantly across economies.
- **H3:** The gross explanatory power of family-based social capital is associated with the cultural dimensions.

Family-based social capital is operationalized using PISA 2009 variables, categorized into structural and process dimensions per the frameworks of Coleman (1988) and Smith et al. (1995). The structural dimension comprises family structure (categorized as nuclear family, single-parent family, and mixed/other family types) and number of siblings, reflecting the potential quantity and dilution of family social capital resources. Process dimensions

include early parental support at the start of primary school (PRESUPP) and current parental support for reading literacy at age 15 (CURSUPP). These indices summarize the frequency of various learning-related interactions between parents and children, constructed through factor analyses, demonstrating good reliability: PRESUPP exhibits Cronbach's α ranging from 0.85 to 0.93 across economies (median = 0.89), while CURSUPP ranges from 0.81 to 0.92 (median = 0.86) (OECD, 2012a, p. 16). Higher scores on these indices indicate more frequent parent-child interactions, resulting in greater social resources. These variables were selected for their theoretical alignment with Coleman's emphasis on functional family structures and their cross-country comparability, though PISA's standardized design may limit capture of culture-specific dynamics. These are summarized in Table 2.

These PISA-based measures offer important advantages for cross-national research. First, standardized design ensures measurement equivalence across diverse cultural contexts, enabling valid comparisons. Second, factor-analyzed composite indices provide superior psychometric properties compared to single-item indicators. Third, the focus on family-specific interactions directly assesses mechanisms through which families influence student achievement, particularly reading literacy.

However, our operationalization necessarily omits several dimensions of family social capital. We do not capture parent-peer networks, extended family connections, or community ties; interaction quality beyond frequency; social closure linking parents to other parents and schools; or culturally specific practices that may constitute social capital in particular contexts. These omissions reflect data constraints inherent in large-scale international assessments and our specific focus on within-family processes. While findings may underestimate social capital's total influence, particularly where unmeasured dimensions are salient,

the standardization enables robust cross-cultural analysis central to our research aims.

Control variables encompass individual and school-level characteristics. At the student level, gender (GENDER), immigrant status (NATIVE), and Economic, Social, and Cultural Status (ESCS) are included. The ESCS index comprises parents' educational levels, occupation statuses, and home possessions, serving as a composite measure of parental human and economic capital (OECD, 2012b). At the school level, the aggregated ESCS index (CESCS) is included to control for compositional effects of human and economic capital beyond the socioeconomic impact at the student level. Detailed variable descriptions appear in Supplementary Table 1.

3.2.2 Analytical procedure

This study investigates cross-national variations in the impact of family-based social capital on students' reading literacy using a two-stage analytical framework based on country-specific two-level hierarchical linear modeling (HLM). Drawing on data from PISA 2009 across 14 economies, the methodology includes data preparation, model estimation, and cross-country comparisons to evaluate the explanatory power and heterogeneity of social capital effects (Figure 1 visualizes the procedure of data analysis).

Stage 1: Model Estimation

In the first stage, four hierarchical linear models were estimated for each economy to assess the contributions of demographic characteristics and family social capital to reading literacy. Each model accounts for students (Level 1) nested within schools (Level 2).

Null Model (Model 00): Baseline with no predictors

This model partitions the variance in reading literacy into within-school and between-school components:
Level 1 (Student Level):

$$Y_{ij} = \beta_{0j} + r_{ij}$$

TABLE 2 A cross-country comparison of school achievement based on the empty model (Model 0).

Country	Intercept	School variance	Student variance	Total variance	ICC
Chile	439.93***	3527.78***	3833.93***	7361.70	47.9%
Germany	497.41***	5146.42***	3892.41***	9038.83	56.9%
Denmark	485.57***	1425.22***	6059.95***	7485.17	19.0%
Hong Kong	533.20***	2959.87***	4156.79***	7116.66	41.6%
Croatia	474.65***	3325.14***	4247.60***	7572.74	43.9%
Hungary	476.24***	5965.12***	2872.55***	8837.67	67.5%
Italy	481.07***	5089.33***	4021.86***	9111.19	55.9%
Korea	538.78***	1996.96***	3991.63***	5988.60	33.3%
Lithuania	462.83***	2353.42***	5123.23***	7476.65	31.5%
Macao	481.00***	2129.95***	4170.19***	6300.14	33.8%
New Zealand	520.99***	2011.49***	8238.68***	10250.17	19.6%
Panama	369.35***	5397.81***	4074.98***	9472.79	57.0%
Portugal	484.33***	2389.09***	5105.86***	7494.95	31.9%
Qatar	376.88***	7352.37***	5916.85***	13269.23	55.4%
AVERAGE	473.15***				
Hedges' Q Test (χ^2)	1211.30***				

*** $p < 0.01$.

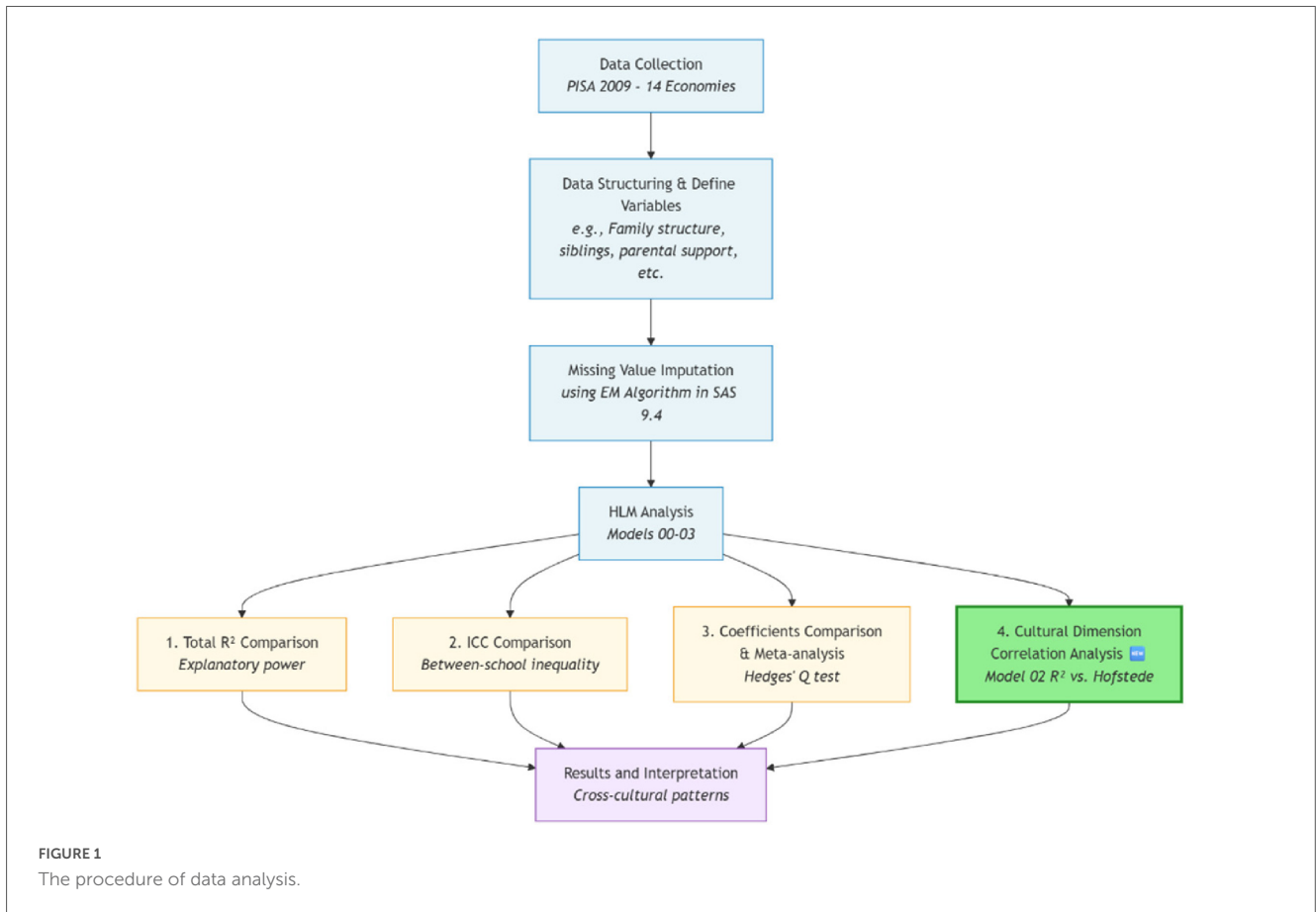


FIGURE 1
The procedure of data analysis.

Level 2 (School Level):

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

Where: - Y_{ij} is the reading score of student i in school j . - β_{0j} is the average reading score in school j . - γ_{00} is the grand mean. - r_{ij} is the student-level residual. - u_{0j} is the school-level residual.

Demographic Model (Model 01): Controls for background characteristics

Level 1:

$$Y_{ij} = \beta_{0j} + \beta_{1j} (\text{Gender}_{ij}) + \beta_{2j} (\text{ESCS}_{ij}) + \beta_{3j} (\text{Immigrant}_{ij}) + r_{ij}$$

Level 2:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} (\text{School_ESCS}_j) + u_{0j}$$

Where:

- ESCS = Economic, Social, and Cultural Status
- Immigrant = Immigrant status
- School_ESCS = Aggregated ESCS at the school level

Social Capital Model (Model 02): Social capital predictors only

Level 1:

$$Y_{ij} = \beta_{0j} + \beta_{1j} (\text{Family Structure}_{ij}) + \beta_{2j} (\text{Number of Siblings}_{ij}) + \beta_{3j} (\text{Early Parental Support}_{ij}) + \beta_{4j} (\text{Current Parental Support}_{ij}) + r_{ij}$$

Level 2:

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

Comprehensive Model (Model 03): Combined demographic and social capital predictors

Level 1:

$$Y_{ij} = \beta_{0j} + \beta_{1j} (\text{Gender}_{ij}) + \beta_{2j} (\text{ESCS}_{ij}) + \beta_{3j} (\text{Immigrant}_{ij}) + \beta_{4j} (\text{Family Structure}_{ij}) + \beta_{5j} (\text{Number of Siblings}_{ij}) + \beta_{6j} (\text{Early Parental Support}_{ij}) + \beta_{7j} (\text{Current Parental Support}_{ij}) + r_{ij}$$

Level 2:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} (\text{School_ESCS}_j) + u_{0j}$$

The explanatory power of each model was assessed using Snijders and Bosker's (1999) total R^2 (also known as Pseudo- R^2):

$$R^2 = 1 - \frac{\sigma_{\text{model}}^2 + \tau_{\text{model}}^2}{\sigma_{\text{null}}^2 + \tau_{\text{null}}^2}$$

Stage 2: Cross-Country Comparisons

Four cross-national comparisons were conducted to compare explanatory power by total R^2 , between-school inequality by intra-class correlation (ICC), magnitude of effects of predictors by Hedges' Q test across economies and models, and the relationship between explanatory power and cultural dimensions. The Hedges' Q test directly addresses Hypothesis 2 by quantifying how cultural and systemic differences influence the impact of family social

capital on reading literacy. This meta-analytic approach tests whether effect sizes (e.g., for parental support, family structure) vary significantly, revealing context-specific patterns that challenge Coleman's (1988) universalist framework.

Model Explanatory Power: Comparing R^2 values from Models 01–03 to evaluate how demographic and family social capital variables explain reading literacy.

Between-School Inequality: The ICC from the null model quantifies school-level disparities in reading literacy:

$$ICC = \frac{\tau^2}{\sigma^2 + \tau^2}$$

Where σ^2 refers to student level variances and τ^2 to school level variances.

Meta-analysis: Cross-country homogeneity of effects was assessed using meta-analysis through Hedges' Q statistic:

$$Q = \sum_{i=1}^k w_i (\bar{y}_i - \bar{y})^2$$

Where $w_i = 1/\text{variance}_i$, and $Q \sim \chi_{k-1}^2$ under the null hypothesis (refer to [Supplementary Appendix 2](#) for detailed information).

Cultural Dimension Analysis: To explore whether cross-national variations in the explanatory power of family-based social capital are systematically related to cultural differences, we conducted an additional analysis examining the relationship between Model 02's total R^2 values and Hofstede's cultural dimensions. Hofstede's cultural dimensions theory provides a framework for understanding how societal values vary across nations along six key dimensions: Power Distance (PDI), Individualism versus Collectivism (IDV), Masculinity versus Femininity (MAS), Uncertainty Avoidance (UAI), Long-Term versus Short-Term Orientation (LTO), and Indulgence versus Restraint (IVR) (Hofstede et al., 2010). The explanatory power of family social capital for each economy was operationalized as the total R^2 from Model 02, which captures the gross effect of family-based social capital (family structure, number of siblings, early parental support, and current parental support) on reading literacy without controlling for demographic factors. Cultural dimension scores for each of the 14 participating economies were retrieved from Hofstede et al. (2010). The analysis proceeded in two stages. First, we calculated Pearson correlation coefficients between Model 02 R^2 values and each of the six cultural dimension scores to identify potential associations between cultural characteristics and the explanatory power of family social capital. Second, for dimensions showing significant or substantively meaningful correlations, we estimated linear regression models with Model 02 R^2 as the dependent variable and the cultural dimension score(s) as independent variable(s) to quantify the extent to which cultural values predict the variance-explaining capacity of family social capital across economies. This approach allows us to test whether the influence of family social capital on student achievement is moderated by broader cultural contexts, thereby addressing the theoretical tension between Coleman's (1988) universalist framework and Bourdieu's (1986) emphasis on context-dependent social reproduction. Given the small sample size ($n = 14$ economies), results are interpreted cautiously, with emphasis on effect sizes and substantive patterns rather than solely on statistical significance.

This two-stage HLM/meta-analytic framework, complemented by cultural dimension analysis, allows for robust modeling of nested PISA data. HLM accounts for the hierarchical structure (students within schools), while Snijders and Bosker's R^2 , Hedges' Q test, and correlation with cultural dimensions offer rigorous metrics for model fit, cross-national generalizability, and cultural contextualization (Hedges and Olkin, 1985; Hofstede et al., 2010; Raudenbush and Bryk, 2002).

Final student weights (W_FSTUWT; see [Supplementary Table 1](#)) were used to account for the sampling strategy to ensure unbiased estimates (Carle, 2009). Missing values were imputed using the Expectation-Maximization (EM) algorithm in SAS 9.4, which can handle sampling weights in complex survey data (Berglund and Heeringa, 2014). Missing data varied across variables: gender (0.0%), immigrant status (2.4%), ESCS (1.3%), family structure (3.5%), siblings (15.6%), early parental support (15.3%), and current parental support (15.3%). Sensitivity analyses revealed substantively identical findings. This robustness validates our imputation approach across the observed missingness range. Weighted mean coefficients assume a normal distribution of regression coefficients across economies, calculated per Hedges and Olkin (1985). Analyses were performed using SAS 9.4 for multilevel linear mixed modeling, and graphs were created with Python 3.13.

4 Analytical report

This section analyzes the role of family-based social capital in student reading achievement across 14 economies, focusing on explanatory power, between-school inequality, the magnitude of social capital effects, and cultural moderation of these effects. We examine whether family social capital predicts achievement beyond human and economic capital (H1) by comparing hierarchical linear models (Snijders and Bosker, 1999) that incorporate demographic and family social capital factors, such as family structure, number of siblings, early parental support, and current parental involvement. Additionally, we assess between-school inequality using the intra-class correlation coefficient (ICC) and explore cross-country variations in family social capital effects (H2), employing Hedges' Q tests to evaluate heterogeneity with a meta-analysis. Finally, we investigate whether cross-national variations in the explanatory power of family-based social capital are systematically related to cultural differences (H3) by examining correlations and regression relationships between Model 02 R-squared values and Hofstede's cultural dimensions (Hofstede et al., 2010), with particular attention to identifying which cultural orientations most strongly predict the explanatory power of family social capital across diverse national contexts.

4.1 Cross-country comparison of model explanatory power

Figure 2 illustrates the explanatory power of family-based social capital on student reading literacy across 14 economies, measured by Snijders and Bosker's (1999) R-squared relative to the null model (Model 00). The figure presents the total R-squared for three models: Model 01 (demographic model, including

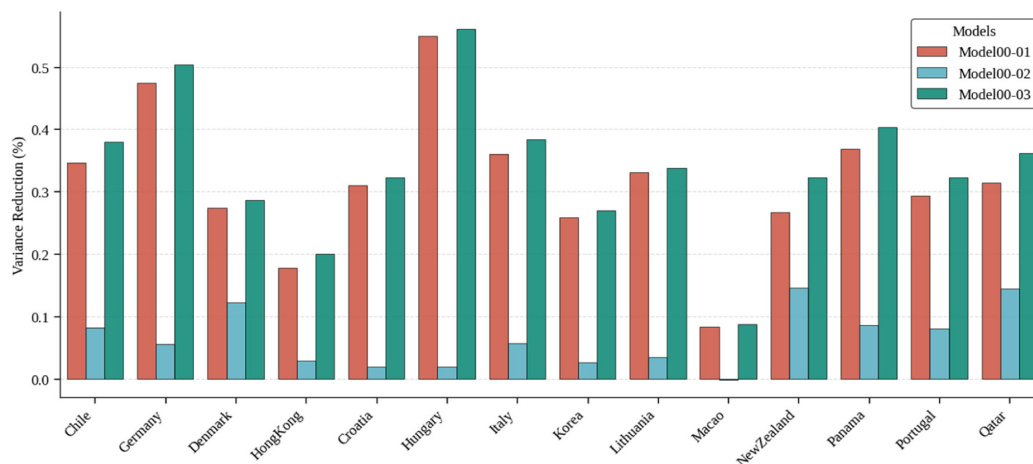


FIGURE 2

Cross-country comparison of variance explained by Model 01–Model 03 in terms of Snijder and Bosker's total R^2 (1994).

demographic factors: student-level gender, economic, social, and cultural status, immigrant status, and school-level economic, social, and cultural status), Model 02 (social capital model, including family social capital factors: family structure, number of siblings, early parental support, and current parental support), and Model 03 (comprehensive model, including both demographic and family social capital factors).

Model 01 explains a substantial proportion of variance in reading literacy, ranging from 54.9% in Hungary to 8.4% in Macao (Figure 2). Notably, economies where demographic factors have the lowest explanatory power—Macao (8.4%), Hong Kong (17.8%), and Denmark (27.4%)—are predominantly from East Asia or exhibit unique socioeconomic characteristics, suggesting regional differences in the influence of socioeconomic and demographic background.

Model 02, incorporating family social capital factors alone, shows varying gross explanatory power across economies. The R-squared for Model 02 ranges from 14.6% in New Zealand to 0.0% in Macao (Figure 2). Economies with the highest gross explanatory power for family social capital include New Zealand (14.6%), Qatar (14.5%), and Denmark (12.2%), while the lowest are Macao (0.0%), Croatia (1.9%), and Hungary (2.0%), indicating considerable cross-country variation. In most economies, the gross explanatory power of family social capital (Model 02) is substantially lower than that of demographic factors (Model 01), suggesting that demographic characteristics capture a larger portion of variance in reading literacy.

Model 03, combining demographic and family social capital factors, yields the highest R-squared values, ranging from 56.0% in Hungary to 8.8% in Macao (Figure 2). Other high-ranking economies include Germany (50.4%), Panama (40.3%), and Italy (38.3%), while the lowest are Macao (8.8%), Hong Kong (19.9%), and Korea (27.0%). The consistent ranking of economies across models suggests that demographic factors remain a dominant influence, with family social capital providing additional but variable explanatory power.

The net explanatory power of family social capital, calculated as the difference between Model 03 and Model 01 R-squared values,

is modest, ranging from 0.4% in Macao (8.8%–8.4%) to 5.5% in Germany (50.4%–47.4%). Other notable net contributions include Panama (3.4%), Portugal (2.9%), and Chile (3.4%). This modest increment highlights a significant overlap between demographic and family social capital effects, indicating strong correlations between family-based social capital and student characteristics, particularly socioeconomic background, at both student and school levels. This overlap suggests that part of the demographic effect may be mediated through family processes or contexts shaped by social capital. However, family-based social capital may also independently influence student achievement alongside socioeconomic factors, warranting further investigation into its unique contribution.

4.2 Cross-country analysis of between-school inequality

We further examine the role of family-based social capital in explaining between-school inequalities in student reading literacy across 14 economies, using the intra-class correlation coefficient (ICC). The ICC quantifies educational inequality potentially arising from unequal learning experiences, selective enrolment, or both (Raudenbush and Bryk, 2002). Figure 3 compares the ICC for Models 00–03 to assess the extent to which demographic and family social capital factors explain these inequalities.

The ICC for the null model (Model 00) reveals substantial cross-country variation in between-school inequality, ranging from 67.5% in Hungary to 19.0% in Denmark (Figure 2). High inequality in Hungary (67.5%) and Germany (56.9%) reflects their tracked educational systems, where students are streamed into academic, technical, or vocational tracks often based on socioeconomic background as well as academic capacity. In contrast, lower ICC values in Denmark (19.0%), New Zealand (19.6%), and Lithuania (31.5%) suggest more equitable systems.

Model 01, incorporating demographic factors (student-level gender, economic, social, and cultural status, immigrant status, and school-level economic, social, and cultural status), reduces the

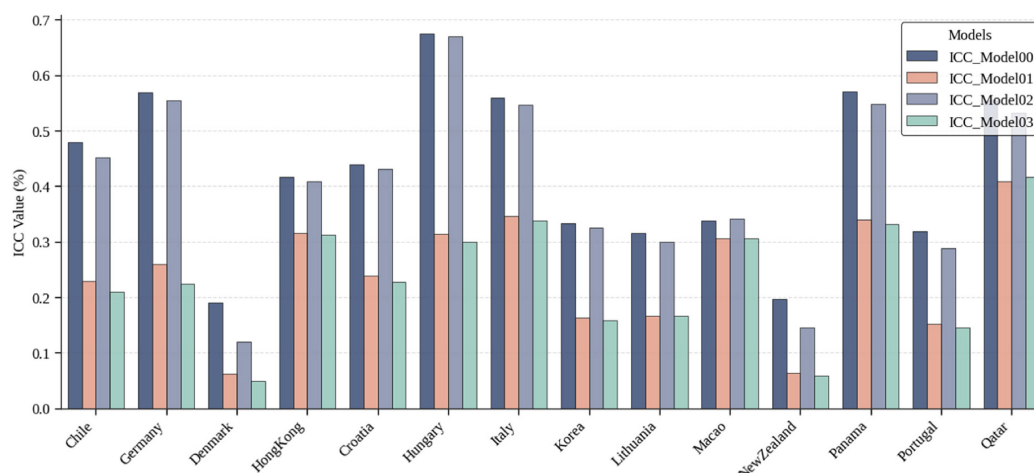


FIGURE 3

Cross-country comparison of between-school differences in student reading achievement (by ICC) in Model 00–Model 03.

ICC across all economies. The largest reductions occur in Hungary (67.5%–31.3%, a 36.2% reduction), Germany (56.9%–25.9%, a 31.0% reduction), and Chile (47.9%–22.9%, a 25.0% reduction), while the smallest reductions are in Denmark (19.0%–6.2%, a 12.8% reduction), New Zealand (19.6%–6.4%, a 13.2% reduction), and Macao (33.8%–30.6%, a 3.2% reduction) (Figure 2). This suggests that between-school inequality is closely tied to socioeconomic and demographic background, particularly in tracked systems like Hungary and Germany.

Model 02, which includes family-based social capital factors (family structure, number of siblings, early parental support, and current parental support), also reduces the ICC from Model 00, though the extent varies considerably across economies. The most significant reductions from Model 00 are in Denmark (19.0%–12.0%, a 7.0% reduction), and New Zealand (19.6%–14.6%, a 5.0% reduction), while the smallest reductions are observed in Hungary (67.5%–67.0%, a 0.5% reduction), Croatia (43.9%–43.1%, a 0.8% reduction), and Lithuania (31.5%–30.0%, a 1.5% reduction) (Figure 2). This indicates that family social capital explains a portion of between-school inequality, though its contribution varies substantially across national contexts.

Model 03, combining demographic and family social capital factors, yields the lowest ICC values, ranging from 41.7% in Qatar to 4.9% in Denmark (Figure 2). The net contribution of family social capital, calculated as the difference between Model 03 and Model 01 ICC values, is most pronounced in Germany (25.9%–22.4%, a 3.5% reduction), and Chile (22.9%–20.9%, a 2.0% reduction). However, in some economies like Qatar (40.8%–41.7%, a 0.9% increase) and Macao (30.7%–30.6%, a 0.1% reduction), the net contribution appears limited or even slightly increases inequality, highlighting the complex interplay between demographic and family social capital factors.

In summary, both the gross (Model 02 vs. Model 00) and net (Model 03 vs. Model 01) explanatory power of family-based social capital vary across economies. The substantial disparity between gross and net effects indicates significant overlap between demographic and family social capital influences, suggesting that family social capital may mediate the effects of socioeconomic

background. This aligns with Bourdieu's (1986) theory that social capital is influenced by economic and human capital, though further research is needed to disentangle these effects.

4.3 Cross-country analysis of predictor effects on reading achievement

We continue to examine the effects of family-based social capital on student reading achievement, with and without controlling for socioeconomic and demographic characteristics, across 14 economies. Tables 2–5 report the results of Models 00–03, alongside a meta-analysis of effect heterogeneity using Hedges' Q test (Hedges and Olkin, 1985).

4.3.1 Null model (Model 00)

Table 2 presents the null model (Model 00) results, including country intercepts (average reading achievement), student-level variance (Var_Stu), school-level variance (Var_Sch), and the intra-class correlation coefficient (ICC). Country intercepts range from 538.78 in Korea to 369.35 in Panama, with an overall weighted mean of 473.15 (Table 2). Hedges' Q test indicates significant heterogeneity in intercepts across economies ($p < 0.01$), reflecting diverse educational contexts. The ICC, indicating between-school inequality, varies significantly, from 67.5% in Hungary to 19.0% in Denmark.

4.3.2 Demographic effects (Model 01)

Table 3 reports Model 01 results, incorporating demographic predictors: gender, immigration status, student-level economic, social, and cultural status (ESCS), and school-level ESCS. The ICC decreases across all economies (e.g., Hungary: 67.5%–31.3%), indicating that demographic factors explain a substantial portion of between-school inequality. Economic, social, and cultural status positively predicts achievement in all economies, with a weighted mean effect of 12.97, ranging from 39.22 in New Zealand to 4.96 in Hong Kong (Table 3). Hedges' Q test confirms significant heterogeneity across economies ($p < 0.01$).

TABLE 3 A cross-country comparison of the base-line model (Model 1).

Country	Intercept	Gender	Immigration status	ESCS	School ESCS	School variance	Student variance	Total variance	ICC	Pseudo- R^2
Chile	458.24***	16.87***	8.91	8.50***	43.27***	1101.75***	3711.04***	4812.79	22.89%	34.6%
Germany	443.57***	31.05***	21.57***	9.53***	114.41***	1230.26***	3525.01***	4755.27	25.87%	31.0%
Denmark	433.49***	28.81***	35.01***	26.45***	35.96***	335.42***	5100.89***	5436.31	6.17%	27.4%
Hong Kong	571.91***	23.42***	-8.23***	4.96***	49.54***	1849.23***	3998.63***	5847.86	31.62%	47.4%
Croatia	467.92***	32.09***	9.10**	10.98***	75.08***	1248.13***	3980.84***	5228.97	23.87%	17.8%
Hungary	495.69***	22.84***	2.60	9.22***	84.25***	1249.01***	2738.73***	3987.74	31.32%	54.9%
Italy	446.98***	24.87***	39.12***	5.16***	86.44***	2021.35***	3811.65***	5832.99	34.65%	36.0%
Korea	395.17***	29.67***	141.23*	11.14***	62.94***	724.91***	3715.19***	4440.11	16.33%	25.9%
Lithuania	434.95***	52.74***	12.11	19.62***	46.11***	829.57***	4171.27***	5000.84	16.59%	33.1%
Macao	487.32***	20.64***	-8.58***	6.00***	17.60	1769.14***	4004.51***	5773.66	30.64%	8.4%
New Zealand	486.07***	44.08***	12.37***	39.22***	54.36***	479.74***	7031.96***	7511.70	6.39%	26.7%
Panama	402.76***	17.02***	16.38**	5.03***	57.01***	2025.09***	3951.31***	5976.40	33.88%	36.9%
Portugal	470.74***	33.81***	19.51***	17.34***	42.69***	802.87***	4493.56***	5296.43	15.16%	29.3%
Qatar	351.57***	32.11***	-44.26***	9.20***	72.41***	3716.02***	5387.90***	9103.92	40.82%	31.4%
AVERAGE	456.20***	29.24***	11.09	12.97***	60.43***					
Hedges' Q Test (χ^2)	781.02***	237.55***	998.58***	644.16***	339.70***					

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 4 A cross-country comparison of raw effects of family-based social capital upon student achievement (Model 2).

Country	Intercept	Family structure		Siblings	Early parental support	Current parental support	School variance	Student variance	Total variance	ICC	Pseudo-R ²
		Nuclear vs. single-parent	Mixed vs. single-parent								
Chile	448.11***	-0.91	-38.88***	-0.47	6.38***	0.78	3055.74***	3707.39***	6763.13	45.2%	8.1%
Germany	506.50***	-1.38	-11.94	-0.75	2.11	0.47	4729.31***	3809.83***	8539.14	55.4%	1.9%
Denmark	488.29***	16.35***	-21.55	0.07	8.79***	1.56	785.88***	5785.69***	6571.58	12.0%	12.2%
Hong Kong	535.45***	0.68	-4.09	-1.02	-1.06	1.19	2823.99***	4081.10***	6905.10	40.9%	5.5%
Croatia	488.12***	-5.63	-33.90**	-3.08**	3.20*	-6.61***	3204.46***	4224.51***	7428.96	43.1%	3.0%
Hungary	483.89***	-0.58	-11.32	-2.82***	3.16**	-3.60**	5802.82***	2860.77***	8663.59	67.0%	2.0%
Italy	491.31***	0.20	-39.89***	-2.66***	5.22***	-2.49***	4698.09***	3899.02***	8597.10	54.6%	5.6%
Korea	542.79***	-0.71	-9.38	0.47	1.07	3.69***	1897.86***	3933.38***	5831.25	32.5%	2.6%
Lithuania	468.41***	13.14***	-7.32	-6.78***	1.23	0.51	2164.03***	5058.20***	7222.22	30.0%	3.4%
Macao	487.31***	-1.88	-12.93**	-1.24	1.97*	-1.18	2152.57***	4156.79***	6309.37	34.1%	0.0%
New Zealand	523.62***	19.75***	-34.44**	-3.89**	12.86***	1.52	1280.30***	7475.08***	8755.38	14.6%	14.6%
Panama	384.37***	11.01***	-16.99***	-5.11***	5.28***	-3.29**	4748.99***	3906.45***	8655.45	54.9%	8.6%
Portugal	507.24***	-2.62	-32.50***	-5.24***	7.75***	-0.21	1993.32***	4896.52***	6889.84	28.9%	8.1%
Qatar	368.43***	40.14***	-1.83	-2.75***	11.21***	-5.83***	6038.47***	5304.53***	11342.99	53.2%	14.5%
Weighted mean	480.37***	6.08*	-19.45**	-2.54**	4.89**	-1.00					
Hedges' Q Test (χ^2)	812.11***	175.85***	59.80***	41.97***	115.89***	70.70***					

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 5 A cross-country comparison of net effects of family-based social capital upon student achievement (Model 3).

Country	Intercept	Gender	ESCS	School ESCS	Immigration status	Family structure		Siblings
						Nuclear vs. Single-parent	Mixed vs. single-parent	
Chile	467.08***	16.04***	6.62***	42.01***	6.89	-0.85	-36.22***	-1.01
Germany	454.34***	31.21***	11.75***	111.73***	17.21***	-2.74	-10.09	-0.27
Denmark	449.54***	29.53***	26.68***	28.74***	23.48***	4.88	-23.53	-0.55
Hong Kong	577.16***	23.91***	5.00***	48.61***	-8.90***	-0.55	-6.26	-2.41**
Croatia	483.03***	31.66***	11.35***	74.19***	8.47**	-7.71**	-33.25**	-2.71**
Hungary	503.24***	23.07***	9.17***	83.80***	3.27	-0.9	-17.29**	-2.81***
Italy	456.66***	23.76***	5.27***	84.08***	38.24***	-0.01	-34.19***	-2.19***
Korea	412.21***	28.49***	11.01***	62.87***	131.75*	-5.33	-7.36	0.31
Lithuania	443.27***	52.75***	19.54***	42.62***	11.78	5.63**	-10.38	-5.41***
Macao	496.33***	21.42***	5.55***	19.28*	-9.36***	-2.46	-11.33*	-2.47**
New Zealand	505.22***	41.84***	35.77***	42.05***	7.33**	6.31	-25.55*	-4.34***
Panama	414.94***	17.52***	4.49**	53.04***	14.25*	9.95***	-15.74***	-4.86***
Portugal	497.09***	32.07***	16.88***	39.25***	13.48**	-3.83	-28.80***	-5.21***
Qatar	347.35***	29.21***	9.89***	60.37***	-36.61***	33.68***	-2.19	-2.28***
weighted mean	467.44***	28.71***	12.70***	56.91***	8.62	2.44	-18.24***	-2.59***
Hedges' Q Test (χ^2)	590.46***	207.65***	434.41***	113846.88***	642.67***	107.28***	45.94***	29.79***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 5 (Continued)

Country	Early parental support	Current parental support	School variance	Student variance	Total variance	ICC	Pseudo- R^2
Chile	5.39***	-0.03	953.06***	3612.56***	4565.61	20.9%	38.0%
Germany	-1.21	-1.12	1005.21***	3478.80***	4484.00	22.4%	32.3%
Denmark	3.86**	-1.34	260.01***	5084.62***	5344.63	4.9%	28.6%
Hong Kong	-1.25	0.12	1776.13***	3921.09***	5697.22	31.2%	50.4%
Croatia	2.17	-7.14***	1162.23***	3962.76***	5124.99	22.7%	19.9%
Hungary	2.13*	-3.73***	1162.21***	2723.61***	3885.81	29.9%	56.0%
Italy	3.88***	-3.68***	1900.18***	3718.04***	5618.23	33.8%	38.3%
Korea	-0.45	2.92**	689.97***	3683.05***	4373.02	15.8%	27.0%
Lithuania	0.48	-2.81*	823.77***	4125.98***	4949.75	16.6%	33.8%
Macao	0.92	-1.07	1756.66***	3991.04***	5747.70	30.6%	8.8%
New Zealand	8.28***	-1.00	402.48***	6534.64***	6937.12	5.8%	32.3%
Panama	4.72**	-3.65**	1879.95***	3776.78***	5656.73	33.2%	40.3%
Portugal	4.43***	-2.30*	740.07***	4339.22***	5079.28	14.6%	32.2%
Qatar	8.95***	-5.90***	3531.61***	4944.78***	8476.39	41.7%	36.1%
Weighted mean	3.00***	-2.15***					
Hedges' Q test (χ^2)	81.70***	62.43***					

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

School-level ESCS, reflecting school composition, also positively predicts achievement in 13 economies (mean effect: 60.43), with effects ranging from 114.41 in Germany to 35.96 in Denmark, except in Macao where it is insignificant; Hedges' Q test

shows significant heterogeneity ($p < 0.01$). Girls outperform boys in all economies (mean difference: 29.24), with the largest gap in Lithuania (52.74) and the smallest in Chile (16.87); Hedges' Q test indicates significant heterogeneity ($p < 0.01$).

Native students outperform non-natives in eight economies but score lower in Macao and Qatar, with significant heterogeneity ($p < 0.01$).

4.3.3 Gross effects of family social capital (Model 02)

Table 4 presents Model 02 results, estimating the gross effects of family-based social capital without controlling for demographic factors. Here, we explore the distinct contributions of family structure, number of siblings, early parental support, and current parental support on student achievement across 14 economies.

Family structure exhibits varied effects across economies. Compared with single-parent families, nuclear families generally hold an advantage in enhancing student achievement, with a weighted mean effect of 6.08, though this difference is only marginally significant ($p < 0.1$) across the 14 economies. Nuclear families significantly improve student achievement in five economies: Denmark (16.35), Lithuania (13.14), New Zealand (19.75), Panama (11.01), and Qatar (40.14). However, in several other economies, this effect is insignificant or occasionally negative. Conversely, mixed/other family structures show a detrimental impact on student achievement, with an overall weighted mean effect of -19.45 . This negative influence is statistically significant in seven economies, ranging from -39.89 in Italy to -12.93 in Macao; Hedges' Q test confirms significant heterogeneity ($p < 0.01$).

The number of siblings negatively correlates with achievement across most economies, with a weighted mean effect of -2.54 . This dilution effect is significantly negative in eight economies, ranging from -6.78 in Lithuania to -2.66 in Italy; Hedges' Q test shows significant heterogeneity ($p < 0.01$).

Early parental support exhibits a positive effect on student achievement, with an overall weighted mean of 4.98. This effect is significantly positive in eight economies, ranging from 12.86 in New Zealand to 3.16 in Hungary. In two additional economies, Croatia and Macao, the relationship is positive, although at a marginally significant level ($p < 0.1$); Hedges' Q test indicates significant heterogeneity ($p < 0.01$).

Conversely, current parental support presents a contrasting pattern. This effect is significantly negative in five economies, spanning from -6.61 in Croatia to -2.49 in Italy. However, a notable exception occurs in Korea, where a remarkably positive relationship (8.84) between current parental support and reading literacy is observed; Hedges' Q test confirms significant heterogeneity ($p < 0.01$). This anomaly might be attributed to unique cultural dynamics in Korea, where parents tend to maintain consistent involvement throughout their children's schooling, particularly during the demanding secondary school years characterized by intense college entrance examination preparation.

4.3.4 Net effects of family social capital (Model 03)

Table 5 reports Model 03 results, estimating the net effects of family social capital after controlling for demographic factors. The marginal advantage previously associated with nuclear families diminishes in terms of the overall weighted mean effect (from 6.08 to 3.21) across all 14 economies. Additionally, the significant associations observed in Denmark and New Zealand disappear entirely after controlling for student socioeconomic

and demographic background, hinting at a substantial correlation between family structure and student socioeconomic factors. The positive effects of nuclear families in Lithuania (13.14–5.63), Panama (11.01–9.95), and Qatar (40.14–33.68) decrease in magnitude. A significant negative association between mixed families and reading literacy emerges in Hungary (-17.29), joining the previous seven economies; Hedges' Q test shows significant heterogeneity ($p < 0.01$).

Concerning the dilution effect of the number of siblings, the overall weighted mean effect remains relatively stable at -2.59 . Hong Kong (-2.41) and Macao (-2.47) show two additional significant negative associations, supplementing the eight previously identified in Model 02. Among economies where significant negative effects were detected in Model 02, these effects diminish somewhat in all economies except New Zealand, after accounting for student ESCS and other demographic features; Hedges' Q test confirms significant heterogeneity ($p < 0.01$).

The overall weighted mean effect of early parental support decreases from 4.89 to 3.00. The two marginally significant positive associations in Croatia and Macao become insignificant, and the strengths of all remaining significant associations identified in Model 02 decrease; Hedges' Q test indicates significant heterogeneity ($p < 0.01$).

The overall weighted mean effect of current parental support becomes significantly negative at -2.15 ($p < 0.01$). In addition to the five significant negative associations identified in Model 02, marginally significant negative associations ($p < 0.1$) emerge in Portugal and Lithuania. Notably, current parental support in Korea remains positively related to reading literacy (2.82), albeit with a slightly reduced effect size, suggesting that Korean parents consistently engage with students throughout their school years; Hedges' Q test shows significant heterogeneity ($p < 0.01$).

Hedges' Q tests consistently indicate significant heterogeneity in the effects of predictors across economies for all models ($p < 0.01$), underscoring diverse educational contexts. Family social capital effects vary substantially across national contexts, with some factors (e.g., family structure, early parental support) showing positive associations in certain economies while being insignificant or negative in others. These findings align with the hypothesis that cultural and systemic differences shape how family social capital influences student achievement, challenging universalist assumptions in Coleman's (1988) framework.

4.4 Cross-country analysis of cultural dimensions

To further investigate the sources of cross-country heterogeneity in the explanatory power of family-based social capital (H3), we examined its associations with Hofstede's six cultural dimensions (Hofstede et al., 2010): Power Distance (PDI), Individualism versus Collectivism (IDV), Masculinity versus Femininity (MAS), Uncertainty Avoidance (UAI), Long-Term Orientation versus Short-Term Normative Orientation (LTO), and Indulgence versus Restraint (IVR). Following the procedures outlined in the research methods section, we first conducted Pearson correlation analyses between the gross explanatory power

of family-based social capital (Model 02 R-squared) and the cultural dimension scores across the 14 economies.

Table 6 presents the correlation matrix. The results reveal significant correlations between Model 02 R-squared and two cultural dimensions: a strong positive correlation with IVR ($r = 0.87, p < 0.01$) and a moderate negative correlation with LTO ($r = -0.57, p = 0.05$). No significant associations were found with the other dimensions (IDV, MAS, PDI, UAI; all $p > 0.05$).

To identify the key predictors, we proceeded with stepwise regression analyses. First, a multiple regression model including both IVR and LTO as predictors of Model 02 R-squared yielded an R-squared of 0.768 (adjusted R-squared = 0.716).

As shown in Table 7, IVR emerged as a significant positive predictor ($\beta = 0.002, p = 0.003$), while LTO was not significant ($\beta = 0.000, p = 0.680$).

A subsequent regression model retaining only IVR as the predictor confirmed its robust significance ($\beta = 0.002, p < 0.001$), explaining 76.3% of the variance (adjusted R-squared = 0.739).

Figure 4 and Table 8 illustrate this strong positive linear association, indicating that economies scoring higher on Indulgence versus Restraint—characterized by greater emphasis on gratification of basic human desires, enjoyment of life, and leisure (Hofstede et al., 2010)—exhibit substantially greater explanatory power of family-based social capital in predicting student reading achievement. This finding suggests that cultural norms promoting indulgence amplify the role of family processes in educational outcomes, potentially through more relaxed and supportive family environments.

4.5 Summary of the comparative analysis

This cross-country analysis across 14 economies confirms that family-based social capital significantly predicts student reading achievement beyond human and economic capital (H1). The intra-class correlation coefficient (ICC) decreases from Model 00 to Model 03, with family social capital associated with between-school inequality, though the extent varies considerably. Nuclear families and early parental support positively correlate with achievement in several economies, while the number of siblings shows consistent negative effects, and current parental support exhibits predominantly negative correlations except in Korea. Hedges' Q tests confirm significant heterogeneity in effects across economies, supporting H2 and highlighting the context-specific nature of family social capital's influence on reading literacy. Furthermore, the gross explanatory power of family-based social capital is strongly positively associated with the cultural dimension of Indulgence versus Restraint (IVR), explaining 76.3% of cross-country variance and confirming H3. This suggests that in societies prioritizing Indulgence, family-based social capital exerts a stronger influence on academic outcomes compared to Restraint-oriented societies. Collectively, these findings challenge universalist assumptions, revealing that the role of family social capital is shaped by a complex interplay of demographic factors, educational system characteristics, and national cultural values.

TABLE 6 Pearson correlation matrix.

		M02_R ²	IDV	IVR	LTO	MAS	PDI	UAI
M02_R ²	Corr.	1.00	0.20	0.87	-0.57	-0.21	-0.22	-0.05
	Sig.		0.49	0.00	0.05	0.48	0.45	0.86
	N.		14.00	12.00	12.00	14.00	14.00	14.00
IDV	Corr.		1.00	0.33	-0.07	0.33	-0.82	-0.23
	Sig.			0.30	0.82	0.26	0.00	0.44
	N.			12.00	12.00	14.00	14.00	14.00
IVR	Corr.			1.00	-0.59	-0.24	-0.59	-0.07
	Sig.				0.04	0.46	0.04	0.83
	N.				12.00	12.00	12.00	12.00
LTO	Corr.				1.00	0.20	0.05	0.02
	Sig.					0.52	0.87	0.95
	N.					12.00	12.00	12.00
MAS	Corr.					1.00	0.03	0.01
	Sig.						0.92	0.97
	N.						14.00	14.00
PDI	Corr.						1.00	0.39
	Sig.							0.17
	N.							14.00
UAI	Corr.							1.00
	Sig.							
	N.							

TABLE 7 Parameter estimates for regression of LTO and IVR on Model 02 R^2 .

Variable	DF	Estimate	Standard error	t-value	Pr > t	Lower 95% CL	Upper 95% CL
Intercept	1.000	-0.002	0.034	-0.040	0.966	-0.078	0.075
IVR	1.000	0.002	0.000	4.130	0.003	0.001	0.003
LTO	1.000	0.000	0.000	-0.430	0.680	-0.001	0.001
R-square		0.768					
Adj R-Sq		0.716					

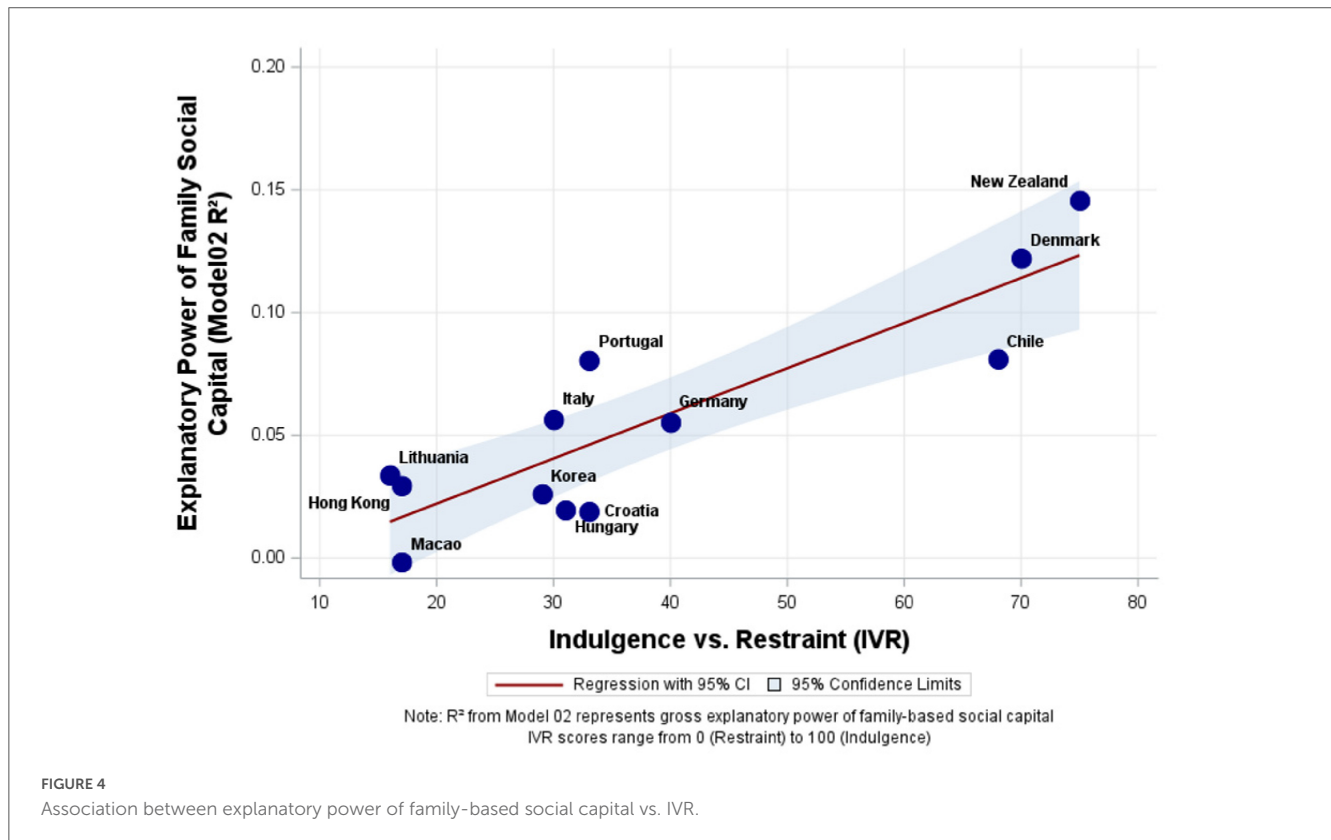


FIGURE 4 Association between explanatory power of family-based social capital vs. IVR.

TABLE 8 Parameter estimates for regression of IVR on Model 02 R^2 .

Variable	DF	Estimate	Standard error	t-value	Pr > t	Lower 95% CL	Upper 95% CL
Intercept	1.000	-0.015	0.014	-1.040	0.323	-0.046	0.017
IVR	1.000	0.002	0.000	5.670	0.000	0.001	0.003
R-square	0.763						
Adj R-Sq	0.739						

5 Discussion and conclusion

5.1 Major findings

Heyneman and Loxley (1983) effects indicate that the influence of family background upon student achievement are conditioned by income levels (Heyneman, 2016; Lee and Borgonovi, 2022), suggesting that the mechanism of family socio-economic background affecting student achievement vary

across countries by levels of economic development. However, influence of material capital diminishes beyond a certain threshold while social capital becomes more significant (Salloum et al., 2018). Within the realm of educational effectiveness research, our exploration has illuminated a fundamental aspect often overlooked in prior research: the profound cultural dimension that underscores the impact of family social capital on educational outcomes. Our study traversed a diverse landscape of economies, each with its unique sociocultural milieu, to unearth the intricate variations in

the strength, direction, and statistical significance of family social capital's influence on reading literacy.

Across all economies examined, social capital has a substantial impact on student achievement in addition to the influence of family socio-economic status (SES). Moreover, there is evidence of an overlap between the effects of family SES and social capital, albeit with varying degrees across countries. Furthermore, there is a moderate, yet statistically insignificant correlation between the explanatory power of family SES and social capital, suggesting that the impact of financial capital and social capital are somewhat independent from each other on the country level. This implies that investing in social capital, without incurring additional financial burdens, could have a positive impact on student achievement. However, all these effects play out depending on socio-economic and cultural contexts.

Our research has also yielded nuanced insights into the multifaceted facets of family social capital. Among these insights, we observed the adverse impact of an increased number of siblings on reading literacy. While in most economies, a larger number of siblings tends to dilute family resources, creating an environment where individual attention becomes a precious commodity, there are notable exceptions. Additionally, our study shed light on the positive correlation between early parental childhood support and reading literacy. Children who receive substantial support during their formative years tend to fare better academically. Intriguingly, Korean current parental support exhibited anomalous positive effects, challenging conventional wisdom suggesting such support is merely reactive. In Korea's collectivist context emphasizing constant parental involvement and intense academic investment, parental support functions proactively, reinforcing literacy development (Jarvis et al., 2020; Kim and Bang, 2017).

A particularly significant contribution is our cultural dimension analysis revealing that Hofstede's Indulgence versus Restraint (IVR) dimension strongly predicts family social capital's explanatory power. This demonstrates that in more indulgent societies—where gratification and enjoyment are culturally valued—family social capital exerts substantially greater influence than in restrained societies governed by strict social norms. This illuminates a critical insight: mechanisms through which family resources translate into educational success are fundamentally shaped by cultural contexts. In indulgent societies, parent-child interactions, family structure, and parental involvement directly influence reading development, aligning with cultural values prioritizing personal fulfillment and interpersonal warmth. Conversely, in restrained societies, educational outcomes may be more strongly governed by institutional factors and formal schooling processes.

Family social capital's net impact varies substantially across economies and often encounters constraints. When considered alongside background factors, added explanatory power is frequently limited. This extends to reducing between-school inequality, where family social capital's contribution ranges from substantial (Hungary, Germany) to minimal (Macao, Hong Kong). Achieving equitable outcomes requires multifaceted approaches considering socioeconomic background, school quality, societal influences, and—as our analysis demonstrates—compatibility between family-based mechanisms and cultural orientations.

Our findings challenge Coleman's social capital theory. While Coleman emphasized norms, social control, and social closure, our

results suggest these concepts may not be universally applicable in culturally diverse settings. The strong predictive power of IVR indicates Coleman's framework requires cultural contextualization. Social capital operates within cultural contexts that define legitimate, valued, and effective family practices, aligning with Bourdieu's (1986) perspective that capital forms operate within field-specific logics, extended by identifying IVR as structuring these dynamics across national contexts.

5.2 Implications

This research has important implications for theory, policy, and practice. First, it underscores the need for critical re-evaluation of Coleman's social capital theory and measurement. The discovery that IVR strongly moderates family social capital's explanatory power suggests researchers must consider cultural dimensions when theorizing about, measuring, and interpreting effects. Future frameworks should explicitly incorporate cultural orientation as a moderating factor rather than treating social capital effects as culturally invariant.

Second, findings highlight the importance of considering family social capital within broader educational contexts profoundly influenced by community and school norms. The cultural dimension analysis reinforces this by demonstrating that identical family practices may have different impacts depending on cultural context. Future research should explore complex interactions between social capital and other capital forms, effectiveness thresholds, and simultaneous influences of multiple social contexts.

Third, findings carry policy implications. In higher-indulgence societies, policies strengthening family social capital—parental engagement programs, family literacy initiatives, family structure supports—may be particularly effective levers for improving outcomes. Conversely, in restrained societies, strategies may need to focus more on institutional quality, pedagogical approaches, and school-based resources. This does not mean family engagement is unimportant in restrained societies, but policymakers should calibrate expectations and investments according to cultural context.

Furthermore, substantial heterogeneity in family social capital effects (Hedges' Q tests, $p < 0.01$) cautions against direct policy transfer across cultural contexts. Interventions proven effective in high-IVR societies (New Zealand, Denmark) may not achieve similar results in lower-IVR societies (Hong Kong, Korea) without substantial cultural adaptation.

5.3 Limitations

This study has several important limitations that warrant careful consideration. First, measurement limitations affect key constructs. The ESCS index has been criticized for lacking contextual sensitivity and pragmatic validity, not fully aligning with SES's multidimensional, context-specific nature (Avvisati, 2020; Rutkowski and Rutkowski, 2013). This may undermine modeling family effects and cross-country comparisons, highlighting needs for improved SES measurement in PISA capturing diverse national and cultural contexts. Similarly, our family social capital measures,

while theoretically grounded in Coleman's (1988) framework, may not fully capture culturally specific practices or the quality of interactions beyond their frequency.

Second, data and sample limitations constrain generalizability. Reliance on decade-old data may not fully reflect current practices and evolving family dynamics in an increasingly digital, globalized world. However, PISA 2009's unique focus on reading literacy and comprehensive family social capital measures provide valuable, relevant insights. The cultural dimension analysis is further limited by relatively small sample size ($n = 14$) and cross-sectional design. While IVR's statistical significance ($p < 0.001$) and large effect size ($R^2 = 0.763$) are impressive, caution is warranted in generalizing. Replication with larger samples and recent data would strengthen confidence. Additionally, Hofstede's dimensions represent national averages that may not capture within-country heterogeneity or how cultural values manifest in specific family practices.

Third, the cross-sectional design imposes fundamental threats to causal inference. Selection bias may operate if families high in social capital differ systematically on unobserved characteristics such as parental motivation, intelligence, or personality traits that independently affect student achievement. Our controls for ESCS partially address this concern but cannot eliminate unmeasured confounding. Omitted variable bias remains likely; while we control for SES, we lack measures of parental personality, time availability, cognitive ability, or child characteristics (temperament, prior achievement) that may jointly determine both family social capital and reading literacy. Reverse causality threatens interpretation, particularly for current parental support where parents may increase involvement in response to children's academic difficulties rather than proactively fostering achievement. The predominantly negative coefficients for current support across most economies (except Korea) suggest compensatory involvement patterns. Measurement error in self-reported parental support may introduce bias through social desirability, with parents over-reporting involvement frequency.

Each threat likely biases estimates in specific directions: selection and omitted variables may inflate social capital effects if unmeasured factors positively correlate with both predictors and outcomes, while reverse causality may attenuate or reverse true effects for current support. Despite these limitations, our findings contribute valuable insights into cross-national variations in family social capital effects and their systematic relationship with cultural dimensions. Future research employing longitudinal designs with multiple measurement occasions, instrumental variable approaches exploiting exogenous policy changes, or family fixed-effects models comparing siblings would better establish causal mechanisms and strengthen confidence in the patterns we have identified.

5.4 Research suggestions

Future research should explore several avenues. First, using recent datasets (PISA 2018 or later) to examine whether educational policy changes, digital technology use, and evolving family dynamics have altered family social capital's influence (OECD, 2019), particularly whether the IVR relationship has persisted or changed. Second, broadening social capital operationalization to include digital social capital and community resources might provide comprehensive understanding of how familial

support interacts with cultural contexts (Coleman, 1988; Tan and Fang, 2023). Third, employing longitudinal designs could clarify causal relationships and illuminate dynamic interplay between family social capital and academic performance over time, particularly regarding mediating factors and whether effects vary across cultural contexts (Dufur et al., 2013). Expanding cultural dimension analysis represents another promising direction. Future research could examine additional cultural frameworks beyond Hofstede's dimensions or explore within-country cultural variation. Qualitative research exploring how families in high-IVR versus low-IVR societies conceptualize and enact parental involvement would provide valuable mechanistic insights into pathways through which cultural orientation shapes family social capital's effectiveness.

6 Conclusion

This research contributes substantially to educational studies by unraveling family social capital's multifaceted impact on reading literacy, underscoring profound cultural dimensions necessitating context-specific approaches. Identifying Indulgence versus Restraint (IVR) as a powerful moderator represents a particularly novel contribution, advancing social capital theory by demonstrating empirically that family social capital's explanatory power is systematically moderated by cultural orientation. This challenges universalist assumptions in Coleman's framework while providing empirical specificity about which cultural dimensions matter most.

For practitioners and policymakers, results suggest effective educational improvement strategies must be calibrated to cultural context, with family-focused interventions likely most impactful in indulgent societies and institutional approaches potentially more effective in restrained contexts. As the world becomes increasingly interconnected yet remains profoundly diverse in cultural orientations and educational practices, understanding how family social capital operates across this diversity becomes critical. Our research provides both empirical evidence and conceptual tools for navigating this complexity, contributing to culturally informed theories of educational effectiveness and contextually appropriate policies for supporting student achievement globally.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: OECD PISA 2009 data: <https://www.oecd.org/en/data/datasets/pisa-2009-database.html>.

Author contributions

HL: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. JV: Methodology, Project administration, Resources, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Correction note

This article has been corrected with minor changes. These changes do not impact the scientific content of the article.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2026.1487031/full#supplementary-material>

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